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Acknowledgements:
Acknowledgements of general support, grants, technical assistance, etc., should be indicated. Authors are responsible for obtaining the consent of those being acknowledged.

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Rampal L, Liew BS, Choolani M, Ganasegeran K, Pramanick A, Vallibhakara SA, et al. Battling COVID-19 pandemic waves in six South-East Asian countries: A real-time consensus review. Med J Malaysia 2020; 75(6): 613-25.

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Books and Other Monographs:
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Goodman NW, Edwards MB. 2014. Medical Writing: A Prescription for Clarity. 4 th Edition. Cambridge University Press.

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World Health Organization, Geneva. 2019. WHO Study Group on Tobacco Product Regulation. Report on the scientific basis of tobacco product regulation: seventh report of a WHO study group. WHO Technical Report Series, No. 1015.

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The association of fatigue severity with pain level, obesity indices and functional performances in women with knee osteoarthritis

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ABSTRACT

Introduction: Knee osteoarthritis is most common among women with obesity. It may lead to physical inactivity that, in turn, causes fatigue or lack of physical enthusiasm to perform meaningful daily activities. Hence, this study aimed to examine whether pain level, obesity indices and functional performances are associated with fatigue severity in women with knee osteoarthritis (KOA).

Materials and Methods: This cross-sectional study recruited women referred to physiotherapy to manage OA. The measurements included fatigue severity (fatigue severity scale); pain level (numerical rating scale); obesity indices (body mass index, fat %, waist circumference); functional performances (upper limb strength, lower limb strength, mobility, exercise capacity and quality of life). A simple linear regression analysis was used to determine which independent variable may be associated with fatigue severity.

Results: Ninety-six women with unilateral KOA participated in this study (Mean age, 55.70, Standard Deviation, SD 6.90) years; Mean fatigue severity, 34.51, SD 14.03). The simple linear regression analysis showed that pain level (β=4.089, *p*<0.001), fat % (β=0.825, *p*<0.001) and QoL (β=0.304, *p*<0.001) were significantly associated with fatigue. After controlling for pain level, only fat % was significantly associated with fatigue (β=0.581, *p*=0.005).

Conclusion: Pain level, fat %, and QoL appear to be associated with fatigue severity in women with KOA. In addition, pain symptoms may interact with factors associated with fatigue severity.

KEYWORDS:
Functional performance, osteoarthritis, obesity, pain, quality of life

INTRODUCTION

Knee osteoarthritis (KOA) is a degenerative joint disease associated with ageing, female sex, obesity, and repetitive joint trauma.[1] Women diagnosed with KOA are at much higher rates than men. It was found that about 18% of women had symptomatic KOA, and only about 9.6% of men had similar conditions.[2] KOA severely impacted women due to differences in anatomy, kinematics, and hormonal influences.[3] Furthermore, women with KOA present for treatment in more advanced stages and have more debilitating pain than their male counterparts.[3]

Pain sensation, the most dominant symptom of KOA, has been shown to limit functional and physical activities such as walking, sitting to standing, performing household chores, climbing stairs and sitting upright.[4-6] Ultimately, lack of physical activity might lead to poor exercise tolerance or fatigue that is defined as an unpleasant and subjective feeling of tiredness, exhaustion or lack of energy.[7] A previous study has shown that fatigue is associated with the life aspects of people with osteoarthritis.[8] About 40% of people with OA reported clinically meaningful levels of fatigue that resulted in significant disruptions to their regular social, leisure time, and activities of daily living.[9]

Based on the prior knowledge of factors associated with osteoarthritis, understanding what factors may influence fatigue warrants further study, as fatigue is an established factor leading to physical inactivity. However, to date, a limited number of studies have identified factors that influence fatigue in individuals with KOA. One study reported the associations between pain and fatigue levels, symptom interference, and physical activity in adults with KOA.[9] However, this study was limited to understanding pain and fatigue-related activities that interfere with physical activity over a day. It is not well established if other factors may associate with fatigue in women with KOA. Since KOA is a progressive degenerative process, management of KOA should include education, exercise and weight loss,[10] that can be targeted to promote pain relief and increase exercise tolerance. However, besides understanding the relationship between pain and fatigue, further investigation on other factors, such as obesity indices and functional performances (e.g., strength, mobility, exercise capacity and quality of life), may provide insights into the association of these variables with the level of fatigue.

Therefore, to provide evidence for clinical practice, this study aimed to measure whether fatigue severity was associated with pain level, obesity indices (body mass index, fat percentage, waist circumference) and functional performances in women diagnosed with KOA.

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Table I: Participants' characteristics (N=96)

Variables	Fatigue Severity Mean (SD)			*p*-value
	ALL (N=96)	Low (n=47)	High Severity (n=49)	
Age (years)	55.70 (6.90)	54.98 (6.75)	54.39 (7.04)	0.320
Height (m)	1.55 (0.53)	1.56 (5.32)	1.54 (5.25)	0.170
Bodyweight (kg)	70.16 (12.13)	68.91 (11.74)	71.35 (2.49)	0.327
BMI (kg/m2)	29.14 (5.00)	28.34 (4.95)	29.90 (4.99)	0.128
Fat %	40.04 (6.41)	38.07 (6.06)	41.93 (6.23)	0.003**
WC (cm)	94.62 (11.11)	94.27 (10.85)	94.96 (11.45)	0.761
Pain level	2.63 (1.51)	2.11 (1.13)	3.12 (1.67)	0.001**
Fatigue	34.51 (14.03)	22.32 (7.24)	46.20 (7.60)	<0.001**
UL strength (kg)	18.83 (5.09)	18.29 (5.87)	19.35 (4.20)	0.309
LL strength (s)	13.11 (5.64)	13.06 (4.81)	13.15 (6.38)	0.940
Mobility (s)	11.65 (2.98)	11.21 (2.36	12.08 (3.45)	0.158
ES (m)	304.54 (56.38)	307.68 (57.73)	301.54 (55.49)	0.596
QoL	23.65 (18.16)	13.58 (10.96)	28.34 (19.01)	0.002**

Note: t-test significant at *p<0.05 and **p< 0.01; SD – Standard Deviation
UL - upper limb, LL - lower limb
WC: Waist circumference
UL: Upper limb
LL: Lower limb
EC (please change ES to EC): Exercise capacity
QoL: Quality of life

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study was conducted among women with KOA who were referred for physiotherapy management. Patients included in the study were diagnosed with unilateral knee OA according to a radiographic grade, aged 40 to 65 years old, understood Malay or English and had a referral from a medical doctor. Patients with knee arthroplasty, pregnant, had knee motion limitation (<70° of knee flexion) or knee deformity associated with KOA, had other medical problems (e.g., rheumatic disease, cardiovascular problem, gastrointestinal tract disease, or neurological problem), and had recent surgery (<6months) were excluded from the study. This study was approved by the Research Ethics Committee of Universiti Teknologi MARA (UiTM) on 3rd September 2019 (Approval no. 600-IRMI (5/1/6)). Informed consent forms were obtained from all participants after a briefing about the study procedure.

Instrumentations

Fatigue severity was assessed using the Fatigue Severity Scale (FSS). The FSS is a self-administered questionnaire with nine items related to how fatigue affects motivation, exercise, physical functioning, and interference with work, family, and social life, based on a seven-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The minimum score is 9, and the maximum score is 63; the higher the score, the greater the fatigue severity.[11] The score at the 50th percentile was used to group participants into low and high fatigue levels. The FSS has high validity and reliability in assessing fatigue levels and how it will affect the patients' daily activity.[12]

The current level of pain intensity was measured using the Numerical Rating Scale (NRS). The NRS is a scale of 0, which indicates no pain, to 10, which indicates the worst pain. The participant was asked to choose the number that best represented the pain level of their affected knee. The NRS has excellent test-retest reliability with intra-class correlation coefficients of 0.95, a standard error of measurement (SEM) of 0.48 and a minimum detectable change of 1.33.[13]

We measured the participant's height and body weight to calculate the body mass index (BMI). These measurements were taken twice by the same investigator to minimise inter-rater error. The participant's body weight was measured using a TANITA weighing scale (Japan) and recorded to the nearest 0.1 kg. The height was measured using the SECA Model Body (Germany) with the head horizontal to the Frankfurt plane to the nearest 0.1 cm. Both measurements were taken with shoes off. Body Mass Index (BMI) was calculated using the body weight in kilogram (kg) divided by the square of height in metres (m^2).

A bioelectrical impedance analysis (BIA) machine (TANITA BC418) was used to measure the body fat percentage (%). The participant stood on the footpads of the BIA platform while grasping the handles and was reminded to remain still and relaxed, as the measurement results appeared in less than 30 seconds. The waist circumference (in cm) was measured using a non-elastic cloth tape in standing with feet shoulder-width apart. The measurement was taken over the bare skin between the costal margin and the top of the iliac crest at the level of the smallest waist diameter, approximately between the lower ribs level and the iliac crest. The participant was asked to remove their clothing except for light underwear. The measurement was recorded to the nearest 0.5cm based on the tape resolution.

The upper limb strength represented by the handgrip was assessed using the Jamar Analogue Hand Dynamometer, which has good reliability and validity for measuring handgrip strength.[14] The participant was instructed to sit with elbows in 90° flexion parallel to the trunk. Then, the participant was asked to squeeze the dynamometer as hard as possible. The assessment was repeated thrice on each

Table II: The Pearson correlation of fatigue with pain level, obesity indices, and functional performances (N=96)

		r (p-value)										
		1	2	3	4	5	6	7	8	9	10	11
1	Fatigue level	1	0.165 (0.108)	0.467** (<0.001)	0.120 (0.244)	0.375** (<0.001)	-0.019 (0.858)	0.053 (0.607)	-0.028 (0.786)	0.200 (0.050)	-0.083 (0.419)	0.459** (<0.001)
2	Age	0.165 (0.108)	1	0.305** (0.002)	-0.149 (0.148)	-0.032 (0.754)	0.079 (0.444)	-0.313** (0.002)	0.225* (0.028)	0.234 (0.050)	-0.202 (0.419)	0.338** (0.007)
3	Pain level	0.467** (<0.001)	0.305** (0.002)	1	0.132 (0.201)	0.283** (0.005)	0.113 (0.271)	-0.096 (0.351)	0.169 (0.100)	0.339** (0.001)	-0.121 (0.241)	0.585** (<0.001)
4	Body mass index	0.120 (0.244)	-0.149 (0.148)	0.132 (0.201)	1	0.633** (<0.001)	0.722** (<0.001)	0.119 (0.250)	0.147 (0.152)	0.015 (0.884)	-0.193 (0.059)	0.296* (0.018)
5	Fat %	0.375** (<0.001)	-0.032 (0.754)	0.283** (0.005)	0.633** (<0.001)	1	0.375** (<0.001)	0.150 (0.145)	0.024 (0.820)	0.059 (0.571)	-0.060 (0.560)	0.250* (0.048)
6	Waist circumference	-0.019 (0.858)	0.079 (0.444)	0.113 (0.271)	0.722** (<0.001)	0.375** (<0.001)	1	0.041 (0.691)	0.127 (0.217)	-0.007 (0.949)	-0.187 (0.068)	0.309* (0.014)
7	Upper limb strength	0.053 (0.607)	-0.313** (0.002)	-0.096 (0.351)	0.119 (0.250)	0.150 (0.145)	0.041 (0.691)	1	0.229* (0.025)	-0.039 (0.703)	0.195 (0.056)	-0.447 (<0.001)
8	Lower limb strength	-0.028 0.786	0.225* (0.028)	0.169 (0.100)	0.147 (0.152)	0.024 (0.820)	0.127 (0.217)	-0.229* (0.025)	1	0.725** (<0.001)	-0.419** (<0.001)	0.460** (<0.001)
9	Mobility	0.200 (0.050)	0.234 (0.050)	0.339** (0.001)	0.015 (0.884)	0.059 (0.571)	-0.007 (0.949)	-0.039 (0.703)	0.725** (<0.001)	1	0.420** <0.001)	0.387** (0.002)
10	Exercise capacity	-0.083 (0.419)	-0.202 (0.419)	-0.121 (0.241)	-0.193 (0.059)	-0.060 (0.560)	-0.187 (0.068)	0.195 (0.056)	-0.419** (<0.001)	-0.420** <0.001)	1	-0.391 (0.002)
11	Quality of life	0.459** (<0.001)	0.338** (0.007)	0.585** (<0.001)	0.296* (0.018)	0.250* (0.048)	0.309* (0.014)	-0.447 (<0.001)	0.460** (<0.001)	0.387** (0.002)	-0.391 (0.002)	1

Note: Pearson correlation coefficient, r, significant at p<0.05* and p<0.001**

Table III: Crude and adjusted (pain level) simple linear regressions of fatigue level

Variable	SLR[a]			SLR[b]		
	β[c]	s.e.	*p*-value	β[d]	s.e.	*p*-value
Age	0.34	0.21	0.108	0.05	0.20	0.795
Pain level	4.09	0.80	<0.001**			
Body mass index	0.34	0.29	0.244	0.17	0.26	0.520
Fat %	0.82	0.21	<0.001**	0.58	0.20	0.005**
Waist circumference	-0.02	0.13	0.858	-0.09	0.12	0.433
Upper limb strength	0.15	0.28	0.607	0.27	0.25	0.283
Lower limb strength	-0.07	0.26	0.786	-0.27	0.23	0.236
Mobility	0.95	0.48	0.050	0.22	0.46	0.625
Exercise capacity	-0.02	0.03	0.419	-0.01	0.02	0.768
Quality of life	0.30	0.07	<0.001**	0.15	0.09	0.084

SLRa: Simple linear regression; SLRb: Simple linear regression adjusted for pain level; s.e.: Standard error; βc: Crude regression coefficient; βd: Adjusted regression coefficient; Regression coefficient is significant at p<0.001**

hand, with a 1-minute rest between attempts. The average score from all measurements was recorded as the final score, in which the higher the value, the greater the handgrip strength. In the handgrip test-retest assessment, 5 to 45 days after baseline, the interclass correlation (ICC) was 0.81.[15]

The lower limb strength was measured using the five times sit-to-stand test (5STS). The participant was instructed to sit with arms folded across the chest and the back against the chair of about a standard height (43-45cm) with a backrest. Then, the investigator instructed, "I want you to stand up and sit down five times in a row, as quickly as you can when I say "GO". Be sure to stand up fully and try not to let your back touch the chair back between each repetition. Do not use the back of your legs against the chair". The time was started once the investigator said GO and stopped once the participant's body touched the chair following the fifth repetition. The score (recorded using a stopwatch) was the amount of time (to the nearest decimal in seconds) it takes a participant to transfer from a seated to a standing position and back to sitting for five times. The shorter the time to complete the test, the stronger the lower limb strength.

The time up and go test (TUG) measures mobility and balance, that is, the ability to stand up from an armchair (seat height of about 46cm), walk a distance of three metres, turn around, and return to sitting in the same chair again without physical assistance.[16] The time required to complete the test was recorded in seconds using a stopwatch. The TUG has been shown to have excellent intra-rater and inter-rater reliability, with ICC values greater than 0.95.[17]

The 6-minute walk test (6MWT) is a sub-maximal exercise test used to measure exercise capacity and the ability to walk over a longer distance.[18] Based on the American Thoracic Society (ATS) Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories guidelines,[19] the participant was instructed to walk for six minutes on a hard, flat, indoor surface and with standardised verbal support while allowing rest in the procedure. The test-retest reliability of the 6MWT among patients with knee OA was excellent, with ICC 0.991 (95% confidence interval; 0.986–0.994).[20]

QoL was measured using the Western Ontario McMaster University Osteoarthritis Index (WOMAC), a widely used self-administered health status measure for assessing pain, stiffness, and function in patients with OA of the hip or knee. Each dimension of the questionnaire assesses the clinical severity of the disease; five questions for pain, two for stiffness and 17 for physical functions. The participant was requested to rate the score of each dimension. In this study, the total score was analysed based on the overall level of quality of life (QoL), in which a higher score indicates a higher level of pain, stiffness and functional limitation. WOMAC is a reliable and valid instrument for evaluating the severity of KOA.[21]

Data Collection Procedures

The study began with the recruitment process of participants in the physiotherapy clinic. The potential participants were approached by the researcher and briefed about the purpose and procedure of the study. The inclusion and exclusion criteria were checked, and those eligible signed an informed consent form. Then, the participants completed all measurements of fatigue level, QOL, obesity indices and functional performances, except for exercise capacity (6MWT). The participants continued the measure for the 6MWT on the second or third day based on their preferences. The sequence of the measurements was organised, starting with the easiest test to avoid fatiguing the participants. All data collected were kept in a secure cupboard that only the main researcher could access it.

Statistical Analysis

Data were analysed using SPSS version 26. A p-value of <0.05 was considered significant. The data were presented using means and standard deviations for all participants and between those with low and high levels of fatigue using the cut-off of 36 based on the 50th percentile of fatigue score. The t-test analysis was conducted to determine the significant differences in the variables of interest between participants with different fatigue levels. A Pearson correlation analysis was used to determine the relationship between fatigue severity (dependent variable) and pain level, obesity indices and functional performances. In addition, the partial correlation was used to determine the relationship of fatigue severity with obesity indices and functional performances while controlling the effect of pain. The stepwise regression analysis included variables significantly correlated with fatigue severity to determine whether the variables predicted fatigue severity. The sample size was calculated using the GPower application.[22] A total of 96 samples was sufficient to

provide a moderate effects size (0.15) with an α error of 0.05 to achieve a minimum of 80% power for a regression model. From the regression analysis, the Durbin-Watson value was 1.2, indicating the assumption of independent errors was met. In addition, there is also an absence of multicollinearity of the independent variables, as the variation inflation factors were from 1.0-1.5.[23]

Ethics Approval and Informed Consent

The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of Universiti Teknologi MARA (Approval number: 600-IRMI (5/1/6).

RESULTS

Ninety-six women participated in this study (mean age=54.76 (Standard Deviation, SD5.54 years). Table I shows the measurement characteristics of all participants, in which we included participants' age and those categorised as low and high fatigue levels. The t-test analysis indicated that only pain level, body fat %, and QoL differed significantly (All $p < 0.05$) between the low and high fatigue levels. The participants with a low level of fatigue presented with a lower pain level, lower body fat percentage and better QoL.

The results of the Pearson correlation analysis, as shown in Table II, indicated that only pain ($p<0.001$), fat % ($p<0.001$) and QoL ($p<0.001$) were correlated with fatigue severity. The simple linear regression analysis (Table III) of age, pain level, BMI, fat %, waist circumference, upper limb strength, lower limb strength, mobility, exercise capacity and QoL showed only pain level ($p<0.001$), fat % ($p<0.001$) and QoL ($p<0.001$) were significantly associated with fatigue. After controlling for pain level as the possible confounding factor, only fat % remained significantly associated with fatigue ($p=0.005$) (Table III).

DISCUSSION

This study evaluated whether fatigue severity is associated with pain level, BMI, fat %, waist circumference, upper and lower limb strength, mobility, exercise capacity and QoL in women diagnosed with KOA. We found that the mean for fatigue level among the participants in this study was 34.51 (SD14.03), which can be considered within the borderline range between low and high levels of fatigue. However, about 51% (n=49) presented with a high level of fatigue severity. According to a previous study, a high perception of general fatigue may indicate that the energy to expend in association with chronic pain may negatively impact subsequent physical activity.[24]

Pain level was associated with fatigue severity and may interact with the association between body indices and fatigue severity and between functional performances and fatigue severity. Previous studies have shown that pain interaction with fatigue leads to limitations in daily activities,[25] and mobility.[8] Pain triggered during movement may create fear among the patients, further restricting their participation in regular physical activity that ultimately cause poor exercise tolerance or undue fatigue during physical activities. On the other hand, physical inactivity may lead to muscle weakness, further increasing the sensation of pain,[26] as weak muscles may not absorb the impact of knee loading on the knee joint. Severe pain is usually associated with a chronic condition, as chronic pain has been shown to increase the energy cost of walking.[27] Accordingly, increasing pain is accompanied by various mitigation strategies that may affect energy differently.[28] Understanding this may have implications for clinical practice; for instance, exercise can be done after taking pain killer or during the best time of the day when pain is felt the least, as well as breaking down the exercise duration into a few sessions so that pain can be controlled. In addition, non-weight-bearing exercises such as swimming or static cycling should be recommended to prevent excessive joint loading. In terms of obesity indices, we found only body fat % that was significantly higher in the participants with a high fatigue level and significantly associated with fatigue severity. However, it is also important to note that the means for all the obesity indices (BMI, body fat percentage, waist circumference) in all participants and participants with low and high fatigue levels exceeded the healthy cut-offs. These results support that most of the participants with KOA had excessive body weight or were obese, an established risk factor for KOA. A previous study reported that a higher BMI would increase knee joint loading, resulting in adverse effects associated with joint inflammation and stress on the articular cartilage beyond its natural ability,[29] thus resulting in degenerative changes.[5] However, BMI may not be the best predictor of fatigue severity compared to body fat percentage, as women tend to have a generalised fat mass around their bodies that increases body weight. A previous study suggested that with every 1 kilogram of total body fat increase, the risk of cartilage defect will become higher and thus may increase the pain sensation that subsequently limits physical activity.[30]

Regarding functional performances, even though there were no significant differences in all measures except for QoL, we noticed that participants with a higher fatigue level also presented with a lower mean in all measures of functional performance than those with a lower fatigue level. The upper limb strength was slightly higher in the participants with a high fatigue level because the hand compensates for the lower extremities' declining functions. It has been suggested that walking pattern in people with KOA may be altered in association with a painful knee that is energetically costly and exacerbate the average reduction of energy reserve.[28] In addition, individuals with KOA may reduce their habitual gait speed below the rate that minimises energy consumption, given the U-shaped relationship between gait speed and energy consumption.[28] This explains the reduction in mobility and exercise capacity performance, as both measures have walking components and require the participants to complete the tests as fast as possible with their habitual gait speed. Furthermore, reduced quadriceps strength associated with arthritic pain can influence the gait pattern by decreasing the gait speed, which correlates with a shorter swing phase and longer support time.[31] In addition, the longer time to complete the five times sit-to-stand test that reflects lower limb strength could be explained by the arthrogenic muscle reaction that inhibits the excitability of the quadriceps' motoneuron pool as a consequence of the pain experienced.[32] The interaction between the independent

variables may have led to poor QoL among the participants, as indicated by a much poorer WOMAC score in the study, ultimately associated with fatigue severity. This study has some limitations. Firstly, the sample size for this study was calculated with a power of 80%, which may have contributed to the non-significant findings in the majority of the independent variables in predicting fatigue severity. Secondly, we did not measure the duration of the KOA as this could influence fatigue severity due to the duration of physical inactivity. On the other hand, this study provided some insights into the importance of conducting future studies to unravel further explanations of the various factors that may influence fatigue severity to provide guidelines for intervention to promote long-term adherence to physical activity.

CONCLUSION

In conclusion, the findings of this study showed that pain level, fat % and QoL were likely to be associated with fatigue severity. However, it is also important to note that obesity indices should be the target for intervention as most participants presented with a pathological level of obesity indices. Future studies with a larger sample size and a consideration of the influence of the duration of KOA should be explored. In addition, a longitudinal study would be more suitable to study how pain severity impacted fatigue with disease progression, providing more information to healthcare providers and patients. These findings may implicate the practice of healthcare providers, especially physiotherapists, to focus on pain management, weight management and modification of exercise and physical activity.

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CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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ORIGINAL ARTICLE

The cytotoxicity effect of bismuth oxide particles synthesized hydrothermally using different reaction temperatures *in vitro*

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ABSTRACT

Introduction: Bismuth oxide (Bi_2O_3) particles gained attention in preclinical research especially in medical imaging. Bismuth oxide with its long circulation time is an alternative to the current iodine contrast media which directly possesses high X-ray attenuation coefficient. Exploration of bismuth compound is hampered owing to challenges in synthesizing control for in vivo stability.

Materials and Methods: This study aimed are to characterize Bi2O3 particles synthesized at 60, 90 and 120 °C via hydrothermal method and investigated cytotoxicity of cell viability assay, cell morphology analysis, intracellular reactive oxygen species (ROS) assay and expression of ER stress genes by real-time PCR.

Results: Results indicated that the size of rod-shaped Bi_2O_3 particles increased with rising synthesizing temperatures. The cytotoxicity of Bi_2O_3 particles in Chang liver cells was size-dependent. Bigger-sized Bi2O3 particles resulted in lesser toxicity effects. mRNA expressions of GRP78 and C/EBP homologous protein (CHOP) were down-regulated in all treated Chang liver cells due to the increasing size of Bi_2O_3 particles. Bi_2O_3 particles synthesized at 120 °C was found to be less toxic than iodine.

Conclusion: Data suggested that the response of Chang liver cells to Bi_2O_3 particle cytotoxicity has a significant relationship with its reaction temperatures. This outcome is important in hazard assessment of Bi_2O_3 particles as a new contrast media and provides better understanding in synthesizing control to enhance its biocompatibility.

KEYWORDS:
Bismuth oxide, hypothermal, cytotoxicity, Chang liver cells

INTRODUCTION

Nanotechnology in medicine could be mankind's giant leap towards having better diagnosis and prognosis of diseases. Due to current limitations of the existing contrast media, researchers focused on searching and fabricating for more compatible metal-based particles relevant in this context.[1] Several compounds of metallic elements with high atomic numbers such as gold, iron, silver and bismuth (Bi) were investigated as potential contrast media. Among all these, bismuth (Bi) is known to have high atomic number (Z = 83) with strong X-ray attenuation power and thus seen as a suitable candidate to replace iodinated contrast media.[2]

Bismuth sulphide nanodots have gained special attention as contrast media due to its characteristics including low toxicity, strong X-ray attenuation power and low price. This material was successfully prepared in a big scale and targeted and used to contrast breast cancer.[3] Bismuth selenide nanoplatlets were also employed for photodynamic treatment of cancer using animal model and bismuth oxide/oxychloride nanotubes were used in stem cell imaging. Unlike bismuth, gold nanoparticles already known with its ability to synthesise, size-control and morphology. Therefore, these factors have caused limitations to bismuth expansion being used as contrast media.[4] The ongoing researches on bismuth modification serve as contrast media have produced nano and micro-sized bismuth particles with various physicochemical properties. The vast differences in physicochemical properties between smaller size particles with bulk material have sparked concerns and debates about its potential risk to human health.[5] Shape, zeta potential, surface chemistry and particle solubility depend on biocompatibility variables, including cytotoxicity, reticuloendothelial system (RES) recognition, cellular uptake and clearance. In-depth understanding of nano and micro-sized particles physicochemical properties and behaviour in biological environment are crucial if better contrast media are to be designed.[6]

Nevertheless, biocompatibility and possible toxicity related to synthesization method and physicochemical properties of a particle remains a challenge. The hydrothermal method is commonly used in synthesizing Bi nanostructures; however, this method is only able to synthesize nanoparticles with wide size distribution and poor mono-dispersity.[7] Yang et al.[8] highlighted the morphology of Bismuth Oxide (Bi_2O_3) particles synthesized by using the hydrothermal method can

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be controlled by reaction temperature. The diameter of Bi_2O_3 particles can be increased by raising the reaction temperature.[8]

Bismuth metal is considered to be non-toxic, but bismuth-induced encephalopathy is still being reported. Turkez et al.[9] reported that 5.0 mg/L of Bi_2O_3 is able to induce oxidative stress in blood. Meanwhile administration of 100 mg/L colloidal bismuth subnitrate can induce liver damage *in vivo*.[10] Abudayyak, Öztaş, Arici, & Özhan[11] recently reported Bi_2O_3 particles induced cytotoxicity effect in mammalian cells via generation of reactive oxygen species (ROS) which leads to increased oxidative stress. However, the relationship between generated ROS by Bi_2O_3 particles and detailed mechanism of endoplasmic reticulum (ER) stress has not been clearly determined. Therefore, ER stress was used in this study as an early biomarker to provide new insights toward understanding Bi_2O_3 particles cytotoxicity *in-vitro*.

The aim of this study is to investigate the cytotoxicity mechanism and the effect of different reaction temperatures used to synthesize the Bi_2O_3 particles. The study outcomes should focus towards minimizing the toxicity risks of Bi_2O_3 particles and so that it as a potential contrast media.

MATERIALS AND METHODS

Chemicals and Reagents

Minimum Essential Media (MEM) for cell culture medium was purchased from *Nacalai Tesque* Inc., Japan. Fetal Bovine Serum and 1X TrypLE express enzyme were purchased from Gibco. 100 X Penicillin-Streptomycin was purchased from BioWest, USA. Phosphate buffer saline (PBS) tablets, dimethyl sulfoxide (DMSO) and 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) were purchased from Sigma-Aldrich. OxiSelect™ Intracellular ROS Assay Kit Green Fluorescence was purchased from Cell Biolab, USA. All Real-Time Quantitative Reverse Transcription PCR (RT-qPCR) kits were purchased from Qiagen, USA. Primers and probes were purchased from IDTDNA, USA.

Bi_2O_3 Particles Preparation

Bi_2O_3 particles used in this research were each synthesized at 60 °C, 90 °C and 120 °C using hydrothermal method. They were in powder form and slightly yellow in color. The particles were produced by NanoBiotechnology Research and Institute (NanoBRI), Institute for Research in Molecular Medicine (INFORMM), Universiti Sains Malaysia (USM), Penang, Malaysia. All Bi_2O_3 particles were suspended in serum-free Minimum Essential Media (MEM) at 1 mg/ml concentration. The suspensions were vortexed at 800 rpm for 20 minutes at room temperature to form homogenous suspension. The stock solutions of all Bi_2O_3 NPs were diluted to 100 µg/ml working solution to perform cytotoxicity evaluations.

Characterization Bi_2O_3 Particles

Morphology and structure of Bi2O3 particles synthesized at 60 °C, 90 °C and 120 °C were characterized at Microscopy Imaging Center, Faculty of Pharmacy, Universiti Teknologi MARA, UiTM Puncak Alam. Bi_2O_3 powders were diluted in ethanol and placed on the sample holder. The sample holders were dried prior to measurement and all Bi_2O_3 particles were observed using FEI Tecnai G2 Transmission Electron Microscope (TEM) under 17000x magnification power. The sizes of all Bi2O3 particles were measured using Zetasizer 1600 from Malvern at Nanopharmacy Unit, Biopharmaceutics and Pharmacokinetics Research Laboratory, Faculty of Pharmacy, UiTM Puncak Alam.

Cell Culture

HeLa [Chang Liver] (ATCC® CCL13™) cells were obtained from American Type Culture Collection. The cells were maintained in a medium consist of Minimum Essential Media (MEM), 10 % Fetal Bovine Serum and 1 % Penicillin-Streptomycin Cells in T-75 flask (Corning, USA) with 37 °C humidified atmosphere of 5 % CO2 and 95 % air for 3 days or until reached 80 % confluency before exposure to Bi_2O_3 particles. Confluent cells were detached from culture flask using 1X TrypLE express enzyme for 5 minutes. Cells suspension was counted using Vi-CELL™ Cell Counter (Beckman Coulter, USA) and seeded at a density of 1 x 104 cells per well in 96-well microplate (Corning, USA) for cell viability and ROS assays.

Cell Viability Assay

In vitro cytotoxicity of Bi2O3 particles synthesized at 60, 90, 120 °C and iodine were determined by MTT assay. Seeded cells in 96-well microplate were incubated for 24 hours (37 °C, 5 % CO2 and 95 % air) before it is exposed to 100 µl of 0-100 µg/ml of all Bi2O3 particles and iodine for 24-, 48- and 72-hours treatment period (37 °C, 5 % CO_2 and 95 % air) to study the concentration and time-dependent cytotoxicity effect. After incubation period, cells viabilities were determined using MTT colorimetric reagent. 50 µl of MTT solution was added to each well and incubated for 4 hours (37 °C, 5 % CO_2 and 95 % air). MTT solution was discarded and 200 µl of Dimethyl Sulfoxide (DMSO) was then added in each well. The fluorescence intensity was measured at 550 nm by using Tecan F200 Infinite 200-TWT Microplate Reader. Results were expressed in percentage of cell viability relative to control cells. First, the percentage of cell death was calculated, and then subtracted with 100 % to obtain the cell viability percentage as shown in the equation below.

$$\text{Cell death (\%)} = \frac{(\text{Absorbance of control cells} - \text{Absorbance of treated cells})}{\text{Absorbance of control cells}} \times 100\ \%$$

$$\text{Cell viability (\%)} = 100\% - \text{Cell death (\%)}$$

Cell Analysis using Light Microscope

Seeded cells were plated in 6-well plate (Corning, Inc., USA). Cells were incubated overnight at 37 °C humidified atmosphere of 5 % CO_2 and 95 % air, and then rinsed with Phosphate Buffer Saline (PBS) before being treated with 2 ml of 100 µg/ml of Bi_2O_3 samples for 24 hours. The cells were observed using light microscope at 10 x magnification power. The images of the cells were captured using Dino-Eye Premier AM4023X digital eyepiece (AnMo Electronics Corporation., Taiwan) with DinoCapture software version 2.0.

ROS Intracellular Assay

Seeded cells in 96-well microplates were incubated 24 hours before treatment with all Bi2O3 particles and iodine. Cells were stained with 100 µL 1 mM (1 X) of the fluorescent dye

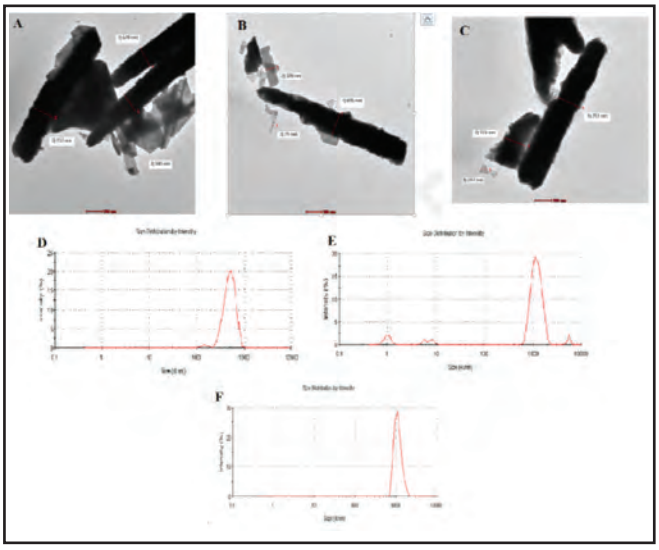

Fig. 1: TEM images of Bi_2O_3 particles synthesized at 60 °C

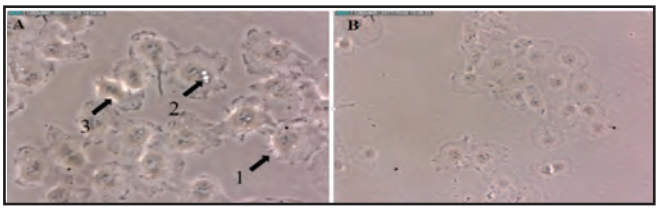

Fig. 3: Morphological changes observed by light microscope of (A) Chang liver cells treated with Bi_2O_3 particles in comparison to (B) untreated normal cells. Solid arrow (1) membrane blebbing, (2) cytoplasmic vacuole, (3) cell shrinkage

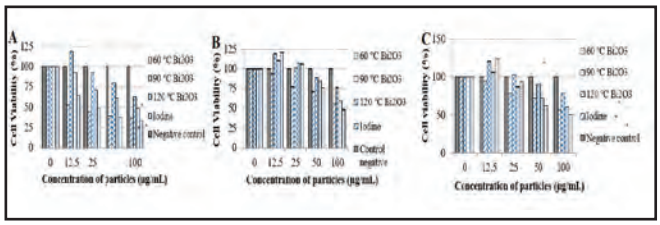

Fig. 2: Cell viability of Chang liver cells on 24 hours (A); 48 hours (B) and 72 hours (C) exposure to Bi_2O_3 particles synthesized at 60, 90, 120 °C and iodine. Values were expressed as mean ± SEM (n =4), ($p<0.05$).
*Indicates significant differences when compared to control negative, ($p<0.05$)

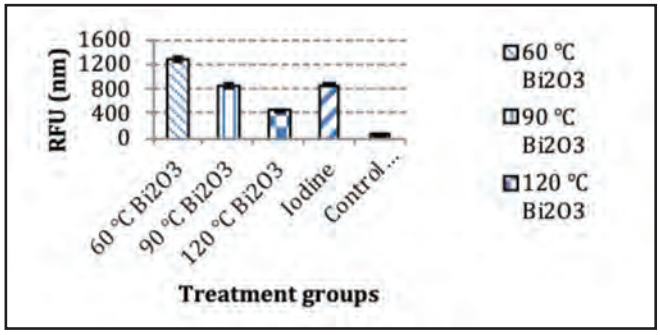

Fig. 4: Intracellular ROS production of Chang liver cells exposed to Bi2O3 particles synthesized at 60, 90, 120 °C and iodine. Values were expressed as mean ± SEM (n = 4), ($p<0.05$). [a]Indicates significant differences when compared to control negative, ($p<0.05$). [b]Indicates significant differences when compared to iodine, ($p<0.05$)

2,7-dichloro-dihydrofluorescein diacetate (DCFH-DA) for 1 hour at 37 °C. After staining, cells were washed and treated with 100 µL of 100 µg/mL of all Bi_2O_3 particles and iodine for 24 hours. After the incubation period, 100 µL of fresh MEM cell culture media was added after cells were washed. 100 µL of 2X Cell Lysis Buffer was added into each well before transferring 150 µL of lysate into to a 96-well black plate. The fluorescence intensity was measured at 480 nm excitation/ 530 nm emissions.

Real-time PCR

The mRNA expressions of ER-stress genes (GRP78 and CHOP) were determined using real-time PCR. Total RNA was extracted from treated Chang liver cells using RNeasy Mini Kit (Qiagen, USA). 1000 ng of RNA was reverse transcribed to cDNA using Quantinova Reverse Transcription Kit (Qiagen, USA). Real-time PCR was done according to manufacturer's protocol in 20 µL final volume of reaction, consisting of 2X Quantinova Probe PCR Mastermix (Qiagen, USA), template cDNA, primers and probes (Prime Time qPCR assay, IDTDNA, USA). The reaction parameters were one cycle at 95 °C for 2 mins, followed by 40 cycles with each cycle at 95 °C for 5 seconds and 60 °C for 30 seconds. GAPDH was used as the housekeeping gene.

Statistical Analysis

All values were expressed as mean ± standard error mean (SEM). Statistical significance of obtained data was determined by using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. Significance of data was designated as $p<0.05$.

Ethics Approval and Infirmed Consent

No ethical clearance needed for this study.

RESULTS

Bi_2O_3 Particles Characterization

The TEM images in Figure 1A-1C shows the Bi2O3 particles synthesized at 60, 90 and 120 °C were in rod shape and well crystallized particles. The mean size of all Bi2O3 particles were analysed using zetasizer shown in Figures 1(D-F). The size distribution graphs showed Bi2O3 particles synthesized at 60, 90 and 120 °C had an average diameter of 813.8 nm, 1280 nm and 1627 nm respectively.

(A), 90 °C (B) and 120 °C (C); mean hydrodynamic size of Bi2O3 particles synthesized at 60 °C (D), 90 °C (E) and 120 °C (F) Cell Viability Analysis

MTT assay was done to measure the cytotoxicity of Bi_2O_3 particles synthesized at 60, 90 and 120 °C on Chang liver cells metabolic activities. Figures 2(A-C) shows the percentage viability of Chang liver cells treated with Bi_2O_3 particles and iodine in the range of 0-100 µg/mL concentrations for 24, 48 and 72 hours. After 24 hours exposure, cells treated with Bi_2O_3 particles synthesized at 60 °C showed the least percentage of viable cells (33.4 %), followed by iodine (37.2 %) and Bi_2O_3 particles synthesized at 90 and 120 °C respectively showed 48.3 % and 63.1 %. The cytotoxicity trend was found to be similar throughout all three-incubation time. The viability of cells increases gradually with cells treated with Bi_2O_3 synthesized using higher reaction temperatures with declining particles cytotoxicity. With prolonged incubation time, the viability of treated cells increased. The cytotoxicity displayed was concentration-dependent as the viability of cells decreased when exposed to higher concentration of Bi_2O_3 particles and iodine at 24 hours. Cells treated with 100 µg/mL of Bi_2O_33 particles and iodine displayed the highest cytotoxic effect and showed significant differences with untreated cells at 24, 48 and 72 hours (p<0.05). Therefore, 100 µg/mL concentration was used to further evaluate the cytotoxicity effect Bi_2O_3 particles synthesized at 60, 90 and 120 °C against iodine in treated cells, via generation of ROS and expression of ER stress genes.

Evaluation of Morphology of Chang Liver Cells Upon Exposure to Bi_2O_3 Particles

The morphology examination in this study revealed the morphological changes of Chang liver cells treated with 100 µg/mL Bi_2O_3 particles after 24 hours. Chang liver cells showed distinct morphological changes indicating unhealthy cells in comparison to untreated control cells (Figures 3A and 3B). The size of treated cells shown in Fig 3A appeared to be larger and irregular compared with untreated cells with formed blebs and cytoplasmic vacuoles.

The effect of 100 µg/mL Bi_2O_3 particles synthesized at 60, 90 and 120 °C was further evaluated by inducing intracellular ROS in Chang liver cells. The cells were treated with 100 µg/mL upon 24 hours exposure and stained with DCF-DA. The fluorescence intensity of cells stained with DCF-DA increased with the presence of ROS. Figure 4 shows the level of ROS gradually decreased with Bi_2O_3 particles synthesized at higher temperatures and showed significant differences in comparison to untreated cells. Cells treated with Bi_2O_3 particles synthesized at 60 °C showed the highest ROS production (1277.02 nm), followed by iodine (865.20 nm), Bi_2O_3 particles synthesized at 90 and 120 °C respectively (835.87 nm and 466.28 nm. When compared to iodine, Bi_2O_3 particles synthesized at 60 and 120 °C showed significant differences in ROS production of (p<0.05).

ER Stress Responses Induced by Bi_2O_3 Particles

RT-PCR was performed to determine the cytotoxicity of 100 µg/mL Bi_2O_3 particles synthesized at 60, 90 and 120°C at molecular level by assessing ER stress genes in Chang liver cells. The mRNA expression of GRP78 and CHOP was measured in cells treated with Bi_2O_3 particles and iodine 24 hours after incubation time. Figures 5A and 5B showed mRNA expression of GRP78 and CHOP were both suppressed in all treated cells in comparison to untreated cells. CHOP gene was observed to be more suppressed than GRP78 gene. Cells treated with Bi_2O_3 particles synthesized at 60 °C exhibited highest suppression of GRP78 and CHOP genes, followed by cells treated with Bi_2O_3 particles synthesized at 90 and 120 °C and iodine when compared to untreated cells.

DISCUSSION

The exploration of finding new novel x-ray contrast media formulation is motivated by the growing concerns over the biocompatibility of iodinated agents especially in patients with iodine intolerance and compromised renal functions.[12] Bismuth is thought to be another potentially useful material for contrast media, after gold which attenuates X-rays strongly, inexpensive and most biocompatible heavy metal. However, the development of bismuth as a contrast media is hampered due to insufficient study on its synthetic approaches in comparison to gold.[13] Bismuth compound has a diverse chemistry and it is least well established among all heavy stable elements in terms of coherent or comprehensive database. Bismuth compound can be prepared using various starting materials, mixtures or preparations which contribute to ill-defined formulas, vague name designations as well as indefinite characterization and properties.[14] As the use of engineered nanomaterials expand as therapeutics and as diagnostic tools, the administration of these materials into the human body should be of high concern due to its toxicity. At nano and microscopic scale, the physical and chemical properties of materials can be dramatically altered hence they warrant thorough assessments of occurrence of unexpected toxicities.[15] In this study, the toxicity profile of Bi_2O_3 particles was assessed to determine the effect of different reaction temperatures using the hydrothermal method on the principle of biological interaction and responses of Bi_2O_3 particles in vitro.

Results in Figures 1A-1C show Bi_2O_3 particles synthesized at all different temperatures are rod-shaped. Similar to previous study, our findings indicate that Bi_2O_3 particles synthesized hydrothermally using alkaline solution yielded well-crystallized rod-shaped particles.[16] Another study, [17] also reported that well-crystallized Bi_2O_3 particles were successfully synthesized using sodium hydroxide (NaOH) in a hydrothermal reaction. This may suggest that strong alkali such as NaOH produces well-defined particles because more OH-ions were produced during the formation of particles. Our findings also revealed that the morphology of Bi_2O_3 particles synthesized hydrothermally can be controlled by the reaction temperature. The size of Bi_2O_3 particles increased with rising reaction temperature. This explains that reaction temperature may influence chemical reaction rate of particles and rising the reaction temperature may increase the formation rate that will later produce bigger particles.[18]

The viability of Chang liver cells assayed by MTT exposed to Bi_2O_3 particles in this study is size-dependent in which the particles size is directly proportional to the synthesizing temperatures. As presented in Figures 2A-2C, cells exposed to Bi_2O_3 particles with a diameter of 813.8 nm synthesized at 60 °C showed the lowest percentage of cell viability. As the particles get bigger and with the rising synthesizing temperature, the viability of treated cells increased. Several

recent articles focused on carbon black particles, silver and silicon dioxide (SiO2) nanoparticles were also in positive agreement with the study results reported that smaller particles contributed to a greater cytotoxicity strengthened the evidence and established a better understanding on size-dependent cytotoxicity in vitro.[19] The cytotoxicity of Bi_2O_3 particles synthesized at all different temperatures was also found to be concentration-dependent.

Figures 2A-2C showed viability of treated cells decreased when exposed to Bi_2O_3 particles and iodine with higher concentrations. However, after 24 hours, the viability of Bi_2O_3 particles was observed to increase with prolonged incubation time. This finding may suggest that Bi_2O_3 particles have a property of acute toxicity and mitigated over time causing the cells to recuperate at extended incubation time. These results were found to be similar with the study reported using bismuth ferrite nanoparticles (BFO NPs) which possessed a nature of acute toxicity upon exposure to neuronal cells.[20] Substantially lower toxicity of bismuth synthesized at 90 and 120°C when compared with iodine was observed shown by the higher percentage of cell viability of treated cells. The results suggested that Bi_2O_3 particles synthesized at 90 and 120°C which possessed bigger particles size due to higher reaction temperatures has outperformed clinically used iodine as contrast media in Chang liver cells culture. Likewise, a study[21] highlighted that bismuth sulphide PVP nanoparticle (BPNP) to be less toxic in hepatocytes and showed superior profile in comparison to clinically used iodine. Notably, on exposure, the shape and size of cells appeared bigger and irregular with the presence of cytoplasmic vacuoles and membrane blebbing indicating unhealthy cells in comparison to untreated control cells. Such alteration in morphology or shape of cells is considered as a significant effect following exposure to toxicant.[22]

Liver is a major organ affected by ROS.[23] The results in Figure 4 shows significant increase in intracellular ROS in all cells exposed to Bi_2O_3 particles and iodine compared to untreated cells. Another study[24] reported elevated intracellular ROS level in HaCat cells after exposure to BiOBr NPs besides than disturbance in cell cycle and cell apoptosis.

Endoplasmic reticulum is a cellular organelle specializes in folding and modifying of protein. This organelle is highly sensitive to external stimuli and homeostasis changes within the cell. Accumulation of unfolded proteins contribute to a condition called ER stress that may activate a series of adaptive response known as unfolded protein response (UPR).[25] Consistent ER-stress may affect cellular signaling processes such as reduction-oxidation (redox) homeostasis, initiating inflammation and apoptosis.[25] Recently, several studies proposed that ER stress-related responses as an early biomarker for nanotoxicity.[26] The ability of Bi_2O_3 particles to induce ER stress in Chang liver cells was measured by the mRNA expression of GRP78 and CHOP. GRP78 serves as an ER stress sensor to control the activation of UPR. During ER stress, GRP78 will be dissociated from the ER lumen to activate pathways leading to UPR survival and apoptosis responses.[27] When the stress in ER prolongs, a UPR downstream effector called CHOP will promote apoptosis through downregulation of B-cell leukaemia/lymphoma 2 (Bcl-2) and depletion of cellular glutathione.[28] The results in Figures 5A and 5B show the low expression of both ER stress gene in treated cells compared to untreated cells, despite high levels of elevated ROS were observed. Smallest Bi_2O_3 particles synthesized using lowest reaction temperature showed the least expression of ER stress genes in treated cells. Corroborating with MTT assay and intracellular ROS data, ER genes showed lesser suppression with bigger size of Bi_2O_3 particles contributed by higher reaction temperature. The results may suggest particles show size-dependent effect that was observed in the suppression trend of GRP78 and CHOP. In agreement with another study[29], they highlighted that 90 nm and bulk-sized ZnO NPs induced less ER stress than

The 30 nm ZnO NPs. suppression of ER stress genes in this study can be inferred that ER stress was inhibited to ensure cell survival from assault induced by Bi_2O_3 particles.[30] Furthermore a study[31] explained that adaptation to physiologic stressors may be harmonize by the expression of all three bunches of UPR and eventually perturb the stress equilibrium occurs in the ER. This phenomenon suggests that suppression of ER stress genes involve in the mechanism to block further cell damage and inhibit ER stress-induced apoptosis.

CONCLUSION

In this study, the cytotoxicity of Bi_2O_3 particles synthesized using different reaction temperatures and iodine on Chang liver cells were comparatively investigated. The results revealed that different reaction temperatures of Bi_2O_3 particles may provoke size-dependent cytotoxicity by reduced cell viability, causing morphological changes to treated cells, induced intracellular ROS level and suppressed ER stress genes expression in order to curtail the stress imbalance. In comparison to other clinically used contrast media, Bi_2O_3 particles synthesized at 120 °C has biggest particles size and was found to be least cytotoxic in Chang liver cells. Nevertheless, additional studies are warranted including histological examination of susceptible organs to support the findings from this study in assessing the safety profile of bismuth-based contrast media.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests that would prejudice the impartiality of this scientific work.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

From tap to table: An assessment of drinking water quality in Perak, Malaysia

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ABSTRACT

Introduction: A study on the quality of drinking water was conducted at Air Kuning Treatment Plant In Perak, Malaysia, based on a sanitary survey in 14 sampling points stations from the intake area to the auxiliary points. This was to ensure the continuous supply of clean and safe drinking water to the consumers for public health protection. The objective was to examine the physical, microbiological, and chemical parameters of the water, classification at each site based on National Drinking Water Standards (NDWQS) and to understand the spatial variation using environmetric technique; principal component analysis (PCA).

Materials and Methods: Water samples were subjected to in situ and laboratory water quality analyses and focused on pH, turbidity, chlorine, Escherichia coli, total coliform, total hardness, iron (Fe), aluminium (Al), zinc (Zn), magnesium (Mg) and sodium (Na). All procedures followed the American Public Health Association (APHA) testing procedures.

Results: Based on the results obtained, the values of each parameter were found to be within the safe limits set by the NDWQS except for total coliform and iron (Fe). PCA has indicated that turbidity, total coliform, E. coli, Na, and Al were the major factors that contributed to the drinking water contamination in river water intake.

Conclusion: Overall, the water from all sampling point stations after undergoing water treatment process was found to be safe as drinking water. It is important to evaluate the drinking water quality of the treatment plant to ensure that consumers have access to safe and clean drinking water as well as community awareness on drinking water quality is essential to promote public health and environmental protection.

KEYWORDS:
Drinking water quality, National Drinking Water Quality Standard, enviromentric technique

INTRODUCTION

The availability of water is critical for the existence of life, as it is a vital component of natural resources and used extensively in various industries such as aquaculture, livestock farming, irrigation, and drinking.[1] However, water contamination poses a significant threat to the survival of all species, as it can contain physical, chemical, and biological impurities that must be eliminated. It must also be tasteless, odorless, and colorless.[2-3] In Malaysia, surface water supplies account for the majority of residential water consumption, with groundwater providing the rest. Municipal needs utilize 30% of Malaysia's internal water resources, estimated to be 580 km^3/year.[4-5] Tap water, bottled drinking water, and bottled mineral water are the most common ways drinking water and this is processed and distributed in Malaysia primarily sourced from surface and groundwater.[6] According to a 2017 report by the World Health Organization (WHO), access to clean and safe drinking water is not only a basic human right but also a crucial component of effective public health policy.[7]

Various types of pollutants such as acute organic waste, heavy metals, suspended particles, and chemicals are well-known for contaminating water.[8] The relevance of water, sanitation, and hygiene in promoting development and health has been highlighted by various international policy platforms.[9] This issue is also significant at the national, regional, and local levels for promoting health and development.[10] In some regions, investing in water supply and hygiene improvements has been reported to have a positive economic impact.[5]

According to the WHO, inadequate sanitation, contaminated water, or a lack of access to water are responsible for up to 80% of all diseases and epidemics worldwide. Additionally, a review by the World Bank of 28 studies has shown that the quality and quantity of water sanitation provided to users are linked to several water-borne diseases.[11] Rahmanian et al.[12], stated that there are about 780 million people who lack access to potable water. As a result, 6 to 8 million people per

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year pass away from diseases brought on by contaminated water.

Water quality factors such as temperature, pH, salinity, and nutrient loads can influence the way biochemical processes occur in surface water systems. Even when present in small amounts, chemical pollutants from various sources, especially persistent compounds, can pose significant health risks to humans. Concerns have been raised by environmentalists, governmental organizations, and health professionals regarding the presence of harmful indigenous pathogens and toxic heavy metals such as Pb, Cd, Cr, and Hg in environmental systems.[13] Therefore, it is crucial to assess the quality of drinking water to ensure that people have access to safe drinking water, even in the absence of scientific data on water quality and the potential sources of water pollution.[14]

The objective of this study was to assess the physico-chemical parameters of water quality such as chemical, physical and microbiological factors, in different locations across Perak, Malaysia. The aim is to compare these parameters with the National Drinking Water Quality Standards of Malaysia (NDWQS) (Table I) and establish a baseline understanding of water quality. Additionally, multivariate statistical techniques were utilized to identify patterns in the data, evaluate similarities and differences between the sampling locations, and predict potential sources of pollution.

MATERIALS AND METHODS

Study Area

Perak, which has a land area of 21,006 square kilometers, is the second-largest state in Malaysia. The climate is tropical rainforest, characterized by a lack of a dry season. The Perak Water Board (PWB) is responsible for providing safe drinking water to the entire state by operating two dams, Sultan Azlan Shah and Air Kuning located at Ulu Kinta, Ipoh, and Taiping, respectively. PWB manages a total of 47 water treatment facilities with a capacity of 1774 million liters per day, currently producing 1081 million liters per day. Water distribution of water is 100% to urban regions and 98% to rural areas, facilitated by a pipeline network spanning 10792 kilometres. Taiping is an oldtown with built up area including commercial areas, residential and small factories such as paper mills and ceramics factory.

Data Collection

In 2021, water samples were collected from various stages of the drinking water supply chain (river water, water treatment plant (WTP), and post-filtration water) at Air Kuning TPO, Taiping Perak (Table II). A total of 42 water samples, were collected, with three replicates taken from each of the 14 sampling stations. The samples were collected in 1-liter polyethylene (PE) bottles, which had been cleaned twice with deionized water after being washed with a 5% nitric acid solution for a day. The water sampling, preservation of samples, in-suite measurements, and laboratory tests were all conducted following established water testing procedures (APHA 1988).

Prior to collecting water samples, in situ measurements of physical parameters were conducted at each processing site, including pH, turbidity, free residual chlorine, and total hardness. The pH of water samples was determined using a color comparator (Lovibond Aqua Comparator), turbidity was measured using a turbidimeter (model HACH 2100Q Portable Turbidimeter), and free residual chlorine was measured using a colorimeter (model HACH Pocket Colorimeter II). Chemical parameters; iron (Fe), aluminum (Al), zinc (Zn), magnesium (Mg), and sodium (Na) were analyzed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES), which is available at the Department of Chemistry, Perak laboratory. The membrane filter technique as per the APHA (1988) standard was used to measure both fecal coliform and total coliform levels.

Statistical Analysis

Statistical analysis of data was done using SPSS version 20. For each sampling point, the mean was calculated to give the average result. Analysis of one sample t-test was carried out to determine the significant differences between sampling points. Additionally, principal component analysis (PCA) was performed with Origin Pro 2017. In PCA, the original variables are projected onto a new coordinate system after being linearly transformed into uncorrelated variables. The anticipated variables are the main components (PCs).[15]

Ethics Approval and Informed Consent

No ethics approval is needed.

RESULTS AND DISCUSSION

Physical Parameters

pH

pH is an essential indicator of water quality, as it measures the concentration of hydrogen ions (H+) in water to determine its acidity or alkalinity. A low pH can cause corrosiveness, while a high pH can cause taste issues.[16] Aquatic life thrives best within the pH range of 6.5 to 9.0. Although both high and low pH values can negatively impact aquatic ecosystems, it is crucial to maintain the pH level within this range.[17-18] The pH of water samples collected from all sources and sites, regardless of treatment, ranged from 7.0 to 7.6 (Figure 1). The lowest pH value of 7.0 was recorded at Buloh River intake (A4 and A5), raw water tanks (A7), TPO Kolam Air Kuning (A10), and Changkat Larut (A11). The highest pH value was observed after treatment at A9. The pH range for treated water samples (A9 to A14), was similar to that of untreated water samples, and significant differences ($p<0.001$) were observed among all sampling points in Table III.

Previous studies conducted at Sekamat River, Kajang, and Langat River,[6,19] have reported similar findings. These studies have shown that very low pH levels (less than 4.0) can cause harm to aquatic life and erosion of rocks, metals, and plumbing systems in the water.[12] On the other hand, high pH levels can lead to an increase in the concentration of ammonia which can be toxic to water. NDWQS recommends pH levels for raw water between 5.5 to 9.0 and for drinking water between 6.5 to 9.0. The pH levels of the water samples collected from various locations in this study fall within the acceptable range set by the NDWQS.

Table I: The safe limits of WHO and NDWQS for determining drinking water quality

Parameter	WHO	NDWQS
pH	6.5 – 8.5	6.5 – 9
Conductivity µS/cm	-	1000
Turbidity NTU	5	-
Total suspended solids (TSS) mg/L	-	25
Total dissolved solids (TDS) mg/L	1000	1000
Copper (Cu) mg/L	2	1
Zinc (Zn) mg/L	None	3
Magnesium (Mg) mg/L	None	150
Iron (Fe) mg/L	0.3	0.3
Cadmium (Cd) mg/L	0.003	0.003
Chromium (Cr) mg/L	0.05	0.05
Lead (Pb) mg/L	0.01	0.01
Arsenic (As) mg/L	0.01	0.01
Mercury (Hg) mg/L	0.006	0.001
Stannum (Sn) mg/L	-	-

Table II: Sampling points starts from the water intake point to the water supply distribution system in Taiping, Perak

Sampling Points	Details
A1	1500 metres from Larut River intake
A2	750 metres from Larut River intake
A3	Larut River intake
A4	1500 metres from Buloh River intake
A5	750 metres from Buloh River intake
A6	Buloh River intake
A7	Raw water tank
A8	Post filtration treatment at Air Kuning TP
A9	Post Treatment at Air Kuning TP
A10	Air Kuning Treatment Plant Outlet
A11	Changkat Larut distribution
A12	Jalan Simpang 2
A13	Jalan Kota
A14	Jalan Simpang 1

Table III: Mean physical parameters of water distribution at 14 sampling points

Parameters	Mean (SD)	t-statistic (df)	p-value*
pH	7.19 (0.18)	150.09 (13)	<0.001**
Turbidity	3.11 (0.89)	13.03 (13)	<0.001**
Free residual chlorine	1.04 (1.25)	3.11 (13)	0.008*

*one sample t-test

Table IV: Mean value of microbiological of water quality parameter

Sampling stations	E. coli MPN Index 100 mL-1	Total coliform MPN Index 100 mL-1
A 1	330	3500
A 2	330	9200
A 3	260	16000
A 4	940	>16000
A 5	180	16000
A 6	790	9200
A 7	460	>16000
A 8	18	1100
A 9	Nd	nd
A 10	Nd	nd
A 11	Nd	nd
A 12	Nd	nd
A 13	Nd	nd
A 14	Nd	nd

nd = not detected

Table V: Mean chemical parameters of water distribution at 14 sampling points

Parameters	Mean (SD)	t-statistic (df)	p-value*
Total hardness	9.29 (4.84)	7.18 (13)	<0.001**
Iron	0.36 (0.31)	4.37 (13)	<0.001**
Aluminium	0.06 (0.02)	9.96 (13)	<0.001**
Zinc	0.03 (0.03)	4.14 (13)	0.001*
Magnesium	0.70 (0.11)	22.95 (13)	<0.001**
Sodium	2.36 (0.50)	17.74 (13)	<0.001**

*one sample t-test

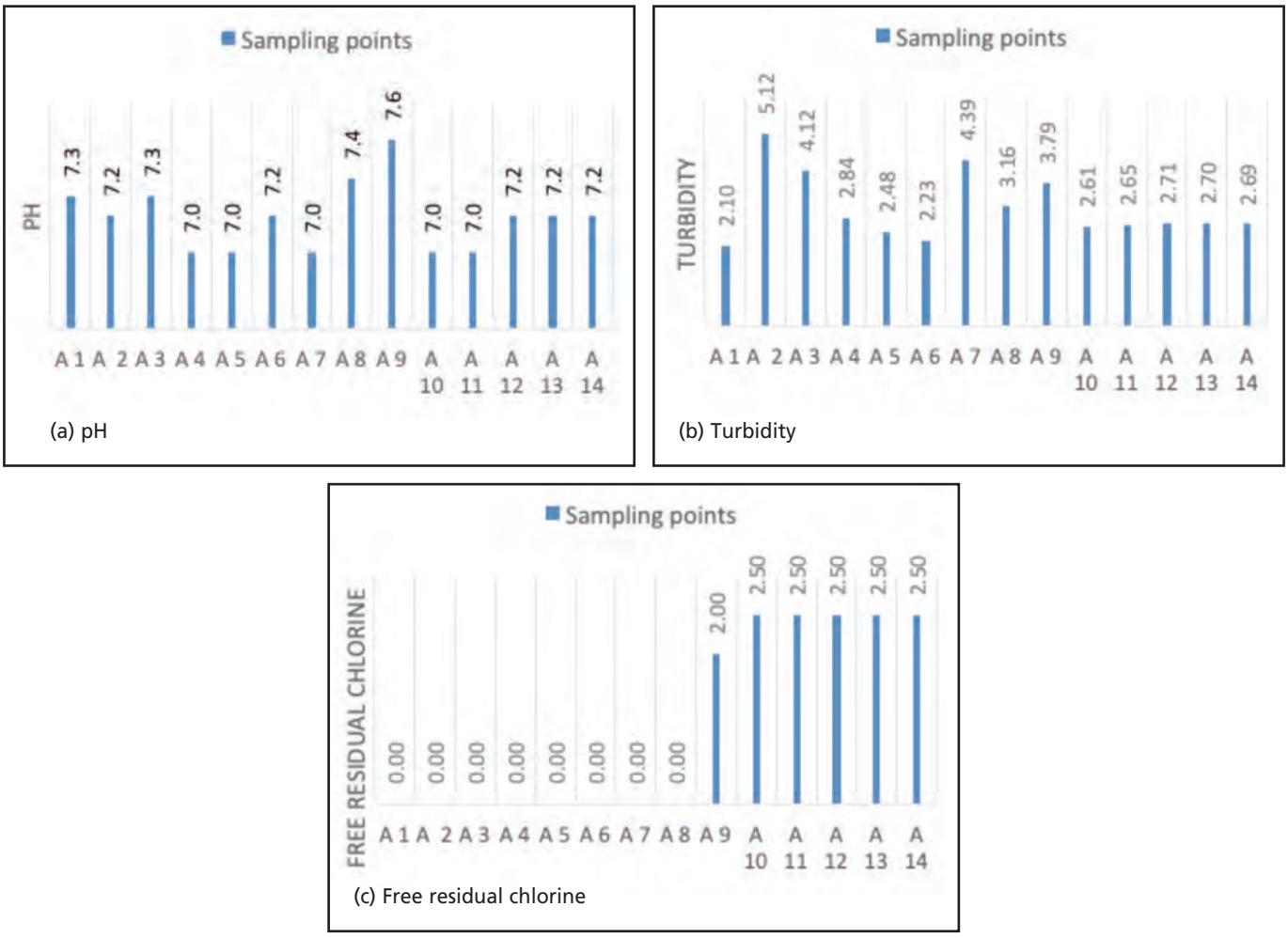
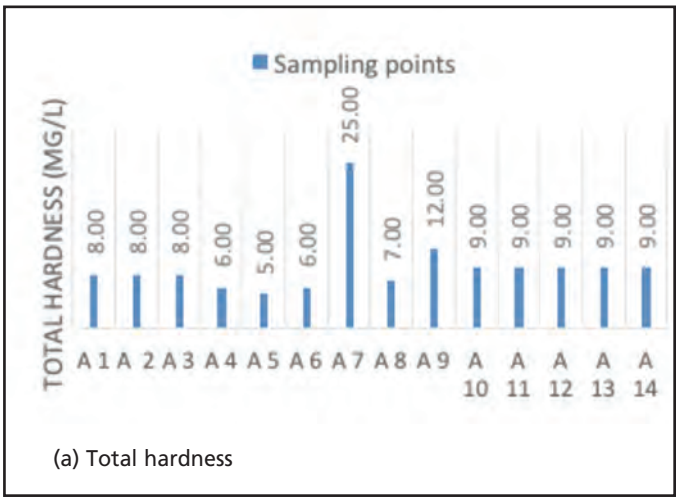


Fig. 1: Distribution of values for (a) pH, (b) turbidity and (c) free residual chlorine

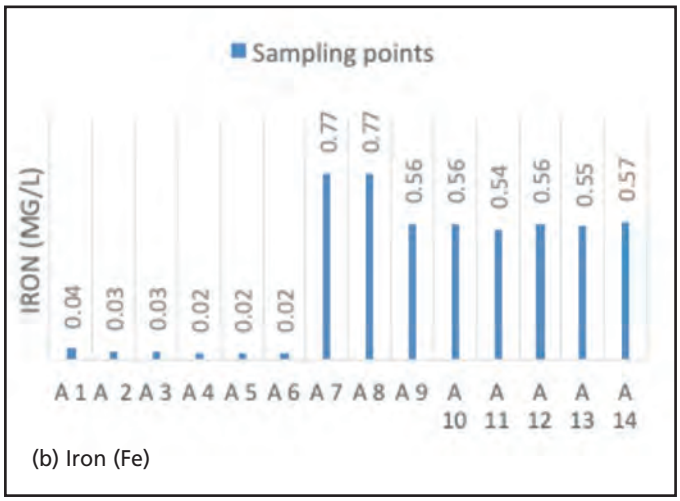
Turbidity

The level of turbidity in water is greatly influenced by seasonal variations (April-May) when high stream flow and surface run-off can increase turbidity level.[20] However, other factors such as surface runoff and riverbed sediment erosion can also affect turbidity.[21] As shown in Figure 1(b), the turbidity values in the studied water samples were within the acceptable range according to NDWQS guidelines. The highest turbidity value was observed at A2, which is located 750 meters downstream from Buloh River intake. This may be due to increased concentrations of suspended solids.[20] Additionally, table III showed significant differences in turbidity concentration were observed among sampling points (p<0.001).

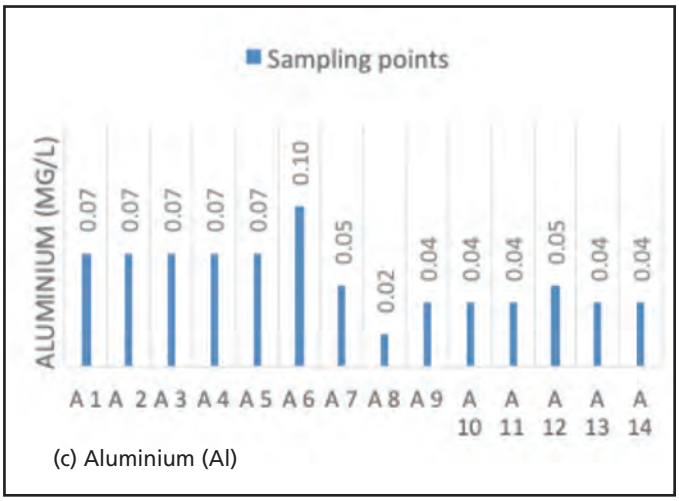
Turbidity is an important parameter for assessing drinking water quality as it measures the ability of water to absorb or disperse light and indicates the cloudiness of water due to various particles.[22] High turbidity can pose health risks, make water appear unappealing, and complicate water supply operations. Suspended substances in water can also provide a protective barrier for bacteria, making it difficult to eliminate them with chlorine treatment. NDWQS recommends a maximum turbidity limit of 5 NTU for drinking water and 1000 NTU for raw water. The analyzed water samples in this study were found to be within the acceptable limit of the NDWQS.



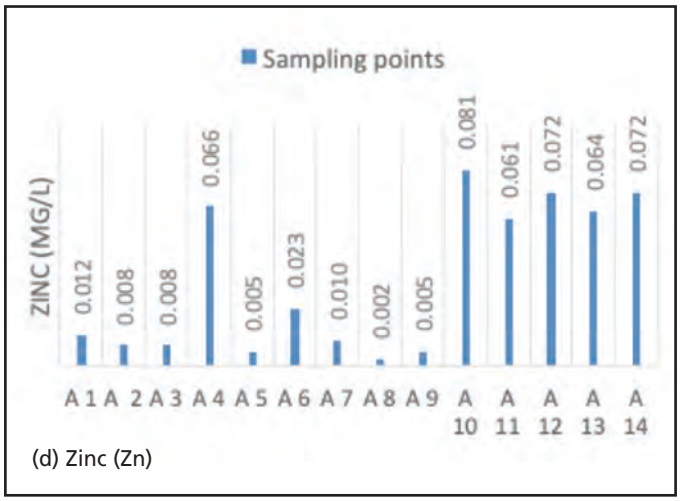
(a) Total hardness



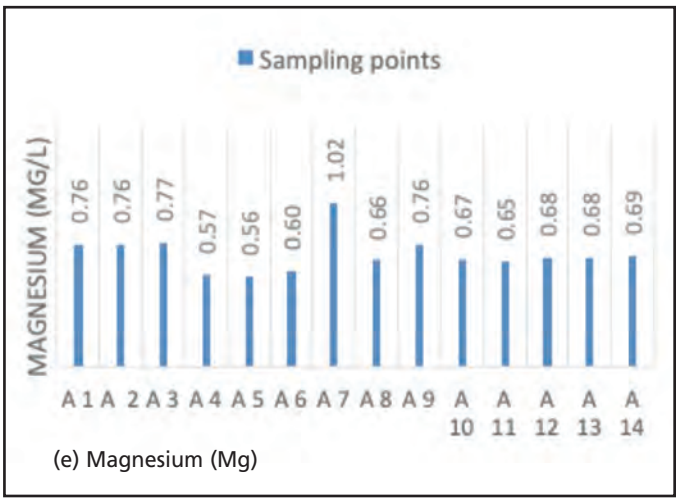
(b) Iron (Fe)



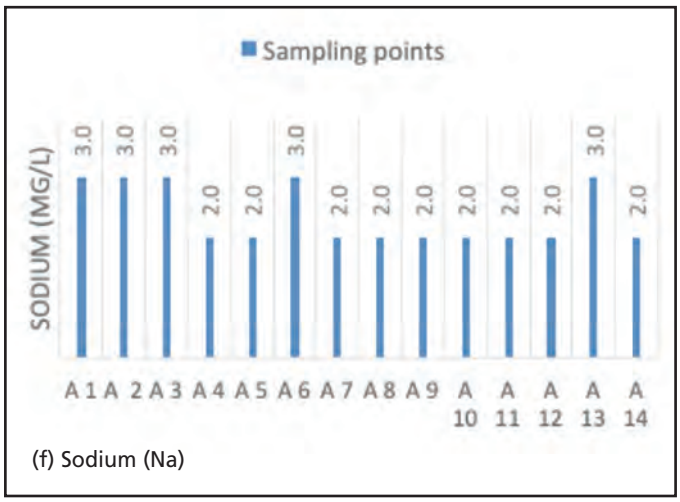
(c) Aluminium (Al)



(d) Zinc (Zn)



(e) Magnesium (Mg)



(f) Sodium (Na)

Fig. 2: Distribution of chemical water quality parameters for (a) total hardness, (b) iron (c) aluminimum, (d) zinc, (e) magnesium, and (f) sodium

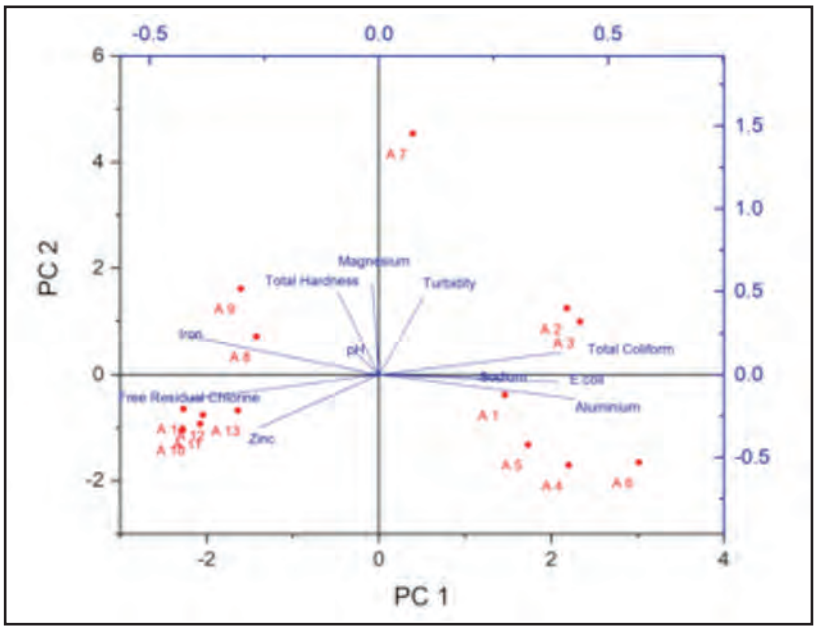


Fig. 3: PCA of Water Quality Samples

After undergoing treatment processes, water samples should have low turbidity values as undesirable particulates and organisms can efficiently remove from turbid water.[12] Previous studies have shown that the turbidity values decrease to acceptable levels after treatment.[23-24] Similar result were observed in the studied water samples, where point A8 to A14, which underwent filtration and treatment processes at the Air Kuning treatment plant, had turbidity values that complied with the recommended standards.[23]

Free Residual Chlorine

Chlorine is commonly used to treat water for human consumption, making it important to regulate the amount of free chlorine present in the water supply. High levels of free chlorine can harm the taste and odour of the water, even though the recommended range by NDWQS is 0.2 to 5.0 mg/L.[24] Figure I(c) shows the free residual chlorine levels measured in 14 water samples. No free residual chlorine was detected in A1 to A8, while the highest concentration was recorded in A10 to A14 at 2.5 mg/L, and the lowest was recorded at A9 at 2.0 mg/L.

This study found that the concentration of free residual chlorine was within the permissible limits of NDWQS and that there were significant differences in the concentration between sampling points (p=0.008) in Table III. This level of free residual chlorines provides adequate protection against microbiological contamination in the water supply system. The relatively low chlorine levels in the sample water indicate its effectiveness as a disinfectant. However, if the concentrations of free residual chlorine are too high, residents may report taste and odour problems.[24-26]

Microbiological Water Quality

The detection of bacteria in drinking water indicates the possibility of contamination from faecal matter, which could occur during disinfection or distribution processes.[27-28] This remains a significant factor in the spread of infectious diseases, both sporadically and during outbreaks worldwide. In the study, all unfiltered water samples (A1 to A7) exhibited the presence of coliforms, faecal coliforms, and *Escherichia coli*, identified by the growth of red colonies.

However, sample A8 which underwent filtration recorded a lower count of 18 MPN 100 mL^{-1}. Furthermore, filtered and post-treatment water samples (A9 to A14) did not show the presence of coliforms, faecal coliforms, or *E. coli*. These findings indicate that filtered water is safe to drink, while unfiltered water is not, and aligns with the recommended limits set by the NDWQS. Similar results were recorded in a previous study that evaluated raw and treated water in Negeri Sembilan, Malaysia where the Linggi River intake and Ngoi-ngoi intake recorded the highest number of coliforms at 7258.8 MPN 100 mL^{-1}.[29]

Coliforms are commonly found in the gut flora of humans and warm-blooded animals, which makes their identification of feces a common practice. They are used to detect the presence of harmful bacteria in aquatic environments, as they are present in higher concentrations than the pathogenic ones. Although certain coliforms are naturally found in various environments, drinking water is not one of them. As a result, their presence in drinking water should not be one of them, and their presence in treated water can be dangerous for human health. Hence, it is crucial to ensure that drinking water is free of coliforms, and their presence can indicate insufficient treatment.[16,30-3] Water treatment facilities commonly use chlorination to remove germs from the water supply, and this study demonstrates that chlorination effectively the number of microbes to less than 100 MPN (Table IV).

Chemical Parameters

Total hardness

The level of water hardness, which is determined by the amount of calcium and magnesium present, may vary in

acceptability among different nations. The taste threshold for calcium is between 100 to 300 mg/L, while that of magnesium is less sensitive.[28] Out of 14 sampling points, the lowest total hardness (TH) values were found at point A5 (5 mg/L), whereas the highest was recorded at the raw water tank (A7; 25 mg/L), which is where the total hardness in water treatment plants is usually tested in the raw water source before it undergoes treatment. However, all sampling points showed no water quality issues since the hardness concentration was within the recommended limit of NDWQS.

The major sources of water hardness are dissolved metallic ions from rocks, seepage, and soil run-off.[22,32] Water exceeding 200 mg/L may result in scale build-up in distribution systems and increased soap consumption, while soft water with a hardness of less than 100 mg/L may cause heavy metal contamination due to pipe corrosion.[33-34] Although epidemiological studies suggest that magnesium or hardness may prevent cardiovascular mortality, this claim is still debated, and more research is needed. As of now, there are no recommended guidelines for minimum or maximum mineral concentrations due to insufficient data.[32]

Iron

The level of iron (Fe) in natural water can vary due to different factors, with ferrous and ferric ions being the principal components of interest.[35] High Fe content in rivers is attributable to nearby sewage or industrial effluent discharge. In water distribution systems, iron pipes are often the cause of Fe contamination, as they can corrode and create iron oxide-dominated scales and deposits. These deposits can negatively impact water quality and arise from sources such as raw water debris and pipe corrosion products.[36]

The concentration of Fe varies at different sampling points in the system, and the results indicate that Fe levels at Larut River and Buloh River intake are lower than NDWQS. However, all treated water sampling points which (A7 to A14) show Fe concentration above 0.3 mg/L, exceeding the recommended limits. Fe concentrations ranged from 0.02 to 0.77 mg/L, and there were significant differences in Fe levels among sampling points (p=0.001) as shown in Table V. The Fe value in treated water exceeds the limitations caused by the material used in the water distribution system, such as galvanized iron. This can affect the color and taste of the water, making it unsuitable for consumption.[36-38]

Aluminium

Aluminium (Al) is commonly utilized in raw water treatment as a coagulant to reduce organic matter, bacteria, color, and turbidity. The concentration of Al in the water samples ranged from 0.02 to 0.10 mg/L, with the highest value at sampling point A6 and the lowest at sampling point A8 (Figure 2 (c)), which met the NDWQS standard of 0.20 mg/L. There were significant differences among sampling points (p<0.001) as shown in Table V. Surprisingly, the Al concentration was higher at the intake area than in treated water, which is contrary to the findings of a previous study that reported higher Al concentrations in treated water than in water sources.[39] The reason for this discrepancy is attributed to the excessive use of alum during the water treatment process, which is added based on turbidity levels and not the calculated amount of Al required.

Additionally, the pH level can influence the concentration of Al in acidic water, leading to pipe corrosion and partial solubilization of the element in the water distribution system.[40] Although low levels of Al in water are unlikely to pose health risks, there is evidence linking excessive concentrations of Al to neurological disorders such as Parkinson's and Alzheimer's disease.

Zinc

Zinc (Zn) is an essential mineral for human health, but excessive consumption can be harmful. The recommended daily intake of Zn is 15 to 22 mg for adults, and the maximum tolerable daily intake is 1 mg/kg of body weight. However, the lowest concentrations of Zn were found in the Larut and Buloh rivers (Figure 2), likely due to the accumulation of Zn in river sediments. The use of zinc in alloys, as well as in the galvanization of steel and iron, can cause zinc to leach into the drinking water system, resulting in high Zn concentrations in some areas (A10 to A14). These levels, while still within recommended limits, can produce adverse effects like nausea and vomiting. There are no current health guidelines for Zn in drinking water but concentrations of around 3 ppm can cause the water to appear iridescent.

Magnesium

Magnesium (Mg) is the eighth most abundant element found on the Earth's surface and it occurs naturally in water and minerals such as dolomite and magnetite. All living organisms require it to function properly.[11] The concentration of Mg in water samples taken from different points ranged from 0.56 mg/L to 1.02 mg/L, with the latter possibly due to underground mineral deposits.[12] The standard range based on NDWQS was not exceeded. There were significant differences in Mg levels among the sampling points. Mg is a major contributor to water hardness, and if its content is high, the calcium concentration is likely to be low.[22] This was observed in all treatment points, according to a previous study.40 The levels of other minerals, including manganese, arsenic, and fluoride, were below the threshold limits in both drinking and mineral water samples. The presence of Mg in drinking water is crucial in understanding Malaysia’s water supply system. Galvanized steel pipes containing Mg alloys might contribute to the presence of Mg in treated water.

Sodium

Sodium (Na) is typically found in water sources at low levels, usually less than 20 mg per litre. However, significant amounts of Na may enter water through various sources such as saline intrusion, mineral deposits, saltwater spray, sewage effluents, and de-icing salt used on roads.[11] In this study, Na values in water samples ranged from 2.0 mg/L to 3.0 mg/L, with the highest recorded at sampling points A1, A2, A3, A6, and A13 (3.0 mg/L). One sample T-test in Table V results indicated statistically significant differences (p<0.001) between sampling points.

The presence of Na in all water samples taken from both Larut and Buloh rivers intake can be attributed to the

mineral rocks that have put ions into the water. Water treatment processes may remove cations like calcium, magnesium, potassium, and sodium, either directly or indirectly. Previous studies have reported similar results, with packaged drinking water brands containing Na within the range of 2 to 13 mg/L.[33,40]

Excessive consumption of sodium can lead to short-term effects such as nausea, vomiting, convulsions, twitching and stiffening of muscles, and swelling of the brain and lungs, and can even result in death. Moreover, excessive salt consumption can worsen chronic congestive heart failure, and adverse consequences of high sodium levels in drinking water have been reported.[33]

Principal Component Analysis (PCA)

PCA is a useful tool for identifying the most significant variables while minimizing information loss by eliminating less important factors. In Figure 3, the upper horizontal axis of principal component 1 (PC 1) revealed positive coefficients for turbidity, total coliform, sodium (Na), *E. coli*, and aluminium (Al), indicating that these factors were the primary contributors to water contamination. The increase in turbidity may be attributed to land clearing in the future.[38] The presence of total coliform and *E. coli* in PC 1 indicated that these bacteria were the main contaminants in the river water intake, especially in A1 and A2. This may be due to a combination of natural and anthropogenic factors. In contrast, principal component 2 (PC 2) showed strong positive loadings on total hardness, pH, free residual chlorine, iron (Fe), and zinc (Zn) which had the highest extractable commonalities. Fe and Zn were released from point and nonpoint sources and their connection may be due to corrosion of steel pipes in water distribution systems.[37]

CONCLUSION

The study found that the physical, microbiological, and chemical characteristics of water samples taken from the Larut River and Buloh River intake, Air Kuning Treatment Plant outlet, and distribution systems at Taiping, Perak were within the recommended limits of the NDWQS except for total coliform at point A1 to A7 which is before undergo the treatment process. Moreover, the levels of four heavy were also found to be lower than the permitted maximum levels except for Fe which show Fe concentration above 0.3 mg/L, exceeding the recommended limits. This may caused by the material used in the water distribution system, such as galvanized iron. However, it is crucial to also focus on emerging contaminants, such as new chemicals and substances that could potentially enter the environment and water sources. It is important to understand the impact of these pollutants on human health. The occurrence of exterior corrosion in water distribution systems presents significant challenges for water utilities. One primary issue is to the malfunctioning of the pipes. Another issue to consider is the pollution of water due to the transportation of soil pollutants into the distribution system. Hence, it is crucial to identify and give priority to the replacement or upgrading of ageing pipes with contemporary materials that exhibit enhanced durability and an extended lifetime. This practise not only has the potential to mitigate water loss, decrease the probability of leaks, and enhance the overall efficiency of the system, but also serves as a preventive measure against the formation of corrosion scales in water supply systems.

Additionally, building public trust and understanding of drinking water quality is crucial. Effective communication strategies can be developed to involve the public in the process. To increase public responsibility, organizations such as the government, water agencies, and NGOs can raise awareness and understanding about water. However, managing water resources in the country is challenging due to increasing demands from households, industries, and agricultural sectors, the contamination of rivers, and the destruction of water catchment regions.

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Predictors of quality of life among individuals with paraplegic spinal cord injury after discharge from hospital to community in Pakistan

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ABSTRACT

Introduction: This study aimed to determine the predictors of quality of life (QOL) among persons with paraplegic spinal cord injury (SCI) after discharge from the hospital to the community in Pakistan, based on the International Classification of Functioning (ICF) components, including participation, impairments of body function/structures, personal factors, and environmental factors.

Materials and Methods: A cross-sectional study was conducted with, one hundred and forty individuals with paraplegic SCI, who met the inclusion and exclusion criteria and attended an outpatient rehabilitation clinic. The impairment of body function/structures of participants was assessed using the American Spinal Injury Association (ASIA) Scale, which classified them as A, B, C, D, or E. A set of questionnaire survey forms was used to collect socio-demographic information, occupational participation, environmental factors, and QOL by using a demographic questionnaire, World Health Organization Disability Assessment Schedule 2.0 (WHODAS-II), Craig Hospital Inventory of Environmental Factors (CHIEF) scale and World Health Organization Quality of Life (WHOQOL) BREF form respectively.

Results: The results showed that occupational participation was the strongest predictor of QOL among persons with paraplegic SCI (β=-0.586, p<0.001). In the second step, variables representing body function/structure factors (ASIA-A, B, C, D, E) were added, and the overall model explained 40.7% of the variance in QOL. In the third step, personal factors (age groups, gender, marital status, level of education, and rehabilitation duration) were added, and the overall model explained 51.4% of the variance in QOL. In the final step, environmental factors (CHIEF 12 Items scale) were added, but they did not significantly explain the model.

Conclusion: The findings suggest that occupational participation was found to be the most significant predictor of QOL among individuals with paraplegic SCI. Body function/structure factors, personal factors, and environmental factors were also significant predictors, but to a lesser extent. The findings of this study can inform healthcare professionals and policymakers in developing interventions and, policies targeting occupational participation, and personal factors that may be effective to improve the QOL of individuals with paraplegic SCI in Pakistan.

KEYWORDS:
Quality of life, paraplegic spinal cord injury, International Classification of Functioning, disability and health, comprehensive rehabilitation

INTRODUCTION

Paraplegic spinal cord injury (SCI) is a devastating event that can result from traumatic or non-traumatic incidents affecting the thoracic, lumbar, and sacral spine segments.[1] This type of injury typically leads to the loss of motor, sensory, and autonomic function in the affected areas, causing significant changes in the individual's life. After being discharged from the hospitals, individuals with paraplegic SCI undergo multi-disciplinary rehabilitation aimed at addressing the sequels of this condition. These include preventing pressure sores, avoiding urinary tract infections, overcoming emotional distress, restoring body function to enable independent living and performing daily activities, participating in community life, and improving the overall quality of life (QOL).[2] Thus, individuals with paraplegic SCI have to deal with a complex set of challenges that require a comprehensive approach.

The World Health Organization (WHO) defines QOL as a broad concept that encompasses an individual's perception of their position in life, taking into account cultural and value systems, as well as their goals, expectations, standards, and concerns.[3,4]

In individuals with paraplegic SCI, QOL is drastically affected, particularly in cases where a young, healthy breadwinner becomes a prisoner of their own body, losing complete control over their movements, leading to a decreased quality of life and increased dependence on family members.[5] It is, therefore, essential to examine QOL in these individuals, as it is considered the best determinant of the

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success of multidisciplinary rehabilitation for SCI, reintegrating individuals into the community, and overall satisfaction with life. Understanding the QOL is crucial for addressing the complex challenges associated with paraplegic SCI and improving the lives of those affected by this condition.

The International Classification of Functioning, Disability, and Health (ICF) is a widely recognized healthcare conceptual framework developed by the WHO. It provides a comprehensive understanding of the disability or functioning of paraplegic SCI in individuals' lives and daily activities.6 The ICF comprises four components including participation, impairments of body function/structures, personal factors, and environmental factors.[6] These factors are interlinked and can restrict long-term participation in their everyday activities, creating challenges for individuals with SCI.[7] Participation is a complex term that encompasses various characteristics and dimensions essential to an individual's overall well-being.[8] It plays a critical role in the comprehensive rehabilitation of people with SCI, as it is a key indicator of their QOL. The relationship between participation and QOL is closely intertwined and is often used to measure an individual's overall well-being.[9]

When an individual can participate in meaningful and enjoyable activities and daily functioning, they are likely to experience higher levels of satisfaction, happiness, and overall QOL.[10] Conversely, limitations or restrictions in participation can disturb an individual's QOL.[11] However, the ICF framework does not account for the concept of QOL, as it only depicts various interrelated elements that influence participation to varying degrees. Previous studies have used the concept of QOL and the ICF to understand the health and well-being of persons with disabilities from an integrated perspective. It has been found that QOL is lower in the population of people with SCI than in the population without SCI.[12-14] Furthermore, many studies have identified the association of ICF domains with QOL among people with SCI, and all predictors have an inconsistent effect on QOL. For instance, community participation was found to have no effect on any QOL dimensions following SCI, while impairment of body function, high education, and being married were determined to be high levels of QOL.[15] Conversely, environmental barriers and five psychological variables were associated with low levels of QOL.[16,17] Several studies systemic reviews, critical reviews, meta-analyses, and conceptual frameworks have reported a strong relationship between participation and QOL in people with SCI.[18,19,20,21] However, none of the studies was conducted in the Pakistani community. Therefore, this study aimed to investigate whether the ICF model can accurately predict the QOL of individuals with paraplegic SCI after their discharge from the hospital and to the community. The results of this study may provide significant new evidence to assist health professionals in developing comprehensive rehabilitation plans and gaining a deeper understanding of the challenges faced by people with paraplegic SCI particularly in the Pakistani community.

MATERIALS AND METHODS

Study Design and Sampling

A cross-sectional study was conducted to identify the predictors of QOL in individuals with paraplegic SCI based on the ICF. This study design was chosen because it is a convenient and inexpensive method for understanding the relationship and association of variables.[22] Purposive sampling was used to recruit participants who were undergoing follow-up therapy services at the Rehabilitation Outpatient Departments of Jinnah Postgraduate Medical Centre and Paraplegic Rehabilitation Centre in Pakistan. A target sample size of one hundred forty (n=140) was calculated using G*Power 3.1 software with an alpha level of 0.05, a power level of 0.8, and a medium effect size of 0.15.23 Participants who had been diagnosed with paraplegic SCI and discharged from the hospital, but were still receiving comprehensive rehabilitation therapies as outpatients, were identified from the record and contacted to offer an opportunity to participate in the study.

Data Collection Instruments

The study utilized a comprehensive set of questionnaires to assess various aspects related to paraplegic SCI. Participants were required to spend 40 to 60 minutes completing the assessment, which included providing their demographic information, undergoing structure examination of body impairment and using the ASIA Scale, and assessing activity and participation using the WHODAS-II Scale. The environmental predictors were evaluated using the CHIEF 12-item scale, and quality of life was assessed using the WHOQOL BREF Scale.

Data Analysis

The data were analysed analysis using Statistical Package for the Social Science (SPSS) version 28. Descriptive statistics were used to summarize the demographic data, while hierarchical multiple linear regression was employed to identify the predictors of QOL among individuals with paraplegic SCI Before running the hierarchical multiple regression analysis, the categorical variables such as personal factors and impairment of body function/structures were recorded from 0 to 1 and transformed into dummy quantitative variables. Tests for multicollinearity and normality were carried out between the dependent and independent variables. A *p*-value of 0.05 and 0.01 was considered statistically significant for all calculations.

Ethics Approval and Informed Consent

Before the commencement of the research study, each participant was required to provide informed consent. Approvals to conduct the study were obtained from the Research Ethics Committee of Universiti Teknologi MARA in Malaysia (Ref no: 600-TNCPI (5/1/6)) and the National Bioethics Committee for Research at the National Institute of Health, Ministry of Health in Pakistan (Ref no: NBC-922/23/1546).

RESULTS

Table: I show the demographic information of individuals with paraplegic SCI. who participated in this study. The sample consisted of 140 individuals, with the majority being

Table I: Demographic Information of Individuals with Paraplegic SCI (n=140)

Demographic Information	Frequency (n)	Percent (%)
Genders		
Male	137	97.9%
Female	3	2.1%
Age groups		
21-41 (Young Adults)	113	80.7%
41-51 (Middle Adults)	25	17.9%
51-60 (Older Adults)	02	1.4%
Marital Status		
Married	80	57.1%
Un-married	60	42.9%
Education Level		
Primary Education	62	44.1%
Secondary Education	50	35.9%
Higher Education	28	20%
Employment Status		
Working Full Time	34	24.9%
Working Part-Time	26	18.6%
Unemployed/Dependent	80	56.5%
Nature of Injury		
Traumatic Injury	120	85.7%
Bolt Injury/Violence	20	14.5%
Bomb Blast Injury	10	7.1%
Vehicle Accident Injury	40	28.5%
Falls Injury	35	25%
Sign Board Fall Injury	05	3.5%
Work Place Injury	10	7.1%
Non Traumatic Injury	20	14.7%
Tumour	08	5.7%
Transverse Myelitis	12	8.5%
Severity of Injury		
Complete	99	70.7%
Incomplete	41	29.3%
Level of Injury		
T1-T12 Level of Injury	100	71.5%
L1-L5 Level of Injury	40	28.5%
ASIA Classification		
A-Complete	74	52.9%
B-Incomplete	17	12.1%
C-Incomplete	25	17.9%
D-Incomplete	20	14.2%
E-Normal	04	2.9%
Rehab Program		
Attended	102	72.9%
Missed	38	27.1%

males (97.9%), and a small proportion were identified as female (2.1%). Age groups were categorized into three functional categories within the range of 21 to 60 years. The first age category 21-41 was classified as young adults (n= 113), accounting for (80.7% of) the sample, the second age category 41-50 was classified as middle adults (n=25), accounting for (17.9%) and lastly, the third age category 51-60 was classified as older adults (n=2), accounting for (1.4%) of the sample. The majority of individuals were married (57.1%) and had received secondary education (35.7%). In terms of post-injury employment status, the majority of participants were unemployed or dependent (56.4%), while (24.2%) were working full-time and (18.5%) were working part-time. The nature of their injuries varied, with traumatic injury being the most common (85.7%), caused by, gunshots, motorcycle, and rickshaw accidents, falls from heights, bomb blast fragments, waves, accidents involving scraping machine belts, and falls from the iron signboards. It was followed by non-traumatic injury (14.3%) cases caused by tumours and transverse myelitis diseases. The majority of individuals had a complete degree of injury (70.7%) and the injury level was primarily at T1 to T12 (71.4%). Based on the ASIA classification score, most individuals had a complete injury or AIS A (52.9%), while AIS E only (2.9%) had a normal score. The majority of individuals had received comprehensive rehabilitation services (72.9%), and the length of follow-up since injury ranged from 15 days to 8 years.

The results of hierarchical multiple regression analysis for predictors of QOL among individuals with paraplegic SCI after discharge from the hospital to the community are presented in Table: II the independent variables included occupational participation, impairments of body function/structure, personal factors, and environmental factors.

Table II: Predictors of QOL in Persons with Paraplegic SCI (n=140)

Hierarchical Multiple Regression Model Independent Variables		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	β	t	Sig.
1	WHODAS-II Scale	-0.497	0.059	-0.586	-8.493	0.000
2	ASIA impairment scale (AIS-A)	0.146	0.159	0.064	0.919	0.360
	(AIS-B)	-0.137	0.131	-0.073	-1.045	0.298
	(AIS-C)	0.318	0.150	0.152	2.118	0.036
	(AIS-D)	0.740	0.268	0.188	2.763	0.007
	Level of injury	-0.359	0.110	-0.225	-3.266	0.001
3	Ages (Young Adults 21-41)	0.009	0.110	0.006	0.085	0.932
	(Middle Adults 41-51)	-0.019	0.155	-0.010	-0.122	0.903
	(Older Adults 51-60)	-0.123	0.419	-0.020	-0.293	0.707
	Gender					
	(Male)	-0.498	0.332	-0.099	-1.502	0.136
	Marital status					
	(Married)	-0.102	0.109	-0.069	-0.937	0.351
	Level of Education					
	(Higher)	0.190	0.108	0.128	1.755	0.082
	(Secondary)	0.414	0.170	0.203	2.441	0.016
	(Primary)	0.649	0.221	0.194	2.939	0.004
	Rehabilitation Duration(Days)	0.121	0.118	0.075	1.028	0.306
	(Weekly)	-0.049	0.140	-0.027	-0.351	0.726
	(Monthly)	0.166	0.131	0.094	1.267	0.208
	Employment status	-0.117	0.116	-0.079	-1.007	0.316
4	CHIEF 12 Items scale	0.033	0.148	0.015	0.223	0.824

Dependent variable: QOL

In the first step of the analysis, occupational participation, as measured by the WHODAS-II scale, was found to be a significant predictor of QOL (Beta=-0.586, $p<0.001$). This variable accounted for 34.3% of the variance in QOL. In the second step, the impairments of body function/structure, as measured by the ASIA impairment scale, were added to the model. Only the level of injury (complete) was found to be a significant predictor of QOL (Beta=-0.225, $p=0.001$). This step added 6.4% of the variance in QOL.

In the third step of the analysis, personal factors, including age groups, gender, marital status, level of education, rehabilitation duration, and job/work status, were added to the model. None of these variables was found to be significant predictors of QOL, except for the level of education (higher) (Beta=0.203, $p=0.016$). This step explained an additional 17.0% of the variance in QOL.

In the final step of the analysis, environmental factors, as measured by the CHIEF 12 Items scale, were added to the model. This variable was not found to be a significant predictor of QOL (Beta=0.015, $p=0.824$). Overall, the hierarchical multiple regression analysis revealed that occupational participation, level of injury (complete), and educational level were significant predictors of QOL among individuals with paraplegic SCI after discharge from the hospital to the community. The other variables, including personal factors and environmental factors, did not significantly predict QOL in this population.

DISCUSSION

This study is the first conducted in Pakistan to examine the predictors of QOL among individuals with paraplegic SCI after discharge from the hospital to the community, based on the ICF components. The ICF components include occupational participation, impairments of body function/structures, personal factors, and environmental factors. Findings of this study revealed that occupational participation is a significant predictor of QOL among individuals with SCI which is consistent with previous research studies. [24-26]

Therefore, health professionals need to design interventions and policies targeting occupational participation that can effectively improve the overall QOL of individuals with paraplegic SCI in Pakistan. Occupational participation can reduce disability and sedentary lifestyles, allowing individuals to perform activities, and decrease their challenges, leading to greater social integration within the community.[27,28] The study finding suggests that impairments of body function and structure, such as the level of injury, were relatively minor predictors in the improvement of QOL for individuals with paraplegic SCI. This is consistent with previous research, which has shown that these factors have an indirect relationship with QOL.[29] On the other hand, secondary impairments, such as neuropathic pain, fatigue, urinary tract infections, and pressure sores, were found to have the greatest direct relationship with QOL, activity limitations, and participation restrictions in previous studies.[29,30] This study however did not include these variables in the analysis.

The findings of this study revealed that personal factors, such as age groups, gender, marital status, rehabilitation duration, employment status, and environmental factors, did not significantly predict QOL among individuals with paraplegic SCI. This is likely due to the complex relationship between these factors and QOL, which can vary depending on individual conditions and situations, and require advanced statistical methods and longitudinal study design for further analysis.[31,32] The regression model also showed that

the level of education is a positive predictor of QOL. Interestingly, some studies have suggested that educational level can have different impacts on individuals depending on their specific circumstances. For example, some individuals with low levels of education may experience a protective and positive effect on their psychological health, ultimately leading to better QOL. On the other hand, some patients with higher levels of education may experience a positive effect on their QOL. These findings highlight the complexity of the relationship between education level and QOL.[33,34]

The findings of this study emphasise the importance of a holistic approach to SCI rehabilitation that considers multiple factors that influence QOL when individuals return to their community. This includes physical and psychological functioning, social support, and environmental barriers. Such an approach can help health professionals to design more effective interventions and policies that target occupational participation and other factors that can improve the overall QOL of individuals with paraplegic SCI in Pakistan.

LIMITATIONS

This study has certain limitations that should be taken into account. Firstly, the sample size was relatively small, which may limit the generalizability of the findings. Secondly, the study was cross-sectional, which limits the ability to draw causal inferences about the predictors of QOL among individuals with paraplegic SCI. Future research should consider incorporating longitudinal designs to better understand the complex and dynamic relationship between the predictors and QOL in individuals with paraplegic SCI in Pakistan.

CONCLUSION

Occupational participation, level of injury (complete), and educational level were significant predictors of QOL in individuals with paraplegic SCI. In contrast, personal factors, including age, gender, marital status, rehabilitation duration, and employment status, did not significantly predict QOL. Furthermore, environmental factors were also not found to be a significant predictor of QOL in this study.

This study highlights the importance of occupational participation and the extent of impairment of body function/structure in predicting QOL among individuals with paraplegic SCI after discharge from the hospital to the community. The lack of significance of personal and environmental factors in the findings suggests that interventions aimed at improving QOL in individuals with paraplegic SCI should prioritise the; interventions that target occupational participation and address impairments in body function/structure. Further research is needed to explore other potential predictors of QOL in this population and to develop effective interventions to improve QOL outcomes in individuals with paraplegic SCI.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHORS CONTRIBUTION

All authors contributed to the design and implementation of the study, analysis of the results, and writing of the manuscript.

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ORIGINAL ARTICLE

A descriptive study on the knowledge and attitude of nurses toward the prevention of pressure ulcers in the intensive care unit

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ABSTRACT

Introduction: The study's objectives are to investigate the level of knowledge, attitude, and performance (KAP) of nurses on the prevention of pressure ulcers (PUs) prevention in the intensive care (ICU) and also to identify the relationship between nurses' KAP toward the implementation of preventive measures for PUs.

Materials and Methods: This cross-sectional study was conducted among 60 registered nurses in the ICU at Taiping Hospital. to assess the nurses' knowledge and attitude level using the Knowledge and Attitude on prevention of PUs questionnaire. A descriptive analysis and Pearson Correlation were used to analyze the data.

Result: From a total of 60 nurses 36 (60%) of nurses demonstrated a moderate level of KAP, and 17 (28%) demonstrated a high level of knowledge. They also exhibited neutral attitudes towards PUs prevention 49 (82%). The findings revealed a positive relationship between nurses' KAP toward implementing preventive measures on PUs (p=0.04; r=0.3). The findings show that nurses regularly performed the assessment of the risk factors of PUs for all hospitalized patients when performing PUs care. However, the plan for preventive nursing care was not properly reviewed.

Conclusion: This study suggested that appropriate guidelines, education programs, and an environment that makes it possible to provide continuing education should be created for nurses to prevent PUs in the ICU.

KEYWORDS:
Knowledge, attitude, Intensive Care Unit, critical care nurses

INTRODUCTION

A combination of physiologic occurrences and external conditions causes pressure ulcers (PUs). The causes of the development of PUs is because of the persistent and prolonged pressure on the skin and tissues surrounding it.

This causes the tissues to become ischemic, furthermore, impaired lymphatic drainage has also been demonstrated to be a factor in injury, in addition to localized ischemia and perfusion injury to tissues. Lymph fluid drainage is impeded by compression, which increases interstitial fluid and waste buildup and promotes the development of PUs. It has been demonstrated that the deformation of tissues is a more accurate indicator of the development of PUs than the pressure applied to tissues alone.[1]

The following describes PUs: Stage one, or the first stage of a PUs, is characterized by intact skin and localized redness. A partial loss of dermal thickness is a characteristic of PUs stage two. The complete loss of tissue thickness characterizes stage three PUs. Bone, tendon, or muscles may not be visible under the skin, but undermining or tunneling may be evident. Stage four PUs completely lose tissue thickness and exposed bone, tendon, or muscle. A patient with a PUs in stage four may experience excruciating discomfort. Stage four of PUs commonly involves undermining, tunneling, or both.[2]

Patients can suffer significant injury from PUs, which can slow rehabilitation, cause discomfort, and lead to deadly infections.[3] According to specific reports, PUs can increase a hospital stay's length by a median of 4.31 days. Because of the adverse effects associated with PUs, ICU PUs prevention is essential.[4] In Malaysia, the average length of stay in the intensive care Unit (ICU) was 4.7 days, with a median of 2.5 days. The incidence of PUs ranged from 0.5 to 21.1 per 1000 Intensive care units' days with a mean of 6.6.[5] In both acute and long-term care, PUs is common.

However, critically ill patients are more likely to develop PUs due to a combination of factors.[6] For many years, preventing PUs has been a concern for nurses. "If the patients developed of pressure ulcers, it is not because of the disease but reflected poor nursing care that they get," Florence Nightingale wrote in 1859.[7]

According to the 2014 World Stop Pressure Ulcer Day study, almost 700,000 patients are impacted by PUs yearly. Each year, approximately 20,000 patients in acute care acquire a new pressure ulcer.

According to this study, between January 2012 and December 2013, 4% and 6% of patients in acute care settings and more than 5 to 10% of patients in non-acute care experienced PUs. In Ethiopia, PUs are responsible for 2% of unnecessary fatalities.[7] The chance of developing blisters in intensive care unit patients is high, and pus can substantially lengthen a

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patient's stay in the ICU. Patients with pressure ulcers are much more likely to suffer from morbidity, death, and financial difficulty. Patients admitted to the intensive care, on the first day of their stay. Very sick patients may require prolonged bed rest, mechanical ventilation, and sedation. These people are susceptible to PUs because of prolonged pressure on areas with bony prominences.[1]

Malaysian researchers from the critical care unit analyzed ventilator-associated pneumonia, catheter-related bloodstream infection, and postoperative complications (PUs) to assess nurses' perceptions of evidence-based recommendations to reduce complications.[8] The suggestions of the pressure ulcer best practice guideline are incorporated into daily nursing patient care. The validated pressure ulcer risk assessment and intervention checklist need to be adopted in order to reduce the prevalence of hospital-acquired PUs and to enhance high levels of nurse compliance. Implementing prevention techniques and applying the risk assessment tool should be improved further.[9,10]

MATERIALS AND METHODS

This study involved 60 registered nurses in Taiping Hospital's intensive care unit (ICU). This study was conducted using a cross-sectional design to assess the nurses' knowledge and attitude level using the Knowledge and Attitude on Prevention of pressure ulcer questionnaire. A descriptive analysis and Pearson Correlation were used to analyze the data.

Setting

This research study was conducted in the Taiping Hospital's general adult Intensive Care Unit (ICU) in Malaysia's northern province of Perak. The Intensive Care Unit is the most important in Hospital Taiping. The ICU is organized into two buildings and units and contains 20 beds. Both ICUs, however, are general ICUs, with a different specialist and nursing manager in charge of each.

Population

The target population was registered nurses working in General Intensive Care Unit. The nurses in the intensive care unit are responsible for all aspects of patient care, with a ratio of one nurse per mechanically ventilated patient and one nurse per two patients for all other patients. Approximately around 60% of Intensive Care Unit nurses are post-basic critical care holders were included in this study. Excluded criteria of nurses in this study are, refusing to participate and being more than 50 years old. A total of 60 nurses from ICU Hospital Taiping participated in this study. The whole investigation lasted about four months.

Section 1: Demographic Questionnaire:

Age, gender, marital status, primary education, formal training on PUs, post-basic, and length of services were among the seven elements on this questionnaire based on demographic data.

Section 2: Nurses' Knowledge of pressure ulcer prevention questionnaire:

It has been used to test theoretical information about all components of the pressure ulcer skincare bundle protocol to the test. PUs development factors, skincare, nutrition maintaining good skin, dealing with mechanical strain, and pre-discharge instructions are among the six topics included. The correct answer received a score of "1," while the incorrect answer received a score of "0."

Section 3: Nurses' Attitude of Pressure Ulcer Prevention Questionnaire:

It consisted of 25 items structured questionnaire with attitude components. It was related to pressure ulcer development. The subject was asked to answer 5 levels of attitude ranging from 1 to 5: 5 = strongly agree, 4 = agree, 3= neither agree, 2 = disagree and 1 = strongly disagree.

Ethical Approval

The approval was obtained from the Ethics Committee of Universiti Teknologi MARA (UiTM); the reference number is RMI (5/1/6). REC/ 110/15. This research was registered under National Medical Research Register (NMRR), reference number is NMRR-16-1106-30167, through Clinical Research Centre (CRC). Then, a permission letter to the director of Taiping Hospital was given.

RESULTS

Each page was personally scored after the data collection was completed. For calculation, the background data sheet was coded and listed in numbers. Calculations were done by hand. The following significance tests were used: Percentage, frequency, correlation, coefficient, and t-test are all examples of statistics.

Demographic Data of Nurses

The majority of nurses (46.7 %) were between the ages of 21 and 30, as shown in Table 1. The majority of them were females (91.7%). Although they all had a nursing diploma, only ten (16.7%) had completed an ICU Nursing Post-Basic course. The Taiping Intensive Care Hospital has the highest percentage of nurses with one to ten years of experience (71.7%). Only 3.3 percent of respondents had more than 21 years of work experience, compared to 11.7% who already had 11 to 20 years. Most had been trained in pressure ulcer prevention (85%).

Nurses' Knowledge Regarding the Prevention of Pressure Ulcer

This data on the prevention of PUs is in nurses' knowledge. Overall, the nurses' knowledge of PUs prevention was moderate (60%). Table II indicates the quantity and frequency of nurses' knowledge levels; none scored below 50%. Nurses' low awareness of PUs prevention ranges from 60 to 69.99 % (7%). Few nurses had a high knowledge score of 80-89.99 % (28 %) in preventing PUs. With scores ranging from 90 to 100 %, 3 nurses (5%) had excellent knowledge, showing a high level of PUs prevention awareness among nurses. The percentage distribution of study group participants corresponded to knowledge level throughout the investigation. According to the result, all ICU nurses have a good level of expertise on how to prevent PUs. More than half of them have advanced expertise. According to the data, more than 40% had a good comprehension (90%) of preventing PUs. In Table II, throughout the study, the percentage distribution of the study group respondents is connected to knowledge level. The nurses' knowledge of PUs

Table I: Frequency and Percentage of Nurses in Demographic Data (N=60)

Characteristics	Frequency (N = 60)	%
Age		
21 – 30	28	46.7
31 – 40	22	36.7
41 – 50	10	16.6
Gender		
Female	55	91.7
Male	5	8.3
Educational status		
Diploma in Nursing	50	83.3
Post Basic	10	16.7
Services experiences (years)		
Less than 1 year	5	8.3
1 – 5	23	38.3
6 – 10	20	33.4
11 – 15	3	5
16 – 20	7	11.7
21 and above	2	3.3
Formal training for pressure ulcer		
Yes	51	85
No	9	15

Table II: Frequency and percentage of nurses' knowledge levels (N=60)

	n	%
Very Low (<60%)	0	0
Low (60-69.99%)	4	7
Moderate (70-79.99%)	36	60
High (80-89.99%)	17	28
Very High (90-100%)	3	5

Table III: Mean Percentage, Standard Deviation, and Level of Nurses' Knowledge in Prevention of Pressure Ulcer

	M (%)	SD	Level
Factors pressure ulcer formation	73.3	0.96	Neutral
Risk assessment	73.3	0.67	Neutral
Skin Care	89.7	1.13	Neutral
Nutrition to maintain Healthy skin	86.3	0.57	Neutral
Management of Mechanical loads	73.3	0.80	Neutral
Educational program	93.3	0.62	Neutral

Table IV: The correlation coefficient

Correlations

		SCORE_ ATTITUDE	SCORE_ KNOWLEDGE
SCORE_PRE	Pearson Correlation	1	.364*
	Sig. (2-tailed)		.048
	N	30	30
SCORE_POST	Pearson Correlation	0.364*	1
	Sig. (2-tailed)	0.048	
	N	60	60

*. Correlation is significant at the 0.05 level (2-tailed).

prevention was displayed in this table. It has been documented that all ICU nurses have a high understanding of how to prevent PUs.

Nurses' Attitude Regarding Pressure Ulcer Prevention

Table III assesses the dimension of the attitudes regarding preventing PUs among ICU nurses. The results showed all dimensions of the attitudes were at neutral levels. Mean Percentage, Standard Deviation, and Level of Nurses' Attitude Regarding Pressure Ulcer Prevention (n=60) assessed each dimension of the attitudes regarding PUs prevention. The results showed nurses had neutral levels in skin care, nutrition to maintain healthy skin, and management of mechanical loads.

Relationship between Nurses' Knowledge and Attitude Regarding Pressure Ulcer Prevention

Correlation: The correlation coefficient r, measures the strength and direction of a linear relationship between variables. The value of r is always between +1 and -1. Suppose the value of r is closest to -1. In that case, it shows that the variable has a negative linear relationship, whereas when it is closest to +1 showed that the variable has a positive linear relationship.

The correlations table above shows a significant relationship between these two tests (sig. 0.048<0.05) with a correlation coefficient of 0.364. The strength between these two tests can be concluded as a weak positive relationship since the coefficient correlation is less than 0.5.

DISCUSSION

The development of PUs is a significant issue for patients and the nurses caring for them. Patients, families, and the healthcare system are all affected by PUs, which cause discomfort, increase suffering, and cost money. They prolong the hospital stay and predispose patients to subsequent infection, sepsis, and recurrent surgery.[11] Although many studies have been conducted internationally to measure the KAP in preventing PUs, nearly none have been conducted nationwide. According to the findings of this study, nurses exhibited a modest degree of knowledge and a neutral to favourable attitude toward PUs prevention. The results were discussed in parts: nurses' knowledge and attitudes level in PUs prevention.

Regarding Socio-Demographic Characteristics of Nurses

The findings of this research reveal that most nurses (46.7%) are under the age of 30. This finding could be because practically all the nurses are recent college graduates who work together in ICU. Meanwhile, the percentage of nurses between the ages of 31 and 40 is less than 40%. In contrast, Li Hu[12] reported that most nurses were between the ages of 21 till 30 when he researched Intensive Care Nurses' KAP (pressure injury prevention in China: A Cross-Sectional Study) (54.9 %).

Nurses' Knowledge Regarding the Prevention of PUs

The findings related to nurses' knowledge in preventing PUs had a moderate to high level of knowledge. There are possible reasons for moderate to high-level knowledge. More than 80% of nurses in the ICU had formal training in PUs. In comparison with the study by Taha.[13] most nurses who participated in the survey had unsatisfactory knowledge levels regarding pressure ulcer management. A study done by Halász B.G[14] also found that nurses had insufficient knowledge (45.5%) overall regarding the prevention of PUs. These findings show that nurses in the UiTM hospital had moderate to high levels of knowledge regarding preventing PUs.

The quality of formal education and training experience among ICU nurses could be a factor in their moderate to high levels of knowledge. However, two of the six elements of nurses' knowledge about pressure ulcer prevention, causes for PUs, and action to reduce friction, had poor levels, resulting in low-pressure ulcer prevention results. This study, supported by study Ebi[15], reported low knowledge regarding the identification, prevention, and management of PUs before program implementation and explained this result as a result of nurses' lack of scientific preparation. It concluded that almost all ICU nurses must develop and maintain their knowledge and skills about critical patients in identifying, preventing, and managing PUs. Our study showed that a nurse's knowledge of pressure ulcer prevention is adequate both before and after the adoption of pressure ulcer prevention.

Nurses' Attitude Regarding Pressure Ulcer Prevention

Most nurses in our study had an overall neutral attitude toward PUs prevention, which is significantly lower than a survey conducted in Sweden, where nursing staff had a positive attitude toward pressure ulcer prevention. According to study[14], participants had a good attitude because they scored higher than 65% regarding the prevention and treatment of PUs for the 5 factors. Although they might not realize it, participants demonstrated a positive attitude toward preventing and treating PUs because they scored higher than 65% for the five variables. The natural attitude of nurses in all aspects of skincare, diet to preserve good skin, and mechanical load control.

Relationship between Nurses' Knowledge and Attitude. *Regarding Pressure Ulcer Prevention*

The result reveals the relationship is not significant between these two variables that is knowledge and attitude regarding PUs prevention. Based on the KAP model, one factor affecting attitudes is a specific area of a knowledge base. Contrary to this finding, it does not support the KAP model. On the other hand, the nurses' attitudes were influenced by their concern, purpose, awareness, or traditional values learned from nursing teachers or senior nurses.[15] This was when they worked for an extended period when their attitudes were not significant with knowledge. Therefore, knowledge is not related to nurses' development of attitudes. This study supported the model when there was no relationship between knowledge and attitude. Future research should explore the nurse's awareness, purpose, or traditional values concerning PUs prevention. The small sample size of this study could be one of the factors for the lack of a link between nurses' knowledge and attitude.

CONCLUSION

Preventing PUs complications in the ICU is a critical issue that faces healthcare providers, particularly nursing staff. Nurses' ability to cope with the problem of preventing PUs. Factors affecting health outcomes are influenced by a complex interplay of system, provider, and patient difficulties. As a result, these elements must be considered when implementing clinical practice improvement interventions such as risk assessment, nurses' attitudes, practices, and knowledge. Although thorough descriptions of these elements exist in the Western world, there is little knowledge about organizational culture available in settings in ICUs in Malaysian to aid planning.

To prevent PUs, healthcare management should identify perceived impediments to care and eliminate them as much as possible to prevent PUs, and healthcare management should identify perceived barriers to care and eliminate them as much as possible. PUs prevention in-service training and refresher courses should be continued, with refresher

sessions lasting at least six months. Nurses should receive further training to improve their understanding of PUs prevention techniques. To improve nursing practice in this area, nurses must increase their KAP of PUs prevention.

This study should be repeated in different environments, such as the general ward, to ensure that the findings above are generalisable. Results from this study should be shared with hospital administrators, researchers, physicians, nurse administrators, and the general public.

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CONFLICT OF INTEREST

There is no actual or potential conflict of interest in this article.

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ORIGINAL ARTICLE

Phytochemical quantification and HPLC analysis of *Parkia speciosa* pod extract

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ABSTRACT

Introduction: *Parkia speciosa* Hassk., commonly known as bitter bean or twisted cluster bean, is a tropical leguminous plant species native to Southeast Asia. The plant's edible pods have been traditionally used in various cuisines, particularly in Malaysian, Thai, and Indonesian cooking. Apart from being used as a food ingredient, the pods of *P. speciosa* also have a range of potential applications in other fields, including medicine, agriculture, and industry. The pods are said to have several phytochemicals that hold great therapeutic values such as reducing inflammation, improving digestion, and lowering blood sugar levels. However, there is limited information on the specific phytochemical contents of the pods in the literature. Thus, the aim of this study is to quantify the total phenolic and flavonoid compounds and to determine the concentrations of four selected phytochemical compounds in the *P. speciosa* pod extract (PSPE).

Materials and Methods: Quantification of the total phenolic (TPC) and flavonoid contents (TFC) in PSPE were done via colourimetric methods; and the determination of the concentrations of four specific phytochemicals (gallic acid, caffeic acid, rutin, and quercetin) were done via High-Performance Liquid Chromatography (HPLC).

Results: Colourimetric determination of PSPE showed TPC and TFC values of 84.53±9.40 mg GAE/g and 11.96±4.51 mg QE/g, respectively. Additional analysis of the phytochemicals using HPLC revealed that there were 6.45±3.36 g/kg, 5.91±1.07 g/kg, 0.39±0.84 g/kg, and 0.19±0.47 g/kg of caffeic acid, gallic acid, rutin, and quercetin, respectively.

Conclusion: The findings show that PSPE contains substantial amounts of caffeic acid, gallic acid, rutin, and quercetin, which may indicate its potential as antibacterial, anti-inflammatory, anti-lipid, and antiviral medicines.

KEYWORDS:
Parkia speciosa, ethanol extract, phytochemicals, HPLC

INTRODUCTION

Parkia speciosa Hassk. is a leguminous plant indigenous to Southeast Asia and is abundantly found in tropical countries like Malaysia, Indonesia, Thailand, and the Philippines.[1] It is locally known as 'petai' and has a distinctive pungent odour which has also led to the name "stinky beans". The flat elliptical seeds are encapsulated by green pericarps and are considered a popular ingredient in traditional cuisines but can also be eaten raw. Besides being incorporated into dishes, the beans were also utilised for medicinal purposes. They were reported to relieve stomach pain, liver disease, diabetes, and worm infestations.[2] The beans even harboured anticancer, antibacterial, antioxidant,[3] antiangiogenic,[4] as well as wound healing[5] properties.

Currently, in the food industry, only the beans of *P. speciosa* are consumed while the pods are discarded as waste,[6] and in mature fruits, they make up more than 60% of the biomass.[3] Since the empty pods are considered useless, they are eliminated once the beans are harvested. To date, there have been several studies published on antihypertension, antidiabetic as well as antimicrobial and antioxidant properties of the empty pods of *P. speciosa*.[7-9]

Medicinal properties of plants lie in their bioactive phytochemical constituents. According to Ahmad et al., polyphenols, flavonoids, alkaloids, terpenoids, and tannins were among the phytochemicals found in the extracts of *P. speciosa* beans.[10] These phytochemicals are responsible for the healing properties reported. Similarly, the empty pods of *P. speciosa* harbour multiple bioactive compounds with many therapeutic potentials. Some of the most reported bioactive phytochemical constituents of the pod are quercetin, rutin, kaempferol, epicatechin, gallic acid, catechin, ellagic acid, and caffeic acid.[1,3,5,7,8,11] Despite extensive investigation in identifying the phytochemical constituents of the *P. speciosa* pods, there is not much information on the quantification of the bioactive compounds present. Hence, the present study aims to quantify four selected phytochemical compounds in the ethanolic extract of the *P. speciosa* pods.

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MATERIALS AND METHODS

Plant Material Preparation

P. speciosa fruits were collected from Kuala Krai, Kelantan in late November, and the plant species was verified by the UPM Institute of Bioscience herbarium (Voucher No. KM 0051/23). Approximately 2 kg of pods was sliced into smaller pieces, washed, and oven-dried at 40℃ for 3 days. An electrical grinder was used to finely grind the dried pods and they were kept in airtight containers at room temperature.

P. speciosa Pod Extraction

The exhaustive extraction method adapted from Fithri et al., was applied for the preparation of the extract.[12] The *P. speciosa* pod powder was soaked in 70% ethanol at room temperature and was filtered using Whatman No. 1 filter paper. The solvent was changed every four days until the solution turns colourless. The pooled extract was then concentrated using a rotary evaporator under reduced pressure at 45℃. The resulting extract was further concentrated using a vacuum concentrator for two hours before being subjected to freeze-drying for three days. The collected powder was kept at -20℃ until further use.

The extraction yield (%) was calculated using the formula:

$$\text{Yield (\%)} = \frac{\text{Dry extract weight (g)}}{\text{Dry starting material weight (g)}} \text{ X } 100$$

Measurement of Total Phenolic Content of PSPE

The Folin-Ciocalteu method from Azizan et al., was applied for the determination of the total phenolic content (TPC) of PSPE.[13] Briefly, the reaction mixture was prepared by mixing 20 µL of 10 mg/mL PSPE and 100 µL of Folin-Ciocalteu's reagent in a 96-well plate in triplicates. After incubation for 5 minutes, 80 µL of 0.75% sodium carbonate ($NaCO_3$) was added to the mixture and incubated in the dark for another 20 minutes at room temperature. The absorbance was read at 765 nm using a microplate reader (Tecan Infinite M200, Austria). The procedure was repeated using gallic acid as the standard solution and the standard curve with a range of 31.25–1000 µg/mL was constructed. The content of phenol in the PSPE was expressed in terms of gallic acid equivalent (mg GAE/g).

Measurement of Total Flavonoid Content of PSPE

The total flavonoid content (TFC) of PSPE was measured using the aluminium chloride (AlCl3) method modified from Abd Manan et al.[14] The reaction mixture was prepared by mixing 100 µL 10 mg/mL PSPE and 100 µL of 2% AlCl3 in a 96-well plate. The tests were conducted in triplicates. After incubation for 15 minutes at room temperature, the absorbance was read at 415 nm using a microplate reader (Tecan Infinite M200, Austria). The procedure was repeated using quercetin as the standard solution and the standard curve with a range of 37.50–1200 µg/mL was constructed. The content of flavonoids in the PSPE was expressed in terms of quercetin equivalent (mg QE/g).

HPLC Instrumentation and Chromatographic Conditions

HPLC analysis was performed using Shimadzu Prominence HPLC system (Shimadzu, Kyoto, Japan), equipped with a reverse-phase C18 column (4.6×250 mm, 5 µm; Agilent Eclipse Plus C18) set at 40°C and a UV/VIS detector that was set at 280 and 356 nm. The mobile phase consists of two different solvents (solvent A: 0.1% acetic acid and solvent B: acetonitrile). All solutions were degassed and filtered. The detection and quantifications of phenolic acids (gallic acid and caffeic acid) were done at 280 nm, using a gradient program that started with 10% B from 0 to 5 min and increased to 30% and back to 10% at 1.0 mL/min. Flavonoids (rutin and quercetin) were detected and quantified at 356 nm, using a gradient starting with 20% B for 5 minutes, increased to 40%, and back to 20% at 1.2 mL/min. All chromatography operations were carried out in triplicates. The PSPE powder was dissolved in HPLC grade methanol (10 mg/mL) and the peaks and retention time obtained were confirmed by comparing them to those of reference standards solutions (100 µg/mL).

RESULTS AND DISCUSSION

Extraction Yield

The dried pod sample was ground into powder to increase the surface area for better contact with the solvent during the extraction process. The solvent of choice was 70% ethanol to retrieve a wider polarity of compounds. While the repetitive maceration technique applied in the exhaustive extraction method ensures the complete removal of active compounds from the plant material.[12]

Both extraction solvents, ethanol and methanol are efficient solvents for phenolic compound extraction, whereby ethanol extracts flavonoids more effectively while methanol easily extracts phenolic acid. However, ethanol is more frequently used for the extraction of antioxidant compounds as it has a lower toxicity level.[15] In the present study, 70% ethanol was the solvent of choice for the maceration technique applied.

A total of 600 g of dried *P. speciosa* pod powder was used in the extraction process. The resulting freeze-dried PSPE acquired was 227 g, making the final extraction yield obtained 37.83%. Thus, our result was substantially higher than those of previous studies. Fithri et al., attained a final yield of 19.66% with the same extraction method[12] while Wonghirundecha et al.,[9] and Gan and Latiff,[6] reported yields of 14.85% and 12.4%, respectively. Despite applying the same method of extraction, we obtained a higher yield compared to Fithri et al., and this is most probably attributed to some changes made. The evaporation temperature used in the current study was 45℃ and it is lower compared to the 70℃ used in the study done by Fithri et al. This might have caused the differences in the yield obtained as flavonoids and phenolic compounds are heat-sensitive and easily oxidized.[16]

Total Phenolic and Flavonoid Contents of PSPE

Phenolics and flavonoids are naturally occurring compounds in plants that possess a broad range of biochemical activities. They account for the majority of the antioxidant activities in plant products. The TPC and TFC of PSPE were determined using the Folin-Ciocalteau and aluminum chloride methods, respectively and the results obtained are tabulated in Table I.

In the present study, the TPC obtained was 84.53±9.40 mg GAE/g and the TFC was 11.96±4.51 mg QE/g. Wonghirundecha et al., studied the ethanolic extract of *P.*

Table I: Quantitative analysis of phytochemicals in ethanolic extract of *P. speciosa*

Sample	Total phenolic content (mg GAE/g±SD)	Total flavonoid content (mg QE/g±SD)
PSPE (10mg/mL)	84.53±9.40	11.96±4.51

P. speciosa pod extract (PSPE)

Table II: Retention time, tr and concentration of phytochemical compounds in 10 mg/mL PSPE

Sample	Gallic acid	Caffeic acid	Rutin	Quercetin
tr standard (min)	3.345	7.666	3.730	8.817
tr PSPE (min)	3.410	7.796	3.640	8.823
Concentration in PSPE (g/kg ± SD)	5.91 ± 1.07	6.45 ± 3.36	0.39 ± 0.84	0.19±0.47

P. speciosa pod extract (PSPE)

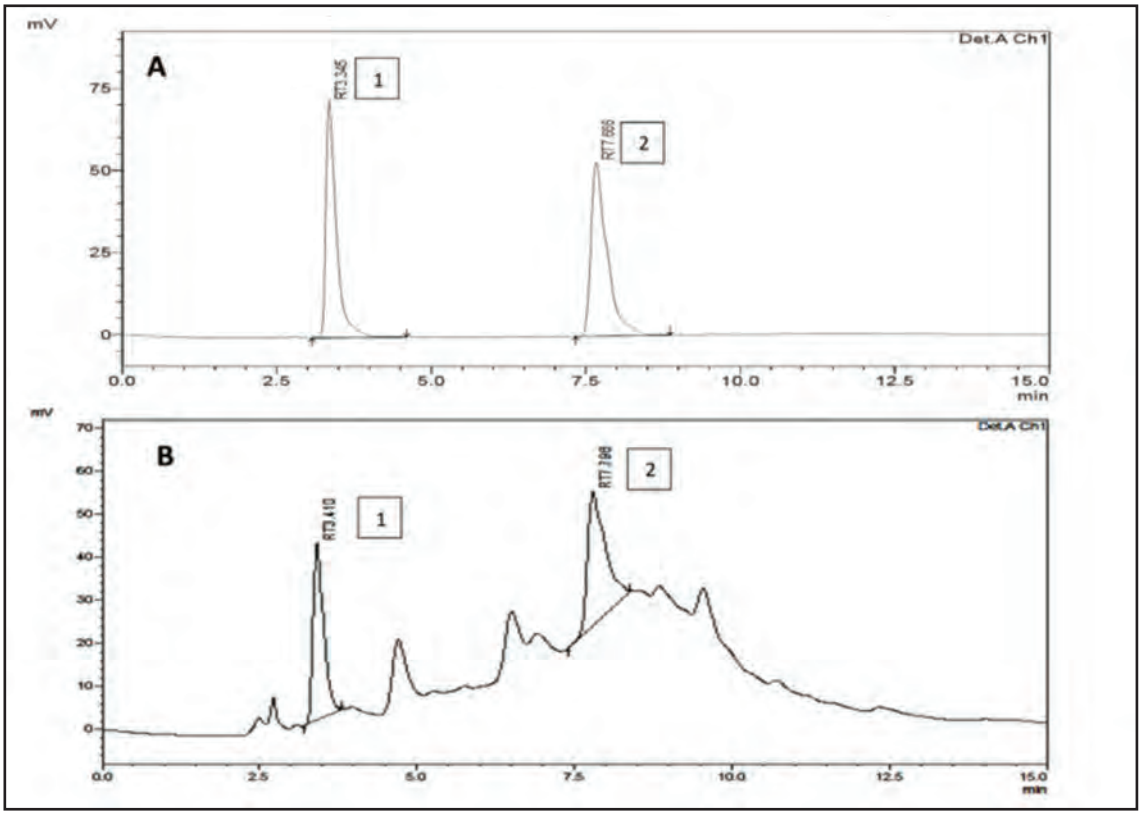

Fig. 1: Chromatogram of reference standard for phenolic acids (A) and PSPE (B) (peak 1: gallic acid; peak 2: caffeic acid) at 280 nm

speciosa pod originating from Thailand and reported TPC value of 71.39±0.08 mg GAE/g, and TFC value of 5.38±0.18 mg CE/g.[9] Another study by Gan & Latiff, reported 21.7±1.0 mg GAE/g sample for TPC and 1.1±0.3 mg PCE/g sample for TFC.[6] Similarly, our results were higher than the previous literature and the difference in results might be due to the variation in collection sites and drying methods of the plant materials. Their study showed that the pods were oven-dried at 70°C[6] and this higher temperature may have degraded some of the bioactive compounds as stated by Le et al.[17] Differences in collection site may also influence the phytochemical constituents in the plant materials since even various soils may have an impact on the phytochemical components of plants, as claimed by Mudau et al.[18]

HPLC Analysis

Using HPLC analysis, four compound standards were compared to PSPE, and multiple peaks were obtained in the sample extract chromatograms as shown in Figure 1 and Figure 2. The retention time (tR) for all standards and compounds detected in the PSPE are shown in Table II.

As recorded in Table II, PSPE contained 5.91±1.07 g gallic acid/kg dry extract and 6.45±3.36 g caffeic acid/kg dry extract. These two phenolic acids have also been reported in a previous study by Ko et al.[3] An almost similar yield of gallic acid was reported (6.58 g/kg) in their ethanolic extract of *P. speciosa* pods while the quantity of caffeic acid detected was not specified. To date, not much information is available regarding these phenolic acid contents in *P. speciosa* pods, unlike the beans. Ghasemzadeh et al., had reported that their *P. speciosa* beans harboured 6.42±0.67 g/kg gallic acid and 1.46±0.67 g/kg caffeic acid.[2] Hence, this shows that the pods and beans of *P. speciosa* possess comparable amounts of these phenolic acids, making the pods as beneficial as the beans.

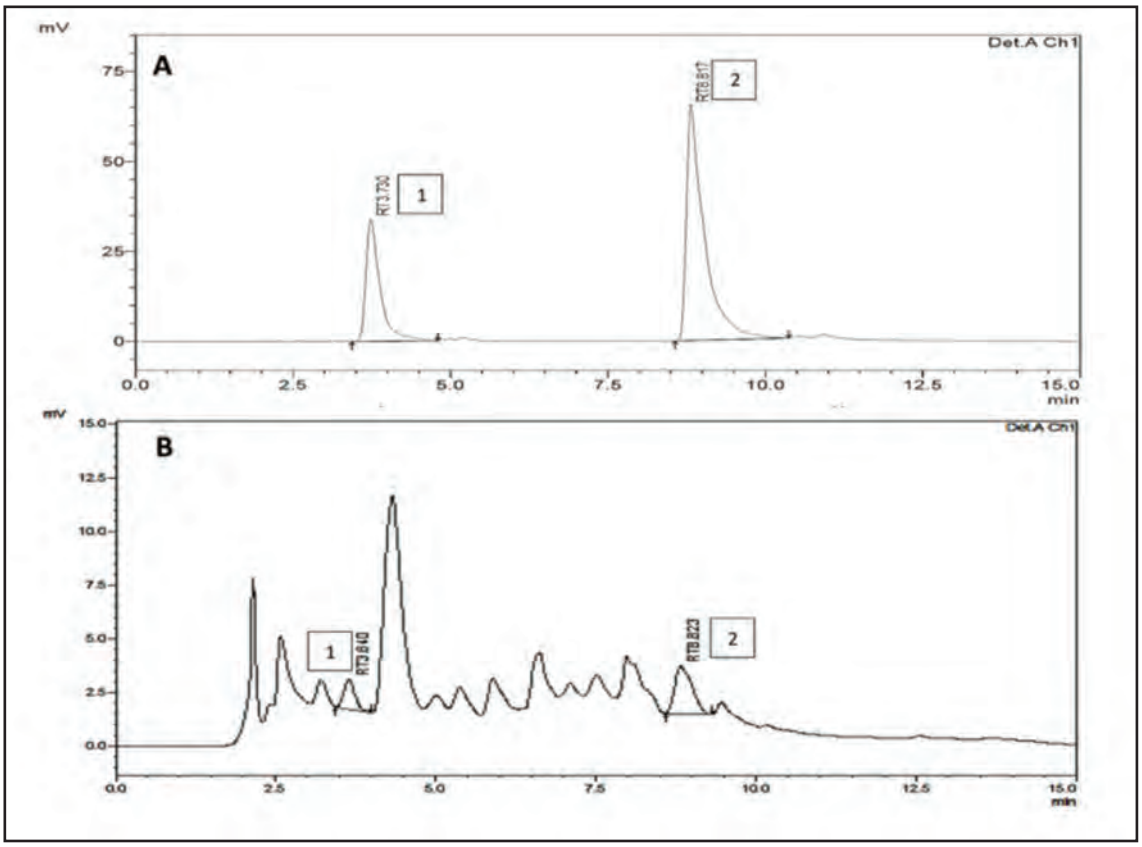

Fig. 2: Chromatogram of reference standard for flavonoids (A) and PSPE (B) (peak 1: rutin; peak 2: quercetin) at 356 nm

The therapeutic propensity of a plant species can be assessed by studying the phytochemicals present as these compounds have been reported to impart various medicinal characteristics. Caffeic acid, which was the most abundant of the four bioactive compounds studied, is usually found in tea, olives, coffee, and propolis. Caffeic acid is well known for its anti-inflammatory, antioxidant, and anticarcinogenic properties. Several studies have demonstrated the ability of caffeic acid to repress inflammation response as well as its potential to be utilised in the treatment of rheumatoid arthritis.[19] On top of that, caffeic acid also demonstrated an antiproliferative effect on cancer cell lines via apoptosis[20], indicating that this compound has the potential as a chemotherapeutic agent.

Gallic acid is frequently reported to have antimicrobial, anti-obesity, and antioxidant properties. This plant-derived hydroxybenzoic acid has a strong antibacterial effect and has the ability to induce irreversible alterations in 61 membrane properties of *Pseudomonas aeruginosa*, *Staphylococcus aureus, Escherichia coli,* and *Listeria monocytogenes*.[21] Based on a study by Pinho et al., gallic acid acted as an antibacterial agent without causing any damage to the animal cells and this shows that the compound is safe for humans according to ISO 10993- 5:2006.[22] In addition, anti-obesity properties of gallic acid have been observed from multiple reports of inhibition of pre-adipocyte proliferation,[23] regarding inhibition of fat droplet formation and triglyceride accumulation in 3T3-L1 cells,[24] and reduced adipocyte size in mice treated with gallic acid.[25]

As for the flavonoid compounds, rutin and quercetin were quantified by comparing their peaks to the compound standards. As demonstrated in Table II, PSPE contained 0.39±0.84 g rutin/kg dry extract and 0.19±0.47 g quercetin/kg dry extract. Previously, Mustafa et al. reported the presence of 5.84 mg quercetin per 100 g dry extract in the ethyl acetate fraction of ethanolic extract prepared from *P. speciosa* empty pod.[1] A study conducted by Ko et al., revealed a much higher quercetin yield at 4.86 g/kg as compared to the present study.[3] In another study conducted by Siti et al., they reported a 15.5 µg rutin/mg extract and 0.11 µg quercetin/mg extract from *P. speciosa* pods prepared with 95% ethanol.[11] The concentration of their rutin was higher compared to our findings. The discordance in the results obtained can be pinpointed to the different extraction techniques and HPLC settings applied in each study which resulted in the difference in yield for the respective compounds. The polarity index of the solvent used during the preparation of extracts must also be taken into consideration since it has an impact on the type and quantity of output obtained from the extraction process.[18] Use of higher water content will increase the polarity of the solvent[26] and allowed for more compounds to be extracted from the plant material. Additionally, more polar solvents can extract a class of compounds with a broader polarity range. This made it possible for non-phenolic polar molecules like proteins and carbohydrates to dissolve during the extraction process thus increasing the extraction yields. Therefore, in contrast to non-polar solvents, highly polar ones will produce high extract yields but lower phenolic and flavonoid contents.[27]

In the conducted study, the presence and quantities of the two flavonoids were successfully demonstrated in the PSPE. Rutin, a flavonoid prevalent in many fruits, vegetables, and cereals is a member of the vitamin C2 family and is commonly studied for its antimicrobial and anticancer properties.[28] It has previously shown strong antimicrobial activity against *S. aureus, P. aeruginosa*, *E. coli, E. faecalis,* and *K. pneumoniae*.[29] In addition, it inhibits abnormal cell growth by increasing caspase activity, induces cell cycle arrest, and stimulates apoptosis in cancer cells as part of its anticancer effect.[30] The anti-lipid activity of rutin has also been demonstrated by Livingston Raja et al. where the reduction in total cholesterol, triglycerides, low density lipoprotein (LDL) and very low density lipoprotein was seen in rats treated with rutin flavonoid.[31]

Finally, quercetin is a flavonoid with a vital scavenging role in oxidation[32] and is commonly reported as a potential antimicrobial agent.[33] According to Jaisinghani, quercetin was able to inhibit *S. aureus, P. aeruginosa, P. vulgaris*, and *E. coli* at various concentrations.[34] Its antimicrobial activities may result from its ability to disrupt bacterial cell wall and nucleic acid synthesis, inhibition of biofilm formation, and reduction of virulence factor expressions. Next, similar to caffeic acid, quercetin also has a reputation as a potential anti-inflammatory agent.[35] Several groups of researchers have demonstrated this particular property of quercetin, most commonly via inhibition of cytokines synthesis.[36-38] Following that, another attribute of quercetin that is popular among researchers nowadays is the anti-lipid property of this compound. Zhao et al. stated that quercetin exerted positive effects on adipose tissue by means of adipogenesis and lipogenesis inhibition and the suppression of preadipocyte differentiation.[39] Eseberri et al. demonstrated that quercetin was also able to reduce fat accumulation in mature adipocytes.[40] The presence of these compounds, therefore, justifies the therapeutic potential of PSPE to be developed into a beneficial health product from natural sources.

CONCLUSION

The ethanolic extract of *P. speciosa* pods (PSPE) prepared via an exhaustive extraction method has been shown to contain the four targeted phytochemicals namely gallic acid, caffeic acid, rutin, and quercetin. These results suggest it may be a potential natural product for antibacterial, anticancer, anti-inflammatory, anti-lipid, and antiviral purposes. While the results are encouraging, deeper and further investigations are required to completely understand the full potential of the extract.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

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ORIGINAL ARTICLE

Early mobilization of critically ill ICU patients: A survey of knowledge, perceptions, and practices of Malaysian physiotherapists

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ABSTRACT

Introduction: Early mobilization and rehabilitation of critically ill patients in the Intensive care unit (ICU) is a topic of growing interest. Current evidence suggests that early mobilization is safe, feasible, and effective at reducing the incidence of ICU-acquired weakness. However, early mobilization is still not the standard of care in most ICUs worldwide. The aim of the study was to determine the level of knowledge, perceptions, and practice among ICU physiotherapists of early mobilization in critically ill ICU patients in Malaysia.

Materials and Methods: A cross-sectional study was undertaken in 45 public, teaching, and private hospitals in Malaysia that provide ≥ 10 beds in their ICUs. Knowledge, perceived barriers, facilitators, and practice of early mobilization were assessed using a previously validated mobility survey questionnaire.

Results: Only 35% of ICU physiotherapists reported receiving training/courses on early mobilization in the ICU. 100 (86%) physiotherapists underestimated the incidence of ICU-acquired weakness, and 88 (75%) were unfamiliar with the current literature on early mobilization in the ICU. The need for physician orders before mobilization, medical instability, excessive sedation, and risk of dislodgement of devices or lines were the most common barriers to early mobilization. Nearly half (49 [42%]) of the respondents reported physiotherapist as early mobilization clinical champion in their setting, but the most common physiotherapy treatment techniques in the ICU reported by the respondents' were still chest physiotherapy, range of motion exercises, and bed mobility.

Conclusion: We observed strong enthusiasm for early mobilization among Malaysian physiotherapists. Most respondents believed that early mobilization is important and beneficial to ICU patients. However, there is still a big gap in knowledge and training of early mobilization in ICU patients among Malaysian physiotherapists.

KEYWORDS:
Early mobilization, intensive care unit, knowledge, perceptions, practice

INTRODUCTION

Bed rest was prescribed for critically ill patients in the past because bed rest was thought to be necessary to prevent complications and for the comfort of patients being 'critically ill'. However, no one randomized controlled trial has been able to demonstrate the benefits of bed rest not only in critically ill patients but also during the postoperative period, where bed rest is common. On the contrary, bed rest has been found to be associated with multiple complications, especially to the musculoskeletal system. Bed rest induced loss of muscle mass predominantly to the lower extremities and is more rapid in the elderly and during critical illness.[1,2] In critically ill ICU patients, the cross-sectional area of rectus femoris was found to be reduced by as high as 12.5% within as short as 7 days.[3] Those with multiple organ failure were found to have greater muscle loss than those with single organ failure (-15.7% vs. -3.0% by day 7 and -8.7% vs. -1.8% by day 3).[3] Despite the availability of such data, bed rest during the period of ICU admission, especially among those requiring mechanical ventilation is common practice in most ICU settings, worldwide.

ICU-acquired weakness is a commonly used term to describe the presence of clinically detectable muscle weakness among ICU patients with no possible aetiology other than being critically ill. In a systematic review of 33 studies involving 2686 ICU patients, ICU-acquired weakness was reported in as high as 1080 patients (i.e., 40%). Even worse, those with ICU-acquired weakness were found to associate with several other negative consequences such as (i) longer mechanical ventilation days (11 vs. 8 days), (ii) extended hospital length of stay (36 vs. 23 days), (iii) greater expenditure ($23,277 vs. $17,834) and (iv) higher 1-year mortality (31% vs. 17%), all $p<0.05$.[4] With the growing literature on ICU-acquired weakness and the harms of bed rest, early mobilization and rehabilitation in critically ill ICU patients has been gaining attention.

Early mobilization is defined as a pattern of increasing activity beginning with a passive to active range of motion through ambulation that starts immediately after stabilization of hemodynamic and respiratory physiology, generally within 24-48 hours after ICU admission.[5] The current evidence suggests that early mobilization is safe and feasible and has the potential to reduce the incidence of ICU-

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acquired weakness.[6] In a systematic review of 32 RCTs involving 2,308 critically ill patients, Zhang et al.[7] found that early mobilization decreased the incidence of ICU-acquired weakness at discharge, increased the number of patients who can stand, shorter the mechanical ventilation days, increased the distance patient can walk independently at hospital discharge and increased the rate of discharge. Adverse events following early mobilization in the ICU were reported between 2%[8] and 21%[9] depending on the number and events each study used to define complications.[8,9] However, it is important to note that most studies reported no differences in the rate of adverse events during in-bed vs. out-of-bed mobilization, and most of the complications resolved after temporary cessation of mobilization (e.g., desaturation, blood pressure changes and ventilator dyssynchrony).[9–11]

Despite the availability of evidence supporting the safety, feasibility, and benefits of early mobilization in the ICU, early mobilization is not yet a standard of care in most ICUs worldwide. In a survey conducted in Australia and New Zealand, Berney et al.[12] found that, of the 498 ICU patients, 140 (28%) completed an in-bed exercise program, 93 (19%) sat over the edge of the bed, 182 (37%) sat out of bed, 124 (25%) stood and 89 (18%) walked. No patient requiring mechanical ventilation sat out of bed or walked. In the USA, a country in which early mobilization practice has been advanced, Jolley et al.[13] found that out-of-bed mobilization was still not a standard of care in 42 ICUs, with only halved (56%) of their non-mechanically ventilated patients received out of bed mobility. In Malaysia, data reporting the levels of mobilization in the ICU is limited. In one teaching hospital in which early mobilization is also considered advanced,[14] bed mobility was still the standard nursing care in the ICU with a majority of the nurses performed supine (88%), side (70%) and fowler/semi fowler (68%) bed mobility. In bed stretching/strengthening exercises was done by less than 20% and standing and walking was done by as low as 11% of the ICU nurses. One of the main barriers to early mobilization reported in this study was majority (72%) of their respondents (i.e., ICU nurses) had not gone through early mobilization training but is expected to keep up with the strong evidence supporting early mobilization in the ICU. Other than nurses who, without doubt, are involve in ICU patient care, the profession that holds the key to the rehabilitation of ICU patients is physiotherapist. Similarly, training on early mobilization may not have been compulsory for all ICU physiotherapists. In fact, in Malaysia, most of the healthcare settings still practice rotation basis where no one physiotherapist stays in an area of practice. Therefore, it is important to first identify the level of knowledge, perception, and practice of early mobilization among ICU physiotherapists in Malaysia for further action and recommendation.

MATERIALS AND METHODS

Study Design and Protocol

This cross-sectional study was conducted from May 2020 to June 2021. Potential study sites were identified through the Malaysia Ministry of Health directory,[15] teaching hospital directory[16] and private hospitals directory.[17] All hospitals that provide ≥ 10 beds in their ICUs were eligible to be included in this study.

The eligibility criteria for the respondents were physiotherapists primarily involved in the management of patients in adult ICU/CICU/CCU/Neuro ICU during the year 2020. Physiotherapists who were on temporary relief duty or were on-call in adult ICU/CICU/CCU/Neuro ICU were excluded from this study.

Survey administration

Initial contact was made with the head of physiotherapy unit or Senior physiotherapist in each of the 45 eligible hospitals (i.e., hospitals that provide ≥ 10 beds in their ICUs) via phone call or email to identify all potential study respondents (i.e., physiotherapist primarily involved in the management of patients admitted to adult ICU/CICU/CCU/Neuro ICU). A total of 200 potential respondents was identified (i.e., 3 to 5 physiotherapists from each study site [depending on the number and size of the ICU]). The survey questions were then sent to the same head of physiotherapy unit or senior physiotherapist through email or WhatsApp using a Google Form link to be distributed to potential respondents. All participants were informed of the objectives of the study and provided informed consent electronically before they were allowed to start filling in the questionnaire.

Study Instruments

A self-administered Mobility Survey Questionnaire was used in this study.[18] The questionnaire has 25-items assessing knowledge of ICU-acquired weakness and early mobilization (4 items), perceptions on levels of activity by patient characteristics and barriers to early mobilization in the ICU (6 items); and assessments for initiation, intensity, and frequency of early mobilization practices; staffing and sedation issues as well as rehabilitation after ICU discharge (15 items).

Each item included various question formats (i.e., true/false, yes/no, nominal, ordinal and Likert scales) but no open-ended questions. Data such as age, gender, level of education, current working area, working experiences, duration of time spent working in ICU, any training or course for early mobilization in ICU, and current workplace were recorded.

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistic software version 26. Descriptive statistical analysis were used to describe the responses in frequency (n) and percentage (%) or mean and standard deviation of the variables of interests.

Ethics Approval and Informed Consent

Approval for the study was granted by the Malaysian National Medical Research Register (NMRR-20-2424-56674), the Malaysian Medical Research and Ethics Committee (202162-10191) and Universiti Teknologi MARA (UiTM) Human Research Ethics Committee (600-TNCPI (5/1/6). All participants were informed of the objectives of the study and provided informed consent electronically before they were allowed to start filling in the questionnaire.

RESULTS

Forty-five hospitals (36 public, 5 privates, and 4 teaching) participated in this study. Table I describes the demographic

Table I: Characteristics of the survey respondents (n=117)

Characteristics	Mean ± SD	n	(%)
Age, years	32.7 ± 5.8		
20-29		36	(31)
30-39		67	(57)
40-49		10	(9)
50-59		4	(3)
Gender, M		32	(27)
Working experience			
6 months to 1 year		5	(4)
2 years to 5 years		18	(15)
6 years to 10 years		60	(51)
>10 years		34	(29)
Current Working Place			
Public		63	(54)
Teaching		44	(38)
Private		10	(9)
Highest education level			
Diploma		81	(69)
Degree		31	(27)
Master		4	(3)
PhD		1	(1)
Type of ICU			
General ICU		74	(63)
Medical-surgical ICU		8	(7)
Cardiovascular ICU		18	(15)
Neurological ICU		17	(15)
Duration Working in ICU			
Less than 1 year		41	(35)
1 - 2 years		37	(32)
<5 years		21	(18)
>5 years		18	(15)

Data are presented as Mean±SD and n (%). Abbreviations: ICU, intensive care unit; M, male.

Table II: Perception of physiotherapists on maximum level of activity for patients with cardiovascular, respiratory, and neurological limitations

Physiological status	Bed rest	In-bed activities	Out-of-bed activities	Not sure
Cardiovascular				
Receiving ≥ 3 vasopressors or inotropic infusions	43 (37)	54 (46)	4 (3)	16 (14)
Receiving 2 vasopressors or inotropic infusions	9 (8)	86 (74)	6 (5)	16 (14)
Receiving 1 high dose vasopressor or inotropic infusion	10 (9)	87 (74)	5 (4)	15 (13)
Receiving 1 medium dose vasopressor or inotropic infusion	2 (2)	89 (76)	10 (9)	16 (14)
Receiving 1 low dose vasopressor or inotropic infusion	0 (0)	74 (63)	29 (25)	14 (12)
Respiratory				
Minimal pressure support on conventional mode of mechanical ventilation (e.g., FiO2 0.5, PEEP 10)	0 (0)	54 (46)	54 (46)	9 (8)
Moderate pressure support on conventional mode of mechanical ventilation (e.g., FiO2 0.5, PEEP 10)	2 (2)	88 (75)	18 (15)	9 (8)
Advanced mode of mechanical ventilation (e.g., high frequency oscillation)	15 (13)	83 (71)	10 (9)	9 (8)
Neurological				
Unresponsive to verbal and motor	5 (4)	101 (86)	6 (5)	5 (4)
Purposeful motor response, not obeying verbal commands	2 (2)	98 (84)	12 (10)	4 (3)
Purposeful motor response, obeys verbal commands	0 (0)	55 (47)	57 (49)	5 (4)

characteristics of the 117 study respondents. The response rate to questionnaire administration was 59%. Of the 117 study respondents, only 41 (35%) reported receiving training/ courses for early mobilization in ICU.

Knowledge

Overall, 100 (86%) respondents underestimated or were unaware of the incidence of ICU-acquired weakness (i.e., 40% based on prospective observational studies of 2686 critically ill ICU patients).[19] Two-thirds of the respondents (88 [75%]) were not familiar with the current literature on early mobilization in the ICU. Only 2 (2%) physiotherapists responded correctly to all five true/false questions in relation to clinical trials on the benefits of early mobilization in the ICU. Despite only involving physiotherapists primarily in charge of ICU patients, only as low as 22 (19%) respondents reported sufficient knowledge to mobilize patients receiving mechanical ventilation.

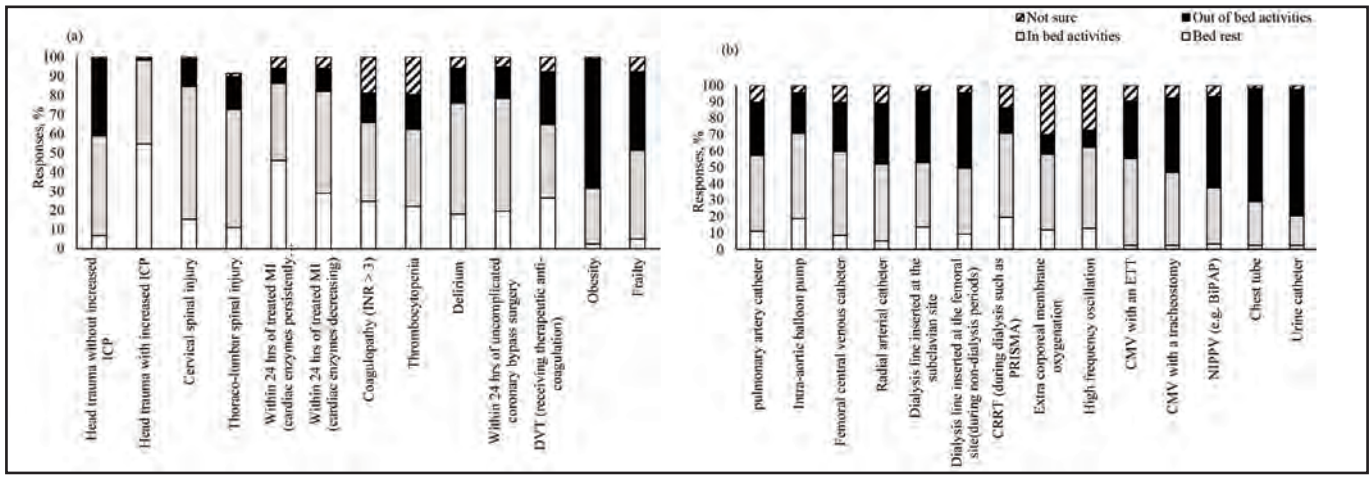

Fig. 1: Physiotherapist perception on permissible level of activity based on patient's diagnosis and condition (a) and devices (b). Abbreviations: CRRT, continuous renal replacement therapy; DVT, deep vein thrombosis; ETT, endotracheal tube; ICP, intracranial pressure; INR, international normalised ratio; MI, myocardial infarction; MV, mechanical ventilation; NIPPV, non-invasive positive pressure ventilation

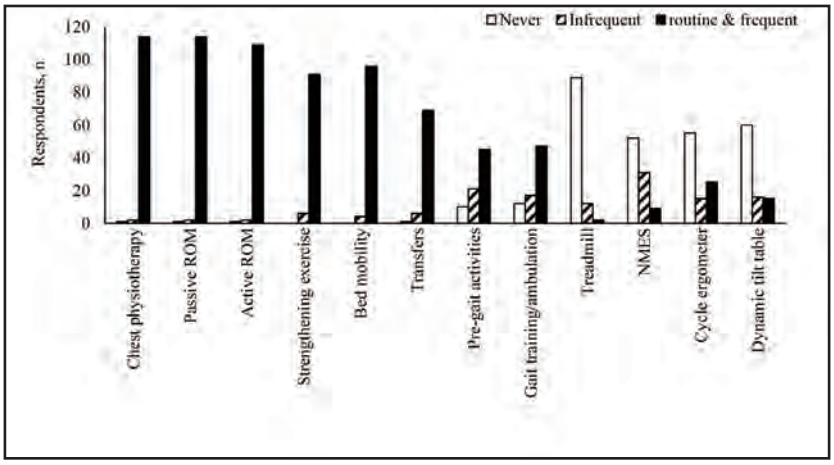

Fig. 2: Frequency (a) and intensity (b) of mobilization performed by physiotherapists

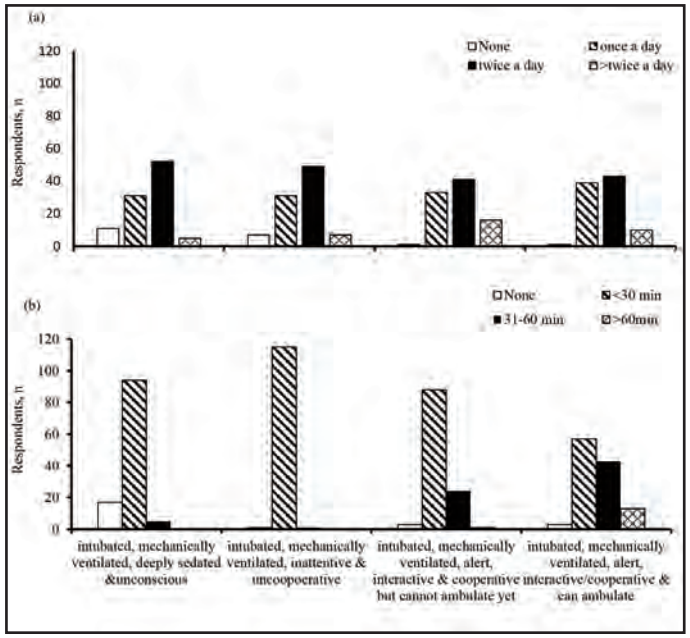

Fig. 3: Frequency (a) and intensity (b) of mobilization performed by physiotherapists

Perceptions

A total of 90 (77%) physiotherapists perceived that early mobilization is crucial in the care of ICU patients. Most of the physiotherapists (106 [91%]) reported early mobilization should be initiated as soon as the cardiorespiratory status of the patients has been stabilized, while over half of the respondents (60%) reported early mobilization should begin as soon as the patient is conscious and able to cooperate.

Barriers to Mobilization of ICU Patients

Several barriers to early mobilization were reported by the respondents. The most common perceived institutional barriers were the need for orders from physicians before mobilization (67%), routine bed rest orders on ICU admission (61%), and insufficient physical space (51%). Most of the physiotherapists reported medical instability (98%), excessive sedation (85%), and risk of dislodgement of devices or lines (80%) as patient-level barriers to early mobilization in the ICU. For the provider level barriers, the most frequently reported barrier was lack of communication about rehabilitation during the handover at shift change among nurses (33%), limited staffing (mainly nurses and physiotherapists) to routinely mobilize the patients (27%),

and lack of specific decision-making authority to initiate early mobilization in the ICU (25%).

Perceptions of Physiotherapists on Permissible Level of Activity based on Patient's Diagnosis, Condition, and Devices

Figure 1 illustrates the perception of the physiotherapists on permissible activity levels based on the diagnosis of the patients, their condition, and devices. Over half of the physiotherapists (64 [55%]) believed that patients with head trauma with increased intracranial pressure should be restricted to bed rest, whereas the majority agreed that bed rest was not necessary for patients with head trauma without increased intracranial pressure (108 [92.3%]). Although majority of the physiotherapists deemed bed rest was not a necessity for patients with a catheter attached, most of them were more comfortable prescribing in-bed activities compared to out-of-bed activities for patients with pulmonary artery catheter (54 [46%] vs. 38 [33%]), a femoral central venous catheter (60 [51%] vs. 35 [30%]) and radial arterial catheter (55[47% vs. 43 [37%]).

Perceptions of Physiotherapists on the Maximum Level of Activity for Patients with Cardiovascular, Respiratory, and Neurological Limitations

More than two-thirds of the physiotherapists (43 [37%]) consider only bed rest for patients receiving ≥ 3 vasopressors/ inotropic infusions (Table II). Majority of the physiotherapist believed that in-bed activities such as passive and active ROM exercises were the highest activity level for patients receiving ≤ 2 vasopressors/inotropic infusion(s). Nearly half of the physiotherapists (54 [46%]), reported out-of-bed activities as the highest level of activity for patients requiring minimal respiratory support. Majority (>70%) believed that only in-bed activities were appropriate for those requiring moderate and high respiratory support (FiO_2 0.5, PEEP 10 and high-frequency oscillation). Regarding neurological limitations, out-of-bed activities was only seen as appropriate to patients with a purposeful motor response and obeying commands by nearly half of the respondents (57 [49%]).

Practices

Although majority of the respondents (82 [70%]) agreed that their initial assessment required a written medical order by a physician, more than half (62 [53%]) reported assessing all ICU patients for the appropriateness of early mobilization even before they received the order or request from any other healthcare provider. In fact, the number of respondents who reported physician as the first healthcare provider to identify patient readiness for mobilization was similar to those who reported physiotherapist as the first to identify patient readiness to mobilization (59 [50%] vs. 56 [48%]). More than half of the respondents (70 [60%]) reported at least one early mobilization champion in their ICU, of which almost half (49 [42%]) reported the champion was a physiotherapist.

Figure 2 illustrates the commonly used physiotherapy treatment techniques in the ICU as reported by the respondents. The four physiotherapy treatment techniques routinely used in the ICU were chest physiotherapy (97 [83%]), passive range of motion (91 [78%]), active range of motion (79 [68%]) and bed mobility (63 [54%]). Figure 3 describes the intensity and frequency of mobilization performed by physiotehrapists in the ICU.

DISCUSSION

Knowledge

The present study reports the findings from a national survey among Malaysian physiotherapists on knowledge, perceptions, and practices of early mobilization of critically ill ICU patients. The results highlight significant gaps in knowledge of ICU-acquired weakness among Malaysian physiotherapists: 100 (86%) of our respondents either underestimated or were unaware of the incidence of ICU-acquired weakness. This number is higher than previously reported 69% of Canadian physicians and physiotherapists also underestimated the incidence of ICU-acquired weakness.[18] Although involving only physiotherapists primarily in ICU patient care, most were unfamiliar with the current literature on early mobilization. Only two physiotherapists answered the true/false questions on the benefits of early mobilization correctly. Only as low as 19% of the physiotherapists reported sufficient knowledge or training to mobilize patients receiving mechanical ventilation. Factors such as majority of the respondents being diploma holders[20] (69% [Table I]) and working in the ICU for less than two years[21] (67% [Table I]) could have in part contributed to the limited knowledge and training on early mobilization among the respondents.[18,21,22] Of note, the training in evidence-based practice was emphasized more in the bachelor's degree than diploma program, and in most setting in Malaysia, physiotherapist is subjected to rotation in the clinical area every 1 to 2 years. The rotation will allow physiotherapist to be competent to practice in all treatment areas but limit specialization. Future physiotherapy practice should consider physiotherapy specialisation so that every healthcare setting has a dedicated physiotherapist for specialized areas like ICU.

Perception

The findings of this study show that majority of the physiotherapits believed that early mobilization is important during the care of critically ill patients in the ICU. Similarly, Anekwe et al.[22] also found physiotherapists are more likely to agree that early mobilization is very important in the ICU and should be initiated as soon as the cardiorespiratory condition of the patients has been stabilized. Sommers et al.[23] recommend initiating early mobilization as soon as the cardiorespiratory status of patients has been stabilized as early mobilization within 48 hours of mechanical ventilation has been found to reduce ICU and hospital stays,[24] while early mobilization within 48 – 72 hours of mechanical ventilation improved ICU-AW and reduce the duration of mechanical ventilation.[25] Thus, it is important to determine when to initiate early mobilization to provide optimal outcomes for patients.[26] However, this study was unable to definitively say to what extent it has been implemented in practice.

Barriers to Mobilization of ICU Patients

The barriers perceived by the physiotherapists in this study are similar as reported in other studies.[14,18,22,27] Interestingly, a patient-level barrier such as medical instability, excessive sedation, and risk of dislodgement of devices or lines has a much higher overall vote compared to other types of perceived barriers in this study. Previous studies found that the medical stability and safety concerns on early mobilization patients were the most common barriers reported in initiating early mobilization.[18,27] This supports the

findings in this study that most physiotherapists generally have insufficient knowledge of the current literature and lack proper training on early mobilization in the ICU. This needs to be emphasized as it reflects the ability of Malaysian physiotherapy to perform early mobilization on critically ill patients. Therefore, there is a need for continuous education and training programs to improve knowledge and technical skills regarding early mobilization in the ICU.

Requiring physician orders to initiate early mobilization and lack of communication about rehabilitation during the handover at shift changes among nurses were the most common perceived barriers at the institutional- and provider-level, respectively. These findings are consistent with previous studies.[14,18,27,28] Requiring a physician referral to initiate early mobilization is most likely a hospital policy and communication issues among nurses may related to the limited available staff in the ICU. Previous studies found that the need to wait for physician orders and lack of nursing availability delay early mobilization [14,29] and cause it to be minimally practiced in the ICU settings.[14] This shows that a sufficient number of staff and utilization of multi-disciplinary teams are needed to overcome multiple barriers of mobilization in the ICU settings.[22]

Perceptions of Physiotherapists on Permissible Level of Activity Based on Patient's Diagnosis, Condition, and Devices

Responses from the physiotherapists on the permissible activity level based on the diagnosis or devices patients' show that most ICU patients did not receive the most beneficial activity level. Most physiotherapists who participated in this survey tend to prescribe in-bed activities for ICU patients. Previous studies in peninsular Malaysia and Sarawak found a low rate of advanced mobilization and ambulation practice done on patients with mechanical ventilation in the ICU.[14,30] This finding shows that Malaysian physiotherapists did not necessarily follow the existing recommendation[31] for early mobilization in the ICU settings. One of the reasons for the low practice of early mobilization in the ICU may be related to physiotherapists who are not familiar with existing evidence on early mobilizations in the ICU. Lack of knowledge[18] and awareness of existing protocol[22] regarding mobilization in the ICU result in poor practice of early mobilization in the ICU.[18,22,28] These findings suggest further education and the presence of a written protocol may help improve the knowledge necessary to facilitate early mobilization in the ICU.

Practice

A physiotherapist is the most important person for early mobilization in the ICU to most of the respondents. Majority reported (i) screening the appropriateness of patients for early mobilization even before they received the order for mobilization from the physician, (ii) being the first to identify patient readiness for early mobilization, and (iii) physiotherapist as the ICU early mobilization champion in their hospitals. Despite the above findings, ambulation was a routine practice in the ICU by not even half of the respondents (Figure 2). Chest physiotherapy, passive/active ROM exercises, and bed mobility, on the other hand, were the three most used physiotherapy treatment techniques in the ICU by majority of the respondents.

When the respondents were asked about their mobilization practice in intubated, mechanically ventilated patients, about 50% reported seeing these patients for <30 min per session twice a day. Less time (<15 min) was spent with intubated patients who were sedated or uncooperative compared to those spent with intubated, mechanically ventilated patients who are cooperative and can be ambulated. These findings must be interpreted cautiously because mobilization in this context includes both in-bed and out-of-bed mobilizations. That could also explain why lesser time is spent on those who cannot ambulate when compared to the time spent on those who can. Future studies reporting early mobilization practices in the ICU should separate the two types of mobilization (in-bed vs. out-of-bed) to understand the concept of early mobilization better.

CONCLUSION

We observed strong enthusiasm for early mobilization among Malaysian physiotherapists. Most respondents believed that early mobilization is important and beneficial to ICU patients. However, there is still a huge gap in knowledge and training of early mobilization in ICU patients among Malaysian physiotherapists. Future studies aimed at intervention to reduce the modifiable barriers (e.g., lack of knowledge and inadequate training, lack of communication among the staff) to early mobilization are recommended.

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CONFLICT OF INTEREST

The authors declare there are no conflict of interests.

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Reliability, validity and responsiveness of the Kurdish version of the questionnaire Disability of the Arm, Shoulder and Hand in patients with carpal tunnel syndrome

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ABSTRACT

Introduction: The Disabilities of Arm, Shoulder and Hand (DASH) questionnaire predicts the amount of the patient's inabilities and symptoms to evaluate the impacts of upper limb conditions in the patient's daily-life activities. This study aims to test the psychometric properties of DASH in Kurdish patients with carpal tunnel syndrome.

Materials and Methods: 93 patients with diagnosed carpal tunnel syndrome subjected to complete the self-report DASH-KU and patient rated wrist\hand evaluation PRWHE-KU questionnaire during two consecutive assessments with a 24-hour interval before any intervention.

Results: DASH-KU questionnaire had excellent internal consistency (Cronbach's alpha = 0.99) and test-retest reliability (intra-class correlation coefficient =0.99). A strong correlation between the DASH-KU score and the PRWHE tool (r=0.792) demonstrated acceptable construct validity of DASH-KU. Bland–Altman plot showed good agreement between the two assessments of DASH-KU, and no floor (3%) nor ceiling effects (0%) were observed. Factor analysis showed that the DASH-KU scale had a high acceptable adequacy (adequacy index = 0.700) and a significant sphericity (p<0.001). The analysis showed a major factor that accounted for 40% of the observed variance with an eigenvalue of 13.14. In addition, five items model also explained 81.23% of the DASH-KU scale variance. However, the responsiveness of DASH-KU was suboptimum, which can be linked to the short 24-hour interval between measurements.

Conclusion: The DASH-KU scale is a reliable, valid, and responsive instrument for assessing disabilities in patients with carpal tunnel syndrome.

KEYWORDS:
DASH questionnaire, carpal tunnel syndrome, psychometric evaluation, outcome measure

INTRODUCTION

Carpal tunnel syndrome (CTS), the most common entrapment neuropathy, is caused by median nerve compression at the wrists.[1] Patient-oriented outcome measures provide a better understanding of the patient's overall functional outcomes following musculoskeletal conditions. Therefore, various subjective, patient-rated assessment tools were developed in the evaluation of the upper extremity, including the patient-rated wrist/hand evaluation (PRWHE) and the disabilities of arm, shoulder, and hand (DASH) questionnaires.[2-4] The DASH questionnaire was originally developed by the American Academy of Orthopedic Surgeons (AAOS) in collaboration with the Institute for Work and Health (IWH). This 30-item scale addresses the patient's disabilities and symptoms in the preceding week to evaluate the extent and impact of injuries on the patient's daily-life activities. DASH has previously shown great clinometric quality and correlation with the international classification of functioning, disability, and health (ICF) assessment.[5,6] The cross-cultural adaptation of DASH has made it available in many regions.[7-9] In this regard, Kc et al. demonstrated that considerable changes during the cross-cultural adaptation of the Nepali version of DASH led to an excellent intraclass correlation (ICC) and test-re-test reliability.[10] Lee et al.,[11] introduced the Korean version of DASH and reported an ICC of 0.91 and a high internal consistency.

In addition, the reliability and validity of this scoring tool were also approved in the Greek cross-cultural adaptation.[12] In continuation with the previous studies, we aimed to test for validity, reliability, and responsiveness of adapted Kurdish DASH[13] questionnaire in patients with carpal tunnel syndrome.

MATERIALS AND METHODS

Participants

Patients with diagnosed carpal tunnel syndrome were recruited in this cross-sectional study. 93 subjects were consecutively and available recruited from the Shahid Saifaddin consultation clinic in Sulaymaniyah, Iraq, between

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Aprils to October 2022. Inclusion criteria were adult patients (age>18 years old) with diagnosed carpal tunnel syndrome having at least primary school education. Patients with any cognitive, linguistic, or vision impairment were excluded from our study.

Outcome Measures
Participants completed the self-report DASH-KU questionnaire two consecutive times within 24 hours.

Statistics
A sample size of 60 patients was calculated to be enough for this study according to the test-retest reliability of 0.90, reported in a previous study,10 and considering a 20% dropout rate (alpha of 5% and beta of 10%).

Reliability
The reliability of the DASH-KU questionnaire was evaluated by assessing Cronbach's alpha, ICC, and kappa statistics. Cronbach's alpha determines the internal consistency of the questionnaire, and scores of 0.70-0.79, 0.80-0.89, and >90 were defined as acceptable, good, and excellent, respectively. ICC was used to evaluate test-retest reliability between the first and second assessments of DASH-KU. An ICC of more than 0.75 was considered excellent. Kappa coefficients were also assessed to indicate the extent of agreement between participants' answers in two instances. Kappa coefficients of more than 0.90 were considered excellent.

Validity
The DASH-KU questionnaire's validity was measured by assessing the Pearson correlation coefficient of the DASH-KU and PRWHE scores. Criterion validity was evaluated by calculating the concordance correlation coefficient (CCC). In addition, ceiling and floor effects were reported. Ceiling and floor effects were considered as scores higher than the 90th percentile and lower than the 10th percentile of the total possible score, respectively. Moreover, we performed a factor analysis and rested the Kaiser-Meyer-Olkin sample adequacy index. A value greater than 0.60 was considered acceptable.[14] Sphericity was assessed by Bartlett's test. Finally, we conducted a principal component analysis and designed a Cattell's scree plot.

Responsiveness
Effect size, standardised response means (SRM), standard error in measurement (SEM), minimal detectable change (MDC) with a confidence interval of 95% (MDC95) and 90% (MDC90) were measured to assess responsiveness. The effect size and SRM were used to determine the ability of DASH-KU to detect improvement rates following the treatments. SEM, MDC95, and MDC90 were calculated to assess the ability of DASH-KU to distinguish true changes in the clinical status of a patient from an error in measurements during the follow-up period. All analysis were performed in MedCalc statistical software version 20.2.

Ethics Approval and Informed Consent
The ethics committee of Sulaymaniyah University has approved this study (Ethical code: 7/29-4758 on April 18th, 2022). Informed written consent was obtained from all participants.

RESULTS

Descriptive Statistics
Ninety-three patients were included in our study. The mean age of the participants was 51.23±9.15 years old. The majority of the included patients were females (77.4%), urban residents (66.7%), non-smokers (83.9%), and without an academic-level education degree (80.6%). The mean duration of symptoms was 15.69±7.10 weeks. The right upper limb was more prevalently involved (57% compared to 43%) (Table I). The mean total score of DASH was 31.40±12.31 in the first and 31.40 ± 12.30 in the second assessment. The mean difference in the time required to complete the form was 0.38±0.84 (Table II).

Psychometric Properties of the DASH-KU Questionnaire
Reliability
The analysis showed excellent internal consistency among the first and second assessments of the DASH-KU questionnaire. The Cronbach's alpha of the questionnaire was calculated as 0.9995. ICC of DASH-KU was 0.9995 (95% CI: 0.9994 to 0.9996), representing excellent test-retest reliability. In addition, kappa statistics of the score was 0.993 (95% CI: 0.987 to 0.999), demonstrating the questionnaire's excellent reliability.

Validity
Construct validity of the DASH-KU questionnaire was assessed by evaluating the correlation of DASH-KU with the PRWHE questionnaire. Results showed a strong correlation between the DASH-KU score and PRWHE (r=0.7921; p<0.0001). In addition, the CCC of DASH-KU (0.9990, 95% CI: 0.9987 to 0.9992) demonstrated strong correlation and validity. Bland–Altman plot showed good agreement between the two assessments of DASH-KU (Figure 1). No floor (3%) nor ceiling effects (0%) were observed (Table III).

Factor analysis showed that the DASH-KU scale had a high acceptable adequacy (adequacy index = 0.700) and a significant Sphericity (p<0.001) (Table IV and Figure 2). The analysis showed a major factor that accounted for 40% of the observed variance with an eigenvalue of 13.14. In addition, five items also explained 81.23% of the DASH-KU scale variance (Table IV).

Responsiveness
The effect size and SRM of DASH-KU were -0.00005 (95% CI: -0.012 to 0.003) and 0.001 (95% CI: -0.122 to -0.220), respectively. Since the follow-up period was 24 hours, a large effect size and SRM were not expected. The ability to detect changes was assessed by estimating SEM, MDC90, and MDC95. The DASH-KU scale's SEM, MDC90, and MDC95 were 0.275, 0.640, and 1.255, respectively (Table III).

DISCUSSION

This psychometric testing of DASH in the Kurdish language showed that DASH-KU has excellent reliability, validity, and acceptable responsiveness in identifying upper limb disorders. Our results demonstrated similar properties for DASH-KU to the English original version.[4]

Table I: Demographic and clinical characteristics of the included subjects

Variables	Value (n=93)
Age (year)	
Mean±SD	51.23±9.157
Gender (%)	
Male	21 (22.6)
Female	72 (77.4)
Educational status (n, %)	
Non-academic	75 (80.6)
Academic	18 (19.4)
Occupation (n, %)	
Employed	52 (55.9)
Un-employed	41 (44.1)
Residency status (n, %)	
Urban	62 (66.7)
Rural	31 (33.3)
Smoking status (n, %)	
Smoker	15 (16.1)
Non-smoker	78 (83.9)
Involved Region side (n, %)	
Right	53 (57.0)
Left	40 (43.0)
Duration of presence of symptoms (mean±SD; weeks)	15.69±7.10

SD: Standard deviation

Table II: Total score of DASH scale in the first and second assessment

	First assessment	Second assessment	Mean difference
DASH			
Total score	31.40±12.31	31.40±12.30	-0.001±0.55
Time needed to complete (min)	7.35±0.87	6.97±1.03	0.38±0.84
PRWHE			
Total score	43.16±15.09	43.12±15.07	0.04±0.24
Time needed to complete (min)	3.62±0.81	3.37±0.68	0.25±0.68

DASH: Disabilities of the Arm, Shoulder, and Hand
PRWE: Patient-Rated Wrist Evaluation

Table III: Psychometric properties of the Kurdish version of DASH

Properties	Value (95% CI)
Reliability	
Cronbach alpha	0.9995
ICC	0.9995 (0.9994 to 0.9996)
Kappa	0.993 (0.987 to 0.999)
Validity	
Pearson Rho	0.7921
Ceiling effect	0%
Floor effect	3.0%
CCC	0.9990 (0.9987 to 0.9992)
Responsiveness	
Effect size	-0.00005 (-0.012 to 0.003)
SRM	0.001 (-0.122 to -0.220)
Ability to detect changes	
SEM	0.275
MDC 90	0.640
MDC95	1.255

CCC: Concordance correlation coefficient
MDC: Minimal detectable change
SEM: Standard error in measurement
SRM: Standardized response means

The reliability of DASH-KU in the present study was excellent. Both internal consistency and test-retest reliability of the DASH-KU was higher than 0.99. In line with the present study, Lee et al., (2004) by examining 161 patients, showed that the ICC of the Korean version of DASH was 0.91 and its Cronbach's alpha was 0.94.15 Also, Themistocleous et al. (2006)12 reported a Cronbach's alpha equal to 0.96 for the Greek version of DASH.[12] Kc and colleagues demonstrated that the reliability of the Nepali translation of DASH was at an excellent level (ICC=0.97 and alpha=0.92).

Table IV: Results of factor analysis

Component	Eigenvalues	% Variance	Cumulative %
1	13.143	43.81	43.81
2	4.155	13.85	57.66
3	3.241	10.802	68.462
4	2.198	7.326	75.788
5	1.632	5.441	81.229
6	1.145	3.818	85.046
7	0.893	2.975	88.022
8	0.712	2.374	90.395
9	0.558	1.86	92.256
10	0.487	1.624	93.88
11	0.437	1.46	95.339
12	0.26	0.866	96.205
13	0.223	0.744	96.95
14	0.197	0.657	97.607
15	0.141	0.475	98.082
16	0.121	0.402	98.484
17	0.108	0.359	98.843
18	0.089	0.296	99.139
19	0.064	0.214	99.352
20	0.057	0.19	99.542
21	0.036	0.121	99.663
22	0.028	0.092	99.756
23	0.025	0.082	99.838
24	0.014	0.047	99.886
25	0.012	0.041	99.927
26	0.008	0.03	99.957
27	0.007	0.022	99.979
28	0.003	0.009	99.988
29	0.002	0.007	99.995
30	0.001	0.005	100

Kaiser-Meyer-Olkin index = 0.700
Bartlett's Test of Sphericity = 9302.143; p <0.0001

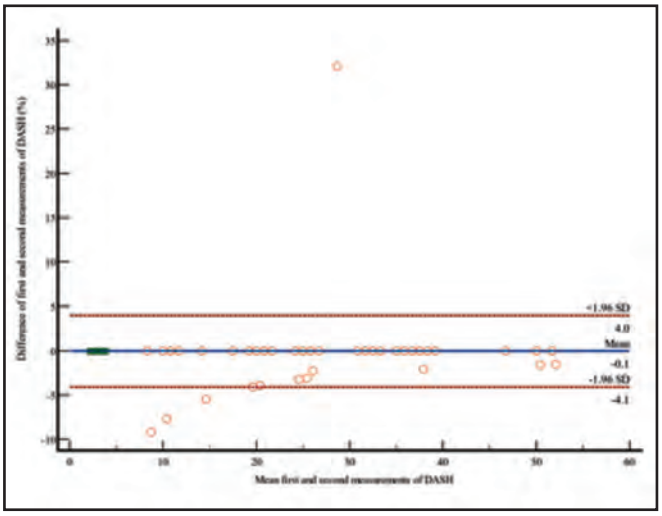

Fig. 1: Agreement between first and second measurements of DASH

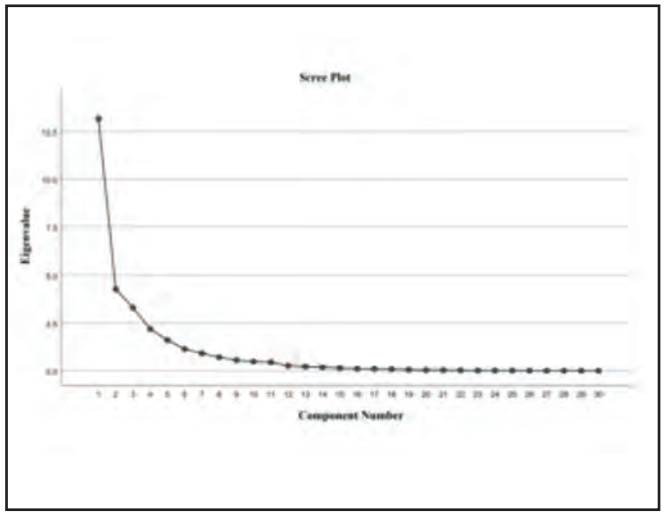

Fig. 2: The screen plot of DASH score

The construct validity of DASH-KU was compared with PRWHE. A strong correlation between DASH-KU and PRWHE was observed in the present study (r=0.79). Other studies have reported the construct validities of the translated versions of DASH ranging from 0.52 to 0.91.[10-12,15-18] Lee et al. (2008) showed a moderate to high relationship between Korean DASH and other tools.[11] Also, Themistocleous et al. (2006)[12] stated that there is a moderate relationship between the Greek DASH and the SF-36 questionnaire. In addition, Fayad et al. (2008)[19] have reported that the correlation coefficient of the French version of DASH with other tools such as visual analogue score, ADL score, strength score, and range of motion score varied between 0.52 and 0.78. The ability of a questionnaire to detect clinically important changes among the studied patients is evaluated by its responsiveness. Two main values of effect size and SRM are reported as the main

parameters for assessing responsiveness. Our results showed a small effect size and SRM since patients were followed for only 24 hours, which is a short time interval to observe any recoveries in patients. Thus, a large effect size was not to be expected in this study for the responsivity of the questionnaire. However, many studies have shown that the translated versions of DASH accurately detect clinically important changes.[15-25] For example, Lee et al. reported acceptable responsiveness for Nepali DASH,[15] and Farzad et al. (2022)[26] concluded that the tool is highly responsive in hand conditions (effect size=1.65). Therefore, the 24-hour time interval in our study to re-test each participant limited the evaluation of responsiveness.

Identification of the condition and outcome of the treatment has yet to be investigated in cross-cultural adoption studies. Although, responsiveness is examined in some studies, statistical indicators such as sensitivity, specificity, and the area under the curve provide more informative data. It is worth mentioning that psychometric properties are not representative of the diagnostic performance of the utilised tool, and tools with acceptable psychometric properties do not necessarily have high sensitivity and specificity. For example, Moraes et al. (2022)[27] reported that the DASH score has 80% sensitivity and 60.3% specificity in identifying cases. Therefore, assessing the diagnostic accuracy of tools in cross-cultural adaptations is suggested.

CONCLUSION

Our results demonstrate that DASH-KU has excellent reliability, validity, and acceptable responsiveness regarding measuring outcomes in patients with carpal tunnel syndrome, and the psychometric properties of DASH-KU were similar to its original version.

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We want to gratitude Jocelyn Dollack, DASH coordinator for all the support in making the Kurdish version of DASH available.[13]

CONFLICT OF INTEREST

No conflicts of interest.

FUNDING

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Stunting and food insecurity among children from low socioeconomic family during COVID-19 pandemic in urban area in Selangor

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ABSTRACT

Introduction: Food insecurity is often link with nutritional status. An increased rate of food insecurity can have a severe impact on children's growth. During the COVID-19 outbreak, little is known regarding its effect on food security and nutritional status, especially concerning vulnerable groups such as children. The purpose of this study was to assess household food security status, children's nutritional status along with their association, and the determinants of food insecurity during the COVID-19 pandemic.

Materials and Methods: This cross-sectional study was conducted from May to July 2022 in urban areas in Selangor among children aged less than two years old from B40 households using purposive sampling through both online surveys and face-to-face interviews. There were 112 children aged < 2 years old from B40 households participating in this study. The data obtained on maternal sociodemographic, Household Food Insecurity Scale (HFIAS), and children's anthropometric measurements were analysed by using the WHO Anthro Survey, descriptive analysis, Person's Chi-square test and Fischer's exact test.

Results: The prevalence of food insecurity was more significant than the prevalence of food secured, at 55.4% and 44.6% respectively. The stunting among the children rated at 34.8%, followed by 7.2% of the sample found underweight, 7.8% (BAZ) and 16.1% (BAZ) of them were wasted, and overweight & obese, proportionately. This study discovered that household size was the sole determinant of household food security status. This finding suggested that size of a household influenced the odds of a household being food insecure.

Conclusion: The findings of this study provide insights into how the COVID-19 pandemic have an impact on children's nutritional status especially those from low-income and bigger size households. Therefore, more thorough and effective interventions should be designed particularly targeting this urban poor community to enhance their nutritional status and health.

KEYWORDS:
Food security, stunting, underweight, children's nutritional status, pandemic COVID-19

INTRODUCTION

Food insecurity is defined as limited access to nutritionally adequate and safe foods. Food insecurity can affect a person's food intake, preventing them from consuming enough nutritious food to stay healthy. Food insecurity has been related to poverty and poor health outcomes for many years. As reported by the Malaysian Department of Statistics Malaysia, up to 40% of M40 households have fallen into the B40 category due to the impact of the COVID-19 pandemic. B40 household is defined as bottom 40% of Malaysians with household incomes of less than Ringgit Malaysia (RM) 4,850 and M40 household is defined as 40% of Malaysians in the middle-income group with household income between RM4,851 and RM10,970. As known, the COVID-19 pandemic negatively affects various sectors, including food security. It is believed that the COVID-19 pandemic will exacerbate this condition. Hence, it adversely impacts people's lives, especially the vulnerable population, including children. Exacerbation of the prevalence of household food insecurity (HFI) would negatively affect children's nutritional status particularly their growth status. According to a study conducted in Uttar Pradesh, HFI rose rapidly from 21.0% in December 2019 to 80.0% in August 2020, with 62.0% of families moving from food secure to food insecure during this difficult period.[1] Meanwhile in Malaysia, it is reported that during the COVID-19 pandemic, majority (93%) of the households are food-secured. Infant and childhood nutrition are critical for healthy growth and development. A child's nutritional status might impact their body response to illness,[3] including malnutrition. Malnutrition can lead to undernutrition, overweight and obesity, together with noncommunicable diseases.

According to a meta-analysis study conducted in 2021, it has been found that household food insecurity due to the pandemic COVID-19 will increase the prevalence of undernutrition in 118 low- and middle-income countries (LMICs). Due to the impact of COVID-19, it is estimated that there will be 9.3 million additions of wasted children and 2.6 million stunted children by 2022 in the 118 LMICs. It is also predicted that the prevalence of wasted and stunted children will increase approaching the year 2022.[4] Moreover, a study has shown that children in the United States, who faced food insecurity during the COVID-19 crisis, may have extreme effects on their health.[5] In addition, according to a cross-

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sectional study conducted among primary school children from low-income households in Kuala Lumpur concluded that being underweight, stunting and wasting are prevalent among low-income children owing to HFI.[6]

Since household food security status has such a significant impact on the nutritional status of children, and COVID-19 pandemic is likely to worsen the condition, more research needs to be done on this topic as the public and healthcare decision-makers would be more alert to the seriousness of this issue. Hence, this study aimed to assess food insecurity and growth status, and the determinants of food insecurity during the COVID-19 pandemic among children <2 years old from B40 households in urban areas in Selangor.

MATERIALS AND METHODS

Design and Study Sample

This cross-sectional study was conducted in low-income residential area throughout urban areas in Selangor from May to July 2022. Purposive sampling was utilised in this study. The target population in this study was mother-child (<2 years, specifically 6 to 23 months) pairs from B40 households (monthly income of less than RM4850) as respondents. The sample size was calculated by using the formula of $n=Z2pq/e^2$,[7] with the addition of a 10% non-response rate,8 the confidence level of 95%, 50% estimated sample population due to unknown prevalence in the study area, and a margin of error with a value of 0.05. The total sample size calculated is 427 participants, but only 112 participants managed to be recruited in this study due to time constraints and social distancing procedures. Healthy children aged two years and below who are from B40 households residing in urban areas in Selangor were eligible to participate in this study.

Research Instruments

A bilingual (Bahasa Malaysia and English) structured questionnaire which consisted of maternal socio-demographic, household food security status, and anthropometric measurements of the children was used to obtain the data through face-to-face interviews. The face-to-face survey took place in low-income residentials throughout urban areas in Selangor. The anthropometric measurement was measured physically. The children were weighed by using a digital infant weighing scale and platform measuring scale (if the child was able to stand erect). The stationary headboard and stadiometer were used to take the recumbent length.

The Household Food Insecurity Scale (HFIAS) is a brief survey tool that assesses the household food insecurity level for the past thirty days. It is a simple and reliable instrument developed by the USAID-funded Food and Nutrition Technical Assistance II Project (FANTA) in partnership with Tufts, Cornell Universities, and other collaborators. This tool is a validated method that has been widely utilized in research from low- and middle-income countries to assess the household food insecurity level of a household.[1,9,10]

Statistical Analysis

The characteristics of maternal socio-demographic includes age, race, employment status, education, household size, and the number of household recipient. There are four categories of Household food insecurity which are; 1) Food Secure, 2) Mildly Food Insecure Access, 3) Moderately Food Insecure Access, and 4) Severely Food Insecure Access. The data on the nutritional status of the children were categorized based on the length-for-age (HAZ), weight-for-age (WAZ), weight-for-length (WHZ), and BMI-for-age (BAZ) Z-score, including stunted, severely stunted, underweight, severely underweight, wasted, severely wasted, possible risk of overweight, overweight, obese, and normal. The anthropometric measurement was processed through the WHO Anthro Survey to calculate the Z-score. Z-scores obtained were then analysed together with the maternal socio-demographic and household food security status by using Statistical Package for Social Scientists (SPSS) Version 26 for statistical analysis. Descriptive statistics were utilized to calculate and characterized the data in frequency and percentage. Pearson's Chi-square test and Fischer's exact test were used in determining the association between food insecurity and sociodemographic characteristics, along with the association between food insecurity with children's nutritional status Pearson's Chi-square test and Fischer's exact test were used to analyse the determinants of food insecurity instead of the logistic regression, due to the small sample size. This was to ensure the accuracy of the results.

RESULTS

A total of one hundred and twelve mothers with children below two years old from B40 households living in urban areas in Selangor were recruited in this study.

Table I shows the respondents' socio-demographic profiles. Majority of the mothers were aged between 29 to 39 years old (58.9%, n=66), with the remainder of 30.4% (n=34) and 10.7% (n=12) being within the age group of 18 to 28 and 40 to 49 years old, respectively. Most of the respondents are Malay (94.6%, n=106), with the remaining being non-Malay (3.6%, n=4 Indian and 1.8%, n=1.8 Chinese). Majorly, 99.1% (n=111) of the respondents are married. Almost half of the participants are employed (45.5%, n=51), with the remaining 39.3% (n=44) and 15.2% (n=17) being unemployed and self-employed, respectively. In addition, the majority of the respondents are the holder of a certificate or diploma (48.2%, n=54), followed by the holder of a bachelor's degree (32.1%, n=36, respectively. Overall, 84.8% (n=95) of the respondents have a household of fewer than six people and 15.2% (n=17) have a household with six and more people. Whilst half (50%, n=56) of the participants have no more than one person of the household income recipient, and the other half (50%, n=56) of the participants have more than one person of the household income recipient

As shown in Table II, the prevalence of food insecurity was 55.4% (n=62). According to the length-for-age (HAZ) WHO Growth Chart, stunting is characterized by a Z-score of -2 to a Z-score of -3, and the Z-score of below -3. Based on Table III, the normal growth status category dominated the current study, which was high at 65.2% (n=73), followed by the stunting rate at 34.8% (n=39) which is more than a quarter of the sample size. According to the weight-for-age (WAZ) WHO Growth Chart, underweight is defined as the Z-score of -2, a Z-score of -3, and the Z-score of below -3. Only 7.2%

Table I: Demographic data of lecturers (N=300)

Characteristics		Frequency (n=112)	Percentage (%)
Maternal age	18-28	34	30.4
	29-39	66	58.9
	40-49	12	10.7
Race	Malay	106	94.6
	Chinese	2	1.8
	Indian	4	3.6
Marital status	Married	111	99.1
	Single mother	1	0.9
Employment status	Employed	51	45.5
	Unemployed	44	39.3
	Self-employed	17	15.2
Education level	No formal Education	2	1.8
	Primary education	2	1.8
	Secondary education	18	16.1
	Certificate or diploma	54	48.2
	Bachelor's degree	36	32.1
Household size	Less than 6	95	84.8
	6 and above	17	15.2
Number of the household income recipient	Not more than 1 person	56	50
	More than 1 person	56	50

Table II: Prevalence of household food insecurity (N=112)

HFIAS Prevalence	Number of Households (n=112)	Percentage of Households (%)
Food secure	50	44.6
Mild food insecure	30	26.8
Moderate food insecure	19	17.0
Severe food insecure	13	11.6
Total	112	100

Table III: Nutritional status of children according to WHO Growth Chart (N=112)

Characteristics		Number of Children (n=112)	Percentage of Children (%)
Length-for-age (HAZ)	Normal	67	59.8
	Stunted	23	20.5
	Severely Stunted	16	14.3
	Normal	6	5.4
Weight-for-age (WAZ)	Normal	96	85.7
	Underweight	8	7.1
	Normal (Risk of growth problem)	8	7.1
Weight-for-length (WHZ)	Normal	78	69.6
	Wasted	3	2.7
	Severely wasted	2	1.8
	Possible risk of overweight	14	12.5
	Overweight	2	1.8
	Obese	13	11.6
BMI-for-age (BAZ)	Normal	67	59.8
	Wasted	6	5.4
	Severely wasted	2	1.8
	Possible risk of overweight	19	17.0
	Overweight	5	4.5
	Obese	13	11.6
	Total	112	100

Table IV: The relationship between household food security status and nutritional status for HAZ and WAZ growth charts (N=112)

Variable	Length-for-age, HAZ n (%)				Weight-for-age, WAZ n (%)			
	Normal	Stunted	X^2 statistic	*p*-value	Normal	Underweight	X^2 statistic	*p*-value
Household Food Security Status			2.051	0.152			6.403	0.021*
Food secure	29 (25.9)	21 (18.8)			43 (38.4)	7 (6.3)		
Food insecure	44 (39.3)	18 (29.0)			61 (54.5)	1 (0.9)		

*Analysed by Fischer's exact test and p<0.05, statistically significant is written in bold

Table V: The relationship between household food security status and nutritional status for WHZ and BAZ growth charts (N=112)

Variable	Weight-for-length, WHZ n (%)					BMI-for-age, BAZ n (%)				
	Normal	Wasted	Overweight & Obese	X^2 statistic	*p*-value	Normal	Wasted	Overweight & Obese	X^2 statistic	*p*-value
Household Food Security Status				7.219	0.020*				3.883	0.146*
Food secure	37 (33.0)	5 (4.5)	8 (7.1)			34 (30.4)	5 (4.5)	11 (9.8)		
Food insecure	55 (49.1)	0 (0.0)	7 (6.3)			52 (46.4)	3 (2.7)	7 (6.3)		

*Analysed by Fischer's exact test and p<0.05, statistically significant is written in bold

(n=8) of the children in this study was underweight, while majority of them have a normal growth status of 92.8% (n=104).

As shown in Table III, following the weight-for-length (WHZ) WHO Growth Chart, wasting is established as a Z-score of -2 to a Z-score of -3, and the Z-score of below -3, whilst overweight and obese are delineated by the Z-score of +2 to a Z-score of +3 and the Z-score above +3, respectively. The present study found that the prevalence of normal nutritional status among children below two years old is 82.1% (n=92), the majority of the sample. About 4.5% (n=5) is wasted, while 1.8% (n=2) and 11.6% (n=13) of the children are categorised as overweight and obese, proportionately.

In accordance with the BMI-for-age (BAZ) WHO Growth Chart, wasting is established as a Z-score of -2 to a Z-score of -3, and the Z-score of below -3, whilst overweight and obese are delineated by the Z-score of +2 to a Z-score of +3 and the Z-score above +3, proportionately. In this study, most of the children have a normal weight status with a prevalence of 76.8% (n=86), followed by wasting at 7.2% (n=8) and overweight and obese valued at 16.1% (n=18). According to Table IV and Table V, it is presented that there are no associations between household food security status with nutritional status in this study. Therefore, despite food security being an important factor in nutritional status, the current study finds that food security does not determine whether a child is stunted.

Findings from the present study indicates that household food security status was associated with being underweight. However, the current study found that food-secured children are more likely to experience underweight than children from food insecure households. In the current study, wasting, overweight, and obesity are not associated with household food security status. Therefore, although food insecurity is closely related to wasting, overweight and obesity, household food security status is not the decisive factor in determining wasting, overweight and obesity based on the current study's findings.

In this study, a few sociodemographic factors that have been analysed against household food security status, including, maternal age, race, marital status, employment status, education level, household size, and the number of household income recipients. However, as shown in Table IV, only household size was concluded as the significant determinant of food insecurity based on the current study's finding, with a p-value of 0.000.

DISCUSSION

Compared to another study conducted among Bangladeshi from lower-income households.[11] It may be deduced that the reduced prevalence of food insecurity shown in this study may be caused by economic factors. As of 2017, Malaysia had a Gross Domestic Product (GDP) per capita of USD29,100, whereas Bangladesh had a GDP per capita of USD4,200 and is also one of the poorest countries in the world.[12] The 6.9 times lower GDP, significantly reduce the economic decision factors such as food price which affects its population's food security status. Hence, this explains the lower prevalence of food insecurity among low-income households among Bangladeshi as compared to the Malaysian population despite both countries' challenges in facing the COVID-19 pandemic.

It is found that from this study, the prevalence of stunting is higher as compared to a previous study, conducted in Indonesia among children below the age of two years old.[13] It can be inferred, relative to the previous study that the higher prevalence of stunting may be due to it being conducted during the COVID-19 pandemic. On top of worsening the economic crisis, the COVID-19 pandemic exacerbates undernutrition in both low- and middle-income countries.[4] This explains the higher stunting rate in this study which is conducted in an upper middle-income country, Malaysia.

The current study findings exhibit a much lower wasting prevalence compared to the previous study conducted in Pakistan at the rate of 15.49%.[14] A possible explanation for this might be due to distinct economic factors. Although both current and previous study was conducted in a low-income household, Malaysia is an upper middle-income country which offers various food assistance program to low-income households from both government and non-governmental organizations (NGOs). Such as *Bantuan Kehidupan Sejahtera Selangor* (BINGKAS) Selangor 2022, *Skim Tabung Warisan Anak Selangor* (TAWAS) and SMART Selangor Food Stamp, PEMULIH, Food Basket Programme, Cheka Movement Malaysia, Happy Bank Crew, and many more. These numerous accessibilities of the food support program in Malaysia may assist poor Malaysian households in combating undernutrition. Therefore, explaining the lower rate of wasting in the current study.

However, the prevalence of obesity and overweight in this present study is 16.1% (n=18). Excessive BMI can occur due to the impacts of poverty, which influence their food choices. In a study that was conducted in an poor urban community in Kuala Lumpur, Malaysia, it was reported that BMI increased as household income decreased.[35] Furthermore, according to

previous study, children who come from low-income household has a higher risk of being overweight and obese due to income inequalities resulting in more unhealthy food choices.[15] It may be suggested that unhealthy foods are much cheaper than healthy foods. Therefore, some might consume unhealthy snacks high in fat and calories to increase fullness which can contribute to obesity. Hence, this explains the higher rate of overweight and obesity in the current study.

There is no association between food-secured household status and nutritional status, particularly stunting found in this study which correlated with previous studies conducted in developing countries, including Ethiopia, Ghana, and Nepal.[16-18] However, some studies are also conducted in developing countries such as Pakistan, Bangladesh, and Nepal, which concluded that food insecurity is associated with stunting.[19-21] The factors contributing to stunting include lack of dietary diversity, inadequate breastfeeding practices, and poor child feeding and care which are closely related to food insecurity.[22] On top of household food insecurity was influenced by sociodemographics including employment status and household income, it was also associated with being underweight and this finding is consistent with the result of previous studies.[17,19,23,24] However, the current study found that food-secured children are more likely to experience underweight than children from food insecure households. A possible explanation for this might be that those children may or may not be due to being picky eaters which, resulted to inadequate food intake even total household income is sufficient. However, this is beyond the scope of this paper and will be discussed elsewhere.

It is found that in this study, wasting, overweight, and obesity, are not associated with household food security status. The absence of a correlation between wasting and food security corresponds with a previous study in Nepal.[25-26] In contrast, previous studies indicated a relationship between wasting, overweight, and obesity with food security status.[27-30] The rise in prevalence of overweight and obesity globally, is mostly due to environmental factors, lifestyle choices, and cultural context. Obesity also may occur in food insecure households as evidenced by both underweight and overweight coinciding within the same households.[31] Extensive evidence showed that larger portion sizes and excessive intake of sugar contribute significantly to the global rise in overweight and obesity rate.[32] Low-income households may choose unhealthy food choices in combating hunger, as unhealthy food choices can be cheap and affordable for low-income households. For instance, some may replace the portion of protein with carbohydrates on a meal plate as protein can be more costly than carbohydrates, which may promote the rate of obesity in children.

Sharing scarce meals among family members is a significant problem food-insecure households face. Household size plays a significant role in determining household food security. Bigger family households bear an additional load on food consumption and are more likely to face food insecurity, as compared to smaller households.[33] Large families frequently have limited access to food availability at home, which causes them to have inadequate food intake or limited mealtimes without considering the quality of their diet or dietary diversity.[34-35] Hence, it explains how household size remarkably affects food insecurity.

The strength of this study was the data collection was conducted within the transition from pandemic to endemic, and therefore could reflect how the COVID-19 pandemic may influence the nutritional status of food-insecure households. However, this study also has several limitations. First, this study used HFIAS, which fails to measure child hunger and this measurement could have a significant relationship between food insecurity, child hunger and nutritional status. The findings of our study are generalized to only some of the population of poor urban community in Malaysia as the sample was only recruited from a single geographical area. Moreover, this present study is cross-sectional and therefore, did not determine the causal inference.

CONCLUSION

This study found that the majority (55.4%) of low-income households are food insecure, with more than a quarter (34.8%) of the children being stunted, 7.8% of them being underweight, 4.5% (WHZ) characterized as wasted, and 16.1% are overweight & obese. However, this study only revealed a relationship between status of household food security and being underweight. In addition, household size was the sole determinant of household food security status, which suggested that food insecurity status of a household was influenced by the number of family members in a household. This study recommends further research with a larger sample to be conducted to allow the data to be more representative of the population and enhance the accuracy of data analysis. Moreover, the current study suggests more involvement by the policymakers through allocating budgets, restructuring policies and legislative guidelines in combating food insecurity.

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ETHICS APPROVAL AND INFPRMED CONSENT

The Universiti Teknologi MARA (UiTM) Research Ethics Committee (REC) has approved this study which involved human participants, with the reference number of FERC/FSK/MR/2022/0079. Each participant was asked to give his or her consent beforehand.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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AUTHORS CONTRIBUTION

Conceptualisation: SB, NM; data curation and formal analysis: NM; Methodology: SB, NM; writing original draft: NM, SB; writing review and editing: SB, NA, AV

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The strain among caregivers of children with disabilities at the community-based rehabilitation centres in Kudat division of Sabah, Malaysia

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ABSTRACT

Introduction: The prevalence of children with disabilities (CWD) is increasing. CWD requires exceptional long-term attention, which often falls on the caregivers. Caring for a CWD affects caregivers in multiple ways, such as physical, social, personal, and financial aspects. Most of the CWD will be cared in Community-Based Rehabilitation (CBR) centres where the caregivers have to play a crucial role as they become partners in the respective service delivery. However, there is still insufficient information on the impact (strain) of a disabled child on the caregivers in the CBR centre in the Kudat division of Sabah, Malaysia specifically. Hence, this study aims to explore the strains among caregivers of CWD at the CBR centre in the Kudat.

Materials and Methods: A cross-sectional study through a purposive sampling method was employed, involving 142 caregivers of CWD at the selected CBR centre. Four CBR centres were selected in this study, which were located in the Kudat division of Sabah. The Malay version of the Modified Caregiver Strain Index Questionnaire (M-CSI-M) was used in this study to obtain information about the caregiver's strain.

Results: Findings from this study revealed that most caregivers experienced moderate strain (72.5%). Some of the leading causes of their strain were upsetting CWD's behaviour (10.6%), financial strain (9.2%), and overwhelmed (9.2%). In addition, there were significant differences between caregiver strain and their level of education, income, and the types of their child's disabilities ($p \leq 0.05$).

Conclusion: The well-being of the caregivers may significantly impact the effectiveness of rehabilitation for CWD, as caregivers are vital interdisciplinary team members.

KEYWORDS:
Strain, caregiver, children with disabilities, community-based rehabilitation

INTRODUCTION

Currently, the exact number of children with disabilities (CWD) in Malaysia are unavailable.[1] However, in August 2015, the registered number of Malaysians with disabilities registered with the Department of Social Welfare Malaysia was 351,114 which is 1.13% of the total population in Malaysia based on voluntary registration.[2] Within these numbers, CWD are registered under seven categories of disabilities in Community- Based Rehabilitation (CBR) centres throughout Malaysia. These are disabilities involving hearing, visual, physical, learning, mental, speech and multiple disabilities.

Over time, the caregiver of a CWD may often be affected by physical and psychological health problems due to strain overload. As defined, a caregiver is a person who has full responsibility for the care of the recipient which requires significant physical or mental support to manage the daily routine for those children in the CBR Centre.[3] As a result, their day-to-day lives may face challenges, and they may need to make adjustments to be able to attend sessions at the local centre. In addition, the caregiver is responsible for fulfilling the physical and mental well-being of the individual under their care; at some point, they may need to coordinate formal and informal community support while keeping things in the family in check.[4]

The word strain is often used interchangeably by caregivers to constitute the dimension of their physical, mental, and financial well-being, which leads to compromising their role in family and society. In general, caregiver strain (also referred to as 'burden' in caregiving parlance) can be defined as the extent to which caregivers perceive that their emotional health, physical health, social life, and financial status have suffered as a result of providing care to the care recipient.[5] Studies have shown a marked increase among caregivers regarding stress and feelings of isolation, financial difficulties, relationship breakdown, and physical complaints.

These negative consequences are thought to be attributable to the physical (e.g., lifting the person with a disability), financial (dual income versus single, unbearable medical cost), and emotional challenges that disability caregiving can experience.[6]

Current evidence suggests that caregivers may be at increased risk of experiencing musculoskeletal symptoms and injury due to repetitive strains. In a study of rural, informal

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caregivers, described physical symptoms such as fatigue, backache, and headache attributable to their activities as caregiving.[7] CWD's medical and childcare costs are also higher than children without disabilities.[8] Additionally, studies have indicated significant elevations in marital distress and divorce rates among couples with CWD compared to couples with normal developing children.[9] Up to 84% of families raising CWD experienced stress due to the daily needs of their children, which may lead to parental caregiver burden.[10] All the challenges above refer to the objective and subjective strain experienced by caregivers related to the difficulty they encounter because of care recipient status.

Caregiving activity demands are often referred to as "caregiver burdens" in the literature.[11] Thus, it is essential to increase recognition of the potential for caregiver strain to identify and, if possible, avert it. In context of Sabah state in East Malaysia, it faces variable challenges as urbanization is scattered, and exploring these challenges will add a new perspective to an occupational therapist.

To date, the impact of a disabled child on the caregiver's sense of strain in the CBR centre in the Kudat division of Sabah, Malaysia remains a relatively unexplored. This may be due to the fact that the application of the medical model is still the predominant practice among professionals in Malaysia. Due to much focus only on the clients, the well-being of the caregivers is often side-lined. Presently, client-centred practice is advocated as an essential aspect of rehabilitation, and caregivers are a crucial part of the interdisciplinary team. Thus, the well-being of caregivers is important to explore to enhance their effective participation as a team player in rehabilitation for CWD. Therefore, this study aims to explore the strains among caregivers of CWD at the CBR centres in the Kudat division of Sabah.

MATERIALS AND METHODS

Design

This study is a cross-sectional design using a self-rated questionnaire to explore caregiver strains. A cross-sectional design is best suited to this study's aims.[12]

Samples

In all 142 caregivers participated in this study. Participants were sampled for selection using the purposive sampling method, which includes caregivers of CWD who participated in centre-based and centre-home-based programmes, caregivers who have children with any disability aged below 18 years old, and the caregivers living with the child. While the caregivers of CWD who have been identified to be enrolled in special education schools or mainstream schools were excluded. Exclusion was also extended caregivers who are participating in CBR's home-based programme only.

Informed consent was obtained from participant's who met the inclusion criteria during their sessions at the respective CBR centres. The CBR centres that were involved are PDK Kudat, PDK Matunggung, PDK Kota Marudu, and PDK Pitas.

Data Collection Procedure

This research was conducted after potential participants were approached either during their arrival at the CBR centre or during their child's end of the session that day. Participants were required to sign consent forms to acknowledge that they understood the procedures and agreed to participate in the study. The procedure of using the questionnaire was explained to each participant prior to the study. Once consent has been obtained, participants needed to fill in the necessary demographic data consisting of eight questions: caregivers' age, gender, number of children, level of education, working status, average income, children's age, and types of disabilities.

The Malay-Translated Version of the Modified Caregivers Strain Index Questionnaire (M-CSI-M) was used in this study with permission from the primary author. The M-CSI-M had been concluded to have the correct face and content material validity.[12] It also had accurate interior coherence reliability, as proven by using Cronbach's alpha (0.75). Therefore, with good internal consistency and reliability, M-CSI-M could be a better choice to assess the strain level experienced by informal care providers in the population of Malaysia. The tool has 13 questions that measure strain related to care provision. There is at least one item for each of the following major domains: financial, physical, psychological, social, and personal. Previous literature identified 13 potential stressors that became the basis for the questionnaire: sleep disturbance (Q1), inconvenience (Q2), physical strain (Q3), confinement (Q4), family adjustments (Q5), changes in personal plans (Q6), competing demands on time (Q7), emotional adjustments (Q8), upsetting behaviour (Q9), the parent or child seems to be a different person (Q10), work adjustments (Q11), financial strain (Q12), and feelings of being overwhelmed (Q13).

The response to 13 items of the M-CSI-M, where the statements receive a numeric score of "yes" on a regular basis, is 2; "yes" sometimes is 1; and "no" is 0. A total score where 0 indicates no caregiving strain, and 26 indicates the extreme tension of caregiving strain. However, the midpoint of the M-CSI-M was chosen as a cut point to define the levels of strain based on a previous study done where > 13 total score indicates a higher level of strain and < 13 indicates a moderate level of strain.[14]

Data Analysis

The Statistical Package for the Social Science (SPSS) version 21 was used to analyse the data collected from the self-report questionnaire by the parents. Using descriptive analysis, the sociodemographic data and M-SCI-M score were examined. The difference between caregiver strain and sociodemographic variable (level of education, income, and the types of their child's disabilities) was analysed using the ANOVA test.

RESULTS

The demographic information about the characteristics of the CWD caregiver is presented in Table I. There were more females (n = 87, 61.3%) than males (n = 55, 38.7%). Most participants were around 50–59 years old (n = 40, 28.2%),

followed by 40–49 years old (n = 39, 27.5%) and above 60 years old (n = 11, 7.7%). Most participants had lower secondary-level education (n = 67, 47.2%). This was followed by primary school level (n = 34, 23.9%), bachelor's or higher degree (n = 7, 4.9%), and higher secondary school education (n = 6, 4.2%). 28 (19.7%) of the participants had no formal education. With respect to their employment status, most participants were unemployed (n = 64, 45.1%), followed by self-employed (n = 62, 43.7%). There were only 16 (11.3%) participants who were public servants. However, none employed participants were from the corporate or private sector.

For average income, most of the participants earned less than RM1000 per month (n = 56, 39.4%). There were 51 (35.9%) participants with no income. Only 5 (3.5%) of them earned RM3001 or more. The number of children among the participants was explored in this study. There are 21 (14.8%) participants who have 2 or fewer children, 70 (49.3%) participants have 3–4 children, and 51 (35.6%) participants have more than 4 children. The demographics of the participant's special needs children were also analyzed. The children's age range between 7 and 12 years old was found to be the highest (n = 60, 42.3%), followed by the age range from 13 to 18 years old (n = 48, 33.8%). The lowest range was from 1-6 years old (n = 34, 23.9%). The findings show that learning disabilities constitute the highest types of disabilities (n = 106, 74.6%), followed by physical disabilities (n = 17, 12.0%). There are 9 (6.3%) children with multiple disabilities, 5 (3.5%) children with speaking disabilities, 3 (2.1%) children with hearing disabilities, and 2 (1.4%) children with mental disabilities.

Table II shows the descriptive analysis of the results of the study measures. This study found that the majority of the participants showed moderate strain (n = 103, 72.5%), and 16 (11.3%) participants were experiencing high strain, while 23 (16.2%) of them had no strain

The descriptive analysis of statements in M-CSI-M is shown in Table III. Among the negative statements that have most affected the caregiver level of strain, which was denoted with the "yes, on a regular basis" column, were Q9 related to upsetting behaviour (n = 15, 10.6%). 13 (9.2%) agreed with Q12 statement that caring for CWD will cause them financial strain. Besides, 13 (9.2%) participants agreed they felt completely overwhelmed (Q13). However, the negative statements of M-CSI-M, which were frequently denoted by "no", were questions related to physical strain (Q3), with agreement of 106 (74.6%) of them. 103 (72.5%) participants disagreed that they were going through family adjustment (Q5). 103 (72.5%) of the participants did not agree with the statement that the child seemed to be a different person (Q10). On Q11, 102 (71.8%) of the participants did not agree with the statement that they have to go through work adjustments.

In order to understand the results of the M-SCI-M scores, it was imperative to identify factors that could have contributed to the levels of strain. Therefore, an independent t-test and one-way between-groups analysis of variance is also being conducted to the significant differences between the mean score of M-CSI-M and demographic variables. The result shows a significant difference between caregiver strain and their level of education ($p < 0.05$, $F = 5.753$, $p = 0.000$), income ($p < 0.05$, $F = 3.726$, $p = 0.013$), and the types of their child's disabilities ($p < 0.05$, $F = 6.277$, $p = 0.000$), as shown in Table IV. However, the data shows there is no significant difference in the level of strain of caregivers with categorical caregiver age, gender, number of children, working status, and their children's categorical age since the p-value more than 0.05, which emphasized that they are not an influencing factor that may raise the level of strain.

DISCUSSION

As far as we know, this is the first study to investigate the impact of a disabled child on the sense of strain of caregivers in the CBR centres in the Kudat division of Sabah. The research investigated caregiver strain among 142 participants who care for children with disabilities (CWD) from 1 to 18 years old, with learning disabilities constituting the highest frequency, followed by physical disabilities. CIC supported the high prevalence of learning disabilities in CBR, indicating that learning disabilities are a category with the highest number of registered people with disabilities, followed by physical disabilities.[2,15] The Social Welfare Department of Malaysia defines learning disabilities as intellectual capabilities that do not conform with biological age, such as late global development, Down syndrome, intellectual disabilities, autistic spectrum disorder, attention deficit hyperactivity disorder (ADHD), and specific learning difficulties (dyslexia, dyscalculia, and dysgraphia) hence contributing to the high number of registrations.[1]

This study reflects similarities to a few articles that found women were more involved in childcare than men.[16,17] Some studies have supported that female figures predominated in the caregiver's role among CWD as culturally childrearing is viewed as a female-defined role.[18,19]

Zarit Burden Interview (ZBI) detected most caregivers in this study were experiencing moderate levels of strain, which concurs with findings from Barros and fellow researchers.[20] The vast majority of participants were above 40 years old. The age similarities of these primary caregivers in both studies could influence this agreement. This age range is known as middle adulthood. The awareness of ageing-related physical changes, chronic illnesses, and health issues that come with middle adulthood could make caregiving more difficult. This stage of life also brings time restrictions and health concerns, particularly when caring for CWD.[21,22] However, the results of this study contradict a study's finding that most of their caregivers had no strain.[23] The later study reveals that most CWD in this respective study was within the mild and moderate severity levels, indicating the child is considered independent with or without assistance. Since an essential aspect of the caregiver's strain is the demands of caring, the decrease in child severity level will reduce the caregiving demand in daily routine management. Thus, indirectly lowers strain among these caregivers.[24] On saying this, our study could not argue further on the severity aspects

Table I: Descriptive analysis of the characteristics of the CWD caregiver

Variables	N	%
Carer's age		
20-34 years old	20	14.4
35-39 years old	32	22.5
40-49 years old	39	27.5
50-59 years old	40	28.2
Above 60 years old	11	7.7
Carer's gender		
Male	55	38.7
Female	87	61.3
Number of children		
Less than 2 children	21	14.8
2-4 children	70	49.3
More than 4 children	51	35.6
Education level		
Not schooling	28	19.7
Ujian Pencapaian Sekolah Rendah (UPSR)	34	23.9
Sijil Rendah Pelajaran (SRP)/ Penilaian Menengah Rendah (PMR)	20	14.1
Sijil Pelajaran Malaysia (SPM)	47	33.1
Sijil Tinggi Pelajaran Malaysia (STPM)/ Matrikulasi/ Diploma	6	4.2
Bachelor's degree or higher	7	4.9
Working status		
Unemployed	64	45.1
Self-employed	62	43.7
Public servant	16	11.3
Corporate/ private sector	0	0
Average income		
No income	51	35.9
Under RM1,000	56	39.4
RM1,001 - RM3,000	30	21.1
Exceeds RM3,001	5	3.5
Child age		
1-6 years old	34	23.9
7-12 years old	60	42.3
13-18 years old	48	33.8
Disabilities categories		
Hearing disabilities	3	2.1
Speaking disabilities	5	3.5
Physical disabilities	17	12.0
Learning disabilities	106	74.6
Mental disabilities	2	1.4
Multiple disabilities	9	6.3

Table II: Descriptive analysis of the study measure scores of CWD caregiver

Variables	Mean	Std. Deviation
Total score of M-CSI-M	5.41	5.290
Level of strain/ cut score	**n**	**%**
No strain (0)	23	16.2
Modetate strain (<13)	103	72.5
High strain (>13)	16	11.3

of CWD as the data available for us was not able to specify this feature.

Thirteen potential stressors became the basis for the questionnaire based on their major domains.[13] The negative statements that most affected the caregiver's high strain level were related to upsetting behaviour. Upset feelings are one of the highest sources of caregiver strain. Such findings could be due to the coping strategies of caregivers related to the numerous difficulties associated with their disabled child.[25] This includes significant challenges in communication and learning, the need to be vigilant about and manage behaviour continually, the extra caregiving needs due to the lack of self-care skills of the children and ongoing dependency needs, the ongoing need to advocate on behalf of the child, particularly with schools and mental health and social agencies, ongoing concerns about their children's uneven developmental progress, worry about their children's future for independent living, and stigmatization from society. The right coping strategies might buffer the impact of caregiver strain.[26]

Table III: Descriptive analysis of distribution of responses from caregiver to statements in M-CSI-M test

Questions	Yes, On a Regular Basis n (%)	Yes, Sometime n (%)	No n(%)	%
My sleep is disturbed (For example: the person I care for is in and out of bed or wanders around at night)	11 (7.7)	48 (33.8)	83 (58.5)	58.5
Caregiving is inconvenient (For example: helping takes so much time or it's a long drive over to help)	11 (7.7)	41 (28.9)	90 (63.4)	63.4
Caregiving is a physical strain (For example: lifting in or out of a chair; effort or concentration is required)	9 (6.3)	27 (19.0)	106 (74.6)	74.6
Caregiving is confining (For example: helping restricts free time or I cannot go visiting)	8 (5.6)	42 (29.6)	92 (64.8)	64.8
There have been family adjustments (For example: helping has disrupted my routine; there is no privacy)	4 (2.8)	35 (24.6)	103 (72.5)	72.5
There have been changes in personal plans (For example: I had to turn down a job; I could not go on vacation)	11 (7.7)	32 (22.5)	99 (69.7)	69.7
There have been other demands on my time (For example: other family members need me)	8 (5.6)	42 (29.6)	92 (64.8)	64.8
There have been emotional adjustments (For example: severe arguments about caregiving))	4 (2.8)	48 (33.8)	90 (63.4)	63.4
Some behaviour is upsetting (For example: incontinence; the person cared for has trouble remembering things; or the person I care for accuses people of taking things))	15 (10.6)	36 (25.4)	91 (64.1)	64.1
It is upsetting to find the person I care for has changed so much from his/her former self (For example: he/she is a different person than he/she used to be)	7 (4.9)	32 (22.5)	103 (72.5)	72.5
There have been work adjustments (For example: I have to take time off for caregiving duties)	11 (7.7)	29 (20.4)	102 (71.8)	71.8
Caregiving is a financial strain	13 (9.2)	48 (33.8)	81 (57.0)	
I feel completely overwhelmed (For example: I worry about the person I care for; I have concerns about how I will manage)	13 (9.2)	58 (40.8)	71 (50.0)	

The second negative statement perceived by caregivers was that it would cause them financial strain, which reflects similarity to previous findings indicating that families caring for disabled children are likely to experience more financial burden than families who have non-disabled children.8 This hinders access to the CBR centre since children may impose direct costs on families for medical care, transportation, and parental labour market activity. The distance between their home and the CBR centre with no systematic transportation requires exceptional care from the parent. Parents might consider reducing working hours or leaving the job to meet the needs of their children. The burden on rural residents might rise due to poverty and less access to formal and informal support.[27] The lack of rehabilitation facilities in rural areas and a public transport system that does not cater to the needs of disabled people pose an additional burden for these caregivers as they have to travel frequently and spend more on transportation fares for routine therapy sessions. The interior areas of Sabah were known to be one of the areas with greater challenges accessing CBR services due to logistical and financial constraints.

Thirdly, participants agreed they felt completely overwhelmed. One explanation for this could be that they had too little time to complete daily tasks and were worried that they were not meeting the needs of their other family members. The caregivers may be ill-prepared for their role and provide care with little or no support, which could also lead to burnout. Overwhelming can be defined as burnout experienced by caregivers.[28] They stated that many caregivers needed more control over their daily activities to meet the recipient's demands. Furthermore, the findings of this study indicate a significant difference in the mean score of M-CSI-M about participants' educational levels. These results are consistent with findings, who found that their participants with a higher educational level were more likely to experience high strain.[29] Since educated caregivers have higher expectations for their families, they experience greater distress when their child's developmental concerns disrupt work, finances, and relationships. A common viewpoint will expect that a high salary often accompanies higher education, so spending more hours at work and fewer at home makes economic sense.[30] It is expensive to replace working time with childcare time, which may increase the strain on their caregiving role.

This study also shows a significant difference in the mean score of M-CSI-M about the participant's average income. These findings are per previous studies where in caregiving, the carers' abilities to provide for their own emotional, personal, physical, social, and financial needs by using their savings or income are seriously compromised.[31] Exceptional levels of care for CWD force income to be spent on the child's needs rather than caregivers, for example, medical care, transportation, adaptive equipment, and others that may influence dissatisfaction feelings. This negative feeling or parenting stress due to overinvestment of time and money in the child's care, coupled with the low contribution to the household's finances, reduces the families' budgetary resources and impairs the caregivers' social and personal needs.[32]

Lastly, this study also indicates a significant difference in the mean score of M-CSI-M concerning the child types of disabilities. The mean M-SCI-M scores about their child's types of disabilities are as follows: the highest mean score

Table IV: The significant difference between CWD caregiver strain and their demographic variable.

Items	Mean	Standard Deviation	F	Sig.
Level of education				
Not schooling	4.29	4.108	5.753	0.000*
Ujian Pencapaian Sekolah Rendah (UPSR)	6.35	5.559		
Sijil Rendah Pelajaran (SRP)/ Penilaian Menengah Rendah (PMR)	2.80	2,668		
Sijil Pelajaran Malaysia (SPM)	5.19	5.265		
Sijil Tinggi Pelajaran Malaysia (STPM)/ Matrikulasi/ Diploma	6.00	3.578		
Bachelor's degree or higher	13.71	7.158		
Income				
No income	3.92	3.799	3.726	0.013*
Under RM1000	5.96	5.336		
RM1000 – RM3000	5.97	5.887		
Exceed RM3000	11.00	9.460		
Types of disabilities				
Hearing disabilities	2.50	1.732	6.277	0.000*
Speaking disabilities	2.00	3.082		
Physical disabilities	6.08	4.551		
Learning disabilities	5.45	5.116		
Mental disabilities	9.33	1.528		
Multiple disabilities	10.65	4.931		
Caregivers age				
20 – 34 years old	4.95	4.383	0.434	0.957
35 – 39 years old	4.47	5.249		
40 – 49 years old	6.41	6.095		
50 – 59 years old	5.85	5.284		
Above 60 years old	3.82	3.459		
Number of children				
Less than 2 children	5.33	6.011	0.372	0.996
2-4 children	4.84	4.554		
More than 4 children	6.22	5.893		
Working status				
Unemployed	5.03	5.249	0.051	3.041
Self-employed	5.02	4.363		
Public servant	8.44	7.677		
Child's age				
0 - 6 years old	5.20	4.732	0.183	1.712
7 – 12 years old	6.85	5.084		
13 – 18 years old	5.76	5.821		
Caregivers genders				
Male	5.42	5.043	0.341	0.986
Female	5.40	5.470		

Difference; ($p<0.05$) statistical test;ANOVA

represented multiple disabilities, and the lowest score was for speaking disabilities. These results agree with other studies that underlined that the mean score of total caregiver burden was highest in children with multiple disabilities, followed by mental and physical disabilities.[33] On the contrary, previous study results showed that the type of child's disability did not affect the caregiver's level of burden.[18] They concluded that dyslexia and cerebral palsy tend to have the highest burdens. This could be because dealing with both physical and behavioural problems encountered by CWD presents more challenges than when the caregiver has to deal with only one pathological condition. Children with multiple disabilities may have impairments in cognition, motor, and sensory functions in combination with each other.[34] Many of these young children struggle to communicate their wants and needs, to freely move their bodies to access and engage their world, and to learn abstract concepts and ideas. The intensity of their needs means that delays are likely to have a pervasive impact on the child's development and continue impacting the family and the child well beyond the early childhood years. Strains significantly exist for caregivers who assist with each type of disability. Besides, caregivers of children with speaking disabilities tend to have fewer burdens, which might be because most of these children don't have other comorbidities. Furthermore, the application and use of sign language can restore their ability to participate and communicate effectively in their daily school and community routines.

There was some limitation to this study. Thoughtful consideration should be given in viewing our findings. Our Sample size was restricted to the Kudat division, limiting the real representation of targeted populations. In the bigger picture, this may constitute skewed data at the national level in response to CBR enrolment or healthcare services. Some important variable moderators could not be gathered, such as functional status and severity of CWD; thus, the child aspects leading to the strain among caregivers remain ambiguous.

CONCLUSION

The study utilized the M-CSI-M to identify strain differences based on caregiver demographics, including education, income, and type of disability, with targeted samples of caregivers of children with disabilities (CWD) in the Kudat division of Sabah. It is found that they have a moderate strain with three main causes: upsetting behaviour, financial strain, and feeling overwhelmed. As caregivers are part of a multidisciplinary team, extending healthcare consideration to CWDs and their caregivers is important. The authors suggest implementing life skills training programs involving healthcare professionals such as occupational therapists. A life skill training programme generally contains assertiveness training, interpersonal skills, social participation skills, communication skills, and so on. In addition, it typically will help in developing coping skills. Such support could enhance these caregiver's quality of life. Educating rehabilitation workers and managers of CBR resources is also an important aspect. They must be aware of factors that might positively or negatively affect caregivers' participation in CBR. Overall, this study provides an initial exploration of strains among caregivers of CWD at the CBR centres of East Malaysia. It serves as a starting point for future research that explores the caregiver strain among caregivers of disabled children. Future research should examine CWD's caregivers and specify conditions (autism, cerebral palsy and etc) for better generalization.

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ETHICS APPROVAL AND INFPRMED CONSENT

Ethical approval was granted by the University Technology Mara (UiTM) Research Ethics Committee (Ref. Number: 600-IRMI (5/1/6)). Permission from the Social Welfare Department to conduct this study at a selected CBR centre was obtained. (Reference letter: JKMM 100/12/5/2: 2019/152).

CONFLICT OF INTEREST

The authors declare that they have no competing interests

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The presence of family during resuscitation in critical care settings: Nurses perspectives

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ABSTRACT

Introduction: Family presence during resuscitation (FPDR) is now an accepted practice in many western countries as research proven its positive impact on patient, family and also health care providers. In Malaysia, it is not known whether nurses in critical care settings agrees on family members' presence during the resuscitation process. This study aims to determine the perspectives of nurses toward family presence during resuscitation in critical care settings at Hospital Universiti Sains Malaysia. This study specifically looked at the risk and benefits perceived by nurses related to family presence during resuscitation, the self-confidence perceived by nurses related to family presence during resuscitation, and the correlation between nurses' perception of risk and benefits with self-confidence related to family presence during resuscitation.

Materials and Methods: A cross-sectional study was conducted using a self-administered questionnaire entitled the Family Presence Risk-Benefit Scale and Family Presence Self-Confidence Scale. Purposive sampling method was used to include 130 nurses working in eight Intensive Care Units at Hospital Universiti Sains Malaysia. Descriptive statistics and Pearson's Correlation test were used to analyse the variables of FPDR.

Results: Findings revealed that nurses in the critical care setting perceived low risk-benefit and low self-confident with regards to family presence during resuscitation. Pearson correlation analysis showed no correlation between perceptions of risk-benefits and self-confidence among critical care nurses (r = -0.016).

Conclusion: Relatively, nurses perceived that family presence during resuscitation would place high risk and low benefit to the family members. Thus there is a need for education, training, and guideline to enrich the concept of FPDR and its implementation.

KEYWORDS:
Family presence, family centered care, resuscitation, and witnessed resuscitation, critical care

INTRODUCTION

The expectations and beliefs of family members for the best treatment should be considered by health care provider especially during resuscitation. Even though the family presence during resuscitation (FPDR) practice is not favourable by the health care provider,[1-5] nurses significantly had a positive attitude toward FPDR.[6] In western countries, some professional bodies such as the Emergency Nurses Association[7] and the American Heart Association[8] have begun to lend support in allowing family members to be present during all resuscitative efforts such as cardiopulmonary resuscitation (CPR), invasive procedure, and others as there has been established policy on that matter and families are encouraged to be present during resuscitation.

It has been shown that the FPDR was accepted by health care professionals and has benefit to family members.[9-11] Allowing family members during resuscitation helps meet emotional and spiritual needs and facilitate the grieving process.[20] Family presence during resuscitation improves patient, and family experience in terms of health outcomes, promote satisfaction and enhances therapeutic relationships between staff, patient and family members.[21] Several studies have shown that FPDR has been favoured by clients and their family members as the positive implications it has to offer.[22-24] However, in Malaysia, family members are not allowed to witness resuscitations as there are lacking in apparent policies and framework in the implementation of FPDR. Moreover, the concept of FDPR is still new in Asia including Malaysia whereby only 15.8% emergency health care staffs were agreeable to the concept of FPDR.[26]

Family-witnessed resuscitation or FPDR is defined as one or more family members are present in the room while a family member is being resuscitated in an effort to sustain life.[12] It also can be described as witnessing or being physically present by the patient side during invasive procedures or resuscitation events by the family members in the patient care area.[13] Resuscitation and effort performing to resuscitate the patients is the process that has always been performed in critical care areas. Therefore, the perspectives of nurses on FPDR practice in critical care settings are crucial as nurses are the first line professionals who witnesses and attends to the clients during resuscitation process. Furthermore, this study would serve as a basis for developing the policy in allowing family presence during resuscitation.

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MATERIALS AND METHODS

Research Design

Cross-sectional method was used to answer the research objectives.

This research was carried out at the intensive care units Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan between May and July 2020 after obtaining ethical approval to conduct the study.

Population and Sample Size

A sample of 130 nurses working in critical care settings (General ICU, Surgical ICU, Surgical High Dependency Unit, Neurosurgery ICU, Trauma ICU, Cardiothoracic ICU, Coronary care unit, and Burn Unit) were involved in this study through a purposive sampling. Recommended sample size was 123 respondents. After adding a 10% drop out, the total number of respondents for this study was 135. However, five questionnaires were rejected for being incomplete.

Eligibility Criteria

Inclusion Criteria: Registered nurse working in critical care settings in intensive care units HUSM between May and July 2020.

Exclusion Criteria: Nurses who are on extended leave during the study period and with managerial position in nursing.

Study Instruments

This study used self-administered questionnaire adopted from Twibell et al.,[12] titled nurses' perceptions of their self-confidence and the benefits and risks of family presence during resuscitation. Permission was granted by the main author to use the questionnaire.

Demographic Characteristic

Demographic characteristic comprises five data, which is gender, age, educational level, years of experience in nursing, and the number of times invited family presence.

Family Presence Risk-Benefit Scale

The risk-benefit scale questionnaire consists of 22 questions. No modification was made from the original questionnaire. Items on scales had a 5-point Likert response opinion. Respondent rating with 5=strongly agree, 4=agree, 3=neutral, 2=disagree and 1=strongly disagree. The cut-off points of 4 and 5 were considered high and indicated that the respondents perceived more risk and benefited toward FPDR. Whereas cut-off points 1, 2, and 3 showed that the respondents perceived less risk and benefited toward FPDR. The higher score indicates a greater level of perceived risk and benefit of family-witnessed resuscitation.

Family Presence Self-Confidence Scale

The Family Presence Self-Confidence Scale consists of 17 questions. No modification was made from the original questionnaire. Items on scales had a 5-point Likert response opinion. Respondent rating with 5=very confident, 4=quite confident, 3=somewhat confident, 2=not very confident and 1=not at all confident. The cut-off points of 4 and 5 was considered high and indicated that the respondents had a greater self-confidence level in managing FPDR. The cut-off points of 1, 2, and 3 showed that the respondents perceived low confidence in managing FPDR.

Validity and Reliability

The questionnaire was validated by three experts, Intensive Care Anaesthesiologist, Matron of Intensive Care Unit, and Advanced Diploma of Intensive Care Nursing Tutor. A pilot study was conducted among 10 critical care nurses in the ICU, HUSM, to test the reliability of the questionnaire. Three of the participants had Bachelor of Nursing degrees, three had Advanced Diploma in ICU, and others are working more than ten years in ICU. The Cronbach's alpha for Family Presence Risk-Benefit Scale (FPR-BS) was 0.75 and 0.93 for Family Presence Self-Confidence. The reliability of the questionnaire of Family Presence Risk-Benefit Scale (FPR-BS) was supported by 0.96 in the previous study and Cronbach's alpha coefficient of 0.95 for Family Presence Self-Confidence Scale (FPS-CS).[12,14]

Ethical Consideration

Ethical approval for this study was obtained from the UiTM Ethics Committee on 4th February 2020 (Reference: REC/01/2020 (MR/17). The study was conducted with permission from The Human Research Ethics Committee of USM (JEPeM) on16 April 2020. (Reference: USM/JEPeM/20010015). Approval from Hospital Universiti Sains Malaysia's director was obtained before data collection. Participants were consented before data collection.

Data Collection

Data collection begun once approval from the hospital director, UiTM and USM Research Ethics Committee was obtained. All participants were briefed on the study objective and certain requirements, including criteria, informed consent, and time requirement for each respondent to answer the questionnaire (about 10–20 minutes). The approval letter from UiTM ethic, USM ethic and the hospital director was also attached. Respondents were chosen according to the method of purposive sampling and based on the working schedule. The questionnaire was filled up by the respondents after working hours, then collected and put in a wrapper. Each respondent was given a numerical code for data analysis, and confidentiality also was guaranteed.

Data Analysis

The coded responses were recorded into IBM Statistical Package for the Social Science (SPSS) version 26 software. For this study, there are six negatively worded items in the FPR-BS questionnaire that have been reverse scores.[12,14] Descriptive statistics analysis (mean, standard deviation, percentage and frequency) was used to analyse the FPDR variables. Pearson correlation was used to determine the relationship between FPDR variables.

The parametric tests were used to determine the relative quality of each data. Kolmogorov-Smirnov normality tests were carried out before inferential data analysis. The results of the normality test for the main variables of this study indicate that these variables are typically distributed with probabilities ($p > 0.05$).

RESULTS

Demographic Data

Most of the respondents were between 25 and 35 years old, with 63.1% (n=82) and mean age was 33.22. The majority of the participants were female 84.6% (n=110), 26.6% (n=32) of respondent had <5 years of experience in nursing profession, 33.1% (n=43) had 6-10 years, 37.7% (n=49) had 11-20 years and 4.6% (n=6) had >20 years of experience in nursing profession. Majority of the participants were diploma holders 90% (n=117), followed by degree holders 8.5% (n=11) and others 1.5% (n=2). The finding showed that more than half of the respondents, 53.8% (n=70) does not have experience in family presence during resuscitation, 40.8% (n=53) have experienced <5 times, and 5.4% (n=7) have and experience more than 5 times.

Nurses' Perception on Family Presence Risk-Benefit Scale

Findings showed that respondents had strongly disagree on the item that family members will panic if they witness a resuscitation effort 50.8% (n=66) [Table II]. Another item that respondent disagrees with is that family members will have difficulty adjusting to the long-term emotional impact of watching a resuscitation effort 30.8% (n=40). Whereas there are two items that respondent is strongly agree regarding the risks on FPDR is the statement of family members will become disruptive if they witness resuscitation efforts 33.8% (n=44) and the resuscitation team will not function well if family members are present in the room 35.4% (n=46).

The two items that strongly agreed by the respondents had a high mean score. The mean score on family members' item will become disruptive if they witness resuscitation efforts were 4.04. The resuscitation team will not function as well if family members are present in the room was 4.07. There are three other high mean scores for perceived risk and benefit among critical care nurses in this study, which is family members are more likely to sue (3.88), and the belief on FPDR effort give benefit to patients (3.58) and the family (3.51).

Items on benefits of FPDR showed that respondents answering disagree with the statement of the presence of FPDR efforts is beneficial to nurses 43.1% (n=56), beneficial to physicians 42.3% (n=55), and should be a component of family-centred care 37.7% (n=49). The mean score for the FPR-BS scale was 2.88 (standard deviation, SD 0.302) and interpreted as low.

Nurses' Perception on Family Presence Self-Confidence Scale

Most nurses in the study answered between the scale of 'not very confidence' and 'somewhat confidence.' [Table III] The respondents in this study were not very confident in performing electrical therapies 49.2% (n=64), encourage family members to talk to their family member 36.9% (n=48), and prepare family members to enter the area of resuscitation of their family members 36.2% (n=47). There are two items that respondents showed high self-confidence toward FPDR. The respondents were quite confident in communicating about the resuscitation effort to family members who are present 36.9% (n=48) and coordinate bereavement follow-up with family members after resuscitation efforts of their ill family member, if required 31.5% (n=41).

The mean score of nurses' perceptions of the Family Presence Self-Confidence Scale by items reveal that only one item was coded as high. Mean score for items regarding nurses' confidence in administering drug therapies during resuscitation with family presence was high with a mean score of 3.46 (SD 1.043). FPS-CS scale's mean score was 2.95 (SD 0.686) as recorded to strongly disagree, disagree, neutral, and strongly agree or agree. The mean score result for FPS-CS scale's coded as low.

The Relationship between Nurses' Perceptions of Risk and Benefits with Self-Confidence Related to FPDR

A Pearson correlation coefficient was computed to assess the relationship between the level of risk-benefits and self-confidence among participants towards FPDR practice [Table IV]. Pearson correlation reveals no correlation between perceptions of risk-benefits and self-confidence among critical care nurses with r = -0.016, n= 130.

DISCUSSION

Nurse Perceptions on Family Presence Risk-Benefit

The mean score of risk and benefits perceived by nurses related to FPDR is low (2.88), with a standard deviation of 0.302. Contrary to the other study,[12] the result indicated nurses' perceived high benefit and low risk toward FPDR. The differences in the mean score in this study compared to others study may be because of the respondents' high number of neutral responses. The respondents might not be sure if they agreed or disagreed with the questionnaire statement due to lack of experience with FPDR influenced by availability or lack of adequate family witnessed resuscitation policy and guidelines.[15]

Three high risks perceived by critical care nurses toward FPDR in this study were that family members will become disruptive, the resuscitation team will not function well with the family present, and family members are more likely to sue were differ with findings in other studies.[1,3,16] These findings suggest that nurses in a critical care setting understand the barrier in managing families in the resuscitation process. Understanding the barrier of FPDR will guide critical care nurses to deliver FPDR as an essential component in nursing care.

This study also showed that the respondents had mixed opinions regarding the benefit of FPDR to the family, patient, nurses, and physician. FPDR showed to give benefit to the patient and family but not to the nurses and physician. This mixed opinion may be caused by a lack of family members' involvement in FPDR in the critical care settings. Participants agreed that family members' presence in FPDR efforts is beneficial to the patients and the family which consistent with earlier study.[5] Overall, critical care nurses in this study perceived high risk and low benefit toward FPDR. The adverse finding on the perception of risks and benefits in this study could be related to the current no formal guideline related to FPDR in the critical care settings.

Nurse Perceptions on Family Presence Self-Confidence Scale

Contrary to the previous study,[12,17] the total mean score of 2.95 result shown negatives perceptions, indicating that

Table I: Demographic characteristics of the respondents (n=130)

Characteristics	n	%
Demographic		
Age (years old)		
21-25	10	7.7
26-35	82	63.1
36-45	33	1.8
>45	5	3.8
Gender		
Male	20	15.4
Female	11	84.6
Years of experience in nursing		
<5 years	32	24.3
6-10	43	33.1
11-20	49	37.7
>20 years	6	4.6
Education level		
Diploma	117	90.0
Bachelors	11	8.5
Other	2	1.5
Number invited family presence.		
0	70	53.8
<5	53	40.8
>5	7	5.4

Table II: Mean score of nurse's perceptions on Family Presence Risk-Benefit Scale (FPRBS) by items (n=130)

Items	N	Mean	SD*	Interpretation of mean
Overall FPRBS	**130**	**2.88**	**0.302**	**Low**
1. Family members should be given the option to be present when a loved one is being resuscitated	130	2.26	1.082	Low
2. Family members will panic if they witness a resuscitation effort	130	1.54	0.586	Low
3. Family members will have difficulty adjusting to the long-term emotional impact of watching a resuscitation effort	130	1.83	0.672	Low
4. The resuscitation team may develop a close relationship with family members who witness the efforts, as compared to family members who do not witness the efforts	130	2.64	0.907	Low
5. If my loved one were being resuscitated, I would want to be present in the room	130	3.16	1.062	Low
6. Patients do not want family members present during a resuscitation attempt	130	3.12	0.659	Low
7. Family members who witness unsuccessful resuscitation efforts will have a better grieving process	130	2.89	1.066	Low
8. Family members will become disruptive if they witness resuscitation efforts	130	4.01	1.008	High
9. Family members who witness a resuscitation effort are more likely to sue	130	3.88	0.957	High
10. The resuscitation team will not function as well if family members are present in the room	130	4.07	0.882	High
11. Family members on the unit where I work prefer to be present in the room during resuscitation efforts	130	3.19	0.855	Low
The presence of FPDR efforts is				
12. … beneficial to patients	130	3.58	0.896	High
13. … beneficial to families	130	3.51	0.942	High
14. … beneficial to nurses	130	2.48	1.006	Low
15. … beneficial to physicians	130	2.52	1.036	Low
16. … should be a component of family-centred care	130	2.55	0.845	Low
The presence of FPDR efforts will have a positive effect on				
17. ...patient ratings of satisfaction with hospital care	130	2.55	0.949	Low
18. … family ratings of satisfaction with hospital care	130	2.77	1.023	Low
19. … on nurse ratings of satisfaction in providing optimal patient and family care	130	2.70	0.970	Low
20. … physician ratings of satisfaction in providing optimal patient and family care	130	2.65	0.921	Low
21. The presence of FPDR efforts is a right that all patients should have	130	2.75	0.973	Low
22. The presence of FPDR is a right that all family members should have	130	2.71	0.927	Low

*SD – Standard Deviation

Table III: Mean score of nurses' perceptions on Family Presence Self-Confidence Scale (FPSCS)by items (n=130)

Items	N	Mean	SD	Interpretation of mean
Overall FPSCS	**130**	**2.95**	**0.686**	**Low**
1. … communicate about the resuscitation effort to family	130	3.88	0.856	Low
2. … administer drug therapies during resuscitation efforts with family members present	130	3.46	1.043	High
3. … perform electrical therapies during resuscitation efforts with family members present	130	2.50	0.958	Low
4. … deliver chest compressions during resuscitation efforts with family members present	130	3.36	1.049	Low
5. … communicate effectively with other health team members during resuscitation efforts with family members present	130	3.18	1.084	Low
6. … maintain dignity of the patient resuscitation efforts with family members present	130	2.91	1.110	Low
7. … identify family members who display appropriate coping behaviours to be present during resuscitation efforts	130	2.88	0.941	Low
8. … prepare family members to enter the area of resuscitation of their family member	130	2.80	0.968	Low
9. …enlist support from attending physicians for family presence resuscitation efforts	130	2.69	0.922	Low
10. … escort family members into the room during resuscitation of their family member	130	2.75	0.973	Low
11. …announce family member's presence to resuscitation team during resuscitation efforts of their family member.	130	3.11	1.021	Low
12. … provide comfort measures to family members witnessing resuscitation efforts of their family member	130	2.68	0.998	Low
13. … identify spiritual and emotional needs of family members witnessing resuscitation efforts of their family member	130	2.84	1.048	Low
14. …encourage family members to talk to their family member during resuscitation effort	130	2.60	1.090	Low
15. ...delegate tasks to other nurses in order to support family members during resuscitation efforts of their family member	130	3.10	1.003	Low
16. … debrief family after resuscitation of their family member	130	2.99	0.919	Low
17. … coordinate bereavement follow-up with family members after resuscitation efforts of their family member, if required	130	3.04	0.935	Low

*SD – Standard Deviation

Table IV: Pearson's Correlation between perceptions on risk-benefit and perception on self-confidence

Variables	1	2
1. Risk-benefits	1.00	
2. Self-confidence	--0.016	1.00

nurses are not confident in managing resuscitation with family members' presence. In this study, nurses showed confidence in administer drug therapies during resuscitation efforts with family members presence consistent with earlier study.[14] The majority of participants in this study are not very confident in performing electrical therapies, have support from attending physicians and escorting family members into the resuscitation room. Some studies highlight the importance of health care providers or nurses escorting family members to the resuscitation room.[4,5,18] The explanation why nurses are not confident in managing FPDR in this study could be because of the newness of FPDR practice in Malaysia. Nurses in critical care settings were confident in items that they are familiar with. There is also no formal education related to FPDR in Malaysia that can helps nurses in critical care settings understand and support the need of the family members during the resuscitation process. Even though nurses and physicians were confident that FPDR practice does not affect their performance, they are concern about the training to support relatives in FPDR situations.[19]

The Relation between Nurses' Perception of Risk and Benefits with Self-Confidence Related To FPDR

The result reveals no relationship between perceptions of risk-benefits and self-confidence toward FPDR among participants in this study with r = -0.016, p˃0.001). The finding in this study was differ with other, studies.[12,14,17] In the previous studies, nurses' perceptions of risks, benefits, and self-confidence toward FPDR were found very significantly and strongly interrelated into each other. It shows that perception of more benefit and fewer risks and more self-confidence in managing FPDR.

This study's different in findings may be explained in terms of varying acceptance of FPDR practice in Asian and Western countries among nurses. However, there is no study in the Asian population has been done to assess the relationship between the perceptions of risk-benefits and self-confidence toward FPDR among critical care nurses. Both scale FPR-BS and FPS-CS can be used to classify nurses who favour family presence quickly, easily, and feel secure in handling it. It also

can be a self-assessment method to understand what the nurses feel regarding FPDR.

Effort should be made to raise awareness toward FPDR practice among critical care settings and critical care nurses by inviting family members in the resuscitation process. On top of that, clear policies or guidelines regarding FPDR may need to be developed by top authorities to enhance nurses' practice.

This study's limitation is that samples are limited to critical care nurses working in an ICU only and do not represent nurses working in other units. The inclusion of nurses from different settings such as medical, paediatric, and surgical wards could provide insights into nurses' perceptions of risk, benefit, and self-confidence toward FPDR. Involving a larger sample of critical care nurses across the country might produce various participant responses to the items related to risk benefits and self-confidence toward FPDR.

CONCLUSION

Critical care nurses had perceived high risk and low benefit toward FPDR and had perceived low self-confidence in managing FPDR. There is no correlation between nurses' perception of risk and benefits with self-confidence related to FPDR. Hopefully, this study will be inspired by nursing and other health care workers to explore more about FPDR concepts in Malaysia in the future. FPDR is an integral component of treatment and requires sufficient training and practice in the hospital environment, especially for critical care nurses. Appropriate educational training would impact awareness toward FPDR and healthcare providers' attitudes regarding perceptions on risk-benefits and their self-confidence. Continued training and assessment are important to build their competencies toward FPDR in the future.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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ORIGINAL ARTICLE

Comparison study of the MRI shoulder PROPELLER technique with differential image quality by variation of shoulder coils

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ABSTRACT

Introduction: Motion and pulsation artifacts are the most prominent types of artifacts in Magnetic Resonance Imaging (MRI) of the shoulder. Therefore, this study examined the Periodically Rotating Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER) technique with small flex coil (SFC) and dedicated shoulder coil (DSC) for the reduction of motion and pulsation artifacts. The signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of the standard proton density fat saturation (PDFS) pulse sequence and the PROPELLER proton density fat saturation (PROPELLER PDFS) pulse sequence were also evaluated.

Materials and Methods: Eighteen (18) participants who met the inclusion and exclusion criteria were scanned using a standard non-contrast MRI shoulder protocol including the PDFS pulse sequence and the PROPELLER PDFS pulse sequence using a small flex coil and a dedicated shoulder coil. Two experienced musculoskeletal (MSK) radiologists evaluated and graded the presence of artifacts on the MR images and the SNR and CNR were measured quantitatively.

Results: The non-parametric Wilcoxon Signed Rank test revealed a significant reduction in motion and pulsation artifacts between the PROPELLER PDFS pulse sequence and the standard PDFS pulse sequence. In addition, the nonparametric Mann-Whitney U test revealed that the mean rank of SNR for the standard sequence was statistically significant when compared to the PROPELLER sequence for both coil types. The CNR of the PROPELLER sequence was statistically significant between fat-fluid, bone-fluid, bone-tendon, bone-muscle, and muscle-fluid when using SFC and DSC.

Conclusion: This study proved that the PROPELLER-PDFS pulse sequence effectively eliminates motion and pulsation artifacts, regardless of the coils utilised. The PROPELLER-PDFS pulse sequence can therefore be implemented into the standard MRI shoulder procedure.

KEYWORDS:
MRI shoulder, PROPELLER, PDFS, coil, artifact

INTRODUCTION

Imaging the musculoskeletal (MSK) system is a valuable diagnostic approach for determining the causes of shoulder disease and formulating the best treatment strategy. MRI with high resolution permits the identification of the tendon, muscle, and ligament in the shoulder. King, Healy and Baird,[1] highlighted that MRI is necessary for evaluating the symptom of tendinopathy since it can evaluate the rotator cuff associated with the bone structure, muscles, tendons, and adjacent soft tissues.

The utilisation of MRI for diagnosing MSK and shoulder diseases has both advantages and disadvantages. The MRI technique has significantly contributed to the enhancement of clinical disease diagnosis, treatment planning, and response evaluation. Furthermore, there is an increasing trend of employing MRI in research investigations focused on musculoskeletal conditions, including shoulder. MRI is an imaging modality that provides additional information on cartilage, inflammation, and injury or degeneration of surrounding soft tissue structures[2] and can identify and monitor abnormalities in their initial phases.[3]

Besides providing excellent soft tissue contrast and high-resolution images, MRI of the shoulder is susceptible to image degradation from various patient motion sources, including respiration and uncooperative patients as well as pulsatile flow, which can significantly impact the image quality and diagnostic value of MRI.[4] According to Goh and Peh,[5] the random motion artifact results from uncooperative patients or pain or discomfort severity. This artifact remains a significant issue in clinical and research MRI applications. The primary appearances of motion artifact are ghosting and blurring, which occur when the patient moves during data acquisition in the k-space using the Cartesian method.[6] Numerous strategies were proposed to rectify the motion artifact, which can be divided into three categories: 1)prevention of motion by restricting the patient's movement during the scanning process, 2)motion correction techniques, and 3)artifact reduction.[7] The use of pads and cushions to prevent motion artefacts is ineffective and often inconvenient for long scanning durations.[8] Motion correction techniques have tremendous potential, but they have not been thoroughly validated and require additional hardware or

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pulse sequence modifications.[9] In numerous MRI studies, artifact reduction techniques such as ordered phase encoding[10] and Periodically Rotating Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER), have been demonstrated to effectively reduce motion.[11] By using Periodically Rotating Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER), image artifacts such as motion artifacts and magnetic susceptibility artifacts can be reduced[12] and the limitations of the MRI can be addressed.[13,14]

The PROPELLER technique was developed to reduce motion artifacts by employing radial k-space coverage. It has been implemented to decrease pulsation and motion artefacts.[11,15-16] Unfortunately, the PROPELLER method produces streak artifacts in MRI images. The MRI images develop streak artifacts because of the under-sampling that occurs during the gridding phase, which transforms the location of the incoming data through complementing processing from an oblique trajectory to an accurate grid in k-space.[16]

Shoulder MRI typically uses a dedicated shoulder RF coil or a small flex RF coil. The dedicated shoulder RF coil operates as a transmitter and receiver (transceiver) coil; meanwhile, the small flex coil operates solely as a receiver coil. The type, size, and position of the RF coil in relation to the patient's body can impact the overall MR image quality. According to Mulyati et al.,[17] the signal-to-noise (SNR) and contrast-to-noise (CNR) ratios of the dedicated shoulder coil are greater than those of the small flex coil. With the invention of the first solenoids, several factors, including coil homogeneity, self-resonance, efficiency, quadrature detection, transmission line effects, and quality factor, have significantly influenced the design of RF coils.[18] Thus, this research aimed to examine the MRI shoulder PROPELLER technique with differential image quality based on shoulder coil variation. In addition, this research examined the reduction of motion and pulsation artifacts and compared the SNR and CNR between standard coronal oblique proton density fat saturation (PDFS) and coronal oblique PROPELLER proton density fat saturation (PROPELLER PDFS) pulse sequences.

MATERIALS AND METHODS

Participants

The study included 18 participants who met the inclusion and exclusion criteria (Table I) and was conducted from November 2022 to January 2023. All participants were given a subject information sheet and consent form before scanning. Participants who agreed and signed the form were recruited in the study. The participants were briefed on MR safety and the potential risks of the examination. The safety screening was carried out and recorded on the MR safety checklist.

Study Setting and Scanning Protocol

The research was conducted using an Ingenia 3.0 T MRI scanner (Philips Healthcare) at the Radiology Department, Hospital Pengajar UPM, Universiti Putra Malaysia, Serdang. Throughout the scanning, the participant remained supine and in a head-first position. The eight-channel receivers (Rx) dedicated shoulder coil (DSC) fitted securely over the affected shoulder, and the laser beam was centred over the coil. The participant was secured with straps and padded with designated sponges. The participant was scanned using the standard, non-contrast shoulder protocol (axial proton density fat saturation; PDFS, coronal oblique T1, coronal oblique T2, coronal oblique PDFS, sagittal oblique PDFS, and sagittal oblique T2 fat saturation; FS) with the addition of the coronal oblique PROPELLER proton density fat saturation (PROPELLER PDFS) pulse sequence as tabulated in Table II. The entire sequences were repeated then, using a small flex coil (SFC) for image quality comparison.

Data Collection

Two certified radiologists with more than three years of experience in magnetic resonance imaging (MRI) and ultrasound (US) musculoskeletal (MSK) imaging, independently evaluated and graded image artifact reduction between standard coronal oblique PDFS and coronal oblique PROPELLER PDFS images using a five-point scale (0: no visualisation and 4: severe visualisation). The SNR and CNR were then quantitatively evaluated between sequences and with various RF coils (DSC and SFC). Three 2cm-elliptical-ROIs were measured at the humerus bone (SNR_A), glenohumeral joint (SNR_B), and supraspinatus tendon (SNR_C) for SNR measurements. For the CNR, nine 2cm elliptical ROIs were measured between fat-fluid (FT-FL), fat-tendon (FT-TDN), fat-bone (FT-BN), fat-muscle (FT-MS), bone-fluid (BN-FL), bone-tendon (BN-TDN), bone-muscle (BN-MS), muscle- fluid (MS-FL), and muscle-tendon (MS-TDN).

Statistical Analysis

The data were analyzed with IBM Statistical Package for Social Science (SPSS) version 26.0 software. The Shapiro-Wilk test was done to assess the normality of the data, and the findings indicate a non-normal distribution. A non-parametric Wilcoxon Signed Ranks test was performed to examine the reduction of image artifact between standard coronal oblique PDFS and coronal oblique PROPELLER PDFS pulse sequences using different types of RF coils. The agreement between the two observers was measured using kappa statistics. The SNR and CNR values between pulse sequences were quantitatively analyzed using the Mann-Whitney U test.

Ethics Approval And Informed Consent

The participation of each participant in this research was entirely voluntary. Prior to scanning, the subject information sheet, consent form, MR safety, and possible risk and injury were explained and documented. The study was approved by the Universiti Teknologi MARA (UiTM) research ethics committee (FERC/FSK/MR/2022/0281) and Ethics Committee for Research Involving Human Subject (JKEUPM), Universiti Putra Malaysia (JKEUPM-2022-928) and adhered to the Declaration of Helsinki 1964.

RESULTS

Image Artifact Reduction between Standard Coronal Oblique PDFS and Coronal Oblique PROPELLER PDFS

Comparing motion and pulsation artifact reduction using SFC, the coronal oblique PROPELLER PDFS pulse sequence significantly reduced both motion and pulsation artifact

Table I: Inclusion and exclusion criteria

Inclusion criteria:
1. Participants age between 18-85years old.
2. Male and non-pregnant female.
3. No contraindication to MRI.
4. Clinical diagnosis of traumatic shoulder injuries (i.e tendon and ligament injury, impingement, rotator cuff tear etc).
5. Informed consent from participants.

Exclusion criteria:
1. Participants with body weight above 95 kilogrammes.
2. Claustrophobia and MRI incompatible.
3. Participants who are pregnant.
4. Clinical diagnosis of shoulder tumour, infectious disease and metabolic changes.

Table II: MRI Shoulder protocol

Sequence	TR (ms)	TE (ms) method	Slice thickness (mm)	FOV (mm)	K-space filling
Axial PDFS	2552	30	3.0	150	Cartesian
Sagittal oblique PDFS	2500	30	3.0	160	
Sagittal oblique T2 FS	3593	87	3.0	160	
Coronal oblique T1	595	18	3.0	160	
Coronal oblique T2	3000	87	3.0	160	
Coronal oblique PDFS	2500	30	3.0	160	
	Additional sequence				
Coronal oblique PROPELLER PDFS	2500	30	3.0	160	PROPELLER

Table III: Mean score image artifact reduction comparison between standard PDFS and PROPELLER PDFS sequences using SFC

Type of artifact, Observer	Small Flex Coil (SFC)			
	Standard PDFS Mean ± SD (Md)	PROPELLER PDFS Mean ± SD (Md)	Z-score	p-value
Motion artifact (n=18)				
Observer 1	1.83 ±1.04 (2.0)	0.83 ± 0.71 (1.0)	-3.286	0.001*
Observer 2	1.67 ± 0.91 (2.0)	0.89 ± 0.58 (1.0)	-3.071	0.002*
Kappa, κ	0.541	0.850		
Pulsation artifact (n=18)				
Observer 1	1.17 ± 0.62 (1.0)	0.67 ± 0.69 (1.0)	-3.00	0.003*
Observer 2	1.22 ± 0.55 (1.0)	0.61 ± 0.70 (0.5)	-3.317	0.001*
Kappa, κ	0.390	0.866		

Notes: Results above are rating by observers formatted as Mean ± Standard Deviation and Medan in parenthesis. Except for Kappa value, Z-score and p-value were calculated using Wilcoxon Signed Rank Test.
* p-value is significant at <0.05 level.
** p-value is significant at <0.001 level.

Table IV: Mean score image artifact reduction comparison between standard PDFS and PROPELLER PDFS sequences using DSC

Type of artifact, Observer	Dedicated Shoulder Coil (DSC)			
	Standard PDFS Mean ± SD (Md)	PROPELLER PDFS Mean ± SD (Md)	Z-score	p-value
Motion artifact (n=18)				
Observer 1	2.06 ±1.00 (2.0)	1.11 ± 0.83 (1.0)	-3.494	<0.001**
Observer 2	1.83 ± 0.92 (2.0)	1.06 ± 0.64 (1.0)	-3.276	0.001*
Kappa, κ	0.741	0.224		
Pulsation artifact (n=18)				
Observer 1	1.17 ± 0.51 (1.0)	0.56 ± 0.51 (1.0)	-3.317	0.001*
Observer 2	1.22 ± 0.43 (1.0)	0.50 ± 0.51 (0.5)	-3.606	<0.001**
Kappa, κ	0.286	0.543		

Notes: Results above are rating by observers formatted as Mean ± Standard Deviation and Medan in parenthesis. Except for Kappa value, Z-score and p-value were calculated using Wilcoxon Signed Rank Test.
* p-value is significant at <0.05 level.
** p-value is significant at <0.001 level.

Table V: Signal-to-noise ratio (SNR) of standard PDFS and PROPELLER PDFS sequences using SFC and DSC

Image Quality	Small Flex Coil (SFC)			
	Standard PDFS	PROPELLER PDFS		
	Mean Rank	Mean Rank	Z-score	p-value
SNR				
SNR_A	22.22	14.78	-2.120	.034*
SNR_B	25.83	11.17	-4.176	<.001**
SNR_C	25.44	11.56	-3.955	<.001**
	Dedicated Shoulder Coil (DSC)			
	Mean Rank	Mean Rank	Z-score	p-value
SNR				
SNR_A	24.50	12.50	-3.417	<.001**
SNR_B	26.72	10.28	-4.683	<.001**
SNR_C	25.83	11.17	-4.176	<.001**

Note: Results above are values from Region of Interest (ROI) formatted as Mean Rank generated from Mann-Whitney U Test. Z-score and p-value were also calculated using Mann-Whitney U Test.
* p-value is significant at <0.05 level.
** p-value is significant at <0.001 level.

SNR_A = humerus bone, SNR_B = glenohumeral joint, SNR_C = supraspinatuss tendon.

Table VI: Contrast-to-noise ratio (CNR) of standard PDFS and PROPELLER PDFS sequences using small SFC

Image Quality	Small Flex Coil (SFC)			
	Standard PDFS	PROPELLER PDFS		
	Mean Rank	Mean Rank	Z-score	p-value
CNR				
CNR_{FT-FL}	13.67	23.33	-2.753	0.006*
CNR_{FT-TDN}	17.22	19.78	-0.728	0.467
CNR_{FT-BN}	25.33	11.67	-3.892	<0.001**
CNR_{FT-MS}	19.94	17.06	-0.823	0.411
CNR_{BN-FL}	11.06	25.94	-4.240	<0.001**
CNR_{BN-TDN}	10.94	26.06	-4.303	<0.001**
CNR_{BN-MS}	11.06	25.94	-4.240	<0.001**
CNR_{MS-FL}	12.94	24.06	-3.164	0.002*
CNR_{MS-TDN}	15.17	21.83	-1.898	0.0580

Note: Results above are values from Region of Interest (ROI) formatted as Mean Rank generated from Mann-Whitney U Test. Z-score and p-value were also calculated using Mann-Whitney U Test.
* p-value is significant at <0.05 level.
** p-value is significant at <0.001 level.

CNR_{FT-FL} = between fat-fluid, CNR_{FT-TDN} = between fat-tendon, CNR_{FT-BN} = between fat-bone, CNR_{FT-MS} = between fat-muscle, CNR_{BN-FL} = between bone-fluid, CNR_{BN-TDN} = between bone-tendon, CNR_{BN-MS} = between bone-muscle, CNR_{MS-FL}= between muscle-fluid and CNR_{MS-TDN}= between muscle-tendon.

Table VII: Contrast-to-noise ratio (CNR) of standard PDFS and PROPELLER PDFS sequences using DSC

Image Quality	Dedicated Shoulder Coil (DSC)			
	Standard PDFS	PROPELLER PDFS		
	Mean Rank	Mean Rank	Z-score	p-value
CNR				
CNR_{FT-FL}	11.39	25.61	-4.050	<0.001**
CNR_{FT-TDN}	13.50	23.50	-2.847	0.004*
CNR_{FT-BN}	26.39	10.61	-4.493	<0.001**
CNR_{FT-MS}	23.50	13.50	-2.848	0.004*
CNR_{BN-FL}	10.06	26.94	-4.809	<0.001**
CNR_{BN-TDN}	10.94	26.06	-4.303	<0.001**
CNR_{BN-MS}	9.94	27.06	-4.872	<0.001**
CNR_{MS-FL}	10.72	26.28	-4.429	<0.001**
CNR_{MS-TDN}	14.22	22.78	-2.436	0.014*

Note: Results above are values from Region of Interest (ROI) formatted as Mean Rank generated from Mann-Whitney U Test. Z-score and p-value were also calculated using Mann-Whitney U Test.
* p-value is significant at <0.05 level.
** p-value is significant at <0.001 level.

CNR_{FT-FL} = between fat-fluid, CNR_{FT-TDN} = between fat-tendon, CNR_{FT-BN} = between fat-bone, CNR_{FT-MS} = between fat-muscle, CNR_{BN-FL} = between bone-fluid, CNR_{BN-TDN} = between bone-tendon, CNR_{BN-MS} = between bone-muscle, CNR_{MS-FL}= between muscle-fluid and CNR_{MS-TDN}= between muscle-tendon.

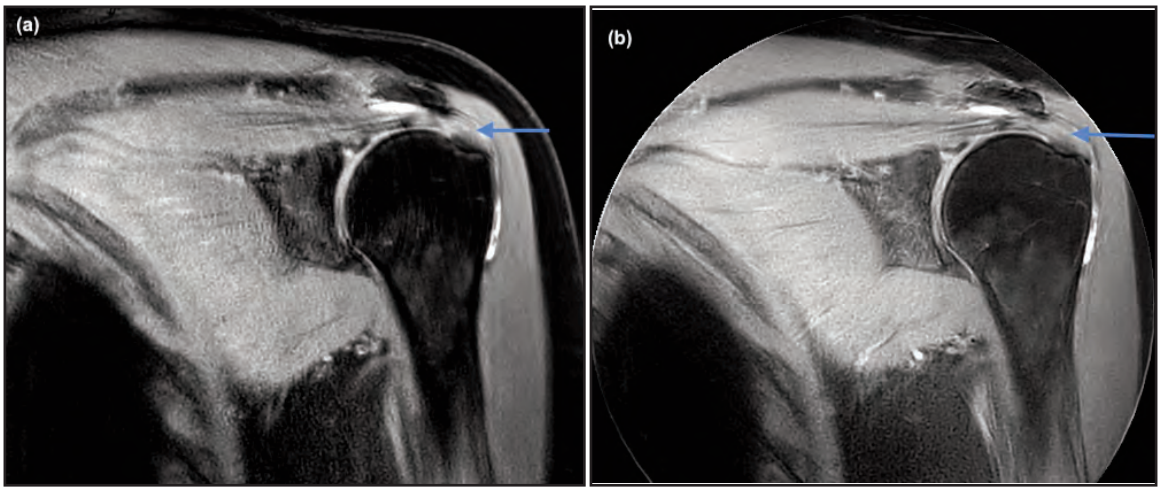

Fig. 1: Shoulder MR images os standard coronal oblique with motion artifact (a: blue arrow) and coronal oblique PROPELLER PDFS with reduction of motion artifact (b: blue arrow)

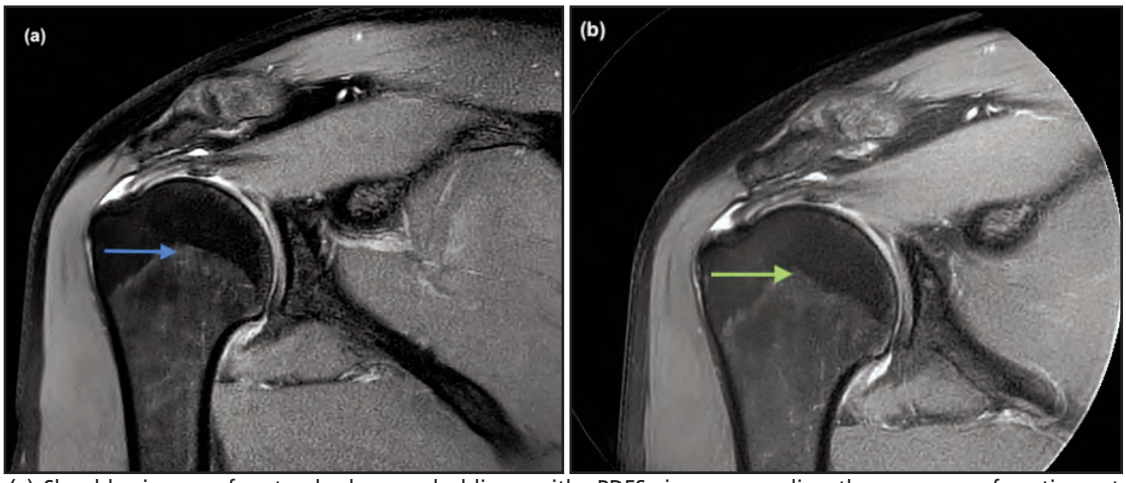

Fig. 2: (a) Shoulder image of a standard coronal oblique with PDFS image revealing the presence of motion artefact at the humeral bone (blue arrow). In contrast, (b) displays a coronal oblique PROPELLER PDFS image, which exhibits an artifact-free image with a clear depiction of the humeral bone (green arrow) and the suprespinatus tendon. Both images were acquired using a small flex coil (SFC)

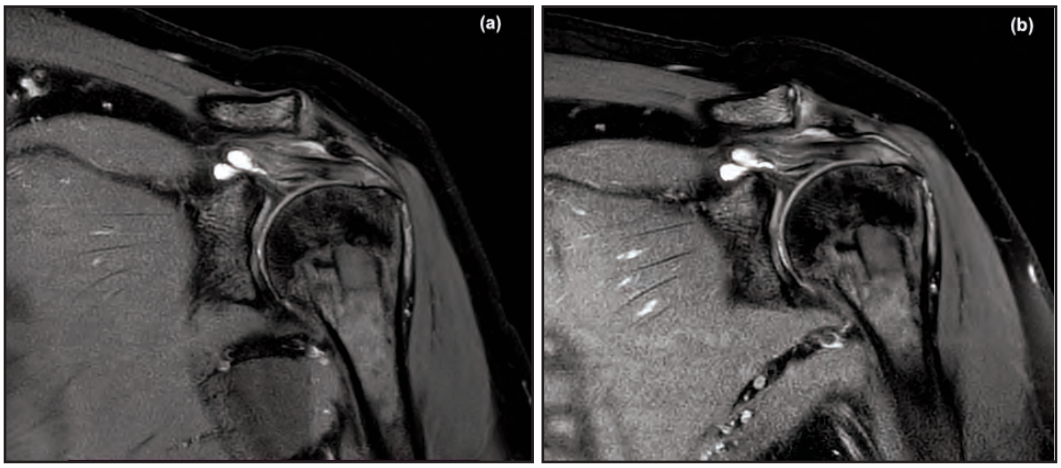

Fig. 3: (a) Standard coronal oblique PDFS image revealed cartilage with a tendon-like appearance. (b) Coronal oblique PROPELLER PDFS show a distinct contrast between cartilage and the surrounding bone, muscle, and soft tissue. Both images were acquired using a dedicated shoulder coil (DSC)

compared to standard coronal oblique PDFS pulse sequence ($p<0.05$) (Fig. 1-3 and Table III). Furthermore, the coronal oblique PROPELLER PDFS pulse sequence also significantly reduced both motion and pulsation artifacts when compared to standard coronal oblique PDFS ($p<0.05$) when scanned with DSC (Table IV).

Signal-to-noise Ratio (SNR) between Standard Coronal Oblique PDFS and Coronal Oblique PROPELLER PDFS by Using Various RF Coils

Signal-to-noise ratio (SNR) was measured from the humerus bone (SNR_A), glenohumeral joint (SNR_B), and supraspinatus tendon (SNR_C) using both sequences and coil types. The mean rank of the SNR of the standard coronal oblique PDFS pulse sequence was statistically significant compared to the coronal oblique PROPELLER PDFS pulse sequence when using both coil types ($p=0.034$ and $p<0.001$) (Table V).

Contrast-to-noise Ratio (CNR) between Standard Coronal Oblique PDFS and Coronal Oblique PROPELLER PDFS by Using Various RF Coils

Contrast-to-noise ratio (CNR) between standard coronal oblique PDFS pulse sequence and coronal oblique PROPELLER PDFS pulse sequence were measured from nine points; between fat-fluid (CNR_{FT-FL}), between fat-tendon (CNR_{FT-TDN}), between fat-bone (CNR_{FT-BN}), between fat-muscle (CNR_{FT-MS}), between bone-fluid (CNR_{BN-FL}), between bone-tendon (CNR_{BN-TDN}), between bone-muscle (CNR_{BN-MS}), between muscle-fluid (CNR_{MS-FL}) and between muscle-tendon (CNR_{MS-TDN}). The CNR of coronal oblique PROPELLER PDFS pulse sequence using SFC were statistically significant between fat-fluid ($p=0.006$), between bone-fluid, between bone-tendon, between bone-muscle ($p<0.001$, respectively) and between muscle-fluid ($p=0.002$). However, the CNR between fat-bone and fat-muscle was significantly higher in the standard PDFS pulse sequence (Table VI).

The CNR of the coronal oblique PROPELLER PDFS pulse sequence was statistically significant and had a higher mean rank than the standard coronal oblique PDFS pulse sequence when using DSC. Significant and higher mean ranks were found between fat-fluid ($p<0.001$), between fat-tendon ($p=0.004$), between bone-fluid, between bone-tendon, between bone-muscle, between muscle-fluid ($p<0.001$, respectively), and between muscle-tendon ($p=0.014$). Similar to the CNR measurement obtained from SFC, the CNR between fat-bone and fat-muscle was significantly higher when the standard PDFS pulse sequence was used with DSC (Table VII).

Inter-rater Reliability Kappa Test (IRR Kappa Test)

IRR Kappa test was run to determine if there was an agreement between two musculoskeletal (MSK) radiologists on image artifact reduction when scanned with standard PDFS and PROPELLER PDFS pulse sequences by using a small flex coil (SFC) and dedicated shoulder coil (DSC). There was moderate and fair agreement between radiologists in evaluating motion and pulsation artifact reduction from standard PDFS pulse sequence using small flex coil (SFC) with $\kappa=0.541$ and $\kappa=0.390$ respectively. While for the PROPELLER PDFS pulse sequence, there was perfect agreement between radiologists in evaluating motion artifact reduction with $\kappa=0.850$ and pulsation artifact reduction with $\kappa=0.866$ (Table III).

When scanned with standard PDFS pulse sequence using a dedicated shoulder coil (DSC), the inter-rater reliability for the raters was found to be a substantial and fair agreement in evaluating motion and pulsation artifact reduction with $\kappa=0.741$ and $\kappa=0.286$ respectively, and fair and moderate agreement of motion artifact reductions with $\kappa=0.224$ and pulsation artifact reduction with $\kappa=0.543$ when scanned with PROPELLER PDFS pulse sequence using DSC (Table IV).

DISCUSSION

PROPELLER significantly reduces motion and pulsation artifacts. These findings are consistent with those of studies by Dietrich et al.,[15] Lavdas et al.,[11] and Nagatomo et al.[16] PROPELLER is a robust motion correction technique that acquires k-space with multiple echo train length (ETL) that is rotated around the center of k-space like rotating bars or blades of readout that focuses on the region with the highest contrast and signal amplitude, the center of k-space.[19,20] Repetitive sampling and oversampling of the higher contrast/signal center of k-space compensate for translational and rotational motion artifacts by eliminating inconsistent data resulting from motion during the scan.[19-21] Artifact reduction was also accomplished by increasing the receiver bandwidth (rBw) and ETL parameters[11] in addition to the blade width and k-space coverage.[22] PROPELLER acquisition has been shown to significantly reduce or eliminate motion artifacts in a variety of clinical applications, including the shoulder,[15,16] bladder,[23] spine,[21] knee[24] and pulsatile flow artifacts in the brain and neck.[21] Propellers have been successfully applied to MRIs of the brain in uncooperative or paediatric patients and are also recommended for free breathing unsedated MRI in children.[19,25]

The quantitative analysis of the SNR sequences with different RF coils revealed that the standard coronal oblique PDFS were significantly superior to the coronal oblique PROPELLER PDFS. The repetitive, oversampling, and multishot nature of PROPELLER k-space filling enhances image quality, but not SNR. The SNR decreases when blades are combined to occupy the k-space because of the unequal distribution of data.[26] However, the SNR can be enhanced by acquiring data for a longer scanning time.[23,27] In PROPELLER, the number of blades acquired to traverse the entire k-space is approximately $N = \pi/2 \times M/ETL$ (M=matrix size); this is approximately a factor of $\pi/2$ longer than standard sequence.[27] In this study, the system-predetermined PROPELLER scanning duration was ten seconds longer than the standard sequence, which was insufficient to achieve a higher SNR than the standard sequence. Meanwhile, the quantitative analysis of the CNR revealed that PROPELLER was significantly superior to the standard sequence, consistent with the study by Forbes et al., CNR is enhanced because of the uniform distribution of echo time across the k-space.[26]

Higher CNR between fat-bone and fat-muscle in standard coronal oblique PDFS sequence was consistent with findings

from previous studies.[11,20,28] CNR is a difference between the SNR or signal intensity (SI) of adjacent regions or tissues. The image contrast primarily depends on intrinsic and extrinsic factors. The elements that influence SNR also control CNR. The increased CNR seen between the tissues in this study may be attributed to the SNR and distinctive tissue properties in conjunction with the use of the PROPELLER technique.[28,29] Furthermore, the noise distribution across the entire coil can be influenced by the type of coil, particularly when employing a new coil system and reconstruction techniques. This, in turn, can have an impact on the measurements of SNR and CNR.[30]

The inter-rater agreement for image artifact reduction on coronal oblique PROPELLER PDFS was found to be perfect when scanned using the SFC, whereas it was seen to be fair to moderate when scanned using the DSC. The image quality improved while utilising SFC due to the secure fitting of the coil to the region of interest, irrespective of the patient's body habitus. Moreover, the coronal oblique PROPELLER PDFS demonstrated superior inter-rater agreement in comparison to the standard coronal oblique PDFS. The findings suggest that the application of PROPELLER PDFS could potentially be beneficial in eliminating motion artefacts in clinical shoulder MRI.

Our study had some limitations. One limitation of this study was the limited size of the sample. The small sample size was mainly attributed to the study's inclusion criteria, which specifically focused on participants who had clinical diagnoses for traumatic shoulder injuries. Further research could encompass broader range of shoulder pathologies, such as tumours, infectious diseases, metabolic changes and movement disorder such as Parkinson's disease. A further limitation of this study was the utilisation of a dedicated shoulder coil in a patient with small habitus. The small body habitus caused the shoulder to not fit properly within the coil, resulting in a gap between the shoulder and the coil. The existence of the gap contributes to the degradation of the SNR, thus resulting in a reduction in the image's quality. It is recommended that in future research, appropriate measures should be taken to ensure that the patient's shoulder and body habitus are suitably immobilised within the coil. The absence of repetitive measurements was another limitation of this study. Each observer provided a single score for the image, and no subsequent measurements were conducted. Hence, intra-rater variability, a measure used to evaluate the degree of consistency demonstrated by a single observer across different time intervals, is therefore impossible to achieve

CONCLUSION

The utilization of the PROPELLER technique has the potential to effectively eliminate motion and pulsation artefacts in shoulder MRI when compared to the standard PDFS sequence. The total scanning time for the PROPELLER PDFS sequence in this study was 4 minutes and 35 seconds, ten seconds longer than for standard PDFS (4 minutes and 25 seconds), with this additional ten seconds mainly due to the k-space filling method. Furthermore, both SFC and DSC has been found to enhance the image quality when employing with coronal oblique PROPELLER technique. This technique has the potential to substitute the standard coronal oblique PDFS sequences of the MRI of the shoulder.

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CONFLICT OF INTEREST

The authors of this study declare that there are no conflicts of interest.

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ORIGINAL ARTICLE

Impact of heat stress on health-related symptoms and physiological changes among workers at a palm oil mill in Mukah, Sarawak, Malaysia

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ABSTRACT

Introduction: The palm oil (PO) industry is one of the most important sectors in the Malaysian economy. Workers at PO mills are, however, at risk for a number of health and safety issues, including heat stress, as the PO is one of the industries with high heat exposure. Heat stress occurs when a person's body cannot get rid of excess heat. Heat stress can result in heat cramps, heat exhaustion, heat rash, and heat stroke. It also results in physiological and psychological changes that can have an impact on a worker's performance. Therefore, this study aimed to evaluate the impact of heat stress on health-related symptoms and physiological changes among workers in a PO mill.

Materials and Methods: This cross-sectional study was conducted in a PO mill located in Mukah, Sarawak, Malaysia. Thirty-one workers from the four workstations (sterilizer, boiler, oil, and engine rooms) were selected as the respondents in this study. Wet Bulb Globe Thermometer was used in this study to measure the environmental temperature (WBGTin). Body core temperature (BCT), blood pressure (BP), and heart rate (HR) were recorded both before and after working in order to assess the physiological effects of heat stress on workers. A set of questionnaires were used to determine sociodemographic characteristics of the respondents and their symptoms related to heat stress. Data were then analyzed using SPSS Ver28.

Results: The WBGTin was found to be above the ACGIH threshold limit value of heat stress exposure in the engine room, sterilizer, and boiler workstations (>28.0°C). Additionally, there was a significant difference in the worker's BCT in these three workstations before and after work ($p<0.05$). Only the systolic BP and HR of those working at the boiler workstation showed significant difference between before and after work ($p<0.05$). The most typical symptoms that workers experience as a result of being exposed to heat at work include headache and fatigue. However, statistical analysis using Spearman Rho's test showed that there is no correlation between heat stress level with physiological changes and health-related symptoms among study respondents ($p>0.05$).

Conclusion: Results of the present study confirmed that workers in PO mill were exposed to high temperatures while at work. Although the evidence indicates the physiological parameters in general are not significantly affected while working, it also demonstrated that worker's body adapts and acclimates to the level of heat. Even so, precautions should still be taken to reduce future heat exposure. It is recommended that a physiological study be carried out that focuses on cognitive function impairment to support the evidence regarding the effects of heat stress on PO mill workers.

KEYWORDS:
Heat stress, health-related symptoms, palm oil mill, physiological changes

INTRODUCTION

The palm oil industry is one of the most important sectors in the Malaysian economy.[1,2] However, workers in palm oil mills (PO) are exposed to numerous health and safety hazards, including heat stress as PO is one of the main workplaces with high heat exposure often throughout the course of an 8-hour shift.[3] PO process involves the physical extraction of crude palm oil and palm kernel from fresh fruit bunches (FFB), where almost all the processes involve high temperatures.[3] There are nine workstations in PO; loading ramp, sterilization, kernel, press, production room, boiler room, oil room, engine room and workshop.[4,5] Previous studies found that the highest ambient working temperatures in PO were in sterilisation, boiler room, oil room, and engine room.[2] Those working in sterilisation workstation are required to perform tasks such as cleaning both the inside and outside of the steriliser. This steriliser (a pressure vessel) operates with saturated steam at temperatures of approximately 140°C and medium pressure at 45 psi. Additionally, they are responsible for managing the sterilizer's operational switches and installing packing on the sterilizer door. In contrast, workers in the boiler room are responsible for tasks such as removing stones from the boiler furnace, mixing fibers within the furnace, dislodging stuck fibers, and maintaining cleanliness in the station area. Furthermore, employees stationed in the oil room are tasked with cleaning the separator and purifier machines, in

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addition to keeping the station area tidy. Meanwhile, those assigned to the engine room are primarily responsible for operating the engines.[6,7] Therefore, this study was focused on heat exposure to the workers in these four stations.

Workers who work in hot environments or are exposed to extreme heat may be at risk of heat stress.[8] Heat stress occurs when a person's body cannot get rid of excess heat which will cause the body's core temperature and heart rate to increase. The person begins to lose attention and has problems focusing on a task while the body continues to retain heat. As a result, there is a reduction in work capacity, inefficiency, and risk of hazardous incidents.[9] They may also feel agitated or ill, and they frequently lose the desire to drink. If that person is not cooled down, the next stage is frequently fainting and, in extreme cases, death.[8] Heat stress not only causes heat rash, heat exhaustion, heat cramps and heat stroke, but also leads to psychological and physiological changes, which can affect workers' performance.[10] The physiological impacts of extreme temperatures, whether hot or cold, are intricately linked to the body's need to maintain its core temperature, ideally around 37°C (98.6°F). It's crucial to note that when the core temperature drops below 25°C (77°F) or rises to 45°C (113°F) or above, it can result in severe health consequences, including fatality.[11] Beyond the physical effects, there are also psychological considerations. Workers' perceptions of anxiety related to accidents and injuries, coupled with the potential for reduced concentration and increased frustration due to thermal stress, can significantly influence their cognitive well-being.[12,13]

According to International Labour Organization[14], while performing physical labor, exposure to a hot working environment or a combination of a hot working environment and high ambient humidity (80% or higher) can lead to a rapid increase in body temperature, potentially overwhelming the body's natural thermoregulation mechanisms. This situation poses serious risks, including the development of heat stress or even heat stroke, which can be fatal. Therefore, it is crucial to safeguard employee health and safety, as stated in the Occupational Health and Safety Act (1994), which states in section 15 that employers are obligated to take all necessary precautions for a worker's protection. This includes creating rules and procedures to guard against heat stress in workers who are exposed to high humidity, radiant heat sources, excessive air temperatures, direct physical contact with hot objects, or rigorous physical activity.[15] Hence, this study aimed to determine the level of heat stress, health-related symptoms, and physiological changes among workers in a selected palm oil mill in Mukah, Sarawak, as well as their association.

MATERIALS AND METHODS

Study Design and Setting

The data for this cross-sectional study was collected by measuring the environmental temperature at the workplace using Wet Bulb Globe Temperature (WBGT) (QUESTEMP °36 Thermal Environment Monitor, QUEST Technologies, USA).[3] Besides, the worker's heart rate (HR), blood pressure (BP), and body core temperature (BCT) had been measured for before and after 8 hours shifts using standard equipment. All instruments were calibrated before use for quality control.

The workers who participated in the study were given a set of questionnaires to obtain their demographic data, working information, and health-related symptoms due to heat exposure. Simple random sampling was used to recruit respondents for this study who met the following criteria: (i) were male, (ii) were at least 19 years old, (iii) had at least one year of work experience in PO mill, and (iv) worked in the boiler room, engine room, oil room, or sterilizer workstation. Those with history of high blood pressure and heat stroke were excluded from this study. There were 33 workers, of which 20 were in the boiler room, four in the engine room, five in the steriliser and four workers in the oil room. The sample size was calculated using the sample size formula. The sample size was calculated by keeping the margin of error at 5%, confidence interval at 95% and population size of 33. Based on the calculation, the sample size was 31.

To assess physiological changes due to heat exposure at workplace, worker's HR, BP and BCT were measured using Omron Healthcare Blood Pressure Monitor (Omron T3) and Instant Ear Thermometer (Omron MC510). Measurements were taken both before and after the eight hours of work. Personal information of workers, namely sociodemographic background, their risk factor history of heat exposure and other information relating to heat stress has also been collected in questionnaires. The questionnaire was adopted from previous study.[16]

Statistical Analysis

The Statistical Package for Social Sciences version 28 (SPSS ver28.0) was used to analyse all the data collected for this study. The frequency in percentage of sociodemographic data, occupational data, and health-related symptom data were calculated using descriptive analysis. Normalisation on data was performed before analysis. Paired sample t-test was conducted to analyse the physiological changes before and after 8 hours shifts.

Pearson correlation test was carried out to determine the association between heat stress level and physiological changes among workers while Spearman's Rho correlation test was carried out to determine the association between heat stress level and health-related symptoms among workers. A significance level (p-value) was set as 0.05 for all statistical analysis.

Ethics Approval and Informed Consent

Ethical approval was obtained from Ethics Committee of Universiti Teknologi MARA, Puncak Alam, Selangor (Ref. number: FERC/FSK/MR/2022/0237). Prior to the study, all respondents signed the consent form. Their identities were kept anonymous, and all the information are kept confidential by researchers.

RESULTS

Sociodemographic Characteristics of Study Respondents

The sociodemographic information of the study respondents

Table I: Sociodemographic characteristic of study respondents (n=31)

Characteristics	n	%
Age group (Years)		
19-28	11	35.5
29-38	14	45.1
39-48	6	19.4
Race		
Malay	4	12.9
Chinese	0	0
Indian	0	0
Others	27	87.1
Education Level		
Primary School	13	41.9
Secondary School	16	51.6
STPM/STAM/Diploma/Matriculation	2	6.5
Workstation		
Boiler	18	58.0
Oil room	2	6.5
Engine room	3	9.7
Steriliser	8	25.8
Duration of employment (Years)		
1-5	21	67.7
6-10	8	25.8
11-15	2	6.5

Table II: Exposure profile for heat stress at various workstation in PO mill

Workstation	WBGTin (°C)
Boiler	28.6
Oil room	27.7
Engine room	28.4
Sterilizer	28.6

Table III: Prevalence of health-related symptoms among PO mill workers

Workstation	Symptom	n	%
Boiler	Red rash on skin	2	11.1
	Muscle cramp	4	22.2
	Headache	9	50.0
	Weakness	2	11.1
	Fatigue	8	44.4
	Dizziness	5	27.8
	Irritability	2	11.1
	Hot and dry skin	3	16.7
	High body temperature	1	5.6
	Confusion	1	5.6
Engine room	Headache	1	33.3
	Fatigue	2	66.7
Oil room	Fatigue	1	50.0
	Hot and dry skin	1	50.0
	Confusion	1	50.0
Steriliser	Muscle cramp	1	12.5
	Headache	4	50.0
	Nausea	1	12.5
	Weakness	3	37.5
	Fatigue	4	50.0
	Dizziness	3	37.5
	Hot and dry skin	3	37.5
	High body temperature	1	12.5
	Confusion	2	25.0

Table IV: Comparison of BCT, BP and HR before and after work at different workstations

Work-station	Variables		p-value
	Before work	After work	
Boiler	BCT: 36.61±0.27°C	BCT: 36.96±0.13°C	<0.001*
	Systolic BP: 134.00±11.92 mm Hg	Systolic BP: 137.33±11.46 mm Hg	0.034*
	Diastolic BP: 78.61±7.00 mm Hg	Diastolic BP: 79.89±7.84 mm Hg	0.538
	HR: 74.94±11.61 bpm	HR: 82.11±16.0 bpm	0.016*
Oil room	BCT: 36.60±0.57°C	BCT: 36.70±0.71°C	0.500
	Systolic BP: 127.50±0.71 mm Hg	Systolic BP: 126.00±1.41 mm Hg	0.500
	Diastolic BP: 67.50±19.10 mm Hg	Diastolic BP: 68.00±15.56 mm Hg	0.874
	HR: 71.00±1.41 bpm	HR: 93.00±19.80 bpm	0.381
Engine room	BCT: 36.70±0.10°C	BCT: 37.00±0.00°C	0.035*
	Systolic BP: 130.67±6.51 mm Hg	Systolic BP: 131.33±6.35 mm Hg	0.742
	Diastolic BP: 76.00±3.61 mm Hg	Diastolic BP: 77.33±9.24 mm Hg	0.873
	HR: 74.00±6.56 bpm	HR: 79.33±6.35 bpm	0.067
Sterilizer	BCT: 35.95±0.53°C	BCT: 36.53±0.53°C	0.039*
	Systolic BP: 133.50±13.85 mm Hg	Systolic BP: 136.13±10.51 mm Hg	0.540
	Diastolic BP: 78.38±15.65 mm Hg	Diastolic BP: 74.50±12.32 mm Hg	0.263
	HR: 78.75±13.37 bpm	HR: 85.25±10.00 bpm	0.056

*p-value was significant at 0.05.

Table V: Correlation between heat stress level with physiological changes and health-related symptoms at different workstations

Work-station	Physio-logical variable	p-value[a]	Health-related symptoms	p-value[b]
Boiler	BCT	0.574	Red rash on skin	0.076
	Systolic BP	0.335	Muscle cramp	0.139
	Diastolic BP	0.498	Headache	0.441
	HR	0.893	Weakness	0.787
			Fatigue	0.765
			Dizziness	0.669
			Irritability	0.076
			Hot and dry skin	0.909
			High body temperature	0.100
			Confusion	1.000
Engine room	Systolic BP	0.031*	Headache	1.000
	Diastolic BP	0.698	Fatigue	0.333
	HR	0.031*		
Sterilizer	BCT	0.571	Muscle cramp	0.846
	Systolic BP	0.598	Headache	0.604
	Diastolic BP	0.501	Nausea	0.555
	HR	0.390	Weakness	0.334
			Fatigue	0.429
			Dizziness	0.200
			Hot and dry skin	0.689
			High body temperature	0.555
			Confusion	0.766

* Correlation is significant at the 0.05 level (2-tailed).
[a] Pearson correlation test
[b] Spearman correlation test

was summarized in Table I. Most of the respondents were between the ages of 29 and 38 (45.1%). Only 12.9% of respondents identify as Malay, with the remaining 87.1% belonging to other ethnic groups. In terms of education level, most of the respondents (51.6%) had finished their secondary school. Out of the 31 respondents, 58.0% work in the boiler room, followed by the sterilizer (25.8%), engine room (9.7%), and oil room (6.5%). Besides, most respondents (67.7%) had worked in the PO mill for between one and five years in terms of working experience.

Level of Heat Stress (WBGTin) and Health-Related Symptoms among Workers

The level of heat stress in each workstation was presented in Table II. Three out of four workstations (boiler, engine room and sterilizer) were found to be above the ACGIH threshold limit value of heat stress exposure (>28.0°C) for moderate metabolic workload level and 75% work, 25% rest regimen.

Table III summarised the prevalence of health-related symptoms due to heat exposure at different workstations. The three health-related symptoms that were most reported by those who were working in a boiler workstation were headache (50.0%), fatigue (44.4%), and dizziness (27.8%). Workers in the engine room, meanwhile, reported feeling fatigued (66.7%) and having headaches (33.3%) while working in the heat. Those who worked in the oil room reported feeling fatigued (50.0%), confused (50.0%), and having hot, dry skin (50.0%). On the other hand, most workers at the sterilizer workstation reported having

headaches (50.0%), fatigue (50.0%), weakness (37.5%), dizziness (37.5%), and hot and dry skin (37.5%).

Comparison of Body Core Temperature (BCT), Blood Pressure (BP) and Heart Rate (HR) Before and After Work at Different Workstations

Comparison of worker's BCT, BP, and HR before and after work are shown in Table IV. Statistical analysis using Paired t-test showed the workers' BCT, systolic blood pressure, and heart rate were significantly different before and after working at the boiler workstation ($p<0.05$). Besides, a statistically significant difference between BCT before and after work was seen among workers at the steriliser and engine room ($p<0.05$). Meanwhile there was no significant difference for physiological variables were found among workers in oil room.

Correlation between Heat Stress Level with Physiological Changes and Health-Related Symptoms at Different Workstations

Correlation between heat stress level with physiological changes and health-related symptoms at three different workstations (boiler, engine room, and sterilizer) are shown in Table V. Statistical analysis using correlation tests revealed that there was a correlation between heat stress level experienced by engine room workers with their systolic BP and HR ($p<0.05$). However, no association was found between heat stress level experienced by the workers with their health-related symptoms ($p>0.05$). Additionally, there was no correlation between the level of heat stress and physiological changes or health-related symptoms in individuals who worked at boiler and sterilizer workstations ($p>0.05$).

DISCUSSION

The present study investigated the possible impact of heat stress on health-related symptoms and physiological changes among workers at a PO mill in Mukah, Sarawak, Malaysia. Three out of four workstations were found to have WBGTin level that were higher than the permitted ACGIH Threshold Limit Value (TLV) limit of 28.0°C for a moderate metabolic workload level and 75% work with 25% rest time regime during the study period.[17] These results are similar with previous studies, which found that the level of WBGTin in the boiler, engine room, and sterilizer workstations in the PO mill exceeded the ACGIH permitted limit.[1,3,18] These indicate that individuals who work in these workstations are having heat stress. In addition, there was a significant different found of workers' BCT in these three workstations before and after work ($p<0.05$) which is consistent with the finding of the preceding study.[3,18]

Human body normally keeps its internal temperature around 37.0°C at a constant level, even when subjected to changing environmental temperatures, emotional state or level of physical activity.[3,19] However, being exposed to or working in a hot environment can stress the body.[17] The body tends to warm-up along with the surrounding environment. By pumping more blood to the skin and increasing sweat production, the body's internal "thermostat" maintains a consistent internal body temperature.[19] However, the body temperature starts to rise when the rate of "heat gain" is more than the rate of "heat loss" in an extremely hot environment, which can lead to heat illness.[17,19] Therefore, an increase in core body temperature is one of the best indicators of upcoming heat stress.[20]

In this study, workers' systolic BP and HR were also found to be significantly increase before and after work at boiler workstation ($p<0.05$). These results were consistent with the earlier studies, which revealed that all physiological variables increased following a work shift in the PO mill.[1,3,18] Since the blood has to carry oxygen to the working muscles, exposure to high heat stress may also put additional load on the blood circulation. In addition, blood also acts as a medium to carry heat from the body to the skin's surface. Therefore, the heart may have to work harder to pump more blood, which raises blood pressure.[21] These might explain the elevated HR and BP measurements that study respondents experienced after working.

Further statistical analysis proved that, except for workers' systolic BP and HR with heat stress level in engine room, there was no correlation between heat stress levels at different workstations with physiological changes or health-related symptoms ($p<0.05$). This indicates that workers had adapted to the high working temperature and the body had acclimatised to the level of heat, regardless of their heat exposure and metabolic load.[18] As demonstrated in this study, heart rate is another physiological variable that best demonstrates the impact of heat exposure. Although heart rate measurement after work at all workstations showed an increase, this increase is regarded as normal and previous suggested that the Malaysian workers have successfully adapted to the tropical climate and high temperature.[18]

In terms of health-related symptoms due to heat exposure, most of the workers experienced fatigue and headaches. These results are supported by an earlier study that identified fatigue and headaches as the most typical symptoms of heat stress.[22] This is probably happens due to workers who spend most of their time in non-air-conditioned indoor workplaces that have a greater risk of health-related symptoms even though they are not directly exposed to sunlight. All the workers experienced minor symptoms of heat illness. However, none of them ever experienced heat stroke while working in PO mill. Even so, PO mill management should encourage workers to take appropriate rest breaks and regularly drink plain water in the workplace to stay hydrated and keep normal core body temperature, heart rate and stroke volume throughout the working hours.[23]

CONCLUSION

Results of the present study indicate that the heat level in boiler, engine room and steriliser workstation exceed the ACGIH TLV limit suggested for moderate work category (75% work with 25% rest regime). Although the results of this study indicated that the PO mill's workers did not experience significant physiological changes or health-related symptoms due to heat exposure at work, continuous improvements to the workplace condition should be made to reduce the risk of heat stress among workers. Hence, it is advisable to enhance ventilation and airflow in both the boiler and engine rooms to mitigate heat accumulation. Effective ventilation not only

dissipates heat but also eliminates potentially harmful pollutants, such as gases and fumes generated during combustion processes in these areas. This contributes to improved indoor air quality, reducing the likelihood of workers inhaling hazardous substances. Regarding sterilization processes, optimization is recommended to minimize heat emissions. Elevated temperatures in the workplace can result in heat stress and related health concerns for employees, including symptoms like fatigue, dizziness, nausea, and, in severe cases, heat exhaustion or heatstroke. By reducing heat emissions, the risk of heat-related illnesses among workers can be significantly lowered. It is also recommended that future physiological study be carried out that focuses on cognitive function impairment to support the evidence regarding the effects of heat stress on PO mill workers.

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CONFLICT OF INTEREST

No conflict of interest.

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ORIGINAL ARTICLE

The level of knowledge and acceptance towards the COVID-19 vaccine among the community in Johor Bahru, Johor

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ABSTRACT

Introduction: Several necessary initiatives have been made to create a readily available vaccine against the Coronavirus Disease 2019 (COVID-19) worldwide pandemic. However, the vaccination program's success is dependent on the population's willingness as well as their knowledge of vaccination. Hence, the present study aimed to assess the level of knowledge and acceptance towards the COVID-19 vaccine among the community in Johor Bahru, Johor.

Materials and Methods: A cross-sectional study was conducted using an online survey between February and May 2022, with 423 respondents. The questionnaire consisted of socio-demographic, assessment of knowledge level and acceptance level towards COVID-19 vaccine. The descriptive analysis and non-parametric tests were employed to investigate the study outline objectives.

Results: Of all 423 participants, 293 (69.3%) of the participants had a high level of knowledge about the COVID-19 vaccine (median knowledge score 6; IQR = 3), and 239 (56.5%) were reported to have a low level of vaccine acceptance (median acceptance scores 4; IQR=2). The knowledge level towards the COVID-19 vaccine was significantly associated with the vaccine acceptance level (p<0.001).

Conclusion: The community's level of knowledge towards COVID-19 vaccine was high; however, the vaccine acceptance was low.

KEYWORDS:
COVID-19 vaccine, knowledge, acceptance, community

INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is the official name assigned for the infection caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which was formerly known as the 2019 novel coronavirus (2019-nCoV).[1] COVID-19 has evolved for four months from its initial appearance in China, and it has quickly spread to other countries worldwide, posing a global threat. COVID-19 was officially labelled a pandemic by the World Health Organization (WHO) on March 11, 2020, with over 118 000 verified cases and over 4000 deaths.[2] Considering the unexpected fast spreading of COVID-19 globally, vaccine development is also progressing quickly to curb the pandemic as vaccines have previously been found to be the most effective way to combat the quickly spreading of infectious diseases as seen in the eradication of smallpox and Ebola.[3] Vaccination can build herd immunity in communities, reducing the prevalence of the disease, preventing transmission, and diminishing the social and financial burden due to the disease. Furthermore, the pandemic can be effectively controlled, additional waves of infection can be avoided, and periodic outbreaks can be contained with very high vaccine uptake which eventually eradicates the disease.[4] The establishment of the National COVID-19 Immunisation Programme or also known as PICK was the Malaysian government initiative to administer the COVID-19 vaccine for free for Malaysian since February 2021. However, community acceptance towards the COVID-19 vaccine was poorly understood and has become a primary concern. Many factors influence people's decision to get vaccinated and one of the factors was their level of knowledge. Therefore, this study aimed to determine the level of knowledge and acceptance towards the COVID-19 vaccine among the community in Johor Bahru (JB) as JB is an urban city with the highest number of COVID-19 cases among districts in Johor as of 8 August 2021.[5] The findings may provide descriptive data that will assist the government and the Ministry of Health in developing effective strategies to increase vaccine uptake, which will eventually lead to herd immunity against COVID-19 in the JB community.

MATERIALS AND METHODS

Sample collection

A cross-sectional, online population web-based survey was conducted from February 2022 to May 2022. The community from JB were selected by using non-probability sampling which was convenience sampling method. Those who were voluntarily willing to participate in the study were recruited.

The inclusion criteria included participants must be aged 18 years old and above, must be born or lived in JB for at least 8 years and must be able to read and understand Malay or English languages plus, provide informed consent to participate in this study. Conversely, the exclusion criteria for this study included foreigners who stayed in JB or have permanent residence status and who were mentally or seriously ill at the time of the study. The target sample size was determined by using the same sample size in similar studies as claimed by Israel,[6] which was in a study by Gallè et

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al.,[7] the author was using a ±5% sampling error and a confidence level of 95%. The formula for the sample size is as follows:

$$n = \frac{(z^2\ pq)}{e^2}$$

Where,
n=sample size
z=1.96 (95% or 0.5) confidence level
p= 50% or 0.5 estimated prevalence
q=1-p
e=5% or 0.05 precision level

Hence,

$$n = \frac{1.96^2\ (0.5)\ (1-0.5)}{0.05^2}$$

$$n = \frac{3.8416(0.25)}{0.05^2}$$

$$n = \frac{0.9604}{0.05^2}$$

Therefore, a total of 423 participants were recruited in the target population after getting approval from The Ethics Committee, Faculty Research Ethics Committee (FREC), Universiti Teknologi Mara (UiTM). The questionnaire consisted of three sections which were collected and adapted from previous studies. The first section was adapted from[8,9] where the participants were required to complete their socio-demographic information (age, gender, marital status, occupation, monthly income in Ringgit Malaysia (RM), educational attainment, the existence of COVID-19 and lastly, risk perceived to be infected with COVID-19).

The second section comprised 15 questions related to participants' knowledge about the COVID-19 vaccine that was adapted from Gallè et al.[7] which included the components in the available COVID-19 vaccine, the doses needed, the effectiveness of the influenza vaccine, the functions of the COVID-19 vaccine (questions 4 to 8), the population needed to be vaccinated (questions 9 to 11), the effect of COVID-19 vaccines (questions 12 and 13), the importance of COVID-19 vaccination and lastly, the sources of information about COVID-19 vaccination. Participants were given multiple answers to choose for questions 1, 2, and 15 and "yes" or "no" response options to the remaining questions. One point was allocated if a correct response to a question was recorded while 0 points were allocated for an incorrect response.

Lastly, for the third section of the questionnaire participants were asked five questions related to acceptance towards the COVID-19 vaccine including their confidence and willingness to get vaccinated (questions 1 to 3), the effect after vaccination and lastly, the willingness to pay for the COVID-19 vaccine.[10] The participants were given simple "yes", "no", "I don't know" or "no opinion" response options to these questions and one point indicated a "yes" response while 0 points indicated for "no", I don't know", or "no opinion".

The questionnaire was completed online using Google Form, an online survey tool where it is a free service from Google and a shareable link will be generated[11] and then disseminated via researchers' personal networks, community leaders, and social media influencer between February 2022 and May 2022. Two main online platforms that were used in distributing this survey were WhatsApp and social media such as Twitter, Facebook, and Instagram.

Participation was voluntary and the participants were granted informed consent before answering the questionnaire.

Data Analysis
All analyses were performed by using software IBM Statistical Package for Social Sciences (SPSS) version 28.0 for Windows (IBM Corp., Armonk, NY, USA). For this study, histogram with normality curve and Kolmogorov-Smirnov test were conducted to check for the data normality. Since the data was skewed, non-parametric tests were utilized. Frequency, percentage, median and Interquartile Range (IQR) were performed in the descriptive analysis. The knowledge level was expressed as a total maximum point ranging from 0 to 11 while the acceptance level ranged from 0 to 5. The median and IQR were calculated for knowledge and acceptance scores.

In addition, Chi-Square analysis and Fisher-Freeman-Halton Exact Test analyses were used to evaluate the possible association between the demographic characteristics with the level of knowledge, and the level of acceptance. Besides, the relationship between the level of knowledge with the acceptance level was also assessed. In particular, the knowledge level was indicated as the number of correct answers lower than median value = 0 = poor, whereas equal or higher than median value = 1 = high, while the acceptance level was indicated as a score lower than median value = 0 = low, whereas equal or higher than median value = 1 = high. The significance level of $\alpha < 0.05$ was assumed.

Ethics Approval and Informed Consent
We obtained approval from the Ethics Committee, Faculty Research Ethics Committee (FREC), Universiti Teknologi Mara (UiTM), with approval reference number: FERC/FSK/MR/2021/0013.

RESULTS

Demographic Characteristics of Respondents
A total of 423 responses were received during the survey period. Table I summarises their demographic characteristics of the respondents. More than half of the respondents (270, 63.8%) were among those aged 18 to 29 years old while those aged 60 years and above were the minority (11, 2.6%). Two-thirds of the respondents were female (280, 66.2%) and majority of them were single (303, 71.6%). The respondents were from different occupational sectors, including students (140, 33.1%), services (53, 12.5%), education (47, 11.1%), and others (46, 10.9%). The remaining occupations such as medical and health (31, 7.3%), management and administrative (28, 6.6%), unemployed (28, 6.6%), construction (18, 4.3%), pensioner (12, 2.8%), security and defence (11, 2.6%), and industrial and manufacturing (9, 2.1%) contributed to the minority of the group.

Table I: Socio-demographic characteristics among the participants (N = 423)

Socio-demographic characteristics	n	(%)
Age (year)		
18-29	270	63.8
30-39	67	15.8
40-49	45	10.6
50-59	30	7.1
≥60	11	2.6
Gender		
Male	143	33.8
Female	280	66.2
Marital status		
Single	303	71.6
Married	105	24.8
Divorced	8	1.9
Widow/Widower	7	1.7
Occupation		
Medical & Health	31	7.3
Education	47	11.1
Security & Defence	11	2.6
Industrial & Manufacturing	9	2.1
Construction	18	4.3
Management & Administrative	28	6.6
Services	53	12.5
Student	140	33.1
Pensioner	12	2.8
Unemployed	28	6.6
Others	46	10.9
Monthly income (RM)		
<1200	171	40.4
1201–4000	167	39.5
4001–8000	34	8.0
>8000	51	12.1
Educational attainment		
Junior/senior school graduated	128	30.3
Diploma graduated	122	28.8
University graduated/post-graduated	173	40.9
Have heard about COVID-19?		
Yes	423	100.0
No	0	0.0
Perceived risk to be infected with COVID-19 (%)		
0	39	9.2
10–20	118	27.9
30–40	119	28.1
50–60	83	19.6
>60	64	15.1

Overall, almost half of the respondents (171, 40.4%) were among those with the lowest income in the group of <RM1200, followed by RM1201–4000 (167, 39.5%), >RM8000 (51, 12.1%), and RM4001–8000 (34, 8.0%). All the respondents had heard about COVID-19 and almost half of them (173, 40.9%) were university- or post-graduated, followed by junior- or senior school-graduated (128, 30.3%), and diploma-graduated (122, 28.8%). A few of the participants (39, 9.2%) believed that they had a 0% risk to be infected with SARS-CoV-2 while 237 (56%) of the respondents were convinced that they had a moderate risk of being infected in the category of 10–20% and 30–40%. Only 64 (15.1%) of them were deemed to have more than 60% of risk being infected with COVID-19.

Knowledge About the COVID-19 Vaccine among the Re-spondents
With the accessibility of the COVID-19 vaccines, 302 participants (71.4%) did not know that the vaccine contained the genetic information to produce the viral antigen spike, however, approximately 308 (72.8%) acknowledge the two doses that had to be administered to them. Overall, approximately 229 (54.1%) accurately answered that the influenza vaccine cannot prevent COVID-19, and almost 70% correctly answered that the COVID-19 vaccines were effective in protecting them, and do not act upon human deoxyribonucleic acid (DNA) modification. Plus, 331 (78.3%) participants believed that the COVID-19 vaccine may reduce COVID-19 symptoms. Conversely, more than half (215, 50.8%) of the participants believe that the COVID-19 vaccines cause the disease and those who had been vaccinated do not need other prevention measures, such as facial masks (246, 58.2%). Next, 281 (66.4%) agreed that not only health personnel and the elderly should be administered the COVID-19 vaccines but, 298 (70.4%) believed that herd immunity will be achieved through the immunization of these latter populations.

Table II: The association between demographic variables and knowledge level towards the COVID-19 vaccine among the respondents (N = 423)

Variables	Knowledge Level		χ2 Statistic(df)	p-value
	High n (%)	Low n (%)		
Age (year)			25.26(4)	< 0.001[a]
18–29	208 (77.0)	62 (23.0)		
30–39	35(52.2)	32 (47.8)		
40–49	26 (57.8)	19 (42.2)		
50–59	20 (66.7)	10 (33.3)		
≥60	4 (36.4)	7 (63.6)		
Gender			8.45(1)	0.004[a]
Male	86 (60.1)	57 (39.9)		
Female	207 (73.9)	73 (26.1)		
Marital status			14.80b	0.001[b]
Single	225 (74.3)	78 (25.7)		
Married	61 (58.1)	44 (41.9)		
Divorced	5(62.5)	3(37.5)		
Widow/Widower	2(28.6)	5(71.4)		
Occupation			21.39(10)	0.019[a]
Medical & Health	19 (61.3)	12 (38.7)		
Education	36 (76.6)	11 (23.4)		
Security & Defence	4(36.4)	7(63.6)		
Industrial & Manufacturing	5(55.6)	4(44.4)		
Construction	11 (61.1)	7(38.9)		
Management & Administrative	22 (78.6)	6(21.4)		
Services	33(62.3)	20(37.7)		
Student	98(70.0)	42(30.0)		
Pensioner	5(41.7)	7(58.3)		
Unemployed	21(75.0)	7(25.0)		
Others	39(84.8)	7(15.2)		
Monthly income (RM)			2.20(3)	0.533[a]
<1200	121(70.8)	50(29.2)		
1201–4000	116(69.5)	51(30.5)		
4001–8000	25(73.5)	9(26.5)		
>8000	31(60.8)	20(39.2)		
Educational attainment			14.67(2)	< 0.001[a]
Junior/senior school graduated	76(59.4)	52(40.6)		
Diploma graduated	80(65.6)	42(34.4)		
University graduated/post-graduated	137(79.2)	36(20.8)		
Perceived risk to be infected with COVID-19 (%)			28.07(4)	< 0.001[a]
0	36(92.3)	3(7.7)		
10–20	65(55.1)	53(44.9)		
30–40	94(79.0)	25(21.0)		
50–60	52(62.7)	31(37.3)		
>60	46(71.9)	18(28.1)		

[a] Pearson Chi-Square
[b] Fisher-Freeman-Halton Exact Test
Significant at p-value < 0.05 are indicated in bold

Finally, most of the participants (354, 83.7%) agreed that all the Johor Bahru populations need to be vaccinated and 256 (60.5%) thought that the COVID-19 vaccines were compulsory to protect against COVID-19 infection. The median of correct answers for the survey participants was 6 (IQR = 3), and this made up to 293 (69.3%) of the respondents have high knowledge about the COVID-19 vaccine while the remaining of respondents had low knowledge as shown in Fig.1. Half of the respondents (223, 52.7%) reckoned that the COVID-19 vaccines might cause some health problems yet, 293 (69.3%) considered that the vaccination did not negatively impact their privacy. Social media was reported as the main source of the information with a percentage of 43.5% followed by healthcare personnel (26.5%), mass media (22.9%), and YouTube or similar web channel (7.1%).

Association between the Level of Knowledge and the Level of Acceptance Towards COVID-19 Vaccine

Table IV shows the significant association between knowledge level and acceptance level towards the COVID-19 vaccine. The relation between these variables was statistically significant, χ^2 (1, N = 423) = 31.62, p<0.001.

DISCUSSION

The COVID-19 pandemic is continuously ravaging the people's health and livelihoods as well as the social and global economic situation,[12] prompting the rapid development of vaccines. However, a previous study reported that the vaccine acceptance was dependent on the level of knowledge about the COVID-19 vaccine.[13] A cross-sectional study was conducted using an online questionnaire between

Table III: The association between the demographic factors and the acceptance level towards the COVID-19 vaccine among the respondents (N = 423)

Variables	Acceptance Level		χ2 Statistic(df)	p-value
	High n (%)	Low n (%)		
Age (year)			10.768(4)	0.029[a]
18 – 29	164(60.7)	106(39.3)		
30 – 39	32(47.8)	35(52.2)		
40 – 49	25(55.6)	20(44.4)		
50 – 59	16(53.3)	14(46.7)		
60 and above	2(18.2)	9(81.8)		
Gender			0.27(1)	0.869[a]
Male	80(55.9)	63(44.1)		
Female	159(56.8)	121(43.2)		
Marital status			10.62[b]	0.011[b]
Single	182(60.1)	121(39.9)		
Married	54(51.4)	51(48.6)		
Divorced	2(25.0)	6(75.0)		
Widow/Widower	1(14.3)	6(85.7)		
Occupation			17.52(10)	0.064[a]
Medical & Health	14(45.2)	17(54.8)		
Education	31(66.0)	16(34.0)		
Security & Defence	7(63.6)	4(36.4)		
Industrial & Manufacturing	5(55.6)	4(44.4)		
Construction	11(61.1)	7(38.9)		
Management & Administrative	16(57.1)	12(42.9)		
Services	27(50.9)	26(49.1)		
Student	91(65.0)	49(35.0)		
Pensioner	3(25.0)	9(75.0)		
Unemployed	11(39.3)	17(60.7)		
Others	23(50.0)	23(50.0)		
Monthly income (RM)			6.27(3)	0.099[a]
0 – 1200	99(57.9)	72(42.1)		
1201 – 4000	91(54.5)	76(45.5)		
4001 – 8000	25(73.5)	9(26.5)		
More than 8000	24(47.1)	27(52.9)		
Educational attainment			31.56(2)	< 0.001[a]
Junior/senior school graduated	47(36.7)	81(63.3)		
Diploma graduated	73(59.8)	49(40.2)		
University graduated/post-graduated	119(68.8)	54(31.2)		
Perceived risk to be infected with COVID-19 (%)			9.15(4)	0.057[a]
0	23(59.0)	16(41.0)		
10 – 20	65(55.1)	53(44.9)		
30 – 40	76(63.9)	43(36.1)		
50 – 60	36(43.4)	47(56.6)		
More than 60	39(60.9)	25(39.1)		

[a] Pearson Chi-Square
[b] Fisher-Freeman-Halton Exact Test
Significant at p-value < 0.05 are indicated in bold

Table IV: The associationbetween the knowledge level and the acceptance level towards COVID-19 vaccine among the respondents (N = 423)

Variables	Acceptance Level		χ2 Statistic(df)	p-value
	Low n (%)	High n (%)		
Knowledge Level			31.62(1)	< 0.001
Low	83(63.8)	47(36.2)		
High	101(34.5)	192(65.5)		

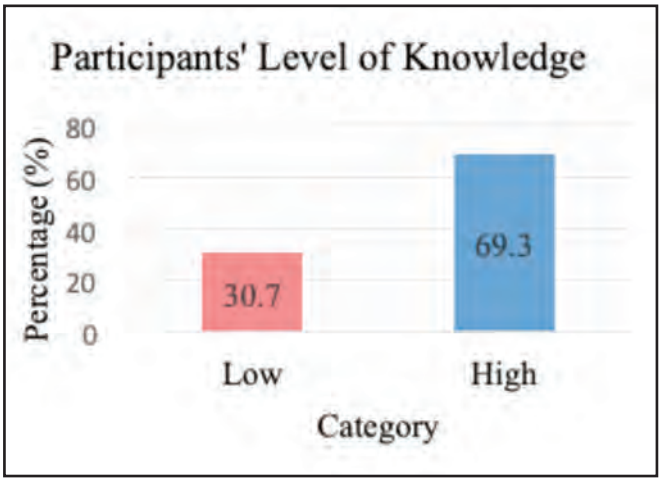

Fig. 1: Participants' Level of Knowledge About COVID-19 Vaccine

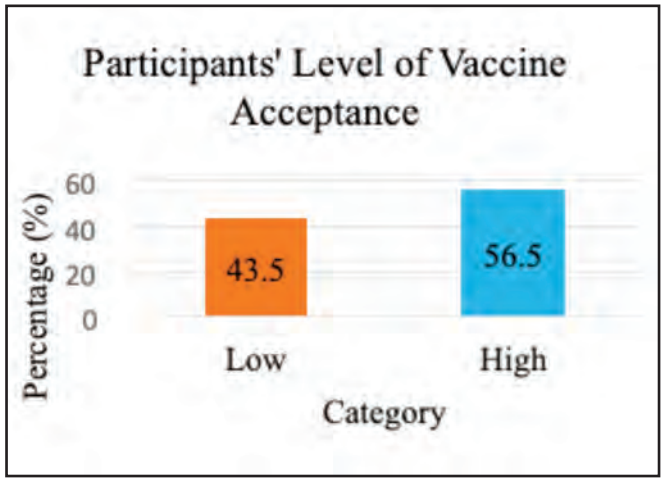

Fig. 2: Participants' Level of Acceptance Towards COVID-19 Vaccine

February and May 2022, with 423 respondents. This current study aimed to determine the level of knowledge and acceptance towards the COVID-19 vaccine among the community in JB, Johor.

In measuring the level of knowledge about the COVID-19 vaccine, this study revealed that 293 (69.3%) respondents had high knowledge about the COVID-19 vaccine which is in line with previous studies in Bangladesh (70.5% and 84.0%) respectively.[14,15] However, different findings were reported in an earlier study among the Malaysians revealed that more than half of the respondents (62.0%) had inadequate knowledge of the COVID-19 vaccine.[16] The high level of knowledge about the COVID-19 vaccine among the JB population could be attributed to the current issue that is being discussed among the community as a major issue, making more people aware of it.

In addition, Johor Bahru is an urban city hence, news and published articles about COVID-19 vaccines have been circulating easily on social media which may have contributed to the higher level of knowledge among the community. Only a few respondents acquired the information via mass media. This might be due to social media has been gaining more popularity than traditional mass media. Due to that, the mass media is now adjusting to fit into social media platforms as verified health information disseminated in social media provides quick and essential knowledge.[17] Oppositely, an overabundance of information about the COVID-19 vaccine and pandemic can cause misinformation and spread fake news.[18] which might contribute to the 30.7% of the respondents that have low knowledge about the COVID-19 vaccine.

Surprisingly, findings also revealed that 239 (56.5%) of the respondents were willing to be vaccinated against SARS-CoV-2 which the vaccine acceptance rate from this study is considerably low but, higher than previous studies from Palestine (55.1%), and from Pakistan (53.0%).[19,20] Conversely, the acceptance rate is quite higher in the United Kingdom (UK) (64.0%),[21] and in Malaysia (83.3%).[9] The disparate findings might cause by the current study conducted when the vaccine was first rolled out and there was negative feedback about the side effects of one of the available vaccines in JB, particularly the AstraZeneca vaccine,[22] which contributed to the lower vaccine acceptance. Besides, the weaknesses of healthcare administration to encourage the COVID-19 vaccination among the community in JB might be one of the key attributes to the lower vaccine coverage, albeit 290 (68.6%) believed that the COVID-19 vaccines were effective against the SARS-CoV-2.

Moreover, this study demonstrated that there is a significant relationship and correlation between the knowledge level and the acceptance level towards COVID-19 vaccines. Even though the relationship is weak as stated in a previous study,[23] the level of knowledge might influence the people's decision to get vaccinated as the level of vaccine acceptance might increase if the level of knowledge increases. These findings are aligned with recent studies[14] and in Bangladesh.[15] Other studies also support that the vaccine acceptance level is affected by the knowledge level about the COVID-19 vaccine.[24,25]

Additionally, this research also found that the higher knowledge level was significantly related to socio-demographic characteristics, in particular, age, gender, marital status, occupation, education level and perceived risk to be infected with COVID-19, except for monthly income as shown in Table III. This finding is similar to the previous study by Gallè et al.,[7] among undergraduate students in Italy. In contrast, only higher education level and higher income were significantly associated among Malaysians.[16] This discrepancy may be due to different periods when the survey was disseminated and different population samples. Nevertheless, the previous studies showed that the higher knowledge level among the population might be due to higher education level which increases the level of knowledge. However, individuals with higher educational level also shown a higher likelihood of COVID-19 vaccine reluctance, and this issue needs to be given greater attention. Besides, the findings also revealed that lower age group,

marital status, and higher education level were significantly related to acceptance rate. These findings were almost similar to the previous study among Malaysian by Syed Alwi et al.,[9] who also agreed that lower age and marital status were significantly associated with vaccine acceptance except for education level. Conversely, Mohamed et al.,[16] reported that higher education level was significantly related to the intention to get vaccinated. The difference between the current study and the previous studies might be due to diverse socio-demographic characteristics among the participants in the study. Although different characteristics of socio-demographic might contribute to the COVID-19 vaccine uptake, it is noted that higher or lower education might influence the acceptance rate.

On the other hand, previous findings unveiled that vaccine acceptance highly depends on the vaccine's effectiveness as published in previous studies by Harapan et al.,[8] in Indonesia, and Elhadi et al.,[26] in Libya. The contrary between the current finding and these findings might be due to the different objectives and methodology of the studies. Plus, the availability of the current vaccines that had been purchased and rolled out in their respective countries and the availability of the health service infrastructure may be the potential cause. Nonetheless, prior research among Malaysian parents found that lack of information affected their choice regarding Human papillomavirus (HPV) vaccination for their children.[27] The prior study in Malaysia confirmed that the lack of information regarding the vaccine was due to poor knowledge about the vaccine which consequently influenced vaccine acceptance. Also, Abebe et al.,[13] agree that the acceptance of the COVID-19 vaccine is highly related to people's knowledge about the COVID-19 vaccine.

This study can motivate different organizations by providing accurate information regarding the COVID-19 vaccine using appropriate techniques thus, resulting in a greater awareness of the vaccine as well as an increase in community vaccine acceptance. Nevertheless, this current study has some limitations. One of the main limitations is the distribution of the participants might not reflect the actual population since the internet-savvy young adults made up the majority of responders, eventually subject to participation bias. Further study should include participants from diverse backgrounds and locations. Since the COVID-19 vaccines are made available and the vaccination coverage is now a primary concern for the country to achieve herd immunity, continuous health education should be given to promote comprehension and dispel any misunderstandings or false information regarding the vaccine which eventually increases the knowledge level as well as the vaccine coverage.

CONCLUSION

The community's level of knowledge was high; however the vaccine acceptance was low, Furthermore, the level of knowledge about the COVID-19 vaccine was positively related to the level of acceptance of the COVID-19 vaccine. Although the community's knowledge about the COVID-19 vaccine was high, a collaborative effort between the government and various organizations should be planned to increase the community's confidence and acceptance of the COVID-19 vaccine. Different organizations, particularly policymakers and the media, should act against irresponsible individuals who may spread rumours about the COVID-19 vaccine, leading to misinformation and lowering public acceptance of the vaccine.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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ORIGINAL ARTICLE

Psychosocial assessment of quarantine (sign-on and sign-off) among oil and gas workers in Malaysia during COVID-19 outbreak

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ABSTRACT

Introduction: COVID-19 still wreaking havoc in Malaysia, with 3,221,680 cases and 32,326 deaths as of 20 February 2022. In the Oil and Gas industry, implementing quarantine before mobilising to or after mobilising from onshore and offshore locations was mandatory to help stop the spread of the virus. However, previous studies have shown that quarantine can significantly impact public mental health. This study intends to assess the psychosocial stress experienced by Oil and Gas industry employees during periods of quarantine in various regions (PMA: Terengganu, SBA: Sabah, SKA: Sarawak) and between onshore and offshore employees. Additionally, it aims to identify the factors that are linked to psychosocial stress in this workforce.

Materials and Methods: A cross-sectional study involving 86 respondents was conducted using an online survey between the middle of March and April 2022. The Perceived Stress Scale (PSS) developed by Cohen et al., (1983) was used to assess the stress levels of individuals. Data analysis was carried out using the SPSS statistical program, which included descriptive statistics, Mann-Whitney, Kruskal Wallis and Linear Regression tests.

Results: The majority of respondents, 75.6% (n=65) reported moderate stress levels, while 14.0% (n=12) declared severe stress levels. The Mann-Whitney test showed no significant difference in psychosocial stress scores among workers between onshore and offshore (χ^2=-0.523, p=0.601), whereas the Kruskal Wallis test showed a significant difference in psychosocial stress scores among workers between states (PMA, SKA, and SBA) (χ^2=6.415, p=0.040). According to the regression test, workers with medical histories of diabetes and Covid-19 (R2=0.158) (p<0.005) are two factors linked to psychosocial stress.

Conclusion: The study found that there were significant differences in psychosocial stress among oil and gas workers between SKA, SBA, and PMA due to quarantine activity. Mobile workers and those with certain medical histories were identified as being particularly vulnerable to psychosocial stress. However, it was noted that the overall improvement in the quarantine period had a positive impact on the mental health of these workers.

KEYWORDS:
Psychosocial assessment, mental health awareness, oil and gas industry, pandemic, COVID-19

INTRODUCTION

On 25th January 2020, the first case of novel coronavirus was identified in Malaysia a few days after the reported case of a cluster in Wuhan, China.[1] As the number of verified cases rose to 673 on 17th March 2020, Malaysia reported its first two coronavirus deaths. The novel coronavirus or COVID-19 has continuously hit Malaysia and almost reach as Spanish Flu in 1918, which killed 34,644 people.[2] The COVID-19 pandemic has become Malaysia's biggest infectious illness outbreak, infecting over three million individuals.[3] Due to the continuous mutating and spread of the COVID-19 variants (such as Omicron, Deltatron, etc), Malaysia has decided to delay the transition from the pandemic into the endemic phase.

Under the Occupational Safety and Health Act 1994 (OSHA1994), it is the general duties of the employer to provide a safe workplace for its employees.[4] Therefore, all sectors, especially essential services continue to play role in maintaining the Standard Operating Procedure (SOP) at the workplace throughout this pandemic. Oil and gas workers in Malaysia are mandated to adhere to COVID-19 preventive measures enforced by their respective companies such as PETRONAS, ExxonMobil, and others. These preventive measures are subject to different guidelines from various authorities such as the Local Authority (PBT), State Health Department, State Disaster Committee, and District Health Office.

The guidelines will be varied at different entry points. This different preventive measure shall align with Annex 9: Management of COVID-19 at Point of Entry imposed by the Ministry of Health (MOH) and the Malaysian National Security Council (MNSC) to further break the COVID-19 chain. Among a few SOPs implemented, isolation or quarantine is the main important step to control infectious disease as stated in section 15(1)(2) of OSHA1994. Oil and gas companies in Malaysia have made quarantine requirements before and after sign-on for both onshore and offshore projects mandatory. This was due to the risk of

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COVID-19 clusters among workers, as exemplified by the Galaxy Cluster in Bintulu.[5] The cluster involved oil and gas workers who were mobilised by a supply vessel, resulting in a total of 125 persons being affected. To prevent similar incidents from occurring and causing losses to the company, workers were required to quarantine before departing (sign-on) and after leaving (sign-off) the platform. In the event of a COVID-19 outbreak, affected workers will be treated at designated facilities, such as the Bintulu Hospital and the district's COVID-19 Low-Risk Quarantine and Treatment Center (PKRC). However, it has been recognised that quarantine before sign-on and after sign-off for mobile Oil and Gas workers could lead to more psychosocial stress.[6]

In Malaysia, quarantine periods for onshore and offshore varies due to their location, with the offshore quarantine period being longer compared to onshore. Moreover, quarantine periods for PMA (Terengganu), SKA (Sarawak), and SBA (Sabah) are varied due to their different state government and regulatory bodies. Terengganu was under the jurisdiction of the State Health Department of Terengganu (SHDT), whereas Sarawak and Sabah were overseen by their respective State Disaster Management Committee (SDMC).

Psychosocial stress experienced during a disease outbreak may encompass concerns about contagion, feelings of isolation, and challenges in interpersonal relationships.[7-8] These health-related fears and social isolation, triggered by the situation, could lead to social exclusion. Such exclusion might impact specific health conditions, such as elevated cortisol levels, especially in individuals with high sensitivity.[9]

There is a belief that quarantine during COVID-19 outbreak could affect the psychosocial well-being of employees in the Malaysian oil and gas sector. Hence, this research was commenced to evaluate the degree of psychosocial stress encountered by workers during quarantine in the Oil and Gas industry. The study aimed to analyze stress levels across various states (PMA, SKA, and SBA) and distinguish between onshore and offshore stations. Moreover, the research aimed to pinpoint the factors associated with psychosocial stress among individuals in this sector.

MATERIALS AND METHODS

Questionnaire Instrument

The questionnaire form was used as an instrument to collect data on the psychosocial study. It is a valid and more reliable tool especially for accessing sociodemographic, economic, and health issues.[10] The questionnaire used in this study was adapted from previous studies[11-14] and divided into four sections. In Section 1, the sociodemographic data of respondents were collected including age, education level, marital status, annual income, primary residence, job position, work-based location, and working experience. For Sections 2 and 3, the medical history of respondents and quarantine experience details were recorded. Lastly for Section 4, mental health status was recorded through the PSS-10. PSS-10[14] is a 10-item survey used in screening for psychosocial depression. The PSS helped to measure respondents' perceptions of how unexpected, unmanaged and overburdened their lives were. The scale also includes several direct inquiries concerning present levels of perceived stress. The PSS showed adequate reliability and was linked with assessments of life events, mental symptomatology, and physical symptomatology.[15] The approval for the questionnaire distributed was obtained from UiTM Research Ethics Committee with Reference Number FERC/FSK/MR/2022/0166. Throughout the research, information confidentiality and respondent anonymity were maintained.

Sample Method

A cross-sectional study, utilizing the convenience sampling method, was conducted for a group of people who were readily available for research. This study focused on a population of oil and gas workers engaged in quarantine activities during the pandemic, encompassing the PMA, SKA and SBA, each with an estimated mobile workforce of approximately 1,000 individuals, spanning both onshore terminals and offshore platforms. The sample size was determined using a conservative response distribution of 80%, a margin of error of 5%, and a confidence level of 95%. According to Raosoft calculator (which is available free at: http://www.raosoft.com/samplesize.html), we calculated that the recommended sample size for a minimum population of 3,000 mobile oil and gas workers was determined to be 228.

Formula:

$$\text{Response rate} = \frac{\text{Number of Respondents}}{\text{Number of Sample}} \times 100\%$$

Response rate = 118/228x 100%

= 51.75 %

The response rate for this study was 51.75%, which was good for specific mobile population considering the survey's time constraints and other restrictions, such as the need to avoid physical contact and maintain anonymity. Moreover, this response rate was in line with response rates from comprehensive reviews of mental health surveys, which exhibited significant variation among different nations, ranging from a low of 7.0% in Australia to a high of 79.3% in Mexico.[16] Additionally, the most recent study, which examined the average response rate across 20 research projects focusing on online questionnaire responses from individuals with anxiety disorders or depression, yielded a mere 42.8%.[17]

Sample Collection

Data collection was carried out between the middle of March 2022 and April 2022. The questionnaire was disseminated through Facebook, WhatsApp, and other social media platforms in google form format daily for one and a half month because the oil and gas quarantine centres operated regardless of weekdays and weekends. A total of 118 respondents from the oil and gas industry completed the questionnaire, and their responses were validated to ensure that they all complied with the criteria stated as follows; oil and gas workers who undergo quarantine/ self-isolation at

Table I: Demographic background and quarantine details of respondents (n=86)

Characteristics	n	%
Demographic		
Age (years old)		
<25	5	5.8
25-30	30	34.9
31-40	35	40.7
41-50	10	11.6
>50	6	7.0
Education level		
SPM / Vocational / Training Certificate	28	32.6
Diploma / College certificate	30	34.9
Bachelor's Degree	25	29.0
Master's Degree	3	3.5
Marital Status		
Single	27	31.4
Married without children	9	10.5
Married with children	50	58.1
Annual Income		
<RM36,000	20	23.2
RM36–72 thousand	39	44.2
RM72–120 thousand	17	19.8
RM120–180 thousand	3	3.5
>RM180 thousand	7	9.3
Primary Residence		
Terengganu	34	8.1
Sarawak	14	31.4
Sabah	29	33.7
KL/Selangor	9	17.5
Others	37	9.3
Job Position		
Technical (Rigger/Technician/Electrician)	36	43.0
Engineering (Engineer/Senior Engineer)	23	25.6
Management (Supervisor/Manager)	6	7.0
Others (Operator, planner, etc.)	21	24.4
Working experience (years)		
<5	24	27.9
5-10	31	36.0
10-20	27	31.4
20-30	3	3.5
>30	1	1.2
Quarantine details		
Purpose of quarantine		
Sign-On	66	76.7
Sign-Off	4	4.7
Positive case	16	18.6
Quarantine location		
OTC	34	39.5
Self-sponsored hotel	36	41.9
Home	16	18.6
No. of days quarantine for this mob		
<3 days	19	22.1
4–7 days	53	61.6
8 – 10 days	10	11.6
More than 10 days	4	4.7
Longest quarantine you have ever spent		
Less than 7 days	6	7.0
7 – 14 days	37	43.0
14 – 21 days	26	30.2
More than 21 days	17	19.8

Table II: Comparison of the psychosocial stress scores for station (onshore and offshore) (n=86)

	Onshore (n=17) Median (IQR)	Offshore (n=69) Median (IQR)	C^2	*p*[a]
Psychosocial stress scores	20.00 (13.00)	20.00 (5.00)	-0.523	0.601

a Mann-Whitney test

Table III: Comparison of the psychosocial stress scores for between states (n=86)

	PMA (n=27) Median (IQR)	SKA (n=24) Median (IQR)	SBA (n=35) Median (IQR)	C^2	*p*[a]
Psychosocial stress scores	18.00 (7.00)	20.00 (9.00)	20.00 (5.00)	6.415	0.040*

a Kruskal Wallis test; * p < 0.05, (statistically significant) (n=86); Post Hoc with pairwise comparisons: Group PMA vs Group SBA: adj p=1.000; Group PMA vs Group SKA: adj p=0.039; Group SBA vs Group SKA: adj p=0.222

Table IV: Association medical history with psychosocial stress (n=86)

Variable	B(95% CI)	SE	t-stat	p^a
Diabetes	16.711	5.388	3.101	0.003*
High blood pressure	2.568	2.188	1.174	0.244
Positive COVID-19	2.766	1.237	2.236	0.028*
Others	5.211	2.796	1.864	0.066

a Simple linear regression; * p < 0.05, (statistically significant) (n = 86); R^2=0.158

PMA, SBA and SKA during the pandemic phase of COVID-19 and aged between 20 to 60 years old. Missing data and irrelevant data in all the variables were removed using the row deletion method.

Statistical Analysis

First of all, the scoring for each PSS-10 question was calculated with a scale of 0 (Never) – 4 (Every often) except the reverse score for Q4, Q5, Q7, and Q8 (0=4, 1=3, 2=2, 3=1, 4=0). Based on total data scoring for the PSS questionnaire, the level of psychosocial stress was determined accordingly for each respondent. The total score was computed and categorized into three categories: 1] Low (scores between 0 to 13), 2] Moderate (scores between 14 to 26), and 3] High (scores between 27 to 40).

All respondents' socio-demographic information, medical and health history, quarantine periods, and level of psychosocial stress were analysed using Statistical Packages for Social Sciences (SPSS) statistic software version 27. SPSS offers data analysis for descriptive and bivariate statistics, numerical result forecasts, and predictions for classifying groups. The descriptive statistic (mean, standard deviation, frequency, and percentage) and inferential statistics (correlation and regression) were used to summarise and describe the result for each objective.

The second objectives were analysed using advanced statistical analyses and non-parametric tests; the Mann-Whitney test and Kruskal-Wallis Test, since the sample size for one group was less than 30. If the sample size was small and the data does not meet the assumption of normality, the standard deviation calculated may be less reliable. Both tests were used to compare the medians of two groups and the medians of three groups respectively. For these non-parametric tests, median and interquartile range (IQR) were presented instead of mean and standard deviation for result presentation and conclusion.

Lastly, the details of the respondents, such as their status as mobile workers, medical histories, and quarantine period, were further analysed to determine the factors associated with the level of psychosocial stress. Linear regression was conducted to identify factors associated with psychosocial stress.

RESULTS

Reliability Test

The Cronbach's Alpha reliability scores obtained for the point of view (POV) and PSS-10 were 0.705 and 0.852 respectively. The reliability values obtained were acceptable if greater than 0.7, based on the statistical analysis performed on the result of the questionnaire. Therefore, the elements in the question about quarantine among Oil and Gas industry workers can be used for data collection and analysis for this psychology study.

Demographic Characteristics of Respondents

The demographic background of respondents and details of their quarantine were categorised into several groups based on their responses utilising a straightforward frequency data analysis (Table I and II).

In summary, the demographic background of this study revealed that most of the respondents were married with children (58.1%), age range from 31-40 years old (40.7%) and majority have diploma qualification (34.9%). The Oil and Gas workers participating in this study were from the technical level (Rigger/Technician/Electrician) (43.0%),

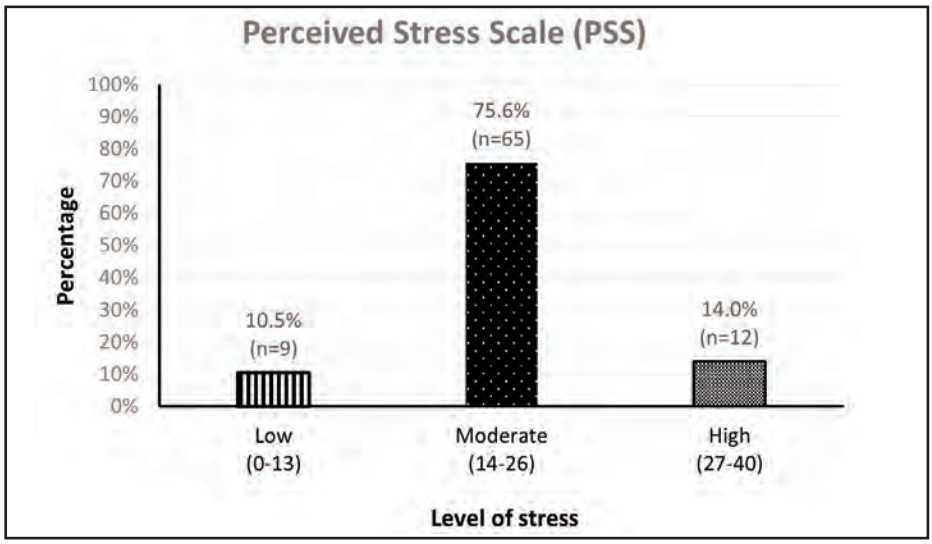

Fig. 1: The level of Perceived Stress Scale (PSS) among respondents

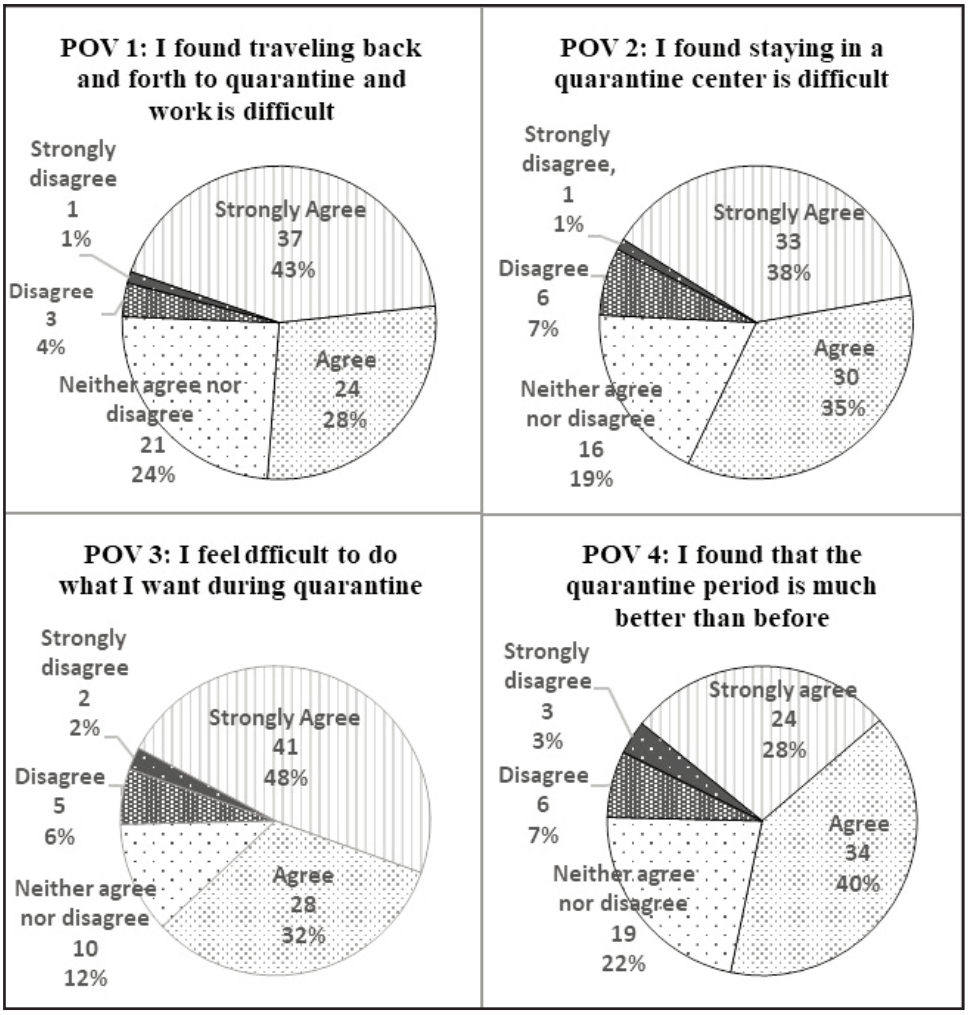

Fig. 2: The Point of View (POV) of the respondent about quarantine (n=86)

engineering level (Engineer/Senior Engineer) (25.0%), management level (Supervisor/Manager) (7.0%) and others (operator, planners, etc.) (24.4%) with average working experience 5-10 years (36.0%) and annual income range between RM36,000 and RM72,000 (44.2%).

Based on quarantine details from Table I, a total of 66 of the respondents (76.7%) were quarantined before signing on to work, followed by 16 positive cases (18.6%) and only four respondents (4.7%) being quarantined after signing off from work. The majority of them were quarantined at a hotel with 39.5% (n=34) at OTC and 41.9% (n=36) at other self-sponsored hotels, leaving 18.6% (n=16) undergoing self-quarantined at home. As moved toward the endemic phase, the quarantine period showed a reduced trend as the majority of them 61.6% (n=53) were quarantined for 4-7 days only.

Psychosocial stress among Oil & Gas workers in Malaysia during quarantine

The psychosocial stress experienced by oil and gas workers in PMA, SKA, and SBA during quarantine is described in Figure 1 The majority of respondents (75.6%) reported feeling a moderate amount of stress, while a smaller proportion (10.5%) reported a low level of stress. However, 12 respondents reported severe levels of stress (14.0%) overall.

Comparison of Psychosocial Stress Due to Quarantine between Onshore and Offshore

The PSS score between onshore (n=17) and offshore (n=69) workers were compared using Mann-Whitney Test (Table II). The Mann-Whitney test showed no significant difference in psychosocial stress scores among workers between onshore and offshore (χ^2=-0.523, p=0.601).

Comparison of Psychosocial Stress due to Quarantine between PMA, SA and SBA

The PSS score between PMA, SKA, and SBA were compared using Kruskal-Wallis Test (Table III). The Kruskal Wallis test showed that there was a significant difference in psychosocial stress scores among workers between the three locations (χ^2 = 6.415, p=0.040). Workers in SKA (median=20.00, IQR 9.00) had significantly higher psychosocial stress scores compared to those in PMA (median=18.56, IQR=7.00, adj p=0.039) by pairwise comparisons. However, there were no significant differences in psychosocial stress scores between workers in PMA and SBA, and between SBA and SKA (adj p>0.05).

Factors Associated with Psychosocial Stress among Oil and Gas Workers during Quarantine

Table IV summarised the association between medical history and psychosocial stress. It was found that diabetes and positive COVID-19 were significantly associated with psychological stress (p<0.05).

According to the POVs demonstrated in Figure 2, it shows that about half of the respondents strongly agreed or agreed with the statement 'I found traveling back and forth to quarantine and work is difficult' (70.9%, n=61). Conversely, about 24.4% (n=21) of respondents neither agreed nor disagreed, and only 4.7% (n=4) of them disagreed or strongly disagreed with the statement. In addition, most of the respondents strongly agreed or agreed that staying in a quarantine centre was difficult (73.3%, n=63) and found it challenging to do activities during quarantine (80.3%, n=69).

Despite all the above difficulties during the quarantine, the majority of the respondents expressed a positive view regarding the improvement of the quarantine period. Around 66.2% of the respondents found that the quarantine period was much better than before, while only 10.5% disagreed or strongly disagreed with this statement. This indicates that most oil and gas workers are aware that the quarantine period has become shorter compared to an earlier outbreak in Malaysia. This improvement towards the Endemic phase has resulted in oil and gas workers experiencing less significant depression than before.

DISCUSSION

As we move toward the endemic phase, the quarantine period has shown a reducing trend, as the majority of workers, 61.6% (n=53) were only quarantined for 4-7 days. This indicates a reduction in the enforcement of quarantine by authorities at PMA, SKA, and SBA. Based on the normal distribution of stress scores among respondents, the majority of participants (75.6%) reported feeling a moderate amount of stress. These results are consistent with research on how people react to trauma (such as earthquakes, fires, and floods), which demonstrates that most people can handle stress but a sizable minority is more likely to develop the psychology of stress.[18] Similarly, the corresponding data reported moderate depression, anxiety, and stress scores (73.2%, 66.5%, and 82.9%, respectively) among the oil and gas workers in Malaysia during the pandemic.[19]

There was no significant difference in psychosocial stress scores between onshore and offshore workers. This may be attributed to the short shift rotations and the fact that majority of respondents (76.7%, n=66) were quarantined at the same onshore quarantine centre before mobilisation. However, if shift rotations were longer and assessments were conducted while working offshore, stress levels may be higher.[20] Another contributing factor is that both onshore and offshore quarantine facilities are handled by the same organisation before mobilisation and demobilisation. This consistent management of quarantine across facilities may have contributed to a lack of noticeable differences in stress levels among workers.[6]

In addition, there was no significant difference in psychosocial stress scores between workers in PMA and SBA and between workers in SBA and SKA (p>0.05). This finding was correlated with the bi-weekly COVID-19 Situation Report Malaysia, which highlighted there was the highest increase in new cases in Sarawak (+79.0%) compared to Terengganu (+22.6%) and a decrease in cases in Sabah (-72,9%).[21] Moreover, the stress levels in these three locations were comparable regardless of whether workers were onshore or offshore due to differences in authorities' management, which vary by state. Terengganu was under the jurisdiction of the State Health Department of Terengganu (SHDT), whereas Sarawak and Sabah were overseen by their respective State Disaster Management Committee (SDMC). Due to the

increase in cases, the Sarawak Disaster Management Committee has drawn more focus toward persons under surveillance and charged compound notices to errant individuals for failing to follow SOPs.

Furthermore, the association between psychosocial stress and medical histories was consistent with recent studies on the psychosocial impact of COVID-19 conducted in Spain and Italy.[22-23] High blood pressure (29.0%), chronic respiratory disease (25.3%), and to a lesser extent, diabetes (8.3%) were the top three health-related factors linked to psychosocial stress.[22] As expected, a history of stressful events and health issues was associated with higher levels of depression and anxiety, whereas having an infected acquaintance was linked to higher levels of depression and stress.[23] Based on a study in China, individuals with pre-existing medical conditions, particularly those with chronic respiratory disease, were at higher risk of experiencing psychological stress during the pandemic.[24] In addition, those with a positive family history of diabetes, severe diabetes, or a specific type of diabetes treatment experienced additional diabetes-related stress even before being quarantined.[25-27]

Despite these challenges, the majority of respondents expressed satisfaction with the improved quarantine period, with 66.2% (n=57) reporting that it is much better than before. Only a small proportion of respondents disagreed or strongly disagreed with this sentiment (10.5%, n=9). This suggests that oil and gas workers are aware that the quarantine period is now shorter than during an earlier outbreak in Malaysia, and this improvement towards the endemic phase has helped to reduce significantly the level of depression experienced by these workers.

Resilience, which refers to the capacity to adapt to stressors and cope positively with adversity, can foster positive adjustment and development even in challenging circumstances. In the context of the COVID-19 pandemic, this study examined the resilience of oil and gas workers in response to preventive measures taken toward the end of the pandemic phase. It has been shown in previous research that individuals with high levels of resilience tend to experience better mental health and psychosocial well-being.[28-30]

CONCLUSION

In conclusion, our study found that there were differences in psychosocial stress among oil and gas workers in SKA, SBA, and PMA related to quarantine activities. However, only a small proportion of respondents (14.0%, n=12) reported experiencing severe psychosocial stress during the pandemic's final stages. Our analysis showed medical history was a significant predictor of psychosocial stress among oil and gas workers during quarantine, regardless of their sociodemographic background. The POVs finding suggests the improvement in quarantine towards the endemic phase.

The limitation of this study is lie in the scope of data collection and analysis, which were constrained by the timing of the COVID-19 outbreak. The survey was conducted only during the final stages of the pandemic and the constantly shifting regulations toward the endemic phase, resulting in a restricted understanding of stress patterns. The time constraints were beyond the researcher's control, and unless the research had been conducted earlier, a more comprehensive and nuanced depiction of the changes in stress levels before and after the pandemic phases could have been achieved. Nonetheless, this study provides valuable insights into the impact of COVID-19 on psychosocial stress, given the available data and resources.

ACKNOWLEDGEMENTS

We would like to express our gratitude to all the respondents from the Oil and Gas industry, particularly the workers in PMA, SBA, and SKA who participated in this research during the pandemic's final stages. This research did not receive any form of external funding and was carried out solely with the resources available to the research.

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ORIGINAL ARTICLE

A case study on the source apportionment of indoor air quality (IAQ) at a kindergarten in eastern Peninsular Malaysia using cluster analysis

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ABSTRACT

Background: Indoor air quality is an important concern for kindergartener because young children are more vulnerable to the effects of poor air quality. Poor indoor air quality can cause respiratory problems and other health issues, which can negatively affect a child's ability to learn and grow. Aim of this study is to determine the trend and status of indoor air pollutants in study areas by using descriptive statistics and cluster analysis.

Materials and Methods: Air temperature (T), relative humidity (RH), air movement (AM), carbon dioxide (CO2), formaldehyde (HCHO), and particulate matter (PM) are the monitored parameters. Monitoring was carried out in the kindergarten for three consecutive days starting from 8.00am to 12.00pm.

Results: Indoor carbon dioxide readings were higher at 0800 when parents drove to kindergarten to drop off their children without turning off the engine. In addition to this, the PM10 reading at 1000 was high but still within the standard range according to ICOP-IAQ 2010.

Conclusion: The findings highlight the importance of indoor air quality improvement measures for kindergarten buildings which can be used to improve indoor air quality in kindergarten environments.

KEYWORDS:
Indoor air quality, pollutants, kindergarten, cluster analysis

INTRODUCTION

Indoor air quality (IAQ) is crucial aspect of children's health and well-being, especially in a kindergarten setting where children spend a considerable amount of time indoors. Poor IAQ can have adverse effects on children's health causing respiratory problem, allergies, and other health issues. Therefore, it is crucial to maintain good IAQ in kindergarten setting to ensure children's safety and health. There are several factors that can affect the IAQ in kindergarten settings, including ventilation, humidity, and presence of pollutants such as mould, dust, and volatile organic compounds (VOCs). Poor ventilation can lead to the accumulation of pollutants which can adversely affect the IAQ. Additionally, high temperature and humidity levels can also contribute to poor IAQ by promoting the growth of mould and other harmful microorganism.

Excessive ranges of indoor air pollutants in kindergarten surroundings can have negative impacts on children's learning performance and increase the possibility of absenteeism due to breathing troubles.[1] Most activities that take part indoors are distinguished by complex chemical components in air quality. Indoor classrooms are a vital setting for young children to learn. Several studies have found that classrooms have high concentrations of these substances, which can be harmful to human health.[2,3] For example, carbon dioxide has been linked to headaches and sleepiness and the exposure to particulate matter can lead to respiratory problems such as asthma. Children are more susceptible to these pollutants than adults because their lungs are still developing, and they breathe more easily than adults.[3]

Children typically spend most of their time in the microenvironment of home and school. There is credible scientific evidence that spending time indoors can increase the likelihood of various respiratory illnesses caused by indoor air pollutant exposure, particularly in children.[4] Exposure to air pollution constitutes children are more likely to have asthma and other respiratory symptoms, even when they are exposed to low levels. Studies have been conducted over the last decade to examine indoor air quality in school settings in different regions.[5,6] The following pollutants were measured in the indoor air of kindergarten and day-care centres: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone, carbon monoxide (CO) and carbon dioxide (CO_2), volatile organic compounds (VOC), bioaerosols, particulate matters smaller than 10 (PM10) or 2.5 ($PM_{2.5}$) microns, polycyclic aromatic hydrocarbons (PAHs), and few heavy metals including mercury.

To ensure that young children receive the best possible care, it is crucial to pay attention to the quality of their indoor environment.[7]

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Kindergarten buildings are the second most common indoor environment after home regarding chemical exposure. Since children spend most of their day indoors, it is crucial to evaluate the adverse health effects of indoor pollutants on kids. According to Reda et al.,[8] approximately 40% of $PM_{2.5}$ comes from outdoor sources, particularly from the combustion of fossil fuels used for heating and transport, and the remaining 60% comes from indoor activities. Indoor $PM_{2.5}$ sources, such as cooking, are often a problem in kindergartens. The most common problems are poor ventilation, infrequently cleaned surfaces in the room, and large numbers of children in a small space.

Kindergartens are locations where indoor air quality must be a key concern, as they are places where children spend an essential step for their development. When parents and guardians think about the school and classrooms, they expect them to be healthy and sustainable, maximising each child's learning potential. A truly effective classroom needs to be more than just a healthy environment; it must also have good indoor air quality.[9] Nowadays, the advantages of good indoor air quality in schools are recognised around the world. Good air quality inside a building lead to fewer absences, healthier occupants, and better learning environment. Studies show that students tend to get better grades and higher test scores when the temperature of their school is moderated.[10]

Mainka et al.,[11] stated that the carbon dioxide is not an indoor pollutant, but it can indicate a low level of ventilation. It has been correlated with decreased learning abilities by 5% and respiratory illnesses. Indoor air pollution from outdoors can also be an issue because pollutants like VOCs and PMs penetrate the building envelope. Materials such as paint and carpet act as sinks for emissions, taking up pollutants such as VOCs and PMs. These materials include fabric partitions and other fleecy materials in nursery schools, particularly those used by younger children during naptimes.[12]

The Department of Occupational Safety and Health (DOSH), Ministry of Human Resources in Malaysia developed an industry code of practice aimed at improving indoor air quality in 2010. This standard is applicable to any enclosed space served by a mechanical ventilation and air conditioning (MVAC) system, and those with air-cooled split systems. Maintaining a good IAQ is critical to health and wellbeing. Effective measures should be put in place to ensure that the IAQ is of the highest standard possible to protect children's health and enhance their learning and development.

MATERIALS AND METHODS

Study Location

The study was located at the Cahaya Elit Kindergarten (5.374221, 103.111613), Kuala Nerus, Terengganu. The location of the kindergarten is in a residential area closed to the roadside. It is considered a strategic place for performing the monitoring of indoor air quality since motor vehicles always passing by the point. This kindergarten operates from 7.00 am until 5.30 pm.

Data Collection and Management

The ICOP-IAQ, 2010 provides a general criterion for sampling campaign. This includes the following: 1) The placement must cause as little disturbance to work operations as possible inside the research area. 2) It must be located at least 0.5m away from partitions, walls, corners, other vertical surfaces, and windows. 3) Avoid standing directly in front of floor fans, induction units, or air supply diffusers.

The level of indoor air pollutants (IAP) in the kindergarten was determined by measuring the indoor air quality (IAQ). Assessment related to IAQ was referred to the Industry Code of Practice (ICOP) for IAQ (2010), which has been provided by the Department of Occupational Safety and Health (2010). In this study, there are two parameters involved and being measured, which are chemical and physical parameters, and carbon dioxide as an indicator of the indoor ventilation. The physical parameters measured are temperature (T), air movement (AM), and relative humidity (RH), and for chemical parameters, particulate matter with a diameter of less than 10µm (PM10), and formaldehyde. The monitoring was performed during the school day for three consecutive days for four hours, starting at 8.00 am and ending at 12.00 pm, with every five minutes of interval. Microsoft Excel version 28.0 (Microsoft 365 MSO version 2205) and Statistical Package for the Social Sciences (SPSS®) version 28.0 were used for data analysis.

Data Analysis

The descriptive statistics were conducted using SPSS Version 28.0 for all parameters. To summarise the main statistical parameters, the mean, standard limit, median, standard deviation, variance, kurtosis, skewness, and minimum and maximum indoor parameters for the selected kindergarten were evaluated. Descriptive research, on the other hand, is primarily concerned with describing the nature or condition as well as the details of the current situation. This method is used to describe the characteristics of the phenomenon as it exists at the time of the study as well as to investigate the cause(s) of a specific situation. This phenomenon in turn should be discussed or explained by means of data analysis gathered through objective forms of measurement.

Cluster analysis is a useful tool for this study because it helps find out where the pollutants in the air in a kindergarten come from. Cluster analysis is known as a technique for identifying and classifying objects in data sets (clusters). As a result, objects with the same information are grouped together, while the remaining are separate from one another. K-means, density-based clustering, and hierarchical methods are a few examples. Hierarchical agglomerative clustering analysis (HACA) is one of the clustering techniques used in air quality studies. The term "hierarchical" refers to clustering in which clusters are grouped from previously clustered clusters in each process. In the meantime, the word "agglomerative" stands for how the clusters combine until they form a single cluster containing all observations. The application of HACA is commonly used for identifying air pollution behaviour at air quality monitoring stations based on their locations.[13] A study by Dotsel et al.,[12] has been done by using bivariate k-means cluster analysis with the aim of

Table I: Descriptive statistics for indoor air pollutants

	TEMP (°C)	RH (%)	AM (m/s)	CO_2 (ppm)	HCHO (ppm)	PM_{10} (mg/m^3)
Mean	31.59	79.44	0.21	505.43	0.03	0.07
Standard Limit	23-26	40-70	0.15-0.50	C1000	0.1	0.15
Median	29.60	79.65	0.17	518.50	0.03	0.06
Standard Deviation	21.87	3.64	0.12	63.93	0.01	0.03
Variance	478.53	13.28	0.02	4087.07	0.00	0.01
Kurtosis	143.38	-0.87	3.81	-0.35	1.62	0.20
Skewness	11.96	-0.07	1.82	-0.54	-0.27	0.95
Minimum	28.10	72.10	0.08	372.00	0.01	0.03
Maximum	29.20	85.30	0.75	646.00	0.05	0.15

TEMP = Air Temperature; RH = Relative Humidity; AM = Air Movement; CO_2 = Carbon Dioxide, HCHO = Formaldehyde; PM10 = Particulate Matter; ppm = parts per million; m/s = metre per second; mg/m^3 = milligram per metre cube

recognising and obtaining the areas that have a high value of PM_{10}. The k-means clustering process involves clustering the data around k points chosen at random from the space represented by the objects being clustered into k groups to form initial group centroids. As a result, the six-cluster solution was discovered to record high concentration regions of PM_{10} that had previously been observed separately on the polar plot.

RESULTS

Trend and Status of Indoor Air Quality (IAQ)

Table I show the descriptive statistics for the indoor air pollutants parameters, which consists of the mean, median, variance, standard deviation, skewness, kurtosis, maximum, and minimum of the data in the kindergarten. Skewness ranges from -0.2680 to 11.9619 along with kurtosis that ranged from -0.3514 to 143.386. The data distribution that is normal must have skewness close to zero and kurtosis close to 3. Unfortunately, the data set from this study were distinct from the statement because of different activities such as the movement of the children in the kindergarten area. Thus, the data are non-parametric. Since the sample size is small (n=35), to determine the normality distribution, a Shapiro-Wilk test was carried out and it appeared that the distribution is not normally distributed due to the significant value (p-value) being less than 0.05 ($p<0.05$). There are many possibilities causing to an abnormality of the data like the number of people that wander around the kindergarten and activities that the children do from inside along with outside the kindergarten. This study involved 35 students in kindergarten and during the first session of the class, all children were gathered in one spot to do their activities.

Figure 1 shows the physical parameters of the IAQ including air temperature, relative humidity, and air movement. The highest temperature reading was at 9.00am. This is because all the children have already started gathering in the play area to start their activities which will be causing an elevated temperature due to their active movement while the main sliding door was closed. As the temperature increases, the relative humidity is low. The ability of air to retain water vapour is entirely dependent on its temperature. The ability to retain moisture increases or decreases as air temperature changes, affecting relative humidity, and the tendency of air to maintain water vapour is completely determined by temperature. The relative humidity-temperature relationship is inversely proportional because as temperature rises, the relative humidity decreases, making the air drier. Indirectly the reading of the air movement also shows an increment. Air movement plays a significant role to determine good ventilation for indoor air. Increased air movement can help to enhance thermal comfort while also providing a pleasant internal sensation.[14] Based on ICOP-IAQ 2010, the recommended indoor air temperature ranges from 23–26˚C, with 40-70% of relative humidity. Meanwhile, the air movement should be 0.15-0.50m/s maximum as stated in the ICOP-IAQ 2010.

At 10.00am, the PM_{10} reading was high but nonetheless, the reading is still within the standard limit according to ICOP-IAQ 2010. Just compared to the reading at other times, the reading at 10.00am was higher because the students were doing cleaning activities at the activity area before they went for recess. Since the kindergarten is near to the road, PM10 may be caused by adjacent traffic. The next pollutant that was monitored is formaldehyde, the reading for formaldehyde does not exceed the standard limit. The highest reading was recorded at 0.0275ppm at 8.00am and the readings went down to 0.0255ppm at 9.00am and the reading rose to 0.0263ppm at 10.00am.

Factor Analysis of IAP

Cluster analysis (CA) is a collection of multivariate techniques that are frequently used to gather objects into groups with a similar number of classes or clusters, just hence the objects in different clusters are distinct from one another. CA greatly increases case correlation in each cluster while trying to minimise dissimilarity between previously unknown groups.[15] A dendrogram known as a tree diagram, which shows the measured similarity or distance between any two variables, illustrates the classifications of objects in CA.[16] CA was used to analyse the variables of indoor air quality pollutants from 8.00am to 12.00pm, with an average linkage between groups. Six variables were collected and applied to HACA. The illustrated dendrogram as shown in Figure 3 demonstrated the variables that took place during the monitoring. From 8.00am to 9.00am, the reading for CO2 concentration was higher than the rest of the hours and variables. The mean and median of CO2 concentration were 505.43ppm and 518.50ppm, respectively. Nonetheless, both reading does not exceed the standard limit based on ICOP-IAQ 2010. With HACA, the variables of Cluster 1 (C1) are the mean and median for temperature and relative humidity

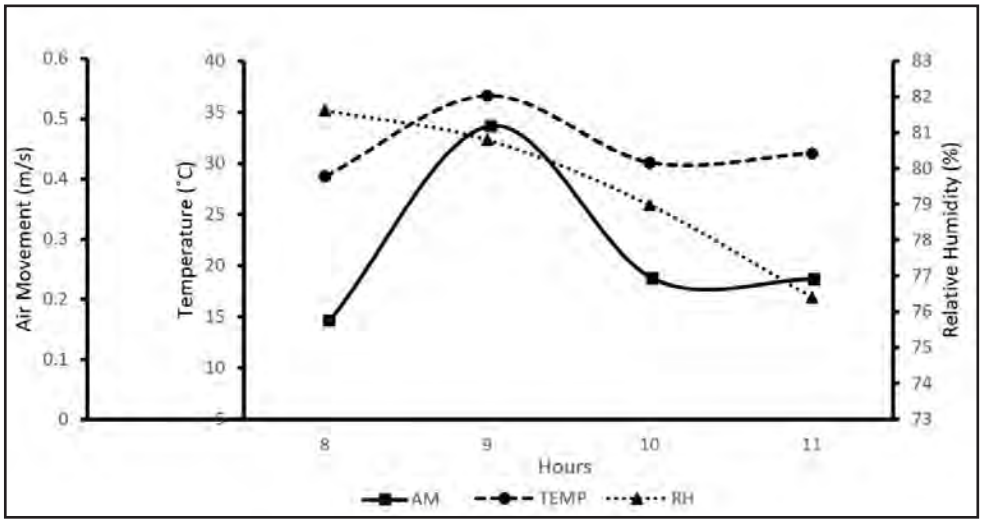

Fig. 1: Physical parameters of air movement (AM), temperature (TEMP), and relative humidity (RH)

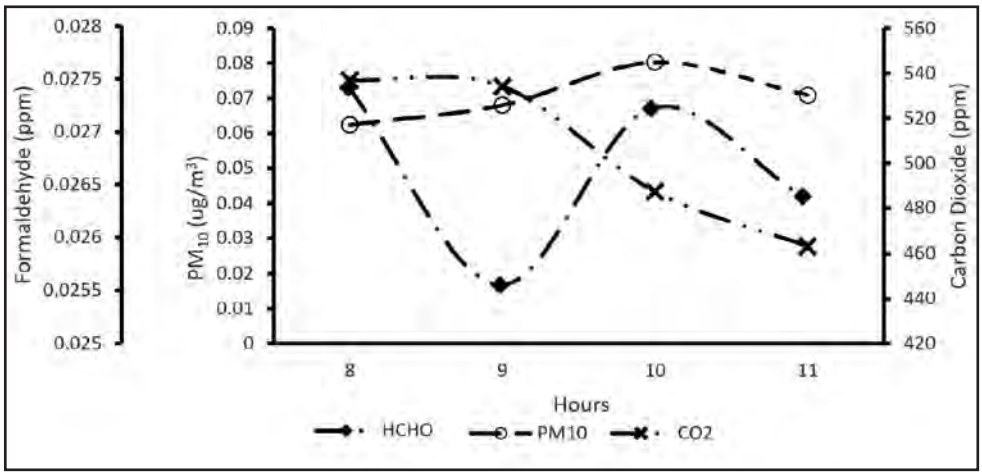

Fig. 2: Chemical parameters of formaldehyde (HCHO), particulate matters (PM10), and carbon dioxide (CO_2)

that exceeded the standard limit. This is because, during the morning, the temperature was between 28-29˚C, and the relative humidity was increasing so the air will become wet. The relationship between temperature and relative humidity is inversely proportional.

DISCUSSION

According to Table I, parameters for Indoor Air Quality (IAQ) were all within the acceptable range as in the Industry Code of Practice on Indoor Air Quality 2010 (ICOP IAQ 2010) except for air temperature and relative humidity which were slightly higher than the stated limit. A study show that air quality can be influenced nearly by all environmental parameters that include relative humidity, air movement, and air temperature.[17] Based on Table I also, HCHO gave the lowest value which is 0.03ppm. HCHO as in known is the most common source of the indoor air pollutant. Though at very low concentrations, it can inflame a person's throat, lungs, and eyes, as well as trigger an asthma attack. In a worse case, if the exposure is prolonged, it will be linked to cancer.[18] Furthermore, the reading for CO_2 showed that the level does not give rise to an immediate risk to health. In a way, if the levels of indoor CO_2 are high, it may thus indicate that the air ventilation rate is insufficient for the number of people living in the room.

Figure 1 represents the physical parameters of the IAQ. The temperature has exceeded the limit as Malaysia is known to be in a tropical area that is humid, and warm so the temperature range was within 29-31˚C that are known to be outside the comfort temperature range (1). The kindergarten is also using fans as their mechanical ventilation. Cabovská et al.,[19] stated that ventilation can help to bring good Indoor Air Quality (IAQ). The main cause of ventilation is to dilute or get rid of the pollutants in the air that was released from building occupants, indoor activities, and building materials. According to Lazovic et al.,[20] humidity and indoor air temperature are the main keys to the thermal comfort of the occupants. Reda et al.,[20] stated that thermal comfort is known as a state of mind that indicate satisfaction with one's surrounding.

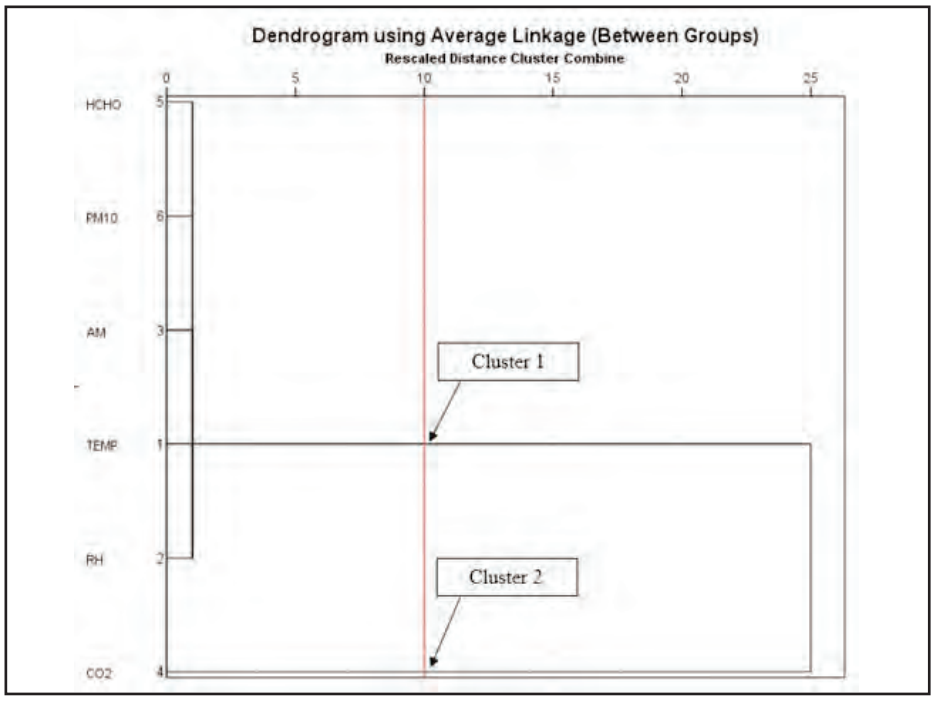

Fig. 3: Data collected using cluster analysis

Mechanical ventilation usually will result in faster ventilation rates as well as lowered CO_2 concentration.[16] As the time goes from 10.00am to 11.00am, it shows a decrease in the CO_2 concentration as the students were getting ready and having their recess time at the back of the classroom which is an opened-air area and has natural ventilation. A study by Zakaria et al.,[1] has done an analysis regarding indoor air pollution in Malaysian kindergartens. The author combined through the local scientific literature regarding the levels of indoor air pollution in kindergartens and derived the data from 17 studies that have been published over a ten-year period. They indicated that children's respiratory activity was the main source of indoor CO_2 and is also usually used as an alternative to represent ventilation rate. After the recess period was over, the indoor CO_2 trend remained lower because students were separated into their respective classrooms according to their schedules and doing their activities outdoors. Indirectly, the concentration of CO_2 falls due to the doors opening and fewer occupants in the living area.

Since the kindergarten is nearby the road, PM_{10} might be generated from the road traffic nearby. As stated by Mansor et al.,[21] it is found that cleaning activities or cooking will significantly help in elevated PM concentration, leading to a raise in PM concentrations in the building. The next pollutant that has been monitored is formaldehyde, the reading on formaldehyde does not exceed the standard limit. It is possible that the reading was influenced by the outdoor activities as this kindergarten is located nearby the roadside where there were multiple vehicles passing by from time to time.[23,22]

Based on the result from CA, it is verified that CO_2 was grouped in Cluster 2 (C2) while the other variables were positioned in Cluster 1 (C1). Regarding the result of the study made by Singh et al.[2], it shows that relative humidity and temperature have a major effect on the production of CO_2 concentration. It is proven based on this cluster that there is a correlation between relative humidity and temperature with CO_2. The contrast between CO_2 concentration and the rest of the variables was the main reason based on the result.

CONCLUSION

In conclusion, parameters of temperature and relative humidity in the kindergarten did not comply with the standard limit, while other parameters are within the acceptable limit by the Department of Occupational Safety and Health, Malaysia. Cluster analysis has shown that ventilation and indoor air pollutants are among the contributor towards poor IAQ in kindergarten, executing by Cluster 1 and Cluster 2. Thus, we suggest for opening windows and doors or running a window air conditioner with the vent control open increases the outdoor ventilation rate. Local bathroom or kitchen fans that exhaust outdoors remove contaminants directly from the room where the fan is located and also increase the outdoor air ventilation rate.

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ORIGINAL ARTICLE

Respirable dust exposure impact on respiratory symptoms among cleaners in a Selangor Public University, Malaysia

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ABSTRACT

Introduction: Cleaners perform a vital role in environmental health by keeping the place clean, but they are also exposed to various hazards. Yet, there is a lack of effective and accessible occupational safety standard measures, thus making this to be difficult to monitor the long-term health effects of cleaners. This study aims to determine the respirable dust exposure on respiratory symptoms among cleaners in a public university in Selangor.

Materials and Methods: A cross-sectional study was carried out among 51 cleaners. The respondents' background information and respiratory symptoms were gathered using a series of standardised questionnaires validated by the American Thoracic Society (ATS-DLD-78-A). The 8- hour respirable dust exposure to cleaners was measured using an air sampling pump (Gillian & Sensodyne Gil Air 3).

Results: The mean of respirable dust was lower than permissible exposure limit with 0.63±0.57mg/m^3. The respiratory symptoms among the cleaners showed no significant association between cough, phlegm, and breathing difficulties with working tenure. Meanwhile, wheezing and coughing with phlegm have an almost significant association with working tenure among cleaners with (χ^2=1.00, p=0.08) and (χ^2=1.00, p=0.07) respectively. Exposure to respirable dust has exhibited 6 times the prevalence of coughing with phlegm among cleaners (PR=6.28, 95% CI: 0.44, 89.38).

Conclusion: The findings of this study demonstrated that the cleaners were significantly affected by the respirable dust. The cleaners' working environment has caused them to be exposed to respirable dust.

KEYWORDS:
Cleaner, respirable dust, respiratory symptom

INTRODUCTION

Maintaining a secure and healthy learning environment through regular campus cleaning is crucial. As the Centers for Disease Control and Prevention noted, the pandemic highlighted the rapid spread of germs and emphasized the importance of keeping facilities clean.[1] The safety and well-being of students and staff are of utmost importance, thus it is necessary to hire a cleaning company to perform professional cleaning in classrooms, offices, common areas, break rooms, restrooms, dorm rooms, clinics, and other locations regularly.[2] Therefore, cleaners play vital roles in ensuring that the environment is clean and hygienic for everyone.

Cleaners are responsible for various tasks and duties, including sweeping, mopping, sanitising, restocking supplies (such as toilet paper), polishing, and collecting garbage, which require them to move from one area to another, both outdoors and indoors.[3] Additionally, garden maintenance, road cleaning, and grass cutting may also fall under the purview of a cleaner's duties. Due to the nature of their work, cleaners at public universities, who typically work for 8 to 9 hours per day for six days a week, are often exposed to particulate matters present in the air throughout their working hours.

Cleaners are mobile workers who work outdoors and indoors, moving from one location to another to perform their cleaning duties. Although they play a crucial role in maintaining environmental health by ensuring that areas are clean, they are also exposed to various hazards. In particular, they are frequently exposed to hazardous particles such as soil, sand, gravel dust particles, vehicle dust, bioaerosols, and plant particles commonly found in the atmosphere.[4] As they move around to clean different areas, cleaners may inhale and exhale respirable dust on the road, mainly due to vehicle emissions and air pollution. Respirable dust refers to particles smaller than 4 micrometres (μm) in size. It can be inhaled into the lung's gas exchange zone, posing significant health risks to workers across various industries.[5]

When cleaners are repeatedly exposed to respirable dust, they are at an increased risk of developing respiratory diseases. Recent research has demonstrated that particulate matter

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harms the respiratory system and can lead to respiratory disorders.[6] Respiratory disease affects the lungs and other components of the respiratory system, with causes including infection, cigarette smoking, second-hand tobacco smoke, radon, asbestos, and other forms of air pollution.[7-8]

Other dust-related disorders, such as cancer, asthma, allergic alveolitis, and irritation, are also associated with it. A bunch of new non-respiratory illnesses can develop at considerably lower levels of exposure.[9] Long-term airborne dust exposure can cause chronic obstructive pulmonary disease (COPD). Peng et al., stated that COPD is a global public health issue and the third most significant cause of death due to cardiovascular and cerebrovascular illnesses. Given these risks, it is critical to assess the relationship between exposure to respirable dust and respiratory disease among cleaners.[10] The mixture of dust can create a massive impact on the lungs of the cleaners as they are categorized as mobilized workers who work indoors but in open spaces. The effects of inhaling dust are indeed well documented, however, studies on the lung function of cleaners are still undertaken. Hence, this study was performed to evaluate the association between respirable dust exposure with respiratory symptoms among cleaners in a public university in Selangor, Malaysia.

MATERIALS AND METHODS

A cross-sectional study was conducted among the cleaners at the public university in Selangor. The list of 112 workers was obtained from the Human Resources Department of the cleaning consortium company. The cleaners were selected using a simple random sampling technique by considering the inclusion and exclusion criteria to recruit study respondents based on the list given. A group of 51 cleaners were selected aged from 20 to 60 years old and have worked for more than six months. The exclusion criteria considered whether the individuals had any respiratory disease during the sample collection or had received any medical treatment for respiratory diseases within six weeks before the sample collection. The collection of the sample was obtained during the working period. The sample size was determined using the formula from Lemeshow and Hosmer (1990) with reference to Ismail and Jalaludin (2014), specifically for the significant odds ratio related to respiratory health affected by respirable dust exposure.

$$n = \frac{(Z_{1-\frac{\alpha}{2}})^2 \; P(1-P)}{d^2}$$

Where;

$(Z_{1-\frac{\alpha}{2}})^2$ = standard errors associated with confidence intervals

(95% confident interval = 1.96)
P = referral proportion
d = desire precision (0.05)

After considering 80% response rate and 90% eligibility rate, the total sample size obtained was 51 respondents.

Instrument

An air pump, Gillian & Sensodyne Gil Air 3, was used to evaluate respirable dust exposure. The measurement procedure took 8 hours, and the flow rate for the pump is 1.7L/ min based on the NIOSH Manual of Analytical Methods for particulates not otherwise regulated, respirable (NMAM 0600).[13] It indicates a healthy human lung flow rate. The pump was calibrated before and after measurement. The 4.0µm PVC filter paper was dried and weighed before and after sampling. The 2-layers filter cassettes for filter paper and the nylon cyclone sampling head were used. The filter paper was dried and weighed before being placed into the filter cassettes. The cassettes were then sealed and stored in a desiccator containing silica gel to prevent moisture while waiting for sampling time.

A questionnaire was used to determine the respiratory symptoms to evaluate respiratory disease. The respiratory symptoms of the respondents were assessed using a validated questionnaire from the American Thoracic Society (ATS-DLD-78-A),[14] which had been translated into Malay. This translated version underwent pre-testing and reliability testing in a previous local study.[15] It consists of four sections: social demographic, past illnesses, symptoms, and tobacco smoking with dual languages, which are Malay and English.

Sample Collection

A simple random sampling under probability sampling methods was conducted for cleaners. The respondents who signed the consent were interviewed for data collection on socio-demographic information. The other questions related to lung disease were obtained from the validated questionnaire developed based on the American Thoracic Society (ATS). The questionnaire contains four sections: socio-demographic, history of respiratory disease, symptoms, and smoking exposure. The socio-demographic, history of respiratory disease, and smoking exposure questions were used to control confounding factors that may influence the results of the study. The socio-demographic questions such as age, gender, family income, education, and race of the respondents were identified to ensure no significant difference among study respondents due to the various backgrounds of study respondents. Besides that, according to American Thoracic Society, smoking exposure and history of respiratory disease should be controlled since these factors might influence respiratory symptoms.[16]

The concentration of respirable dust was collected using an air sampling pump (Gillian & Sensodyne Gil Air 3). The pump was hung on the respondent waist while the cyclone with filter cassette was attached to the breathing zone of the respondent which is a 20cm radius from the nose. The duration of personal air sampling took 8 hours of working period by using a 4.0µm PVC filter. All the study respondents work in a similar environment, which involves working indoors with an open ventilation system as in Fig. 1. Air quality parameters were measured to ensure that there were no significant differences in the environmental conditions during this study. This was accomplished using the TSI Q-Trak Indoor Air Quality Monitor, which measured parameters including CO2 levels, temperature, and relative humidity.

The final weight was taken using the same analytical balance during sampling preparation to determine the weight changes from the filter paper. A filter sample's post-sampling weight, W2 (mg), was recorded, including field blanks. The concentration of respirable particulate (mg/m^3) was calculated using the following formula:

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \quad X\ 10^3, mg/m^3$$

Where;
W1 = tare weight of filter before sampling (mg),
W2 = post-sampling weight of sample-containing filter (mg)
B1 = mean tare weight of sample-containing filter (mg)
B2 = mean post-sampling weight of blank filters (mg)
V = volume as sampled at the nominal flow rate (1.7L/min)

Statistical Analysis
Data collected in the study were analysed using SPSS version 28. Descriptive analysis was used to determine the respirable dust exposure and respiratory symptoms among cleaners by stating sample size (N), the centre of data (mean and median), data dispersion (standard deviation and frequency), and shape of data distribution. Kolmogorov-Smirnov statistics were used to test normality for all continuous variables. Univariate testing was used to analyse the socio-demographic data in the questionnaire. The inferential analysis was conducted for each objective. Next, a chi-square analysis was run to determine the respiratory symptoms among cleaners at a public university in Selangor. Lastly, an odd ratio (OR) was used to identify the association between respirable dust exposure and respiratory symptoms among cleaners at a public university in Selangor.

Ethics Approval And Informed Consent
The application of ethics and permission letter was approved by the ethics committee of UiTM Puncak Alam. The reference number for ethical approval is FERC/FSK/MR/2022/0292.

RESULTS

Demographic Characteristics of Cleaners
A total of 51 cleaners were included in this study. Most of the cleaners were females (92.2%), with males accounting for only 9.8%. Malay cleaners comprised around 80.4% of the chosen population, followed by Indians with 19.6%. The most significant level of education attained, at 2.0%, was a certificate, while most workers required SPM level education with 70.6%. The majority of the cleaners were 51 to 60 years old at 35.8%, followed by 41 to 50 at 27.5%. The lowest percentage, 9.8%, was among those 60 years old and older. The cleaners' body mass index (BMI) found that 45.1% were overweight and 33.3% were obese, respectively. Only 9.8% of cleaners are single, making marriage the most common demographic (90.2%).

Various concessionaires employ cleaners at public universities, and their typical work days are between 8 and 9 hours. Nine hours comprised most of the respondents' working hours (74.5%), followed by 8 hours (25.5%). Public transport was first among the cleaners' modes of getting to work (43.1%), while motorcycles came in second with 39.2%. The least was by car, with 17.6%. Table I shows most of the cleaners, 49.0%, did not have any pets at home, whereas 37.3% had cats. Last but not least, only 5.9% of cleaners smoked, followed by 94.1% of cleaners who did not smoke. This may be related to the fact that most responses were female.

Table III shows air quality parameters, comprising CO2, temperature, and relative humidity. The mean of CO2 is 500.92±93.75ppm. The mean temperature was 25.82±1.09°C and the mean for relative humidity was 73.38±5.62%. The low standard deviation value indicates that there is little variation in the air quality parameters of the study environment, suggesting that they are relatively consistent and not significantly different.

Respiratory Symptoms among Cleaners
The respiratory symptoms of respondents were categorised into cough, phlegm, wheezing, breathing difficulty, and cough with phlegm. There is a clear correlation between increased symptoms and longer work hours as reported by Ratanachina et al.[17] A Pearson chi-square was used to observe respiratory symptoms among cleaners according to their working tenure. Table IV shows the respiratory symptoms among the cleaners have no significant association between cough, phlegm, and breathing difficulty, and working tenure. Meanwhile, wheezing and coughing with phlegm have an almost significant association with working tenure among cleaners (χ^2=1.00, p=0.08) and (χ^2=1.00, p=0.07) respectively.

Association between Respirable Dust Exposure with Respiratory Symptoms among Cleaners
Exposure to respirable dust has six times higher odds of coughing with phlegm among cleaners shown in Table V (OR=6.28, 95%CI: 0.44, 89.38). Despite this, the cleaner has almost twice higher odds of getting a cough with exposure to respirable dust while working (OR=1.88, 95%CI: 0.68, 5.20). Cleaners would also have the probability of getting phlegm and breathing difficulty with 1.39 higher odds (OR=1.39, 95%CI: 0.38, 5.17) and (PR=1.39, 95%CI: 0.44, 89.38) respectively. Meanwhile, no respondent had wheezing symptoms that were excessive compared to the standard; thus, no association data was generated.

There was no significant association between respiratory symptoms and factors such as tenure, smoking status, and a history of respiratory disease. Therefore, conducting a multivariate analysis to control for confounding factors was not found to be significant.

DISCUSSION

An assessment of respirable dust exposure was undertaken to ascertain the employees' exposure using an air pump, considering the workers' exposure to respirable dust. There were 51 responders who have participated in this respirable dust exposure level monitoring. The mean exposure level of respirable dust was 0.63±0.57mg/m^3 which is lower than permissible exposure limit.

The presence of occupants and their daily activities had a significant impact on the concentration of respirable dust.[18-19]

Table I: The sociodemographic among respondents

Variables (n=51)	N	%
Age (years)		
20 - 30	7	13.7
31 - 40	7	13.7
41 - 50	14	27.5
51 - 60	18	35.8
> 60	5	9.8
Gender		
Female	47	92.2
Male	4	7.8
Body Mass Index (BMI)		
Obese	17	33.3
Overweight	23	45.1
Ideal	10	19.6
Underweight	1	2.0
Race		
Malay	41	80.4
Indian	10	19.6
Marital Status		
Married	46	90.2
Single	5	9.8
Level of Education		
Non-Schooling	2	3.9
Primary School	12	23.5
Secondary School	36	70.6
Certificate	1	2.0
Workings Hours		
8	13	25.5
9	38	74.5
Mode of Transportation		
Motorcycle	20	39.2
Public Transport	22	43.1
Car	9	17.6
Pets		
Cat	19	37.3
Dog	6	11.8
Other	1	2.0
No Pets	25	49.0
Smoking		
Yes	3	5.9
No	48	94.1

Table II: Respirable dust exposure concentration

Variable (n = 51)	Mean ± SD (mg/m^3)	min (mg/m^3)	max (mg/m^3)
Respirable Dust	0.63 ± 0.57	0.058	2.176

Table III: Air quality Parameters

Variable (n = 51)	Mean ± SD	min	max
CO_2 (ppm)	500.92 ± 93.75	474.56	527.30
Temperature (°C)	25.82 ± 1.09	25.51	26.13
Relative Humidity (%)	73.38 ± 5.62	71.80	74.96

Table IV: The presence of symptoms with working tenure

Symptoms (n=51)	Working Tenure	N (%)		χ^2	p-value
		Yes	No		
Cough	6-12	4 (30.8)	17 (44.7)	0.52	0.78
	1-5	9 (69.2)	21 (55.3)		
Phlegm	6-12	3 (27.3)	18 (45.0)	0.49	1.12
	1-5	8 (72.7)	22 (55.0)		
Wheezing	6-12	1 (33.3)	20 (41.7)	1.00	0.08
	1-5	2 (66.7)	28 (58.3)		
Breathing difficulty	6-12	5 (45.5)	16 (40.0)	0.74	0.11
	1-5	6 (54.5)	24 (60.0)		
Cough with phlegm	6-12	1 (50.0)	20 (40.8)	1.00	0.07
	1-5	1 (50.0)	29 (59.2)		

Chi-Square test (Fisher Exact Test)
*Significant p-value < 0.05

Table V: Association between respirable dust exposure with respiratory symptoms

Symptoms (n=51)		Respirable dust		χ^2	PR (95% CI)
		Exceed	Not exceed		
Cough	Yes	3 (5.9)	10 (19.6)	1.28	1.88
	No	4 (7.8)	34 (66.7)		(0.68-5.20)
Phlegm	Yes	2 (3.9)	9 (17.6)	0.23	1.39
	No	5 (9.8)	35 (68.6)		(0.38-5.17)
Wheezing	Yes	0 (0.0)	6 (11.8)	1.08	0
	No	7 (13.7)	38 (74.5)		
Breathing difficulty	Yes	2 (3.9)	9 (17.6)	0.23	1.39
	No	5 (9.8)	35 (68.6)		(0.44-89.38)
Cough with phlegm	Yes	1 (2.0)	1 (2.0)	2.31	6.28
	No	6 (11.8)	43 (84.3)		(0.38-5.17)

Chi-Square test (Fisher Exact Test)
Significant OR > 1, 95% CI

Fig. 1: The cleaners wearing an air sampling pump while working

The study was carried out at a library, laboratory and administrative building with a minimal number of occupants and limited daily activities especially during semester break. This study aligns with the research on indoor air quality within a multi-storey central office building at a university in Johor. The study found that the respirable dust levels were within acceptable limits and suitable for occupancy, despite the presence of some observable symptoms of Sick Building Syndrome (SBS) among its occupants.[20]

The cleaners can be categorised as administrative workers because they work outdoors and indoors.[21] Workers in administration occasionally spend time in a building, which did not shield them from the dusty environment.[22] Cleaners usually clean the building and also surrounding areas of the building such as corridors, roadsides around the campus, and others. Although the university did not have traffic congestion like on the main road, but respirable dust was also be present from the smoke emissions of the vehicle. Besides, inside the building, respirable dust is also present

from the cleaning items and others. Both external and indoor factors, including building supplies, cleaning supplies, air fresheners, heating, cooking, and smoking activities can contribute to indoor pollution with particulate matter.[4,23,24]

The air quality parameters measured during the sampling were temperature, CO_2, and relative humidity. The rooms where the cleaners were sweeping, wiping, and picking up trash is where the readings of the air quality parameters were taken. Overall, the measurement for CO_2 and relative humidity are almost similar with the study from various study in Malaysia.[25-27] Therefore, symptoms such as coughing, wheezing, and phlegm are not associated with extreme temperatures, humidity, or CO_2.

According to the results, all of the symptoms were insignificant against the working tenure. Most of the cleaners who worked for 1 to 5 years have a symptom rather than cleaners who worked for more than 6 years. The researchers found that age, personal dust exposure, and the number of years spent working on the landfill were all significantly linked to the presence of cough, chronic cough, and nasal congestion.[22,28,29] In this study, similar protective effects were seen for other measured respiratory symptoms; however, they were not statistically significant.[30]

Most of the respondents claimed that they always wear face masks during cleaning task, even before COVID-19 spread. It can be one of the reasons why the cleaners did not develop any symptom during work.[31] Furthermore, Dugré et al. (2020) stated that limited evidence that the usage of masks may lower the incidence of respiratory infections.[21] However, there may be a decreased risk of influenza-like illness among mask users in the community.

The respirable fraction was associated with all respiratory symptoms, an increased chance of getting a cough and/or phlegm, and shortness of breath.[23] Although this study was significant, the number of PRs in their study corresponds roughly with this study for cough (PR=1.29) and breathing difficulty (PR=1.33).[23,32] This indicates that the cleaners had an elevated risk of experiencing the mentioned symptoms. Even so, there was no relationship found between respirable dust exposure and respiratory symptoms. This could be due to the sample size being too small, hence there was no seasonal change, and no control group.[22,33] Instead, having a minimal number of occupants and limited daily activities results in lower levels of respirable dust. Therefore, there was no association between respirable dust exposure and respiratory symptoms, which could be attributed to the all factors. This study was cross-sectional and was carried out in a relatively constrained amount of time, which could potentially be the reason.

CONCLUSION

This study has successfully met the objective by examining the impact of respirable dust on cleaners. The results indicated that cleaners were significantly exposed to respirable dust, both indoors and outdoors, likely due to pollution from vehicle exhausts and indoor sources. However, the study found no significant correlation between respiratory symptoms and the duration of employment as a cleaner, with only a few reporting such issues. This could be attributed to the majority of cleaners wearing face masks while working. Although there was no significant association between respirable dust and respiratory symptoms, the potential for such exposure remains high as the OR exceeds 1. Overall, this study underscores the need for greater awareness of the risks posed by respirable dust to cleaners. Building upon the existing findings, a promising avenue for future research involves conducting extended longitudinal investigations to gauge the enduring consequences of prolonged respirable dust exposure on the respiratory health of cleaners. Next, delve into the impact of genetic factors and individual variations in how people respond to dust exposure. Subsequently, assess the efficacy of a range of intervention strategies, including enhanced personal protective equipment (PPE), workplace ventilation enhancements, and revised cleaning techniques, in reducing dust exposure and its effects on respiratory health. Concurrently, this research has the potential to enhance and rigorously implement regulatory guidelines pertaining to permissible exposure limits for respirable dust within cleaning work environments.

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CONFLICT OF INTEREST

There were no potential conflicts of interest disclosed by the authors in connection with the research, authorship, and/or publication of this work. The findings of this research have never been published before.

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Factors associated with different types of hip fractures among elderly patients a tertiary hospital in Pahang: A retrospective cross-sectional study

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ABSTRACT

Introduction: Hip fractures, predominantly due to decreased bone density and falls, significantly impact elderly health, disproportionately affecting women and placing a strain on healthcare resources. This study aims to conduct an in-depth epidemiological analysis of hip fracture incidence among the elderly in Pahang, Malaysia, to inform better healthcare strategies.

Materials and Methods: In this retrospective study, medical records of patients admitted with hip fractures between 2019 and 2021 at Hospital Sultan Haji Ahmad Shah (HoSHAS) in Pahang were analyzed. Data on sociodemographic characteristics, nature of trauma, fracture types, and comorbidities were collected and examined using descriptive and inferential statistics.

Results: Among 3856 Orthopaedic Department admissions at HoSHAS (2019-2021), 296 hip fracture cases were identified, predominantly in women (71.3%), Malay ethnicity (75.3%), and aged 71-80 (38.5%). Intertrochanteric femur fractures were prevalent (62.8%). Unintentional falls accounted for 94.9% of cases. Logistic regression showed age and gender as significant predictors of femoral neck fractures. Specifically, Chinese seniors were 1.96 times more likely, and women over 65 were 1.95 times more likely to suffer these fractures. Notably, the absence of comorbidities increased the risk by 3.41 times ($p < 0.05$).

Conclusion: With increased longevity among Malaysian citizen, the number of hip fracture cases are growing and leading to other health-related problems such as disability, depression, and cardiovascular. Various preventive interventions for osteoporosis and falls should be implemented to reduce the incidence of hip fractures among older adults.

KEYWORDS:
Hip fracture, elderly, epidemiology

INTRODUCTION

Hip fractures are defined as any fracture in the upper section of the femur between the tip of the femur's head and 5cm below the lesser trochanter.[1] Hip fractures are common among the elderly related to osteoporosis and fall.[2] Hip fractures affect millions of adults annually around the world, leading to major disability, serious consequences, and high mortality rates.[3-5] Older adults who sustained hip fractures are highly exposed to the risk of complications and comorbidities.[4,6,7]

Life expectancy in Malaysia has risen by 20 years in the last 60 years, from 54.3 in 1957 to 74.75 in 2016; the elderly comprise 2.83 million (9.13%) of the country's total population of 31 million.[8] While life expectancy is rising, a significant concern in many trauma centres across multiple nations in the twenty-first century is an increase in elderly patients hospitalized with hip fractures.[9-11] Throughout 1996 and 1997, 56 public and private hospitals in Malaysia participated in the extensive study on hip fracture epidemiology. The overall rate of total incidence was 90 cases per 100,000 adults aged 50 and up. There was no change in the incidence rate between the two years. It was, however, more prevalent in women and older age groups.[12] Hip fractures represent an increasing financial impact on healthcare resources.[13] The incidence of hip fractures in Malaysia is expected to rise by a factor of 3.5 in 2050, from 6,000 to more than 21,000. This rise will result in an annual increase in healthcare spending of over USD 125 million (MYR 540 million), making Malaysia the country with the highest projected growth.[14] According to studies, the 1-year mortality rate following hip fracture is as high as 22% or even 30%.[15,16] Only 50–71% of hip fracture survivors are expected to regain their pre-fracture levels of mobility 12 months following the fracture, and 10–20% will remain institutionalized permanently.[17,18] The lifetime risk of experiencing a hip fracture for females is 40–50%, while for males, it is 13–22%.[19]

To the author's knowledge, there has been very little research on the epidemiology of hip fractures. Similar to studies conducted in other countries, the demographics of elderly sustained hip fractures in Malaysia were as follows: they were older, multimorbid, predominantly female, and at an increased risk for falls and fractures.[20,21] We believe that a retrospective investigation is warranted. The purpose of our study is to determine the incidence of hip fracture and its associated factor in Hospital Sultan Haji Ahmad Shah (HoSHAS) in Malaysia. Such studies would corroborate the current findings and shed light on how knowledge about hip fractures among the elderly in Malaysia is being constructed.

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MATERIALS AND METHODS

This study is a retrospective cross-sectional study conducted among elderly patients with hip fractures presented at the Orthopedic Department of HoSHAS from January 2019 until December 2021. Convenience sampling was applied for this study. Medical Records for HoSHAS patients are stored digitally. Data were collected after obtaining ethical approval from the Medical Research and Ethics Committee (MREC). (RSCH ID-22-01590-WZS). The initial sample size was calculated using Raosoft software[22], and 298 samples were needed for a population of 3856. However, when we filtered the participants' ages and types of fractures, we included the final sample 296 in this study. Data were gathered by searching through the ward census. Patients with hip fracture diagnoses, which include fractures of the femoral neck, intertrochanteric, and subtrochanteric, will be searched for their Registered Number (RN). Patients with ages below 60 were excluded from the study. Then, the patient's medical record, which was stored in an integrated hospital information system, was retrieved using the RN. The patient's medical record was studied on various parameters, including age, race, gender, number of comorbidities, types, and causes of fracture.

The researcher used a research identification number to identify the subject data collection form and when presenting or entering the data. The data were entered into Microsoft Excel[23] and analyzed statistically with SPSS version 26[24]. Descriptive statistics were reported using frequency and percentage. In addition, binary logistic regression was conducted to identify the prediction of each type of hip fracture through the patients' age, race, gender, number of comorbidities, and cause of fracture with a significance level of $p<0.05$. In the binary logistic regression model, the Malay male elderly between 91 and 100 years, with four or more comorbidities that had fractures due to motor vehicle accidents, were used as indicator variables for their categories, respectively. Moreover, the 'Enter' method of binary logistic regression was employed, enhancing the robustness of the analysis, as this method allows for the inclusion of all predetermined variables in the analysis.

RESULTS

Of 3856 fracture cases admitted to the Orthopaedic Department of HoSHAS from 2019 to 2021, 296 patients met the study criteria. The majority of the patients were female (71.3%), Malay (75.3%), and aged between 71 to 80 years (38.5%). Meanwhile, the intertrochanteric femur fracture (62.8%) was the highest reported fracture, followed by the femoral neck fracture (27.7%) and the subtrochanteric fracture (9.5%). Subsequently, unintentional fall was identified as the most significant accident (94.9%) that caused hip fracture among elderly patients. At the same time, more than half of the patients had two to three comorbidities (59.1%). Table I shows the patients' descriptions according to the type of hip fracture.

Subsequently, binary logistic regression was conducted to identify the relationship between age, race, gender, number of comorbidities, and cause of fracture in predicting each hip fracture (Table II). In the initial model, the logistic regression for femoral neck fracture was significant ($\chi^2(10)=25.521$, $p=0.004$). The model's overall prediction accuracy was 73.6%, with a particularly high accuracy of 94.9% for predicting the absence of femoral neck fractures but a lower accuracy of 18.3% for predicting their presence. The Nagelkerke R Square value of 11.9% indicates that the model accounts for approximately 11.9% of the variance in femoral neck fracture outcomes. Additionally, the Hosmer and Lemeshow test result ($\chi^2(8)=10.994$, $p=0.202$) suggests a good fit for the model.

Overall, the model found that age did matter. Meanwhile, femoral neck fractures were 1.96 times more common in Chinese seniors than in Malay ones. The risk of a femoral neck fracture also increased by 1.95 times for women compared to men. The risk of femoral neck fracture was also 3.41 times higher in the elderly without any comorbidity and 2.91 times higher in the elderly with four or more comorbidities.

For the second logistic regression model, the logistic regression model for intertrochanteric femur fracture was statistically significant ($\chi^2(10)=18.429$, $p=0.048$). The Nagelkerke R Square value of 8.2% suggests that the model explains a modest proportion of the variance in intertrochanteric femur fracture outcomes. The model's overall prediction accuracy was 66.2%, with it being notably more effective at correctly identifying cases with an intertrochanteric fracture (94.1%) than those without (19.1%). The Hosmer and Lemeshow test showed a good fit for the model ($\chi^2(8)=4.535$, $p=0.806$), indicating that the predicted values align well with the observed data. The model indicated that age was significant as a whole. There was no other significant predictor in this model. However, for the third logistic regression model, the logistic regression model for subtrochanteric femur fracture was not statistically significant ($\chi^2(10)=3.745$, $p=0.958$).

DISCUSSION

A previous study that was conducted in Malaysia among elderly patients who sustained hip fractures reported that falls are the most common cause of hip fractures at a tertiary medical centre in Malaysia.[25] Meanwhile, the incidence of hip fracture was reported to be 90 per 100,000 population among people aged 50 and above in Malaysia.[12] However, this study attempted to investigate the factors contributing to different types of hip fractures among elderly patients attending an Orthopaedic Department. Therefore, the findings of this study contributed to the baseline data to assist the health care providers in planning for necessary support for elderly patients who sustained hip fractures. Bone Mineral Density (BDM) begins to decline with age, particularly in postmenopausal women, due to bone loss.[26] Osteoporosis is a chronic disease affecting one out of every three women and one out of every five men over the age of 50.[26] As a result, women with this disease are more vulnerable to fracture risk from a slip, fall, or even spontaneous.[27] The current study yielded consistent results, revealing that 71.3% of the participants were female. Individuals over the age of 85 are 15 times more likely than those under the age of 60 to experience a hip fracture, with female older adults reported for 80% of hip fractures.[28]

Table I: Patient's characteristics according to the type of hip fracture (n=296)

Variable	Femoral Neck Fracture n (%)	Intertrochanteric Femur Fracture n (%)	Subtrochanteric Femur Fracture n (%)	Total n (%)
Age				
60-70	17 (28.3)	40 (66.7)	3 (5.0)	60 (20.3)
71-80	41 (36.0)	61 (53.5)	12 (10.5)	114 (38.5)
81-90	20 (18.2)	78 (70.9)	12 (10.9)	110 (37.2)
91-100	4 (33.3)	7 (58.3)	1 (8.3)	12 (4.1)
Race				
Malay	56 (25.1)	146 (65.5)	21 (9.4)	223 (75.3)
Chinese	21 (38.9)	28 (51.9)	5 (9.3)	54 (18.2)
India	5 (26.3)	12 (63.2)	2 (10.5)	19 (6.4)
Gender				
Male	18 (21.2)	59 (69.4)	8 (9.4)	85 (28.7)
Female	64 (30.3)	127 (60.2)	20 (9.5)	211 (71.3)
Caused of fracture				
Unintentional fall	79 (28.1)	175 (62.3)	27 (9.6)	281 (94.9)
Motor vehicle accident	3 (20.0)	11 (73.3)	1 (6.7)	15 (5.1)
Comorbidities				
None	11 (36.7)	17 (56.7)	2 (6.7)	30 (10.1
1 only	19 (38.8)	27 (55.1)	3 (6.1)	49 (16.6)
2 to 3	44 (25.1)	113 (64.6)	18 (10.3)	175 (59.1)
4 and more	8 (19.0)	29 (69.0)	5 (11.9)	42 (14.2)
Reported case	82 (27.7)	186 (62.8)	28 (9.5)	296

Table II: Predicting different types of hip fracture by the patients' demographic characteristics

Omnibus Tests of Model Coefficients Model	Chi-square	df	Sig.
Femoral Neck Fracture Model	25.521	10	0.004
Intertrochanteric Femur Fracture Model	18.429	10	0.048
Subtrochanteric Femur Fracture Model	3.745	10	0.958

Variables in the Equation for Femoral Neck Fracture Model

		B	SE.	Wald	df	Sig.	aOR	95% CI for aOR	
								Lower	Upper
Step 1a	91-100 years*			11.066	3	0.011			
	60 to 70 years (1)	-.196	.699	.078	1	0.780	0.822	0.209	3.239
	71 to 80 years (2)	.166	.665	.062	1	0.803	1.180	0.321	4.347
	81-90 years (3)	-.927	.683	1.845	1	0.174	0.396	0.104	1.508
	Malay*			4.121	2	0.127			
	Chinese (1)	.672	.338	3.959	1	0.047	1.959	1.010	3.799
	Indian (2)	-.074	.566	.017	1	0.896	0.928	0.306	2.816
	Female (1)	.666	.323	4.269	1	0.039	1.947	1.035	3.664
	≥4 Comorbidities*			7.617	3	0.055			
	No comorbidity (1)	1.225	.575	4.547	1	0.033	3.405	1.104	10.503
	1 Comorbidity (2)	1.069	.517	4.286	1	0.038	2.914	1.059	8.019
	2-3 Comorbidities (3)	.424	.444	.912	1	0.339	1.529	0.640	3.653
	Fall from height (1)	.597	.709	.708	1	0.400	1.816	0.453	7.285
	Constant	-2.455	1.013	5.877	1	0.015	0.086		

Model summary: -2 Log-Likelihood: 323.832; Cox & Snell R Square: 0.083; Nagelkerke R Square: 0.119; Estimation Termination Note: iteration number 5

Variables in the Equation for Intertrochanteric Femur Fracture Model

Step 1a	91-100 years*			8.955	3	0.030			
	60 to 70 years (1)	.348	.664	.275	1	0.600	1.416	0.386	5.201
	71 to 80 years (2)	-.214	.632	.115	1	0.734	0.807	0.234	2.786
	81-90 years (3)	.633	.638	.985	1	0.321	1.884	0.539	6.580
	Malay*			3.413	2	0.181			
	Chinese (1)	-.586	.319	3.376	1	0.066	0.557	0.298	1.040
	Indian (2)	-.024	.511	.002	1	0.962	0.976	0.358	2.658
	Female (1)	-.505	.286	3.103	1	0.078	0.604	0.344	1.059
	≥4 Comorbidities*			3.431	3	0.330			
	No comorbidity (1)	-.776	.519	2.232	1	0.135	0.460	0.166	1.274
	1 Comorbidity (2)	-.645	.462	1.946	1	0.163	0.525	0.212	1.299
	2-3 Comorbidities (3)	-.263	.382	.472	1	0.492	0.769	0.364	1.626
	Fall from height (1)	-.597	.632	.891	1	0.345	.551	0.159	1.901
	Constant	1.713	.916	3.497	1	0.061	5.547		

Model summary: -2 Log-Likelihood: 372.180; Cox & Snell R Square: 0.060; Nagelkerke R Square: 0.082; Estimation Termination Note: iteration number 4

a. Variable(s) entered on step 1: Age, Race, Gender, Comorbidity, Caused of Fracture.

b. aOR – adjusted odds ratio

The elderly population suffers from simple falls, which account for 95% of hip fractures.[19,26] When combined with other risk factors, these modifications increase the likelihood of a fall.[29-30] Because women are more prone to acquire osteoporosis and have lower bone mineral density than men, they are more likely than men to sustain a hip fracture. In this study, women's risk variables were more significant than men's. In the current and past studies, people of different ethnicities have different risks for hip fractures.[21,31,32]

Our findings show that intertrochanteric femur fractures are common, accounting for 62.8% of reported cases, indicating a significant burden of this type of fracture in the studied population. This prevalence is significantly higher than that of femoral neck fractures (27.7%) and subtrochanteric fractures (9.5%). The prevalence of intertrochanteric femur fractures emphasizes the need for targeted preventive and intervention strategies in orthopaedic care. These findings are consistent with previous research[33-34], highlighting the importance of ongoing research to elucidate the underlying risk factors and potential preventive measures for intertrochanteric femur fractures. Intertrochanteric femur fractures are common in the elderly; the femur's intertrochanteric aspect comprises dense trabecular bone between the greater and lesser trochanters.[33] Intertrochanteric fractures are among the most common hip fractures, particularly in the elderly. The prevalence of intertrochanteric fracture is increasing due to an increase in the number of older adults combined with osteoporosis.[34] Understanding the distribution of various femur fractures is also essential for optimizing resource allocation, healthcare planning, and the development of tailored treatment protocols.

Low body mass index (18.5), smoking status, alcohol addiction, malnutrition, and low physical activity are all modifiable or lifestyle risk factors.[35] A study in New Zealand identified the risk factors among older adults and reported that age, female sex, ethnicity, and falls were significantly related to hip fractures.[30] Similarly, age was significant in this study with intertrochanteric, femoral neck, and subtrochanteric femur fractures. However, Chinese women are more likely to sustain femoral neck fractures than Malay women, and women are more likely to suffer from femoral neck fractures than men.

The likelihood of falling increases as risk factors such as previous falls, weakness, gait, and balance issues increase.29 According to one study, a patient with four risk factors has a 78% chance of falling.[36] Elderly falls and fractures are greatly influenced by the high prevalence of comorbidities such as hypertension, diabetes, neurological impairment, and impaired vision.[37] In addition, the heterogeneity of the patients included in the study and identifying other risk factors to predict hip fracture cases. In light of these considerations, it is clear that additional risk factors must be identified, necessitating a holistic approach to improving predictive accuracy and preventive strategies for hip fractures in the elderly population.

It is also crucial to address the limitations of this study. We acknowledge a limitation of the study, which is the extent of the data collected, which could provide more information on the prognosis of hip fracture among older adults. Other significant variables, such as functional capacity, post-operative prognosis, and death rate after sustained hip fracture, cannot be evaluated because we only gathered the data from the medical records of the patients. Then, this study focuses only on the elderly patients presented to the Orthopaedic Department, who might be admitted to other wards based on their medical condition.

CONCLUSION

In conclusion, this study sheds light on the factors contributing to the various types of hip fractures seen in elderly patients visiting an orthopaedic department. The findings significantly contribute to the baseline data required by healthcare providers to plan necessary support for elderly patients who sustain hip fractures. The study confirms that falls are the leading cause of hip fractures in the elderly, consistent with previous research in Malaysia. Women's vulnerability, particularly those aged 85 and up, highlights the need for targeted preventive measures, given their increased risk of hip fractures. Various osteoporosis prevention measures combined with efforts to reduce falls in the elderly will significantly reduce osteoporotic hip fractures and the burden of healthcare costs for treating these fractures. Hip fractures in older persons necessitate more than just a hip fracture repair. It is essential to pay attention to their existing medical conditions, pre-operative care, rehabilitation, minimizing complications acquired while hospitalized, and reducing the risk of future fractures.

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Assessing the Impact of Temperature on the Duration of COVID-19 Transmission in Terengganu, Malaysia: Implications for Public Health Strategies

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ABSTRACT

Introduction: The SARS-CoV-2 virus, responsible for the global COVID-19 pandemic and its associated high morbidity and mortality, continues to be a significant public health concern. This study investigates the influence of temperature variables on COVID-19 transmission in Terengganu, Malaysia, which, despite having experienced a comparatively lower number of cases, presents a unique environment for understanding how temperature factors may play a critical role in virus transmission dynamics.

Materials and Methods: We conducted a descriptive analysis to assess the spatial distribution of COVID-19 cases in our study area. To explore the relationship between temperature variables and COVID-19 transmission, we employed Pearson correlation analysis, examining the correlations between daily average, minimum, and maximum temperature data and the temporal distribution of COVID-19 cases as reported by the Ministry of Health, Malaysia. This approach allowed us to comprehensively investigate the impact of weather on the transmission dynamics of COVID-19.

Results: Our findings reveal a noteworthy correlation ($p<0.05$) between average and maximum temperatures and COVID-19 transmission, highlighting the influence of weather on disease dynamics. Notably, exceptions were observed in the Hulu Terengganu district, where fewer than 10 cases occurred in each sub-district throughout the study period, warranting special consideration.

Conclusion: In summary, our study highlights the significance of temperature in shaping COVID-19 transmission. This stresses the importance of including weather variables in pandemic strategies. We also suggest comparing various cities to broaden our understanding of how weather affects disease spread, aiding future public health efforts.

KEYWORDS:
COVID-19, weather, temperature, Terengganu, Malaysia

INTRODUCTION

The emergence of coronavirus disease in 2019 (COVID-19) has triggered a global health emergency. The disease is transmitted primarily by droplets in the breath when an infected person coughs, sneezes, or talks; however, it can also be transmitted through contact with contaminated surfaces.[1] Symptoms of COVID-19 can range from mild to severe and include fever, cough, fatigue, body aches, loss of taste or smell, and shortness of breath. The disease can lead to pneumonia, acute respiratory distress syndrome (ARDS), and even death in severe cases. The incubation period for COVID-19 is usually 2-14 days after exposure, during which asymptomatic but contagious persons may be present.

Environmental factors such as temperature, humidity, and wind speed have been shown to play a role in the transmission and survival of SARS-CoV-2. Studies suggest that the virus is more stable at low temperatures and low relative humidity, and that higher wind speeds may facilitate the spread of the virus over longer distances.[2-4] Understanding these factors may help in the development of COVID-19 containment strategies. Epidemiological modelling of infectious diseases such as COVID-19 often requires population scaling to account for differences in disease transmission patterns across populations. This is because different population variables, such as population density and social interactions, can influence the mechanisms that determine the spread and duration of epidemics. Epidemic transition models with population scaling are advisable for a better understanding of infectious disease transmission and management.[5]

Previous studies on the impact of meteorological factors on COVID-19 transmission up to September 2021 suggested the possibility of some seasonality, with warmer and more humid conditions potentially reducing transmission rates. While research indicated that higher temperatures and humidity might reduce the stability of the virus, inconsistencies in data, global variations, and the complex interplay of other factors made it difficult to establish a clear and universal relationship between meteorological factors and COVID-19 transmission. Furthermore, research was ongoing, and the understanding of this relationship might have evolved since

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that time, particularly in the context of specific regions like Malaysia.

Therefore, the objective of this study is to examine the correlation between temperature and COVID-19 transmission in Terengganu, Malaysia, a region with a relatively low number of confirmed virus cases. This research aims to enhance our comprehension of the determinants of COVID-19 transmission and potentially inform the development of effective public health measures and interventions to mitigate the virus's spread.

MATERIALS AND METHODS

Study Site and Population

The study was conducted in Terengganu, a state on the east coast of Peninsular Malaysia between 103.1324° E and 5.3117° N. The state is divided into eight main administrative districts, including Kemaman, Dungun, Marang, Kuala Terengganu, Hulu Terengganu, Setiu, Kuala Nerus, and Besut. The Kuala Terengganu district is the most populous and serves as the administrative centre of the city. Terengganu has a total area of 13,035 km^2 and a population of 1.125 million (as of 2013) (Fig. 1). The lower number of cases in Terengganu provides an opportunity to investigate the interplay between temperature and virus transmission in a less-affected region. By studying this context, we aim to offer valuable insights into potential patterns and implications that may have relevance in both tropical and global contexts. The strategic choice of Terengganu allows us to explore the impact of climatic conditions on COVID-19 transmission, contributing to the broader understanding of the factors influencing the spread of the virus in diverse environmental settings.

Study Design

In this integrated epidemiological study, we aimed to investigate the impact of weather variability on the distribution of COVID-19 cases in Terengganu, Malaysia. We conducted a cross-sectional study in 2021, utilizing data from the Ministry of Health of Malaysia (MOH) and the Malaysian Meteorological Department (MMD). The data sources included the distribution of COVID-19 cases and district-specific meteorological data, specifically temperature. We collected COVID-19 case data from eight major administrative districts in Terengganu, spanning 52 epidemiological weeks over one year (2021). Data collection commenced on August 1, 2020, and concluded on July 31, 2021, covering a full calendar year. Meteorological data on average, maximum, and minimum temperatures were sourced from official applications provided by the Malaysian Meteorological Department, ensuring data accuracy and quality for the study.

Data Collection and Management

The data collection and management for this study were conducted meticulously to ensure accuracy and reliability. The primary sources included the Ministry of Health of Malaysia (MOH) for COVID-19 case data and the Malaysian Meteorological Department (MMD) for meteorological data, specifically temperature. Data collection spanned from December 15, 2020, to March 23, 2021, capturing a significant period of COVID-19 transmission. Subdistricts with less than 10 confirmed cases during the study period and those with limited cases before or after the peak were excluded to avoid data sparsity. Descriptive analysis involved normalizing COVID-19 case data and calculating a 7-day moving average (Fig 2). Daily temperature data were collected from accessible weather stations in five Terengganu districts, with data backed by the MMD for accuracy. This rigorous data collection and management approach aimed to deliver reliable and valid results, essential for informing public health strategies and understanding temperature's impact on COVID-19 transmission in Terengganu, Malaysia.

This study aims to investigate the influence of temperature on the duration of COVID-19 transmission in Terengganu, Malaysia, focusing on the "spreading phase" and "decay phase." The "spreading phase" is defined as the period from the onset of the outbreak until the daily or weekly new case counts reach a peak and begin to stabilize or decrease, signifying the initial stage of the outbreak when the virus is actively transmitted. The "decay phase" follows the peak, representing the time when new cases consistently decrease until reaching a stable or low level, indicating a declining transmission phase. These operational definitions will be used to assess how temperature affects the duration of each phase, with implications for informing public health strategies.

Data Analysis

The data analysis in this study was structured to investigate the relationship between weather variables and COVID-19 transmission, with a specific focus on Transmission Duration. Transmission Duration was clearly defined as the period from the onset of the COVID-19 outbreak in Terengganu, marked by the first confirmed case, to the beginning of the "decay phase" characterized by consistently decreasing daily or weekly case counts. The analysis commenced with the collection of daily temperature data from five local weather stations in Terengganu for the year 2021. In this study, the hierarchical clustering technique was employed, resulting in the identification of two distinct clusters or groupings. The initial cluster, designated as the "red group," encompasses districts exhibiting a higher temperature association compared to the second cluster. This clustering method serves as a valuable tool for exploratory analysis and can facilitate subsequent in-depth investigations. Then, a Pearson correlation analysis was then conducted to examine the linear relationships between weather variables and COVID-19 cases. Subsequently, cross-correlation analysis was employed for each district in Terengganu, dividing the analysis into eight distinct sections, one for each district, to facilitate a detailed understanding. This approach allowed for the determination of the percentage of correlation between COVID-19 cases and temperature variables, providing insights into the impact of weather on COVID-19 transmission in Terengganu. Importantly, a significance level (p-value) of 0.05 was applied to ensure the statistical significance of the results, enhancing the credibility of the findings and their relevance to public health strategies.

Ethics Approval and Infprmed Consent

No ethical issue required for this research

Table I: Starting and terminating dates of the spread and decay stages of the COVID-19 pandemic and the date (year 2020 and 2021) when the highest daily peak value of confirmed cases was reported. Time parameters extracted from the definition are TSS (start of spread), TSE (end of spread), TDS (start of decay), TDE (end of decay), DS (spread duration), and DD (decay duration)

Districts	TSS	TSE	Daily Peak	TDS	TDE	DS	DD
Bukit Kenak	2-Jan	8-Feb	12-Feb	16-Feb	20-Mar	37	33
Jabi	11-Jan	7-Feb	2-Feb	17-Feb	1-Mar	27	13
Kg Raja	8-Jan	31-Jan	5-Feb	10-Feb	20-Mar	23	10
Kerandang	6-Jan	17-Jan	22-Jan	27-Jan	17-Feb	11	22
Kbg. Bemban	22-Jan	11-Feb	12-Feb	17-Feb	22-Mar	16	34
Lubuk Kawah	8-Jan	31-Jan	5-Feb	10-Feb	15-Mar	23	34
Pelagat	7-Jan	21-Jan	22-Jan	27-Jan	17-Mar	10	48
Kuala Besut	21-Jan	8-Feb	13-Feb	18-Feb	17-Mar	18	28
Jerangau	8-Jan	11-Jan	16-Jan	21-Jan	13-Feb	3	23
Rasau	6-Jan	9-Jan	14-Jan	19-Jan	13-Feb	3	25
Sura	8-Jan	23-Jan	28-Jan	2-Feb	24-Feb	15	22
Paka	19-Jan	7-Feb	12-Feb	17-Feb	22-Feb	19	5
Kerteh	11-Jan	16-Jan	21-Jan	26-Jan	1-Feb	5	6
Chukai	8-Jan	24-Jan	29-Jan	3-Feb	13-Feb	16	10
Bukit Payong	18-Jan	19-Jan	24-Jan	29-Jan	8-Feb	1	10
Bandar	7-Jan	25-Jan	30-Jan	4-Feb	26-Feb	18	22
Chabang Tiga	5-Jan	7-Jan	12-Jan	17-Jan	31-Jan	2	14
Chendering	11-Jan	17-Jan	22-Jan	27-Jan	13-Feb	6	17
Manir	8-Jan	17-Jan	22-Jan	27-Jan	17-Mar	9	49
Serada	8-Jan	10-Jan	15-Jan	20-Jan	15-Feb	2	26
Kubang Parit	22-Feb	4-Mar	9-Mar	14-Mar	20-Mar	10	6
Kepong	21-Jan	26-Jan	31-Jan	5-Feb	7-Feb	5	2

Table II: Correlation between the spread (DS) and decay durations (DD) of COVID-19 transmission with daily average, maximum, and minimum temperature

	DS			DD		
District	Avg	Max	Min	Avg	Max	Min
Kemaman	0.050	0.190	-0.103	0.305	0.382	0.305
K.Tgganu	-0.471*	-0.443*	-0.216	0.491*	0.801*	-0.207

RESULTS

Table I lists the start and end dates of the spread and decay phases (using a 7-day moving average) and the date of the highest number of confirmed cases observed daily in each county and subcounty.

Figure 3 is a graphical representation of the time series of confirmed new positive cases during the spread and relapse phases of the pandemic. Fig. 3a shows that the number of normalized confirmed cases increased in most districts, with some districts having multiple maxima. This indicates that the pandemic did not spread evenly across all districts and that some districts experienced multiple waves of infection. Fig. 3b shows the decline of the pandemic, with the number of normalized confirmed cases decreasing over time in most districts. Similar to Fig. 3a, multiple maxima were observed in certain districts, suggesting that the pandemic decline was not uniform across all districts. For policymakers and public health officials, these findings are critical for targeting interventions to control the spread of the pandemic in specific districts and regions.

In this case, the hierarchical clustering technique yielded two distinct clusters or groupings. The first group, referred to as the "red group," consists of districts with a higher temperature association than the second group. Depending on the context of the analysis, the second group may or may not be identified by a particular colour. The red group of districts is easily distinguished from the other groups, as shown in Fig. 4. This clustering method can be used for exploratory purposes or to facilitate further analysis, and interpretation of the clustering result should be based on the specific context and objectives of the analysis.

Table II show that there is a statistically significant, moderately positive correlation between the duration of degradation and the average and maximum temperatures in the Kuala Terengganu district. This was determined using Pearson's correlation coefficient, which measures the linear relationship between two variables. The p-value of both the average and maximum correlation coefficient with the expiration time is below the 5% significance level, which means that the correlation coefficients are significantly different from zero. Therefore, the null hypothesis, which states that there is no linear correlation between these variables, can be refuted.

The correlation coefficients (r) between the decay time and the average and maximum temperatures are 0.49 and 0.80, respectively. These values indicate that there is a moderately positive linear relationship between these variables. This indicates that the decomposition time tends to increase with increasing temperature. In addition, the results show a statistically significant, moderately positive correlation between the duration of dispersal and the average and maximum temperatures in Kuala Terengganu. For both

Fig. 1: The geographical representation of the area of interest for this study which is Terengganu

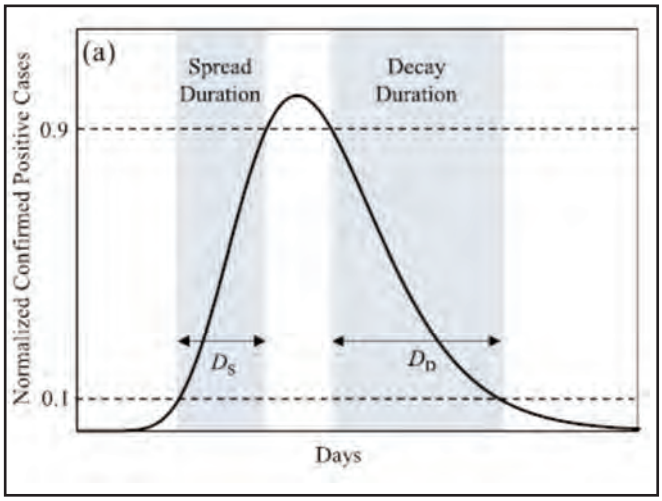

Fig. 2: Proposed definition of the spread and decay durations along the curve of the COVID-19 pandemic, which has been applied to the 7-day moving average of original data. Time parameters extracted from the definition are TSS (start of spread), TSE (end of spread), TDS (start of decay), TDE (end of decay), DS (spread duration), and DD (decay duration)

average and maximum temperatures, the P-values for dispersion duration are less than 0.05, which is at the significance level. The observed correlation coefficients between dispersion duration and average and maximum temperatures are -0.471 and -0.443, respectively. These values indicate that these variables have a moderately negative linear relationship. This means that the dispersion duration tends to decrease as the temperature increases.

DISCUSSION

Environmental health researchers have been interested in the effects of temperature on human health and disease transmission for decades. The current pandemic COVID-19 has brought this issue to the forefront of public attention, and the effects of temperature on disease transmission have been discussed extensively in many countries, including Japan. Japan is an optimal location for studying the environmental factors that may affect the spread of COVID-19 [6,7] because it has a high-quality health care system, social measures, and consistent data collection. However, one of the difficulties in analysing COVID-19 data there is the limited availability of data due to various policies in Japan and problems with data consistency, reliability, and uniformity.

In this study, the duration of the propagation and recovery phases of COVID-19 and the effects of temperature on these phases were investigated to address this problem. The results provide valuable insights into the effects of temperature on

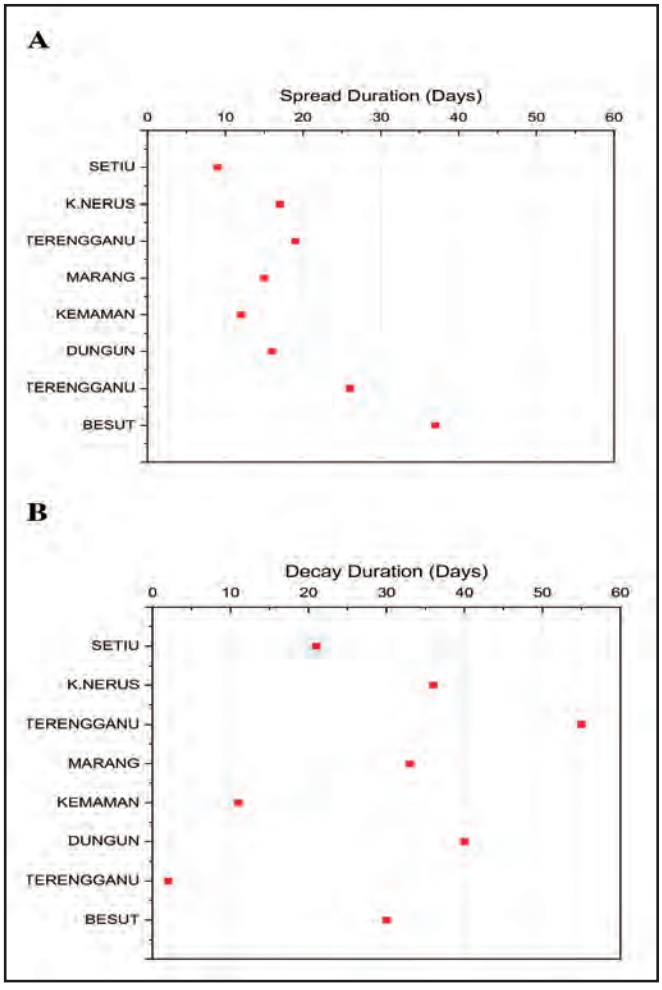

Fig. 3: (a) Spread and (b) decay durations (in days) of analyzed districts in Terengganu

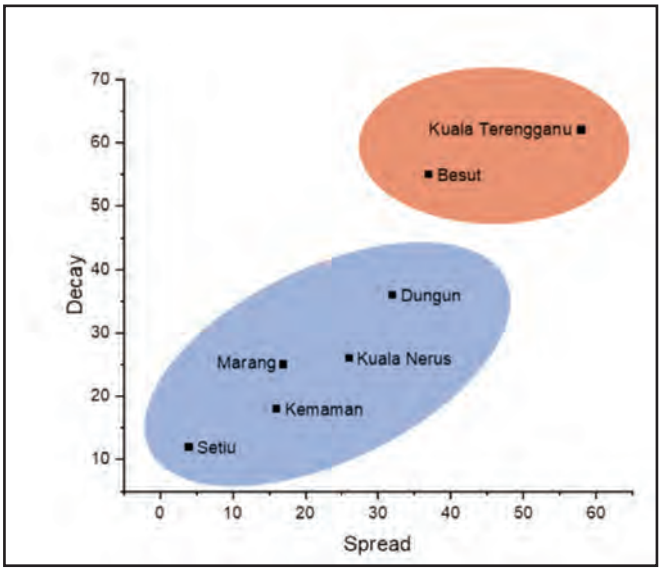

Fig. 4: Relationship between the durations of spread and decay (in days). The red ellipse highlights districts with relatively high temperature, while the blue ellipse highlights those with relatively low temperature

the transmission phase of a pandemic and can be used to formulate plans and measures to control the spread of disease.[8] It is important to note that the results of this study may not be directly applicable to all situations, as environmental factors and social responses to disease outbreaks can vary widely by region and country. However, the results contribute to our understanding of how temperature affects the spread of COVID-19 and can serve as a basis for decision making and planning in similar situations. This study highlights the importance of considering environmental factors such as temperature when assessing the risk of pandemic transmission.

This study compares the COVID-19 spread and decay duration of 7 districts in Terengganu where more than 10 cases were confirmed during the studied wave. The Hulu Terengganu district was excluded from the analysis because all of its sub-districts had fewer than 10 cases throughout the study period. The study used the range of 10-90% of normalized confirmed cases to establish the metrics for both time periods. Normalization was performed to avoid potential differences in the absolute number of reported cases between districts due to differences in regulations. One of the challenges faced by the study was the relatively low number of COVID-19 cases in Malaysia compared to other countries. The number of cases in Malaysia was one to two orders of magnitude lower than most European countries.[9] This made it difficult to collect enough data to perform a robust analysis. However, because the study focused on districts with higher numbers of cases, it was able to provide useful insights into the prevalence and decline of COVID-19 in the Terengganu region.

The results of this study show that the number of confirmed COVID-19 cases generally follows a bell-shaped or lognormal curve, with an increase followed by a decrease.[7] However, in Besut and Kuala Terengganu districts, several peaks were observed in both the spread and decay phases. Hierarchical cluster analysis revealed that these two districts belonged to the same cluster as they had relatively high daily temperatures (26.3°C-28.1°C) during the propagation phase. Temperature data were obtained from weather stations in Kuala Terengganu and Felda Belara. Both districts recorded relatively long duration of propagation days, 58 and 37 days, respectively. In addition, these two districts recorded the highest number of days for rot duration at 62 and 55 days, respectively.

However, the fact that temperature was considered high does not fully explain the longer duration of transmission in these two districts. Other factors such as the increase in the number of travellers returning from other countries/regions, the lack of social distance, and attendance at large gatherings without following standard operating procedures (SOPs) may have contributed to the longer transmission duration.15-18 It is worth noting that the study excluded counties with minor spikes to ensure robustness of conclusions.

It is important to recognize that comparing the results of this study with those of other countries is difficult because of differences in the measurement of data with different SOPs, testing rates, validation techniques, and other factors that may introduce bias. In addition, closure restrictions and public responses are also important factors affecting the accuracy of the data from COVID -19.

The collection of various data sets can provide a basis for developing a predictive model for the future outbreak of COVID-19, a critical aspect of public health planning. The collected data will be analysed using a causal relationship focusing on epidemiological patterns of COVID-19 transmission and meteorological trends, and statistical models will be developed to determine the relationship between temperature and COVID-19 cases. These data will help stakeholders such as investors, public health epidemiologists, and health professionals understand the prevalence of COVID-19 transmission in their respective areas and make informed decisions. Due to the unique meteorological conditions in Terengganu, the results of this study may also assist policy makers in developing effective and targeted strategies to prevent the spread of COVID-19.

In this study, certain limitations should be acknowledged, primarily stemming from the decision not to incorporate temporal lags into our analysis. The dataset utilized exhibited specific characteristics, including limited temporal granularity and insufficient historical data, posing challenges to the effective integration of temporal lags. Moreover, the nature of the relationship between temperature and COVID-19 in the study area may not prominently feature delayed effects; instead, it might be more immediate in nature. This characteristic of the relationship influenced our decision to adopt a non-lagged approach. The constraints imposed by resource and time considerations also played a pivotal role in shaping our methodology. Conducting a more extensive analysis involving temporal lags would have necessitated additional data processing, computational resources, and time commitments, which were beyond the scope of this study. Despite these limitations,

we believe that our chosen approach still yields meaningful insights into the relationship between temperature and COVID-19 transmission within the specific constraints of our study. We appreciate the reviewer's suggestion, and while acknowledging these limitations, we remain confident that our analysis, as presented, contributes valuable perspectives to the field.

CONCLUSION

In summary, this study provides insights into the correlation between temperature and stages of spread and decay of COVID-19 in 7 districts of Terengganu. Despite the limited number of cases reported, the uniformity of the data supports the conclusion that temperature can influence the duration of transmission. The results highlight the significant impact of temperature on COVID-19 transmission in Terengganu during the wave of infection studied. However, it should be noted that Hulu Terengganu district was excluded from the analysis because there were not enough cases, and there may be some exceptions. Therefore, when formulating protective strategies for a potential pandemic, including the next wave of COVID-19, it is critical to consider factors such as comparing multiple cities and district-specific exceptions.

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CONFLICT OF INTEREST

The authors declare that they have no known competing interest or personal relationship that could have appeared to influence the work reported in this paper.

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ORIGINAL ARTICLE

Computer vision syndrome and dry eye symptoms among breastfeeding women

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ABSTRACT

Introduction: Breastfeeding women are susceptible to musculoskeletal symptoms and hormonal changes that can affect the ocular surface. As exposure to visual display units (VDU) that is known to cause symptoms of dry eye and computer vision syndrome (CVS) is increasing worldwide, including among breastfeeding women, it is unknown whether this group of VDU users would experience CVS more than non-breastfeeding women. Therefore, this study aimed to investigate the association between breastfeeding status and symptoms of CVS and dry eye.

Materials and Methods: In this cross-sectional study, self-reported CVS and dry eye symptoms were compared between 80 breastfeeding and 72 non-breastfeeding VDU users. Two questionnaires were administered online, which were the CVS-Questionnaire (CVS-Q) and the Ocular Surface Disease Index (OSDI) questionnaire, to evaluate symptoms of CVS and dry eye, respectively. Mann-Whitney test was used to compare CVS and OSDI scores between groups, while correlations between the scores were analyzed using Spearman's test.

Result: Results showed that OSDI scores were significantly higher in the non-breastfeeding group (U = 2263, z-score = -2.276, p = 0.023), indicating more dry eye symptoms experienced by respondents in this group, while no significant group difference was found in terms of CVS scores (U = 2772, z-score = -0.400, p = 0.689). Additionally, no significant association was observed between breastfeeding status and severity of dry eye symptoms as well as CVS symptoms.

Conclusion: This study reported the possible benefit of breastfeeding in reducing dry eye symptoms. The CVS symptoms found in the breastfeeding group were possibly due to VDU usage rather than caused by breastfeeding. Public education on preventive measures to reduce the occurrence of CVS symptoms and ocular dryness among VDU users is essential to improve the quality of life.

KEYWORDS:
Breastfeeding, computer vision syndrome, ocular dryness, dry eye, digital devices, estrogen

INTRODUCTION

Computer vision syndrome (CVS) is defined as a group of eye-related symptoms due to prolonged use of visual display units (VDU) such as computers, tablets, television, and smartphones.[1] Several factors may contribute to the increased risk of CVS, including the number of hours spent on digital devices, external factors such as improper lighting or position, as well as individual factors such as uncorrected refractive errors.[2-4] It has been suggested that a minimum of three hours of VDU usage per day can increase the risk of developing CVS, low back pain, tension headaches, and psychosocial stress.[5,6] This is expected to increase with longer exposure to VDU, where CVS symptoms and more pronounced visual problems were reported among computer users who spent more than seven hours per day on VDU at work.[7-9] These suggest that increasing demand for VDU usage in modern days may increase the prevalence of CVS in the community.

The symptoms of CVS can be broadly classified into three which are extraocular symptoms, accommodative symptoms, and ocular surface symptoms.[10,11] The extraocular symptoms of CVS are associated with musculoskeletal symptoms such as tingling and numbness of the fingers and arm, cervical stiffness, backache, and pain in the neck and shoulder. According to Gerr et al.[12], musculoskeletal symptoms are common among VDU users, whereby more than 50% of VDU users have reported experiencing the symptoms during the first year of starting a new job. These symptoms are usually associated with improper placement of computer screen and viewing distance of VDU, poor seating posture, and prolonged duration of VDU usage without a break.

On the other hand, the accommodative symptoms of CVS refer to fatigue or spasm of intraocular muscles following a sustained VDU usage. This may cause blurry vision, double vision, difficulty focusing at near, and increased time taken to change focus from near to distant target.[10,11] Another group of symptoms is related to changes to the ocular surface, particularly to the tears and cornea following prolonged use of VDU. Research has shown that extended period of computer usage reduced blinking rates, possibly due to increased cognitive demand.[13] This will cause ocular dryness symptoms such as irritation, burning sensation, and grittiness, which collectively contribute to CVS symptoms.

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Ocular dryness was also found in several conditions with hormonal imbalances indicative of the influence of hormonal changes on the ocular surface.[14] Among the hormones that can influence ocular dryness are estrogen, androgen, insulin, and thyroid hormones.[15] Although the effects of estrogen and progesterone on tears are less understood, studies have shown that estrogen and progesterone hormone replacement therapy in menopausal women did worsen ocular complaints and increase the incidence of dry eye.[16,17] Apart from hormonal treatment, practising breastfeeding could also lead to natural hormonal changes in women,[18] which in turn could influence the tears' quality and quantity. These changes could result in ocular dryness which can be aggravated by prolonged VDU usage.[19,20]

In a study conducted on medical and engineering students, neck and shoulder pains were among the common musculoskeletal symptoms reported by VDU users.[21] Similar musculoskeletal problems were also experienced by breastfeeding mothers due to improper positions during breastfeeding.[22] Various positions are practised during breastfeeding including sitting on a chair, on a mat, on the bedside, and side-lying. Among these positions, sitting on a chair has been described to have the least prevalence of musculoskeletal pain compared to other positions.[22]

Since breastfeeding women are more susceptible to hormonal changes that can cause ocular dryness, and are more likely to experience musculoskeletal symptoms, it is unknown if CVS and dry eye symptoms are more prevalent among breastfeeding women who are also VDU users compared to non-breastfeeding VDU users. Therefore, the current study aimed to investigate the association between CVS, dry eye, and breastfeeding by comparing self-reported symptoms of CVS and dry eye between breastfeeding and non-breastfeeding VDU users.

MATERIALS AND METHODS

Study Design and Sample Population

A cross-sectional study was conducted on a sample of breastfeeding and non-breastfeeding women in Malaysia to investigate the association between breastfeeding status and self-reported symptoms of CVS and dry eye. G*Power[23] was utilized to calculate the estimated sample size for this study. The effect size used in the calculation was derived from Nkiru et al. (24) which compared OSDI scores between the third trimester and post-partum phases. As no study comparing OSDI scores between breastfeeding and non-breastfeeding groups was found, the effect size from the former comparison was deemed relevant for our sample size estimation. For a power of 0.80 and an alpha level of 0.05 for a two-sided test, the sample size needed for each group was 60. Considering attrition rate and that the calculation was based on a slightly different sample, a higher number of participants for each group was aimed in this study. All respondents recruited through purposive sampling were Malaysian citizens aged between 18 to 45 years old, using any kind of VDU devices for a minimum of three hours per day in at least five days per week and were able to understand either English or Malay to answer the questionnaires. Women in the control group must be non-breastfeeding, while women in the breastfeeding group must be currently breastfeeding a baby of six months and below. Pregnant and menopausal women, as well as women with any systemic diseases, currently having active eye diseases, has history of eye surgery or taking any medications that could affect the tears, were excluded from the study.

Materials

Data were collected using a questionnaire consisting of five sections namely: Section A for socio-demographic data, Section B for health background, Section C fro breastfeeding practice, Section D for CVS Questionnaire, and Section A for Ocular Surface Index (OSDI) questionnaire.

Computer Vision Syndrome Questionnaire (CVS-Q)

The CVS questionnaire (CVS-Q) was adopted from Seguí et al.[25] to assess 16 visual and ocular symptoms associated with VDU exposure including burning, itching, foreign body sensation, tearing, and excessive blinking. Scoring was done according to the guidelines of the author. Responses were collected using the Likert scale to determine the frequency of occurrence of each symptom with 0 indicating never, 1 indicating occasionally (sporadic episodes or once a week), 2 indicates often (two or three times a week) while 3 indicates very often or always (almost every day). If respondents reported having the symptoms for at least 'occasionally', they were asked to rate the intensity of the symptoms as either 'moderate' or 'intense' with a score of 1 or 2 respectively. The total score for each symptom was then calculated as frequency x intensity, with a score of 0 recoded as 0, a score of 1 or 2 recoded as 1, and a score of 4 recoded as 2. The total scores from all symptoms were calculated giving a range of total scores between 0 to 24. Total scores of 6 or more indicate suffering from CVS symptoms.

Ocular Surface Disease Index (OSDI)

Ocular Surface Disease Index (OSDI) is a 12-item questionnaire developed by the Outcomes Research Group at Allergan (Irvine, California, USA) to assess symptoms, functional limitations, and environmental factors related to dry eye syndrome. Both the original version of the questionnaire in English[26] and the translated version in Malay were used in this study.[27] This questionnaire was used in the study to quantify the symptoms of ocular dryness, which were graded according to the author's guidelines. The presence of specific dryness symptoms was graded on a scale of 0 to 4, whereby 0 indicates none, 1 indicates some of the time, 2 indicates half of the time, 3 indicates most of the time while and 4 indicates all the time. The total OSDI score was then calculated and categorized according to the severity with 0 to 12 points indicating normal or not having dry eye, while OSDI scores of 13 to 22, 23 to 32, and 33 to 100 indicate mild, moderate, or severe dry eye, respectively.[28]

Research Procedures

The questionnaire was administered online between March 2022 and July 2022 using Google Form distributed through social media such as WhatsApp and Telegram. Prior to the actual questionnaire, an online consent form was completed by all participants. Questions to screen for the inclusion and exclusion criteria were included in sections A and B of the

Table I: Demographic data of the participants in each group

Characteristics	Non-Breastfeeding (n=72)	Breastfeeding (n=80)
Age (years)	M=28.08 (SD=6.38)	M=31.06 (SD=4.80)
Digital devices usage (hours)	M=8.29 (SD=4.31)	M=7.22 (SD=4.64)
Breastfeeding categories, n (%)		
• Exclusive Breastfeed		51 (64%)
• Mixed Feeding		29 (36%)
Baby's age (months)		M=6.68 (SD=0.62)

Note. M and SD represent the mean and standard deviation of the samples respectively.

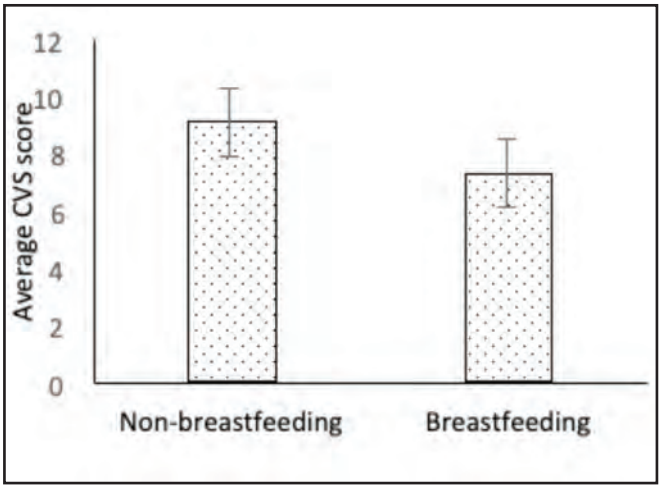

Fig. 1: The average CVS score by group. Error bars represent standard errors

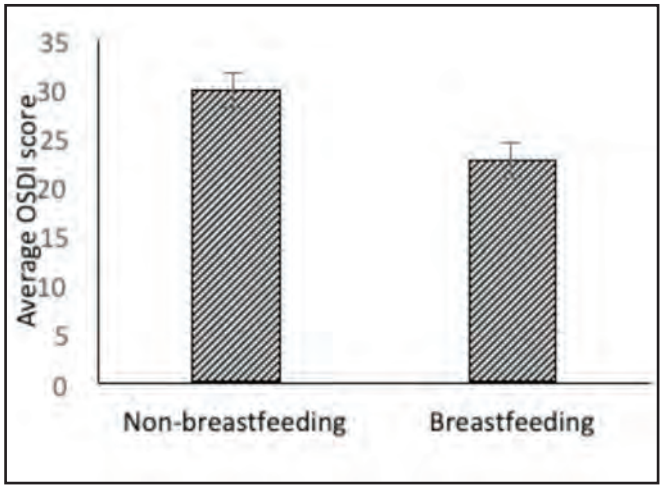

Fig. 2: The average OSDI score by group. Error bars represent standard errors

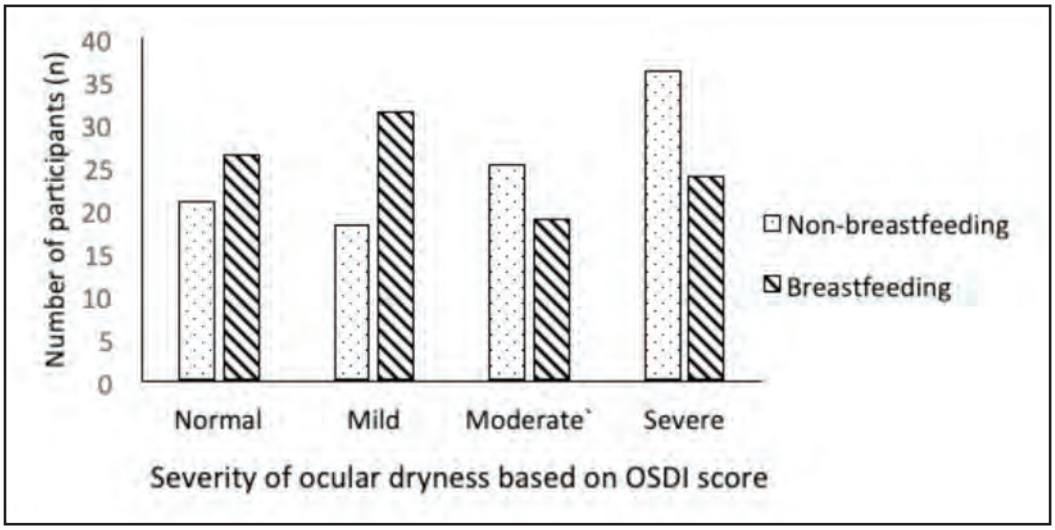

Fig. 3: Number of participants in each group according to the severity of ocular dryness based on OSDI score

questionnaire to determine if the respondents were eligible to participate in the study. The whole online questionnaire including the consent form took not more than 10 minutes to complete. This study was conducted in accordance with the Declaration of Helsinki and was approved by the ethical committee (FERC/FSK/MR/2022/0074) of the Universiti Teknologi MARA Selangor.

Data Analysis

The statistical analyses were performed using IBM SPSS statistics version 28 (SPSS Inc., Chicago IL). Kolmogorov-Smirnov test showed that the data obtained were not normally distributed, therefore non-parametric tests were used to analyze the data. A Mann-Whitney test was used to compare CVS and OSDI scores between breastfeeding and non-breastfeeding groups. In addition, Pearson's chi-squared test was used to find the association between CVS, dry eye, and breastfeeding. Finally, the association between the CVS score and OSDI score was tested using Spearman's correlation test. All tests conducted were two-tailed with an alpha value of 0.05.

RESULTS

A total of 80 breastfeeding women and 72 non-breastfeeding women participated in the study with the age range of 21 to 45 years. Duration of VDU usage was not significantly different between groups, with an average of seven to nine hours per day in both groups (U=4053, Z=-2.276, p=0.23). Most participants in the breastfeeding group practised exclusive breastfeeding, while the rest were mixed feeding (a combination of breastfeeding and formula feeding). The demographics of the participants in each group are summarized in Table I.

The average CVS score across groups was 8.11 (SD=8.31), while the average OSDI score across groups was 25.89 (SD=17.83). CVS scores were slightly higher in non-breastfeeding group compared to breastfeeding group (Figure 1). However, Mann-Whitney test showed that this difference was not statistically significant between groups (U = 2772, z-score = -0.400, p = 0.689). In contrast, group difference was found in OSDI score (U = 2263, z-score = -2.276, p = 0.023) with a slightly higher score found in the non-breastfeeding group indicating more ocular dryness symptoms experienced by respondents in this group (Figure 2).

Additionally, a Pearson chi-square was conducted to compare the presence of CVS and dry eye based on the scores between breastfeeding and non-breastfeeding groups. Results showed no significant difference in the percentage of CVS between breastfeeding and non-breastfeeding VDU users ($c(1) = 0.05$, $p = 0.823$) indicating that there was no association between the presence of CVS and breastfeeding. Similarly, Pearson chi-square showed no significant difference in the percentage of all categories of dry eye between the groups indicating that the severity of ocular dryness was not associated with breastfeeding ($c(3) = 5.746$, $p = 0.125$) (Figure 3). Furthermore, Spearman's correlation test demonstrated a moderate positive correlation between CVS and OSDI scores ($r = 0.41$, $p < 0.001$) indicating a moderate association between the two.

DISCUSSION

This study aimed to investigate the association between breastfeeding and self-reported symptoms of CVS and dry eye by comparing the CVS-Q and OSDI scores between breastfeeding and non-breastfeeding women. It was hypothesized that CVS and OSDI scores will be higher among breastfeeding compared to non-breastfeeding VDU users indicating more symptoms reported in the former. However, results showed no significant association between breastfeeding and CVS symptoms, meanwhile, a higher OSDI score was found to be associated with the non-breastfeeding group.

A previous study has reported that CVS was more prevalent in females than males, possibly due to a lower androgen level in the former.[29] The meibomian gland, lacrimal gland, and goblet cells on the ocular surface are important components in tears production and are highly influenced by the androgen levels. Androgen helps to increase the quality and quantity of the meibomian gland's lipids composition, therefore, promoting tear film stability. Additionally, it encourages the secretion of protein, electrolytes, and water, all of which contribute to the aqueous layer of the tear film as well as enhance the function of goblet cells in mucin production.[30] In females, androgen level is dropping in the third trimester of pregnancy towards several months after birth during the lactation process.[31] The decreasing androgen level post-partum explains the increase in ocular dryness as indicated by higher OSDI score with increasing baby's age as found in the current study.

Temporary ocular surface dryness is believed to be associated with estrogen, progesterone, and prolactin released from the placental tissues, ovaries, and pituitary gland respectively.[15,32] Estrogen has the biggest impact on ocular surface dryness by inhibiting androgen's actions, which consequently reduces lipid synthesis and promotes meibomian gland dysfunction, increasing dry eye symptoms.[33] Estrogen level is lower in pregnant women starting from the third trimester which falls rapidly after delivery, until a few months after breastfeeding as compared to pre-pregnancy level, causing an increase in prolactin levels within the blood in preparation for milk secretion. The current study revealed that the OSDI scores were higher in non-breastfeeding compared to the breastfeeding group indicating a more prominent ocular dryness in the former group. This finding supports the earlier claim that decreasing estrogen levels in breastfeeding women would have an impact on reducing the symptoms of dry eye in this group.

Although the OSDI scores were significantly lower in breastfeeding compared to the non-breastfeeding group, it is unknown if the score changes with the breastfed baby's age since the range of baby's age was restricted in this study. According to Nkiru et al. [24], the prevalence of dry eye and its symptoms both substantially rose from the second to the third trimester of pregnancy but then declined to the lowest value six weeks after delivery. However, they also stated that objective tears assessment using tear break-up time and Schirmer's test showed moderate values during the post-partum period suggesting that dry eye symptoms persisted even until six weeks after delivery. No previous evidence suggests whether the symptoms will decline or rise again after six weeks post-delivery. As the estrogen level continues to rise while the androgen level decreases post-partum, ocular dryness symptoms may get worse in breastfeeding mothers with increasing babies' age after six weeks.

According to Stapleton et al. [19], one of the risk factors for dry eye is the use of a computer or other VDU displays. The present study found a moderate positive correlation between CVS and OSDI scores in line with the previous reports.[34,35] When using digital devices, the decreased blink rate and frequent incomplete eye closure during the tasks lead to ocular surface dryness, hence increasing both the OSDI and CVS scores. Parihar et al. [36] emphasized that the mechanism by which the images are seen in the VDU unintentionally decreases blinking, thus reducing tear secretion, decreasing meibomian gland expression, and preventing the proper distribution of the tear lipid; each of which leads to the occurrence of dry eye syndrome.

As estrogen aggravates dry eye symptoms, breastfeeding women can potentially benefit from lower estrogen level that reduces dry eye symptoms, although they are more

susceptible to musculoskeletal disorders. Musculoskeletal problems might contribute to overall discomfort when using VDU, but its impact on CVS seems to be less than the influence of ocular surface dryness on CVS. Findings in this study suggest that increased eye dryness has more impact on CVS than the musculoskeletal problem, which leads to a higher CVS score indicating intensified symptoms. Lower OSDI in the breastfeeding group, despite the absence of group difference in CVS score, suggests that there are other factors that contribute to CVS symptoms in addition to dry eye in the breastfeeding group such as accommodation factors and ergonomic aspects.

Although CVS and dry eye are not vision-threatening problems, increasing symptoms of these conditions can remarkably affect VDU users' productivity and quality of life, resulting in a substantial economic burden.[37] The major limitation of this study was the low response rate which caused difficulty in getting enough participants to achieve the required sample size that represents the population of breastfeeding mothers in Malaysia. However, the results provide useful insight into the association between breastfeeding and ocular symptoms. Since this study only involved self-reported symptoms of dry eye, future studies involving clinical data would be useful to confirm the benefit of breastfeeding to the ocular surface of the mother.

CONCLUSION

To conclude, the present study reported the association between breastfeeding and a lower OSDI score but not the CVS symptoms, suggesting a potential benefit of breastfeeding in reducing ocular dryness; however, the causal relationship between the two was not established in the study. A possible reason for this is a lower estrogen level in breastfeeding compared to the non-breastfeeding women. Although the breastfeeding group had lesser dry eye symptoms, CVS symptoms were comparable between groups indicating both groups were equally affected by VDU. As CVS and dry eye can negatively impact one's productivity and quality of life, health education on the risk and the preventive measures of CVS are recommended to reduce the prevalence of CVS and eye dryness among the community and maintain good health alongside the demand for VDU usage.

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ORIGINAL ARTICLE

Night eating and its relationship with BMI, stress, sleep quality and duration of study among university students

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ABSTRACT

Introduction: Night eating is a very common dietary behaviour among university students. This study aims to investigate the relationship between night eating and BMI, stress, sleep quality and duration of study among university students.

Materials and Methods: A total of 385 university students including foundation and undergraduate students took part in this study. Self-administered online surveys were used to obtain sociodemographic data, and anthropometry measurements including weight and height, night eating during studying, duration of the study, opinion on eating and academic performance, sleep quality, level of depression, anxiety, and stress of the respondents. Questionnaires were validated and IBM SPSS Statistics Software version 26.0 was used to analyse categorical and continuous variables.

Results: The findings showed that there was an association between night eaters and coffee consumption with BMI ($p<0.001$) and sleep quality ($p<0.05$). However, there was no association ($p>0.05$) found between the types of food eaten during night studying and the mean duration of the study. The results showed drinking coffee had an association with depression, anxiety, and stress ($p<0.05$) among Malaysian university students.

Conclusion: Coffee consumption was common among undergraduate students during studying. Awareness of the risk of overconsumption of caffeine intake should be implemented in the future. However, this study did not include all types of food choices and drinks. Thus, frequency of eating energy dense food during night studying among students should be conducted in the future.

KEYWORDS:
Night eating, sleep quality, body mass index, university students, stress, coffee

INTRODUCTION

Night eating among university students is very common because they need something to help them stay awake while doing assignments and studying for upcoming tests. The definition of night eating varies because many studies have concentrated on Night Eating Syndrome (NES) rather than night eating. Three definitions had been examined based on the previous study. According to Striegel-Moore et al.,[1] night eating was defined as the consumption 25% of daily total calories between 7.00pm and 4.59am. Another definition of night eating was the consumption of energy 50% of the daily total calories from 7.00pm to 4.59am.[1] Striegel-Moore et al.,[1] also defined night eating as the consumption of any food from 11.00pm to 4.59am without sticking to how many calories were consumed. Night eating or evening hyperphagia is defined as the consumption of meal after evening meal that is more than 25% calories per total daily calorie which was one of the main criteria of NES.[2] However, this current study was mainly focused on night eating among university students, not on NES.

Night eating was often linked to weight gain due to the nature of people's eating behaviour at night such as snacking.[2] In the study aimed to investigate the relationship between night eating and body mass index (BMI), many studies found that night eating had no associations with BMI. However, Kwan et al.[3] stated there was a positive association between night eating and BMI among private university students in Malaysia. The previous studies regarding the associations between night eating and BMI were not in line, therefore, this study aimed to determine the direction and association between night eating and BMI among Malaysian university students.

Conversely, sleep quality refers to the degree to which one is satisfied with sleep experience, considering aspects such as sleep initiation, sleep maintenance, sleep quantity, and feeling refreshed upon waking.[4] Several previous recent studies have shown that night eating had an association with poor sleep quality.[3,5] The consumption of high-sugar beverages and junk foods at night was associated with sleep disruption.[5]

Thus, this study aimed to determine the association between foods, energy drinks, and coffee or decaffeinated coffee at night and the sleep quality of the students. Also, diet and

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nutrition were highly affected by focus and concentration. This study will examine the night eating of Malaysian university students and the relationship with BMI, sleep quality, and duration of study.

MATERIALS AND METHODS

Study Design

A cross-sectional online survey was conducted among Malaysian public university students from May 2021 to August 2021.

Sample Size

The sample size of this study was calculated using the Cochran formula (1977). A total of 385 students were required in this study.

Data Collection

This study was conducted online through Google Form platform on a self-reporting basis. A set of questionnaires was used, which consists of seven parts: (1) sociodemographic data, (2) anthropometry measurements, (3) type of food and beverages consumed during night studying, (example: 'Do you prefer junks food while studying?, 'Do you prefer to drink coffee/ decaffeinated coffee while studying?', Do you prefer energy drink while studying?) (4) opinion on eating and academic performance and (example: 'Do you think what you eat has any role in your academic performance?')(5) duration of study, (6) sleep quality (Pittsburgh Sleep Quality Index), and (7) the scale of depression, anxiety, and stress (DASS-21).

Statistical Analysis

IBM SPSS Statistics Software version 26.0 (IBM Corp., Armonk, NY, USA) was used to analyse all the collected data. The categorical variables were described as frequency and percentage, while the continuous variables were described as mean and standard deviations. Independent Sample T-Test was used to determine the relationship of night eating and BMI. Pearson Chi-square test was used to determine the relationship of night eating and sleep quality status. Independent Sample T-test was used to analyse the association between the type of food consumed during night studying and BMI. An Independent Sample T-test was also used to determine the relationship between the type of food consumed during night studying and sleep quality. Independent Sample T-test was carried out to determine the difference in duration study among university students on different types of food eaten at night.

Ethical Consideration

This study was approved by the Faculty Ethics Review Committee of UiTM (FERC/FSK/MR/2022/0125). Prior to the data collection, an online consent form was obtained from each of the participants. The respondents had been informed they could withdraw at any time before or during the study. All the information answered by the respondents was kept confidential.

Ethics Approval and Informed Consent

This study was approved by the Faculty Ethics Review Committee of UiTM (FERC/FSK/MR/2022/0125). Prior to the data collection, an online consent form was obtained from each of the participants. The respondents had been informed they could withdraw at any time before or during the study. All the information answered by the respondents was kept confidential.

RESULTS

Characteristics of Night Eaters and Non-Night Eaters

Table I shows the respondents' characteristics of night eaters and non-night eaters. Analysis showed that 79.5% of female respondents appeared to be night eaters but no significant relationship (p=0.302) was found between night eaters and non-night eaters regarding gender.

Furthermore, based on the analysis, characteristics such as age, race, faculty of study, year of study, weekly allowance, dieting to lose, physical activity, and stress rate showed no significant relationship (p>0.05) towards night eating.

Association of Consumption of Coffee or Decaffeinated Coffee during Night Studying and BMI

An Independent Sample T-test was carried out to compare the mean BMI in coffee. Based on Table II, there was a significant difference (p<0.001) in the mean BMI for coffee drinkers (M=23.16, SD=4.87) and non-coffee drinkers (M=21.32, SD=3.91) conditions; t (383) =3.99, p<0.001. Coffee drinkers had an overweight BMI of above 23kg/m^2.

Association of Consumption of Coffee or Decaffeinated Coffee during Night Studying and Sleep Quality Score

Based on Table III, there was a significant difference in the sleep quality score between students who consumed coffee or decaffeinated coffee during night studying and who did not consume coffee during night studying. For coffee and non-coffee drinkers, there was a significant difference (p<0.05) in the mean sleep quality score between both groups.

Association of Consumption of Coffee or Decaffeinated Coffee during Night Studying and Duration of Study

As shown in Table IV, there was no statistical difference (p=0.294) in the mean of study duration between coffee drinkers (M=2.02, SD=0.89) and non-coffee drinkers (M=1.93, SD=0.91) conditions; t (382) =1.05, p=0.294.

Association of Depression between Coffee Drinkers and Non-Coffee Drinkers

There was a significant difference (p=0.020) found in the depression score for coffee drinkers (M=8.52, SD=5.80) and non-coffee drinkers (M=7.15, SD=5.46) conditions; t (383) =2.34, p=0.020 (Table V).

DISCUSSION

Night eaters are defined as a person who consumes more than 25% of their daily energy intake at night or consumed anything from 11pm to 5am. regardless of the amount of calorie intake. Based on this present study, the prevalence of night eaters was higher among females (79.5%) compared to male students (74.0%). However, there was no significant

Table I: Sociodemographic characteristics of the respondents by night eating status

Characteristics	Night-eaters, n (%)	Non- night eaters, n (%)	p-value*
Age (Mean±SD)	(22.2±1.9)	(22.0±1.9)	0.331[a]
Gender			0.302[b]
Male	54 (74.0)	19 (26.0)	
Female	248 (79.5)	64 (20.5)	
Race			0.829[b]
Malay	156 (77.2)	46 (22.8)	
Chinese	50 (76.9)	15 (23.1)	
Dusun	28 (82.4)	6 (17.6)	
Others	68 (81.0)	16 (19.0)	
Faculty of study			0.107[b]
Health sciences	73 (70.2)	31 (29.8)	
Business and Accountancy	43 (87.8)	6 (12.2)	
Engineering	37 (84.1)	7 (15.9)	
Psychology	19 (79.2)	5 (20.8)	
Others	130 (79.3)	34 (20.7)	
Year of study			0.498[b]
Year 1	90 (75.6)	29 (24.4)	
Year 2	61 (84.7)	11 (15.3)	
Year 3	116 (77.3)	34 (22.7)	
Year 4	35 (79.5)	9 (20.5)	
Weekly allowance			0.445[b]
≥RM 200	74 (81.3)	17 (18.7)	
≤RM 200	228 (77.6)	66 (22.4)	
Dieting to lose weight			0.603[b]
Yes	126 (79.7)	32 (20.3)	
No	176 (77.5)	51 (22.5)	
Physical activity			0.343[b]
Active (≥5 times/week)	81 (81.8)	18 (18.2)	
Inactive (≤5 times/week)	221 (77.3)	65 (22.7)	
Self-reported stress rate			0.191[b]
Normal	133 (73.9)	47 (26.1)	
Mild	42 (80.8)	10 (19.2)	
Moderate	14 (77.2)	13 (22.8)	
Severe	55 (85.9)	9 (14.1)	
Extremely severe	28 (87.5)	4 (12.5)	

*Independent Sample T-testa was performed with a significant difference at p< 0.05.
*Pearson Chi- square testb was performed with a significant difference at p<0.05.

Table II: Association of consumption of coffee/decaffeinated coffee during night studying and BMI

Variables	Coffee/decaffeinated coffee		Mean diff (95% CI)	t-stats (df)	p-value*
BMI	Yes (n=221) Mean (SD) 23.16 (4.87)	No (n=164) Mean (SD) 21.32 (3.91)	1.84 (0.93,2.75)	3.99 (383)	<0.001

*Independent Sample T-test was performed with a significant difference at p<0.05.

Table III: Association of consumption of coffee/decaffeinated coffee during night studying and sleep quality score

Variables	Coffee/decaffeinated coffee		Mean diff (95% CI)	t-stats (df)	p-value*
Sleep quality score	Yes (n=221) Mean (SD) 8.37 (3.56)	No (n=164) Mean (SD) 7.14 (3.36)	1.23 (0.53,1.94)	3.43 (383)	0.001

*The Independent Sample T-test was performed with significant differences at p<0.05.

Table V: Association of mean depression score between coffee drinkers and non- coffee drinkers

Variables	Drink coffee/decaffeinated coffee		Mean diff (95% CI)	t-stats (df)	p-value*
Depression score	Yes (n= 221) Mean (SD) 8.52 (5.80)	No (n=164) Mean (SD) 7.15 (5.46)	1.36 (0.22,2.51)	2.34 (383)	0.020

*The Independent Sample T-test was performed with significant differences at p<0.05.

relationship (p=0.302) between gender and night eating. The present finding was contradictory to the previous study conducted by Kwan et al.[3], which found that there was an association between gender and night eating. Furthermore, a study conducted by Gan et al.[6] reported that males had a higher urge to eat later at night and would have NES three times highly likely compared to women. However, a low prevalence of night eaters among females was found in the study by Dzulkafli et al.[7] The low prevalence of night eaters among females was due to concerns about body appearance, overeating, and weight gain.[7] This previous finding was slight inconsistencies as compared to the current findings where night eaters were higher among females than males. This could be due to the low number of male university students pursuing tertiary education hence females dominated most as the respondents in this study.

The prevalence of night eaters was highest among Malay (77.2%) compared to Chinese and Dusun, respectively. This study's results were not in line with the prior study conducted by Kwan et al.,[3] where Chinese university students had been involved more in night eating compared to Malay and Indian university students. This was due to the settings of the study which was conducted in Malaysia's private university where most of the students were Chinese, as opposed to the current study which involved both participants from public and private universities in Malaysia. Nevertheless, this current finding found no significant difference (p=0.829) in ethnicity between night eaters and non-night eaters. This result was in line with the other previous studies where ethnicity did not found to be correlated with night eating.[1,3]

The present result found that most of the night eaters were studying courses in Health Sciences. In contrast, Gan et al.[6] reported that most of the non-health sciences students preferred to eat late at night due to the lack of knowledge about healthy eating behaviour. However, the present study findings found that the majority of the health sciences students preferred to eat unhealthy food at night during studying ignoring the knowledge they had learned related to nutrition and healthy eating behaviour. Our results are similar to the study by Trahearn et al.,[8] in the United Kingdom stated that found nutrition students practicing unhealthy eating behaviour despite having excellent nutritional knowledge.

Results show that there was no significant difference (p=0.498) between the year of study and night eating. Results were consistent with the previous study carried out by Kwan et al.[3] In addition, the eating habits such as night eating among students were first developed in year-1 of the study and will be carried forward until the final year of studying.[9] In this study, first-year students had the second highest rate of night time eating after third-year students, we can predict these night eating practices will be carried on until the students graduated.

No association (p=0.445) was found between weekly allowance and night or non-night eaters. In contrast, previous studies stated that there was an association between weekly allowance and the risk of night eaters being engaged with NES.[3,10] The reason may be due to having online learning at home,[11] the place where the availability of unhealthy food such as junk food, coffee, and energy drinks was often in stock, especially for students from lower household incomes.[12]

Moreover, previous study also found that during home online learning, there is an increment of people ordering foods through delivery application and less people going out to buy food.[13]

Furthermore, there was no association (p=0.603) between dieting to lose weight and stress rate with night eating. The results of this present study were consistent with the previous study by Kwan et al.[3] Corresponding to a study performed by Kinsey and Ormsbee,[14] they found that consumption of 2/3 cup of cereal with low-fat milk as a snack 90 minutes after dinner helped obese men to lose 1.61kg of body weight over the course of four weeks. Therefore, this previous finding showed that someone who engaged in night eating did not necessarily gain weight. Moreover, the current study findings found that the majority of the students who opted for night eating were less active. Even so, no significant difference (p=0.434) was found between students who preferred night eating and the type of physical activity. According to Cheng and Kamil,15 students who experienced stress preferred to eat food that contain high fat.

Consumption of Coffee or Decaffeinated Coffee during Night Studying and BMI

Coffee was the most preferred drink choice among university students (p<0.05). The research finding was consistent with the previous study carried out by Solomon et al.,[16] where the researcher found out that most of the medical students studying in Dominica choose coffee the most than junk foods and energy drinks to stay focused during studying. Coffee contains caffeine which was highly known as the best stimulant to stay focused and alert. Results show that there was a significant relationship (p=0.000) between the consumption of coffee and BMI. Higher BMI value was among the coffee drinkers compared to non-coffee drinkers. This might be due to the high sugar content in 3 in 1 coffee and the habit of drinking coffee more than once per day. The current findings were supported by the previous study by Lee et al.,[17] which indicated that the higher frequency of coffee consumption was significantly associated with an increased risk of being overweight or obese among women.[17] In contrast, a study by Sirotkin and Kolesarova[18] found that there was no association between drinking coffee with higher BMI. The authors emphasized that the polyphenol chlorogenic acid in coffee could help to reduce fat and prevent obesity.

Consumption of Coffee or Decaffeinated Coffee during Night Studying and Sleep Quality

This current study discovered that there was a significant difference (p=0.001) between coffee drinkers and sleep quality with the highest mean sleep quality score of 8. The findings of this current study were in line with a previous study carried out by Ramakrishn et al.,[19] which found that university students that had coffee after 8pm had sleep quality index scores of above 5. In addition, respondents who took coffee within 3 to 6 hours of bedtime had significant differences in sleep disturbance.[19] Furthermore, someone who had coffee six hours before sleep was in danger of having a lower hour of

sleep duration owing to caffeine consumption.[20] This statement supported the current research results where a high prevalence of students sleeps for less than seven hours daily.

Consumption of Coffee or Decaffeinated Coffee and Duration of Study

Corresponding to the finding by Solomon et al.16 where there was a possible connection between consuming coffee with the duration of study (more than 3 hours). However, the current research found no significant relationship (p=0.294) between drinking coffee and the mean duration of study. This result was supported by a study that found no association between drinking coffee with the duration of study among medical students in Dominica.[16] In this recent study findings, students who preferred night coffee or decaffeinated coffee had the longest mean duration which was 2 hours of studying compared to students who consumed junk foods and energy drinks. Caffeine, a stimulant found in coffee, interacts with adenosine receptors to prevent sleepiness and improve alertness.[19]

Coffee Drinkers and Non-Coffee Drinkers on Depression

Current findings indicated that consuming coffee at night had a significant effect on depression mean score (p<0.02). Most of the students consumed coffee to stay awake whilst studying, however, they are not aware that overconsumption of coffee could induce the risk of mental health. Similarly, a study by Jin et al.[21] reported that the intake of coffee was positively associated with the severity of depression among Korean teenagers. Contradictory, a few studies found that the risk of depression was reduced through increased consumption of caffeinated coffee.[22–24] The results from observational studies on the relationship between coffee intake and the risk of depression and the relationship between caffeine consumption and depression remain controversial.

CONCLUSION

To conclude, this study showed that there was an association between the consumption of coffee during night studying towards BMI, and sleep quality. However, no association was found between the consumption of junk foods, energy drinks, and coffee and the duration of study. Nonetheless, there were few limitations were detected in this study. Firstly, the researcher did not include the current cumulative grade point average (CGPA) of the students. Also, the questionnaire did not contain a variety of food options hence it was possible that some students may ate other energy dense food during night studying. Additional research about night eating with various type of food choices including healthy foods, type of coffee they preferred to drink and the frequency of eating unhealthy food during night studying among students should be conducted in the future. This current study highlighted that coffee drinkers among students were associated with depression. Thus, government, university authorities, and health professionals must play a vital role in educating students about the link between excessive coffee intake and depression. Moreover, frequent screening and assessment of depression need to be done to identify those students who need help and emotional support.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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ORIGINAL ARTICLE

Preliminary study of a new online and equipment-free vision screening alternative for remote and isolated community

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ABSTRACT

Introduction: Vision screening has been initiated to detect potential vision problems, paving referral pathways towards a full eye examination. Time-cost-labour practicality challenges of equipment-based vision screening have lingered for decades. Going for the highest sensitivity and specificity or opting for a pragmatic and affordable vision screening program remains a dilemma in public eye health. We aimed to report the development of a new online and equipment-free vision screening called Eye: Questionnaire-based Vision Screening (EyeQVS). We also analysed the visual profile of Orang Bateq resided in a remote locality, using findings from EyeQVS, single test vision screening and full eye examination.

Materials and Methods: Multi-perspective development strategies were employed in designing EyeQVS. The questionnaire items were constructed using the working backward technique, compiling common vision disorders from the literature and face validation using expert panels. Face validation and usability assessment were performed on EyeQVS. The vision screening was carried out using EyeQVS and single test visual acuity screening method. The full eye examination included visual acuity, refraction, binocular vision and ocular health assessment. The visual profile of indigenous people (Orang Bateq) at Kampung Bengoi and Kampung Atok, Jerantut, Pahang was analysed using EyeQVS, single test visual acuity screening method and full eye examination.

Results: The performance of EyeQVS was affirmative in both face validation and usability. About 95% of Orang Bateq failed full eye examination, while 55% failed EyeQVS screening. None of them failed single test vision screening. Binocular disorders and dry eye problems were commonly found in Orang Bateq. EyeQVS unearthed more various vision problems compared to the single test vision screening (visual acuity alone) as a screening tool in a remote location.

Conclusion: EyeQVS can screen for binocular disorders and dry eyes problem commonly found among indigenous people, which might be missed using a single-test visual acuity screening approach. EyeQVS is a practical alternative for vision screening in places where financial or location hinders eye healthcare access.

KEYWORDS:
EyeQVS, validation, usability, indigenous people, vision screening, Orang Asli Bateq

INTRODUCTION

There are two schools of thought concerning vision screening, resulting in two distinctive approaches to implementation.[1–4] The 'idealistic' group advocates for accuracy, specificity and sensitivity and only opt for the best vision screening program, like Modified Clinical Technique or none. Those screening programmes usually involve professional and extensive equipment. On the other hand, the 'practical' group favours functionality and serviceability. They believe in mass screening, reaching out to the broader community and accepting the limitations of simplified vision screening that usually only involve visual acuity testing. Both dogmas have positive and negative implications for the eye care system. Current vision screening programmes have limitations due to the type of test used, inter-screener variation and reliability of responses that affect the accuracy of vision testing.[5,6] Most focused on reduced visual acuity.[7–9] Over-emphasis on one aspect of vision may cause other components to be neglected. A more holistic eye care program is needed for optimal vision. Tool-based vision screening programs are challenging to implement because it has significant time-cost-labour constraints.[10] Alternative screening methods have been consistently explored. Utilising a questionnaire as an eye care screening programme has the potential to be a community-based mass vision screening appliance.[11] A questionnaire approach is usually perceived as cheap, has enormous potential for better outreach, and collects quick information.[12] However, current questionnaires are mainly devised for specific target conditions and target populations.[13]

The shortage of professional eye care practitioners, increasing eye-related morbidities worldwide, and the limitation of existing tests to detect a broader range of visual problems at affordable cost uphold the urgent need to develop an inexpensive but pragmatic screening alternative.[1] In this study, we aimed to report the development of a new online and equipment-free vision screening called Eye: Questionnaire-based Vision Screening (EyeQVS). We also analysed the visual profile of Orang Bateq resided in a remote locality, comparing findings from a full eye examination, EyeQVS, and single test vision screening.

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MATERIALS AND METHODS

Development of EyeQVS

There were three stages of EyeQVS development. The first stage was concept generation. The origination was to improve the accessibility of vision screening. The previous screening forms were accessed based on our experience with internal and external screening programs among the communities since 2012.[14] The similar standard criteria used in the previous screening programs adapted for the condition and test in health screening approach.[15]

The second stage was about problem-solving. The solution was to resolve the inconvenience of equipment-based vision screening with a questionnaire-based vision screening approach to expand the eye care service. The third stage was development. We followed standard questionnaire design procedures advocated in previous studies.[16,17] The questionnaire items were constructed using the working backward technique. We established the goal of the questionnaire by determining the target groups, identifying the scopes, deciding on the question type and answer options. We developed a clear question progression with appropriate wordings or phrases to optimise the length of the questionnaire. English language was the EyeQVS medium, designed to be implemented by eye care practitioners or specially trained vision screeners.

Validity of EyeQVS

The validity of EyeQVS encompassed readability, clarity of wording, layout, and feasibility. We ensured that EyeQVS covered relevant questions of respective vision problems that EyeQVS aimed to measure. There were two essential steps in the process of validity. The first step was to engage ten experts (certified optometrists) in examining the questionnaire. The experts evaluated whether each measuring item matched any given conceptual domain and effectively captured the scopes under probing. The agreement of the expert panel was calculated. Items with less than 80% agreement was restructured or removed. Items with 80-90% agreement were revised. Items with 90-100% agreement were retained. The second step was to check for common errors like ambiguity, confusion, and leading questions. This focus group approach was to scrutinise whether a measure seemed relevant and appropriate for what it was assessing (to detect the vision problems) only on the surface.

Usability of EyeQVS

Usability investigation aimed to probe how well the application met the user's requirement (intuitive, easy to navigate, and overall user experience). Eight volunteers aged 30 to 50 years old) were recruited using convenient sampling to serve as proxy-administration screeners. The inclusion criteria were English proficiency. The volunteers come from final-year students, office workers, and parents. The subject involved in the proxy-administration were their children. Informed consent was obtained before participation. The usability assessment of the EyeQVS experience was tested via interviews using structured questionnaires. Each volunteer was interviewed face to face (no time limit) with two items before EyeQVS administration: (1) Have you ever used the online vision screening before? Yes/No; (2) How confident are you with doing those online vision screenings? 1-2-3-4-5-6-7-8-9-10 (10 very confident, 1 no confidence). There were sixteen questions to be answered after the EyeQVS administration as below:

Six close-ended questions on the general perception of EyeQVS:

- How would you like to rate your overall experience? Likert scale of 10 points (10 very like, 1 extremely dislike)
- Is EyeQVS design good? Yes/No
- How was the design experience? Likert scale of 10 points (10 very like, 1 extremely dislike)
- Do you like EyeQVS offering? Yes/No
- Is there anything EyeQVS resembles? Yes/No
- Did EyeQVS perform the way you expected? Yes/No

Three close-ended questions on usability:

- Was EyeQVS easy to navigate through? Likert scale of 10 points (10 very easy, 1 very difficult)
- Were you easily able to understand the function on EyeQVS? Likert scale of 10 points (10 very easy, 1 very difficult)
- How would you rate the difficulty level of EyeQVS? Likert scale of 10 points (10 very easy, 1 very difficult)

Seven open-ended questions on the EyeQVS experience:

- What did you like the most about EyeQVS?
- What did you like the least about EyeQVS?
- What would you change in EyeQVS?
- How would you improve EyeQVS?
- What information about EyeQVS was missing?
- Was there a particular function that was missing in EyeQVS?
- Is there anything here that doesn't make sense? Was anything out of place? If so, what was it?

Visual Profiling of Orang Bateq in Remote Location using full eye examination, EyeQVS and single test vision screening

This community screening project has obtained approval from JAKOA [Jabatan Kemajuan Orang Asli Malaysia, Jabatan Perdana Menteri: JAKOA/PP.30.032 Jld 47 (53)]. Ethical approval was also obtained from the UiTM Research Ethics Committee [REC/04/2020 (MR/88)]. Two targeted locations of Bateq villages were selected: Kampung Bengoi and Kampung Atok in Jerantut, Pahang. The data collection of this cross-sectional study was carried out in June 2022.

Indigenous people recruitment was either by walk-in or through community leaders (they addressed as 'Batin'). Consent was obtained prior to the vision screening and full eye examination procedures. Two vision screening counters were randomly assigned: (1) EyeQVS screening counter and (2) single test visual acuity screening counter. This eye screening is primarily used to detect possible abnormalities or predisposing factors for ocular diseases or disorders. It is frequently employed as a first evaluation to ascertain if additional investigation is required. Two optometrist screeners for each counter. A double-blind tactic was used. EyeQVS was administered using a proxy responses approach. This approach was employed due to the English language barrier. The single-test visual acuity screening method was carried out using a letter chart.

The full eye examination (including visual acuity, refraction, binocular vision, and ocular health assessment) was performed by six certified optometrists. A full eye examination is a thorough evaluation that aims to analyse the eyes' overall health, diagnose particular eye diseases, and determine the necessity of corrective procedures such as glasses or contact lenses. The distance visual acuity was examined using a letter chart or LEA symbol chart with a range from 6/1 to 6/60 Snellen Notation. For the illiterate, a matching card approach was used. The near visual acuity was examined using reading charts N3 to N24.

The refractive status was investigated using dry retinoscopy and subjective refraction. The ocular health was examined using a modified slit lamp technique and ophthalmoscopy to examine the anterior and posterior segments, respectively. The binocular status was examined using eight different tests. Hirschberg Test and Cover Test were used to determine if there is any tropia. Howell card was used to measure heterophoria for distance (3metres) and for near (33cm). Monocular Estimated Method (MEM) was used to estimate accommodative response at the near working distance of 40cm. The near point of accommodation and near point of convergence was measured using the RAF rule. The simultaneous perception and fusion levels of binocularity were assessed using Worth-4-Dot. The horizontal Lang two-pencil test was used as a screening test to detect gross stereopsis and binocularity.18 We used two fingers instead of two pencils.

The dry eye status was assessed using the non-invasive tear break-up time (NIBUT) technique19 and McMonnies Dry Eye Questionnaire.[20] NIBUT had significantly higher sensitivity and specificity.[21] We measured NIBUT using images from a handheld Placido disc. The reliability and validity of the McMonnies Dry Eye Questionnaire have been reported to be good for patient care and clinical studies of patients with dry eye disease.[22] All the tests conducted on the same day. The duration of the time gap between tests varies depending on the level of cooperation required for each participant, often ranging from 3 to 5 minutes. The scopes of eye test parameters and the respective pass-fail criteria are summarised in Table I.

The study protocol was summarised in Figure 1.

Ethics Approval and Informed Consent

We would like to express our gratitude to the Department of Wildlife and National Parks of Peninsular Malaysia (PERHILITAN) and the Department of Orang Asli Development (JAKOA) for their approval, in addition to all our Orang Asli Bateq respondents in Jerantut, Pahang, Malaysia for participating in this research with consent.

RESULTS

Description and Validity of EyeQVS

EyeQVS employed a closed-ended questions approach utilising patient-reported outcomes measures (PROM) and patient-reported experience measures (PREM) in designing the item constructs with pre-coded responses and neutral opinion options. Its design emphasised the advantages of wide-ranging characteristics, lower operational costs, and better accessibility. The questionnaire length was kept as short as possible to avoid questionnaire fatigue and reduce attrition rates. The wordings and phrases used in the questionnaire were carefully selected to meet the simple and easy-to-understand criteria. Answer options were thoroughly researched and adapted to minimise confusion and contamination of data. Neutral filters ('not sure' & 'I don't know') were built-in as one of the answer options. The finishing version of EyeQVS for the remote and isolated community (Figure 2) consisted of 20 items that screened for reduced vision (2 items – Questions 1-2), visual field defect (2 items – Questions 3-4), binocular disorders (6 items – Questions 5-10), dry eye (5 items – Questions 11-15), and postural ergonomic problems (5 items – Questions 16-20). The scopes of questions encompassed visual sensation (7 items – Questions 1-7), primary sensation (3 items – Questions 8-10), surface sensation (5 items – Questions 11-15), and systematic sensation (5 items – Questions 16-20). EyeQVS could be completed in less than five minutes. The ultimate goal of this questionnaire was not to diagnose specific eye disease but to create an alternative pathway into the eye healthcare system.

Usability of EyeQVS

No volunteer [0%, 0/8)] had previously used online vision screening. The average overall experience of EyeQVS was 6.62±1.92 on Likert 10-point scale. All volunteers [100% (8/8) rated EyeQVS as a good design with an average = 6.75±1.16 on Likert 10-point scale. All volunteers liked what the product offered. About 25% (2/8) said they had encountered a similar tool like EyeQVS. Seventy-five per cent (6/8) of them attested that the EyeQVS performed how they expected.

The usability assessment and EyeQVS experience are summarised in Table II and Table III, respectively. All rated above average for both experience and task difficulty of EyeQVS, which signified the good acceptability of EyeQVS. The three favourite features of EyeQVS were paperless, simple, and easy to use.

Visual Profiling of Orang Asli Bateq at Kampung Bengoi and Kampung Atok, Jerantut, Pahang, Malaysia

There were approximately 15 families with 40 indigenous people. Twenty Orang Bateq aged 12 to 60 underwent the full eye examination (50% of the population). The remaining 50% of indigenous people were not at home during our visit. The findings are summarised in Table IV. The most common vision disorders were dry eye (85%), followed by binocular problems (55%) and ocular health (10%).

As high as 95% of indigenous people failed full eye examinations for various reasons (refer to Table IV). None of them failed the visual acuity test. Approximately 55% failed EyeQVS for multiple reasons [ocular health problem (15%), vision problem (30%), binocular vision problem (55%), dry eye problem (55%)]. The prediction of eye health and binocular vision problems using EyeQVS were closely related to respective clinical tests. Nevertheless, the dry eye screening using EyeQVS was 30% lower than the clinical dry eye test battery. EyeQVS seemed to overestimate the visual acuity problem by 30% in this preliminary study.

Table I: The list of eye test parameters and pass-fail criteria

Scopes	Parameters	Tools	Pass-Fail Criteria
Physical Vision Investigation	Distance visual acuity	Letter Chart / LEA symbol chart	Fail if equal or worse than 6/12
	Near visual acuity	Near Reading Chart	Fail if equal or worse than N10
	Refraction (SE = Spherical Equivalent)	Dry Retinoscopy & Subjective Refraction	Hyperopia, SE ≥2.50D; Astigmatism, Cylinder ≥1.50D; Myopia, SE ≤ -1.50D; Anisometropia, ≥ 1.00D (difference in SE)
Binocular investigati on: Motor signs of neuromusc ular anomalies of the eyes	Ocular symmetry	Hirschberg Test	Fail if any tropia detected
	Ocular alignment	Cover Test	Fail if any tropia detected
	Distance Phoria	Howell Card (3m)	Fail if outside the normal range: 1 ESO TO 3 EXO PD
	Near Phoria	Howell Card (33cm)	Fail if outside the normal range: ORTHO TO 10 EXO PD
Binocular investigati on:	Near point of accommodation	RAF rule	Fail if worse than the age norm using the minimum amplitude of accommodation age formula as 15 - (0.25 x patient's age in years)
	Accommodation Response at near	Monocular estimated method	Fail if not within the normal range of +0.50D to +0.75D
Binocular investigation: Sensory & depth perception	Fusion	Worth-4-Dot	Fail if detect any suppression (2 lights/ 3 lights) or diplopia (5 lights)
	Gross Stereopsis	Modified Horizontal Lang twopencil test	Fail if two fingers cannot meet accurately
Dry Eye Investigation	Anterior Segment	Ophthalmoscope / pen torch + magnifier	Fail if any abnormality detected
	Posterior Segment	Ophthalmoscope	Fail if any abnormality detected

Table II: Summary of usability assessment. The number indicates the average score with a standard deviation of the 10-point Likert scale

Three items were assigned to assess usability	10-point Likert scale (10 very easy, 1 very difficult)
Was EyeQVS easy to navigate through?	7.13 ± 1.89
Were you easily able to understand the function on EyeQVS?	7.00±1.69
How would you rate the difficulty level of EyeQVS?	7.63±1.41

*Independent Sample T-test was performed with a significant difference at $p<0.05$.

Table III: Summary of the EyeQVS experience

Items for EyeQVS experience	Summary of Responses
What did you like the most about EyeQVS?	• Easy • Paperless • Mobile/Portable • Allows wide accessibility • Simple and easy
What did you like the least about EyeQVS?	• List of selection not much • Operating interface to register • Age not automatically calculated • Limited by internet network.
What would you change in EyeQVS?	• Colour coding to differentiate the section • Demography and result section
How would you improve EyeQVS?	• More options or selection for each info/date • Incorporate automated age calculation in personal data section
What information about EyeQVS was missing?	• Result section: Suggest to put in address/info that subject can call for further information
Was there a particular function that was missing in EyeQVS?	• Demo on how to use the apps • Referring centre • Button or function to go back to previous pages Is there anything here that doesn't make sense? Was anything out of place? If so, what was it? • Cannot do without coverage

Table IV: Visual profile of Orang Asli Bateq

Scope of Investigations	Parameters	Percentage fail (subject number, n)
Physical Vision Investigation	Distance visual acuity	0%
	Near visual acuity	0%
	Refraction (Spherical Equivalent)	0%
Binocular investigation: Motor ocular signs of neuromuscular anomalies.	Ocular symmetry	0%
	Ocular alignment	0%
	Distance Phoria	5% (1 fail)
	Near Phoria	5% (1 fail)
Binocular investigation: Near vision complex	Near point of Convergence	20% (4 fail)
	Near point of Accommodation	0%
	Accommodation Response at near	55% (11 fail)
Binocular investigation: Sensory & depth perception	Fusion	15% (3 fail)
	Gross Stereopsis	0%
Dry Eye Investigation	Tear assessment	40% (8 fail)
	Self-reported dry eye symptoms	0%
Ocular Health Investigation	Anterior Segment	10% (2 fail)
	Posterior Segment	0%

Table V: The visual profile summary of Orang Asli Bateq using the full eye examination, EyeQVS and single-test (visual acuity alone)

Subject	Full Eye Examination	Reason(s) of referral	EYEQVS	Reason(s) of referral	Single test vision screening (Distance visual acuity alone)
S01	F	BV+DE+EH	F	VA+RX+BV+DE+EH	P
S02	F	BV+DE+EH	F	VA+RX+BV+DE+EH	P
S03	F	BV+DE	F	VA+RX+BV+DE+EH	P
S04	F	BV+DE	F	VA+RX+BV+DE	P
S05	F	BV+DE	P	-	P
S06	F	BV	F	VA+RX+BV+DE	P
S07	F	BV	F	BV+DE	P
S08	F	BV+DE	F	BV+DE	P
S09	F	BV+DE	F	BV	P
S10	F	DE	P	-	P
S11	F	DE	P	-	P
S12	F	BV+DE	F	BV	P
S13	F	DE	P	-	P
S14	F	DE	P	-	P
S15	F	DE	P	-	P
S16	F	DE	P	-	P
S17	F	DE	P	-	P
S18	P	-	P	-	P
S19	F	DE	F	VA+RX+BV+DE	P
S20	F	BV+DE	F	BV+DE	P

Note: EyeQVS - Eye: questionnaire-based vision screening; F - fail; P- pass; VA - visual acuity, RX - refractive error; BV - binocular disorders; DE - dry eye; EH - eye health. The formulation for pass/fail criteria of EyeQVS - refer to Tables 4-7 in publication by Chen et al.[23]

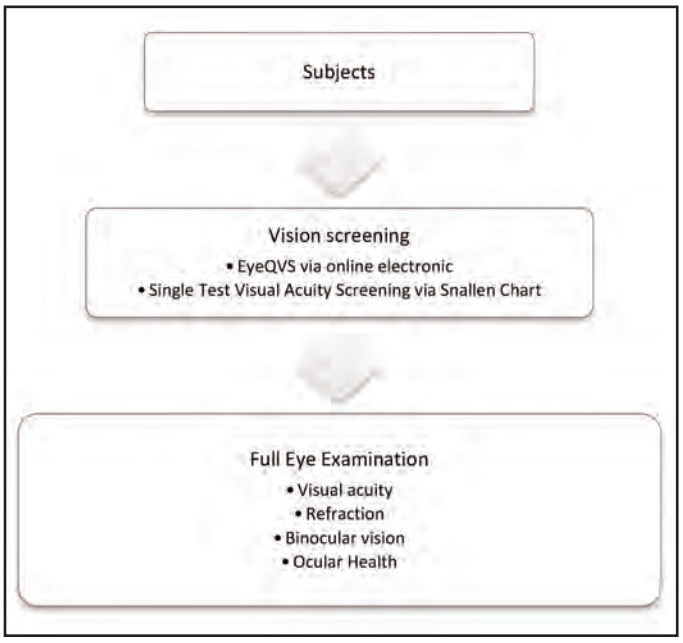

Fig. 1: Flowchart of the Study Protocol Process

The comparison between the outcomes of full eye examination and vision screening using EyeQVS and a single test (visual acuity alone) was summarised in Table V. About 95%, 55% and 0% of the subjects failed the full eye examination, EyeQVS and single test vision screening, respectively.

DISCUSSION

Eye: Questionnaire-based Vision Screening (EyeQVS)

Financial restrictions and labour constraints of qualified eye care practitioners are among the main hindrances to implementing comprehensive eye care in most countries. Due to the time-cost-labour impracticality challenge of full eye examination and equipment-based vision screening, seeking an alternative and more practical screening approach would be unavoidable. In response to the provisions, EyeQVS was initiated. The 20-item EyeQVS for the remote and isolated community can screen for five significant vision scope problems: reduced vision, visual field defect, binocular disorders, dry eye, and postural ergonomic problems. It also provides information on visual, primary, surface, and systematic sensations. EyeQVS used a closed-ended questions approach using patient-reported outcomes measures and patient-reported experience measures.[24] It is designed to lessen the burden of expensive equipment-based vision screening by leveraging the unique properties of questionnaires (convenient and cost-effective).

Developing a visual profile of indigenous people is essential due to their distinctive lifestyle. All of them had never had an eye exam before. Orang Asli Bateq, in this study, exhibited good eyesight and good ocular health. All passed visual acuity tests and refraction. They were either emmetropia or negligible hyperopia. None of them was myopia. Only 10% required referral in ocular health investigation. Our findings were consistent with previous reports on the low prevalence of blindness (0.64%) and low vision (2.88%) among indigenous people.[25] Much lower than the three main ethnicities (Malay, Chinese and Indian) in Malaysia.[26–28] The prevalence of myopia among Chinese, Indians and Malay in Malaysia was approximately 30-50%, 12-31% and 4-25%, respectively. The prevalence of myopia was also recorded as lower in rural compared to urban in all races. Lifestyle was suggested as one possible explanation for the discrepancy.

Many parts of the world reported 'super acuity' among indigenous people. The vision of Aboriginals was reported to be four times better than non-Indigenous people.[29] Our data on our indigenous people seemed in agreement with many worldwide reports of 'super acuity' among indigenous people. The habitual visual acuity range of *Orang Asli Bateq* was between 6/6 (20/20) to 6/2.4 (20/8). None of them had unaided visual acuity worse than 6/6 (20/20). Only three of them had to present visual acuity of 6/6. *Orang Asli Bateq's* visual acuity was better than the indigenous Australians, who were reported to have the best vision of 6/3.5 or 20/12.[29]

However, the 'super acuity' ability does not prevent the development of eye diseases. The burden of eye diseases is not uncommon among indigenous people. Visual impairment was unfailingly stated to be higher in indigenous people than non-Indigenous people.[29–31] Higher prevalence of visual impairment and burden of eye diseases among indigenous, highlighting that improvements in eye healthcare in Indigenous communities are crucial. The causes of visual impairment and blindness reported included uncorrected refractive error, cataracts, optic atrophy, diabetic eye disease and trachoma.[25,29–31]

However, all *Orang Asli Bateq* in our study passed subjective and objective refractive error evaluations. The majority were emmetropic or negligible hyperopic (below +0.50D) except one with +1.00D and another with +1.25D. None of them was myopic. Only 10% of the *Orang Asli Bateq* had ocular diseases. The Orang Asli Bateq may display several health-related features that extend beyond refractive errors and ocular state. When performing a thorough health evaluation, it is important to take into account multiple elements such as nutritional status, lifestyle factors, and living conditions that may influence health, as well as social economy and environmental factor[32]. This element is beyond on our study scope.

Binocular investigation in this study was subdivided into three categories: motor, near vision complex and sensory. Most Orang Asli Bateq displayed good motor signs of neuromuscular anomalies of the eyes, and no manifested strabismus was found. No one failed the ocular symmetry and alignment investigation. Two uncompensated heterophoria cases were detected. One had esophoria of 3 prism dioptres at near, while the other had seven prism dioptres of esophoria at far. Among those who passed the heterophoria assessment, 80% were orthophoria at both distance and near. Only 5% of *Orang Asli Bateq* were esophoria (one prism dioptre esophoria at a distance) and exophoria (four prism dioptres exophoria at near), respectively. The low percentage of strabismus is also found in another tribe, Orang Asli Temuan.[33] Near vision, complex examined both vergence and accommodation systems. The remote near point of convergence (NPC) was used to investigate the vergence system. Only four cases of remote

NPC were detected: one reported break point at 11cm, two at 14cm, and one at 24cm. The accommodation system was inspected using near point of accommodation (NPA) and modified estimated method (MEM). All Orang Asli Bateq passed the NPA test. More than half failed the MEM test. These might relate to the hyperopic refractive range of the *Orang Asli Bateq*. However, it was not a concern because all failed subjects had MEM of +1.00D. Only +0.25D is higher than the normal range. In the sensory and depth perception investigation, three suppression cases were detected despite all passing the gross depth perception test. Perhaps a monocular cue was used. A study of the Visual Profile of Queensland Indigenous Children found that Indigenous children who have less refractive error and strabismus significantly commonly developed convergence insufficiency and reduced visual information processing skills compared to non-Indigenous peers.[34] This might be due to less near-work exposure in their daily life experience. Our *Orang Asli Bateq* might be sharing exposure to a similar environment. We can observe the after-effect of their binocular status here after they achieve age 12. These concerns may impact scholastic achievements during childhood and their correlation with asthenopia symptoms, attention span, and exhaustion.

All *Orang Asli Bateq* passed the McMonnies Dry Eye Questionnaire in the dry eye investigation. However, approximately 40% of *Orang Asli Bateq's* non-invasive tear break-up time was below six seconds. Dry eye can affect individuals from all ethnic backgrounds and is influenced by various factors, such as age, gender, environmental conditions, overall health, and lifestyle. Only two *Orang Asli Bateq* failed anterior segment assessment in ocular health investigation. One case of cataract and one case of pterygium were detected. Cataracts and pterygium are ocular disorders that can impact individuals of many ethnicities, and their prevalence is not exclusive to Indigenous communities. however, higher exposure to sunlight might be the main factor of cataracts and pterygium among the Indigenous.[35] All *Orang Asli Bateq* passed posterior segment assessment in ocular health investigation.

The comparison of visual outcomes using full eye examination, EyeQVS and single-test visual acuity screening

Vision screening aims to identify populations with vision disorders. They emphasise early detection and facilitation of appropriate visual rehabilitation to prevent or minimise visual disability. When we compared the full examination results with EyeQVS or single-test vision screening, we found that EyeQVS could detect more vision problems than the single-test vision screening approach. Using the single test vision screening alone, all *Orang Asli Bateq* would have passed the vision screening. The conflicting results might indicate that certain vision disorders would be missed. Although visual acuity testing is the most common method used in vision screening worldwide,[7–9,36–38] simple vision screening alone is insufficient to resolve the diverse eye health issues in this preliminary vision screening of indigenous communities. There was a high incidence of binocular problems (55%) and dry eye problems (85%) in *Orang Asli Bateq*. Eye health care for indigenous people should include binocular and dry eye assessment. Although EyeQVS cannot be as accurate or precise as the full eye examination, our findings revealed that the vision screening outcome of EyeQVS was better than the single test visual acuity screening tactic.

CONCLUSION

The presence of eye diseases harms the lifestyle among indigenous people. It has been highly recommended for countries with indigenous communities conduct vision screening. EyeQVS is a potential alternative vision screening option when the full eye examination or equipment-based vision screening is not feasible. However, EyeQVS is not intended to replace the full examination or to substitute tool-based vision screening programs. EyeQVS can cover broader vision problems (five most common vision problems: reduced vision, visual field defect, binocular disorders, dry eye, postural ergonomic problems) than single test vision screening (visual acuity alone). One of the limitations was the small sample size of *Orang Asli Bateq*. Future research would target other indigenous population in Malaysia.

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AUTHORS CONTRIBUTION

Conceptualisation: AHC, SAR, AA, BDM; data curation and formal analysis: AHC, SAR, BDM; Methodology: AHC, SAR, AA; writing original draft: AHC, SAR; writing editing: AHC, SAR, AA, BDM

CONFLICT OF INTEREST

No conflict of interest in this research study

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SYSTEMATIC / NARRATIVE REVIEW ARTICLE

Viability of unmanned aerial vehicles in identifying potential breeding sites for mosquito: A scoping review

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ABSTRACT

Introduction: Surveillance of mosquito breeding sites is essential because it provides the information needed to assess risks and thus respond to dengue outbreaks. This article aims to review existing research on the viability of using unmanned aerial vehicles (drones) to identify potential breeding sites for *Aedes* mosquitoes and highlight the issues related to their implementation.

Materials and Methods: The authors conducted a literature search in four databases (Scopus, Web of Science, Science Direct, and IEEE Xplore) and completed it in December 2022. Articles that do not directly address the application of drones for surveillance and control of mosquito breeding sites were excluded.

Results: The initial search using the keywords yielded 623 documents. After screening abstracts and reviewing the full text, only 17 articles met the inclusion criteria. Most of the studies were in the proof-of-concept stage. Many studies have also incorporated drone technologies and machine learning techniques into surveillance efforts. The authors have highlighted seven key issues related to the operational aspects of using drones. Those are hardware, software, law and regulation, operating time, expertise, geography, and community involvement.

Conclusion: With rapid developments in drone technologies and machine learning techniques, the viability of drones as surveillance tools can be enhanced, thus effectively responding to global public health concerns.

KEYWORDS:
Mosquito, breeding site, unmanned aerial vehicle, vector control, machine learning

INTRODUCTION

The dengue virus infects humans via a female mosquito bite. Dengue fever is now deemed endemic in over 100 countries, with Asia bearing more than two-thirds of the burden.[1] The principal vector of dengue, yellow fever, and chikungunya is *Aedes aegypti*.[2] The spread of *Ae. aegypti* is a severe public health issue. This relationship is further increased by the mosquito's ability to disperse and adapt to new surroundings and poor sanitation.[3] Targeted environmental and ecosystem management remains critical in controlling dengue due to the lack of effective vaccines or antiviral treatment.[1] Dengue can thrive in either artificial containers or naturally occurring environments.[4] Stagnant and unpolluted water is ideal for the reproduction of *Aedes* mosquitoes.[5] They have adapted to human environments and can now be seen breeding in various small containers.[1]

The prevention of mosquito-borne diseases will continue to pose a difficulty in the forthcoming years because of rapid urbanization and globalization, coupled with the dynamic change of mosquito populations.[6] Various strategies available to control mosquitoes can be tailored to suit individual, community, and regional environments. By mitigating mosquito proliferation can lessen the future effects of diseases transmitted by mosquitoes.[7] Such efforts could result in costly, time-consuming, ineffective monitoring and control without efficient mosquito management strategy.[2,8] Field technicians have encountered a new occupational risk when performing dengue surveillance and control due to the COVID-19 pandemic.[9] Health inspectors must visit residences to find and eliminate potential mosquito breeding sites. This technique presents a considerable challenge for officials and has various drawbacks, including time limits, safety concerns, and cost.[2,5]

Drones are rotary or fixed-wing aircraft operated remotely. When equipped with suitable sensors, drones have been used in a wide range of public health studies, agriculture, forestry and ecological monitoring.[2,10] Drones are viable alternatives to manual assessment because they can be maneuvered to overcome obstacles that impede human access. It can be used as a suitable remote photographing, mapping, and data collection platform.[3] Drones can capture images or recordings with a higher spatial or temporal resolution from various angles and altitudes.[11] Using a programmable drone enhances the auditors' safety by reducing their exposure to potentially hazardous situations or locations.[12-14]

This study aims to review existing research on the viability of using drones to identify potential breeding sites for *Aedes* mosquitoes. The advancement of drone technology and its integration with machine learning have made drones promising tools to complement the current methods of dengue prevention strategies. This review highlighted the recent research's issues, challenges, and limitations in using drones as a guideline for future studies before field implementation.

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MATERIALS AND METHODS

This research adhered to a framework by Arksey et al.[15] to conduct a scoping review, which provides a comprehensive perspective of a complex topic by mapping the available data from different sources.[16] The five stages of this approach include identifying the research question, identifying relevant studies, selecting studies, charting the data, and collating, summarizing, and reporting the results.[15] This review also follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations (Figure 3).

Data Sources and Search Criteria

A literature search was completed in December 2022 using the four online databases: Scopus, Web of Science, Science Direct, and IEEE Xplore. There were no time constraints imposed on the literature search strategy. To maximize the scope of the initial literature search, a two-block search strategy was used and modified from Hiebert et al.[17] Block one contained drone-related nomenclature, whereas block two contained mosquito-related nomenclature (Table I).

The search was constructed in three steps: (1) the Boolean operator "OR" was used to connect all terms in block 1; (2) the Boolean operator "OR" was used to connect all terms in block (2); and (3) the Boolean operator "AND" was used to connect all terms in block 1 with all terms in block 2 to ensure all documents retrieved included both drone- and mosquito-related nomenclatures (Figure 1).[17] The same search string was used for all online databases selected (Figure 2).

Study Identification and Selection

Following the article search strategy (Figure 2), the significance and relevance of the selected literature were evaluated based on its subject matter and publication format. During title and abstract screening (Figure 3), documents were maintained for full-text review if they fulfilled the following inclusion criteria:

i. The title or abstract emphasizes the application of drones for surveillance and control of mosquitoes breeding sites;
ii. The studies conducted for any species of mosquito regardless of any stage of the life cycle; and
iii. The document must be a full research paper and written in English.

At this stage, documents were omitted from analysis if any of the subsequent conditions were met:

i. The document was not related to the application of drones for surveillance of mosquitoes breeding sites;
ii. The document was a review article, operational note, newsletter, book chapter, commentary, editorial note, unpublished manuscript, or conference abstract;
iii. The document was authored in a language other than English; and
iv. The document was duplicate or non-availability of the full text articles.

Following the identification of articles in the aforementioned databases, the articles were imported into the EndNote Version 20.4.1 (Clarivate, Philadelphia, Pennsylvania, United States), where any duplicates were deleted. Only those documents that appeared to be relevant to the topic at hand and fulfilled inclusion criteria, were kept for a more in-depth read. The full texts of articles were then retrieved to identify which were eligible for inclusion in the review as shown in the PRISMA flowchart (Figure 3).

A data extraction form (Table II) was used to extract study details such as the paper ID, the author(s), the year of publication, the study objectives, the study sites, the mosquito species, and disease studied (if specified), the methodological approaches and the application of drone.

RESULTS

The initial search using the keywords yielded 623 documents from four databases: Scopus (N=192), Web of Science (N=119), Science Direct (N=273), and IEEE Xplore (N=39). A total of 342 articles were excluded due to title, abstract, and duplicate removal screening. The remaining 51 articles were assessed for eligibility on an individual basis. Finally, only 17 full-text articles met the inclusion criteria. The comprehensive review process for the study collection is depicted in Figure 3.

General Characteristics of the Articles Included in the Review

Table III summarizes the articles included in the scoping review. The included publications were published between 2016 and 2022. There were two studies in 2016, three in 2017, one each in 2018 and 2019, two in 2020, five in 2021, and three in 2022, with 71% published within the last five years. Most of the articles reviewed were from Brazil. Sri Lanka was second with three articles, followed by Tanzania and Malawi with two articles each. United States, Ecuador, India, Mexico, and Peru each contributed one article. Dengue fever treatment has a significant economic impact in several countries, particularly Brazil. A study conducted in 17 Latin and Central American countries estimated that the annual cost of dengue outbreaks in these countries is more than US $3 billion, with Brazil alone accounting for US $1.4 billion annually.[18] There has also been considerable international collaboration; some authors studied regions outside their own. As mosquito populations continue to expand, greater international collaboration is expected.[7]

The objectives of the selected studies can be summarized under four main headings. First, nine documents (50%) focused on identifying and mapping potential mosquito breeding sites using high-resolution drone imagery. Seven documents (38.9%) addressed computer-based approaches, including machine learning and remote sensing, to map mosquito breeding sites using aerial drone imagery. One paper (5.6%) examined the effectiveness of the two technologies for surveying a study area which are drones and global positioning system-based receivers. One document (5.6%) examined the relationship between socioeconomic status and mosquito breeding sites.

Dengue fever is endemic in many of the regions studied. The most studied species is *Aedes* mosquitoes (*Ae. aegypti* and *Ae. albopictus*). *Aedes sp.* accounted for 64.7% of the mosquito species analyzed; *Anopheles sp.* accounted for 29.4%, and one study did not report any of the mosquito species involved (5.9%). Dengue was the most frequently discussed disease (41.7%), followed by Zika (25%), malaria (20.8%), and chikungunya (12.5%). A single mosquito species can serve as

Table I: Terms used in the initial document search

Block 1: Drone-related Nomenclature	Block 2: Mosquito-related Nomenclature
Unmanned aerial vehicle	Mosquito
Unmanned aircraft system	Vector control
Drone	Breeding site

a vector for multiple mosquito-borne diseases; therefore, some studies addressed multiple diseases. In general, most of the studies were conducted in urban areas or a combination of suburban and rural areas. 52% of the study focused on urban areas, 33% on most suburban areas and 14% on rural areas.

Integrating machine learning techniques into surveillance activities has gained interest in many studies. 70.6% of the selected articles used machine learning in their research. Another 29.4% analyzed high-resolution imagery from drone technology. Most of the study was conducted using a DJI drone from Shenzhen, China. The DJI Phantom 4 was the most widely used, accounting for 47.1%, followed by the DJI Phantom 3 (23.5%), and only one study used the DJI Phantom 2 (5.9%). Another type of drone from the French company Parrot AR was also used in one study (5.9%). In the remaining three studies (17.6 %), the type of drone used was not specified. All studies conducted (100%) were at the same implementation level, which is proof of concept and descriptive study design. However, the application of drones in the study was either for surveillance purposes (82.4%) or larval control (17.6%).

DISCUSSION

The Application of Drone Technology as Surveillance Tools

The applications of drones are essentially governed by variables such as size, power, and operating conditions, which vary widely depending on the type of drone.[19] The application of drone technology has already led to numerous remarkable results. The images of water bodies are examined to identify potential mosquito breeding sites.[14] Drone surveying approaches for artificial containers are becoming more accurate by combining global positioning system receivers with machine learning techniques and imaging technologies such as multispectral imaging.[24] In other research they merged internet of medical things and geographic information systems.[25] They contain and manage dengue virus outbreaks by analyzing call records. Hardy et al.[26] analyze drone data using a mix of mapping methods: supervised image classification with machine learning and technology-enabled digitizing mapping accessible to those without a technical background.

Machine learning can detect patterns in data at or above human levels, which is useful for classification, prediction, and clustering.[7] Artificial intelligence can accurately estimate the number of larvae and pupae in a sample by automating repetitive learning processes.[12] Many studies used orthomosaic maps that are constructed by stitching together 2D aerial photographs with at least 70% picture overlap as reference points.[20] Drones were used to collect many aerial photo configurations for a database.[21] The proposed system was tested and trained using the collected photos and the annotated database. This technology allows the detection of tiny objects that existing remote sensing methods cannot detect.[22] In an example of architectural innovation that combining and applying two established technologies to a new market and context.[23] Results showed that drone deployment and insecticides could reduce mosquito populations in an irrigated rice agroecosystem. Improving the precision of the technology requires extensive engagement and data from many images representing a wide range of situations.

The Issues, Challenges, and Limitations of Using Drone

This review has highlighted and grouped the operational issues of using drones under seven themes, including hardware, software, law and regulation, operating time, expertise, geography, and community involvement (Table III). The ability of drones to fly in inaccessible areas is their most important advantage. Drones are available in different sizes and configurations; therefore, specific criteria must be taken into consideration to determine which model is best suited for searching breeding habitats.[3]

The most highlighted issue by many authors is software (22%) (Figure 4), which includes drone control software, formatting, data processing, and image classification. The study by Prasad et al.[27] highlighted the failure of SVM-based approaches and optical flow, after which a combined method called horizon mask, was developed to address this issue. Identifying waters in the resulting orthomosaic can be challenging, especially when waters with significant suspended sediment are the same color as bare ground.[13] There needs to be more techniques for rapid data processing and solutions for accelerated image processing.[14] Obtaining unbiased, ethical, comprehensive, and global datasets is challenging but needed for practical machine learning applications in mosquito control.[7,28] Creating orthomosaics from drone imagery is a time-consuming process that requires a powerful computer, a large data storage capacity, and specific software.[10]

Regarding hardware (20%), some aspects such as specification, flight duration, maximum altitude, signal strength, spare parts supply, data management, and cost efficiency are among the highlighted issues. A drone can only stay in the air for up to 20 minutes before its battery runs out.[4] Therefore, numerous flights over the area are required to create a single map; this may result in some temporal variation between scenes on the single map and affect the spectral signature, although this effect is likely minimal.[14] Drone signals are lost when there is a large body of water or telecommunications towers between the drone pilot and the drone, as these areas absorb drone signals.[4] Although purchasing commercially available drones in the country is possible, obtaining replacement parts or repairs becomes difficult and expensive when technical problems occur.[10]

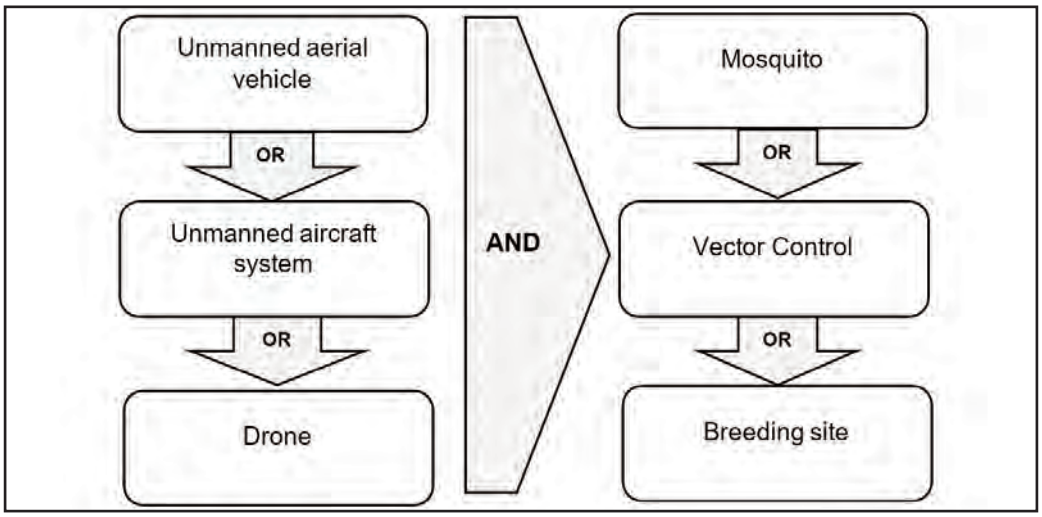

Fig. 1: Boolean operators used to connect the term search

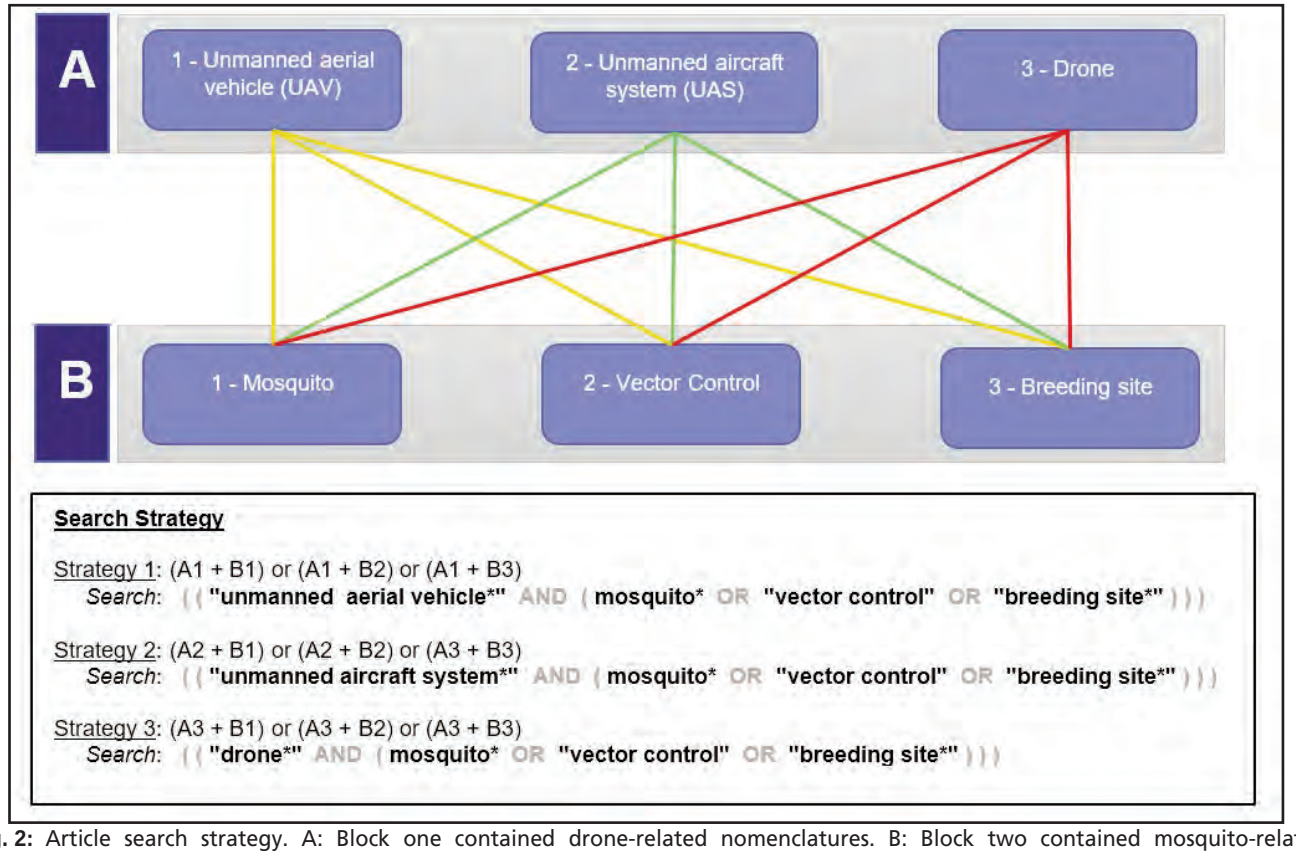

Fig. 2: Article search strategy. A: Block one contained drone-related nomenclatures. B: Block two contained mosquito-related nomenclatures

Expertise issues (20%) include incompetence, training hours for drone pilots, and insufficient previous research data. The aerial inspection is manually controlled, which depends on the drone pilot's ability to fly the drone.[4] Drone flight requires a certain level of skill.[14] In searching for water bodies in a rural setting, drone image capture inevitably presents technical and skill-based challenges.[10,29] The lack of comprehensive research on this topic in the past and the small sample size in the training phase of deep learning presented a significant challenge for researchers.[5,30]

Regarding geographic limitations (12%), drones cannot be used in very difficult-to-access locations, such as areas with high plant density or tree canopies. Due to the dynamic nature of water bodies, conducting large-scale surveys from the ground has not been possible.[13] Other obstacles such as power lines and telecommunication towers, auto-fly mode cannot be used in urban areas.[4] This limits the application of the drone. The operating time (10%) for the drone's flight was another factor that need to be considered. Since drone could not be flown in wet or windy conditions, the flight experience

Table II: Summary finding of eligible articles

ID	Author (Year)	Main Objective	Methodology					Application of drone	
			Study Site	Species of Mosquito Studied	Disease concerned	Study Design / Area	Integrate Machine Learning Techniques (YES/NO)	Type of Drone	Type of Activity
1	Mehra et al., (2016) [5]	To identify the presence of stagnant water bodies in images taken from UAVs	Brazil	Aedes	Zika	Descriptive / Urban	YES	Not specified	Surveillance
2	Prasad et al., (2016) [27]	To inspect and identify stagnant water patches in hard-to-access areas using a quadcopter	India	Not specified	Dengue	Descriptive / Urban	YES	Parrot's AR drone	Surveillance
3	Amarasinghe et al., (2017) [4]	To capture the images of the water retention areas via a drone	Sri Lanka	Aedes	Dengue	Descriptive / Urban & Suburban	YES	DJI Phantom 4	Surveillance
4	Suduwella et al., (2017) [31]	To identify the possible water retention inaccessible areas via drone images	Sri Lanka	Aedes	Dengue & Zika	Descriptive / Urban	NO	DJI Phantom 4	Surveillance
5	Hardy et al., (2017) [13]	To map water bodies as targets for larval source management by using low-cost drones	Tanzania	Anopheles	Malaria	Descriptive / Suburban	NO	DJI Phantom 3	Control (Larva)
6	Dias et al., (2018) [21]	To determine mosquito-breeding habitats' location by employing computer vision tools on aerial images using UAVs	Brazil	Aedes	Dengue, Chikungunya, Zika	Descriptive / Suburban	YES	DJI Phantom 2	Surveillance
7	Carrasco-Escobar et al., (2019) [14]	To identify mosquito breeding sites with high-resolution imagery from drone	Peru	Anopheles	Malaria	Descriptive / Suburban	YES	DJI Phantom 4	Control (Larva)
8	Schenkel et al., (2020) [24]	To investigate the effectiveness between the two technologies of interest in surveying a study area: drones and global position system-based receivers	USA	Aedes	Zika	Descriptive / Urban	NO	DJI Phantom 3	Surveillance
9	Amarasinghe et al., (2020) [34]	To identify possible mosquito breeding grounds using drone images and propose two algorithms to identify small-scale standing water bodies.	Sri Lanka	Aedes	Dengue, Zika, Chikungunya	Descriptive / Urban	YES	DJI Phantom 4	Surveillance
10	Bravo et al., (2021) [22]	To propose computational approaches for the automatic identification of mosquito breeding sites by using aerial images from drones	Brazil	Aedes	Dengue	Descriptive/ Urban & Suburban	YES	DJI Phantom 3	Surveillance
11	Stanton et al., (2021) [10]	To identify larval habitat by using high-resolution images from drone	Malawi	Anopheles	Malaria	Descriptive / Suburban	YES	DJI Phantom 4	Control (Larva)
12	Valdez-Delgado et al., (2021) [9]	To evaluate the effectiveness of low-cost drone images in identifying mosquito breeding sites	Mexico	Aedes	Dengue	Descriptive / Urban	NO	DJI Phantom 4	Surveillance
13	Cunha et al., (2021) [30]	To detect possible mosquito breeding sites using remote sensing and deep learning; to investigate the area's socioeconomic level	Brazil	Aedes	Dengue, Zika, Chikungunya	Descriptive / Urban & Suburban	YES	DJI Phantom 3	Surveillance

cont..... pg 153

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Table II: Summary finding of eligible articles

ID	Author (Year)	Main Objective	Methodology					Application of drone	
			Study Site	Species of Mosquito Studied	Disease concerned	Study Design / Area	Integrate Machine Learning Techniques (YES/NO)	Type of Drone	Type of Activity
14	Lee et al., (2021) [32]	To explore the use of UAV mapping as a tool to identify spatial risk factors for symptomatic dengue	Ecuador	Aedes	Dengue	Descriptive / Urban & Rural	NO	Not specified	Surveillance
15	Passos et al., (2022) [2]	To have a comprehensive dataset of aerial videos, from a drone, containing possible mosquito breeding sites.	Brazil	Aedes	Dengue	Descriptive / Urban	YES	DJI Phantom 4	Surveillance
16	Hardy et al., (2022) [26]	To compare the results of two mapping approaches, supervised image classification using machine learning and Technology-Assisted Digitising (TAD) mapping	Tanzania	Anopheles	Malaria	Descriptive / Rural	YES	DJI Phantom 4	Control (Larva)
17	Stanton et al., (2022) [35]	To detect larval habitats using high-resolution images by drones	Malawi	Anopheles	Malaria	Descriptive / Rural	YES	Not specified	Surveillance

Table III: General characteristics of articles included in the scoping review

Characteristic	Number of articles, n (%)
Publication Year	
• < 2018	5 (29.4)
• 2018 – 2022	12 (70.5)
Study Objective (can be more than 1 objective per article)	
• Identify and map the potential breeding sites of mosquitoes using a drone	9 (50)
• Study computational approaches including machine learning and remote sensing for the automatic identification of objects and mapping mosquito breeding sites by using aerial images from drones	7 (38.9)
• Investigate the effectiveness of drones and global positioning systems (GPS) in identifying potential mosquito breeding sites.	1 (5.6)
• Investigate the area's socioeconomic level associated with identified breeding sites of mosquitoes.	1 (5.6)
Study sites	
• Brazil	5 (29.4)
• Sri Lanka	3 (17.6)
• Tanzania	2 (11.8)
• Malawi	2 (11.8)
• USA	1 (5.9)
• Ecuador	1 (5.9)
• India	1 (5.9)
• Mexico	1 (5.9)
• Peru	1 (5.9)
Species of mosquito studied	
• Aedes sp.	11 (64.7)
• Anopheles sp.	5 (29.4)
• Not specified (general)	1 (5.9)
Type of disease concerned (can be more than 1 disease per article)	
• Dengue	10 (41.7)
• Zika	6 (20.8)
• Malaria	5 (25.0)
• Chikungunya	3 (12.5)
Integrate Machine Learning Techniques	
• Yes	12 (70.6)
• No	5 (29.4)
Type of Study Area (can be more than 1 type of study area per article)	
• Urban	11 (52)
• Suburban	7 (33)
• Rural	3 (14)
Type of drone	
• DJI Phantom 4	8 (47.1)
• DJI Phantom 3	4 (23.5)
• DJI Phantom 2	1 (5.9)
• Parrot's AR	1 (5.9)
• Not specified	3 (17.6)
Level of implementation	
• Proof of concept	17 (100)
Type of drone activity (can be more than 1 activity per article)	
• Surveillance	14 (82.4)
• Control (larva)	3 (17.6)

is critical in determining optimal flight times.[10] The tilt angle of the drone camera should be 90 degrees, and the drone should fly around midday to reduce the shadow effect.[31] Shadows cast by large trees and structures can obscure potential water sources.[13] Therefore, avoid conducting drone surveys when the sun is low in the early morning or evening to mitigate this effect.

For law and regulation (8%), the authors emphasized the licensing process, no-fly zone areas, and military deployment control. Before utilizing drones for any activities, national civil aviation authorities require drone pilots to get approved qualifications and secure relevant authorization, even though rules differ by country.[10] The importance of community involvement (8%) was also addressed in several studies. Researchers are experimenting with community-based monitoring systems that integrate technology into communities. Partnering with communities to collect surveillance data was also an effective data-collecting technique for public health practitioners and epidemiologists.[32] Concerns have been raised about how local communities will respond to the use of drones, the number of drones required, the area of coverage, when these drones will be used, and how human privacy will be protected. Therefore, community members must be involved to help address all these potential future issues.[33]

With recent advancement in drone technology, particularly the internet of things, smaller drones can take high-resolution photos and upload them to the cloud in real-time for rapid data processing. These drones are energy efficient and can cover large areas without losing connectivity to their

Table IV: Issues, challenges, and limitations of using drone

Issues & Challenges	Paper ID																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Hardware (specification, flight duration, height, signal strength, spare parts replacement, managing in-house data, cost-effectiveness)		√	√	√	√		√	√	√	√	√	√	√	√	√	√	√
2. Software (piloting drone, formatting, data & image processing/classification)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3. Law & Regulation (licensing, no-fly zone, military deployment)								√	√			√		√		√	√
4. Operating time (weather, shadows effect, time-consuming)			√	√	√		√				√		√	√	√		
5. Expertise (skill/training hours / previous research & data)		√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
6. Geographical (hard-to-reach locations, tree canopies, area covered)			√				√	√	√	√			√	√	√	√	
7. Community involvement	√										√	√	√	√		√	

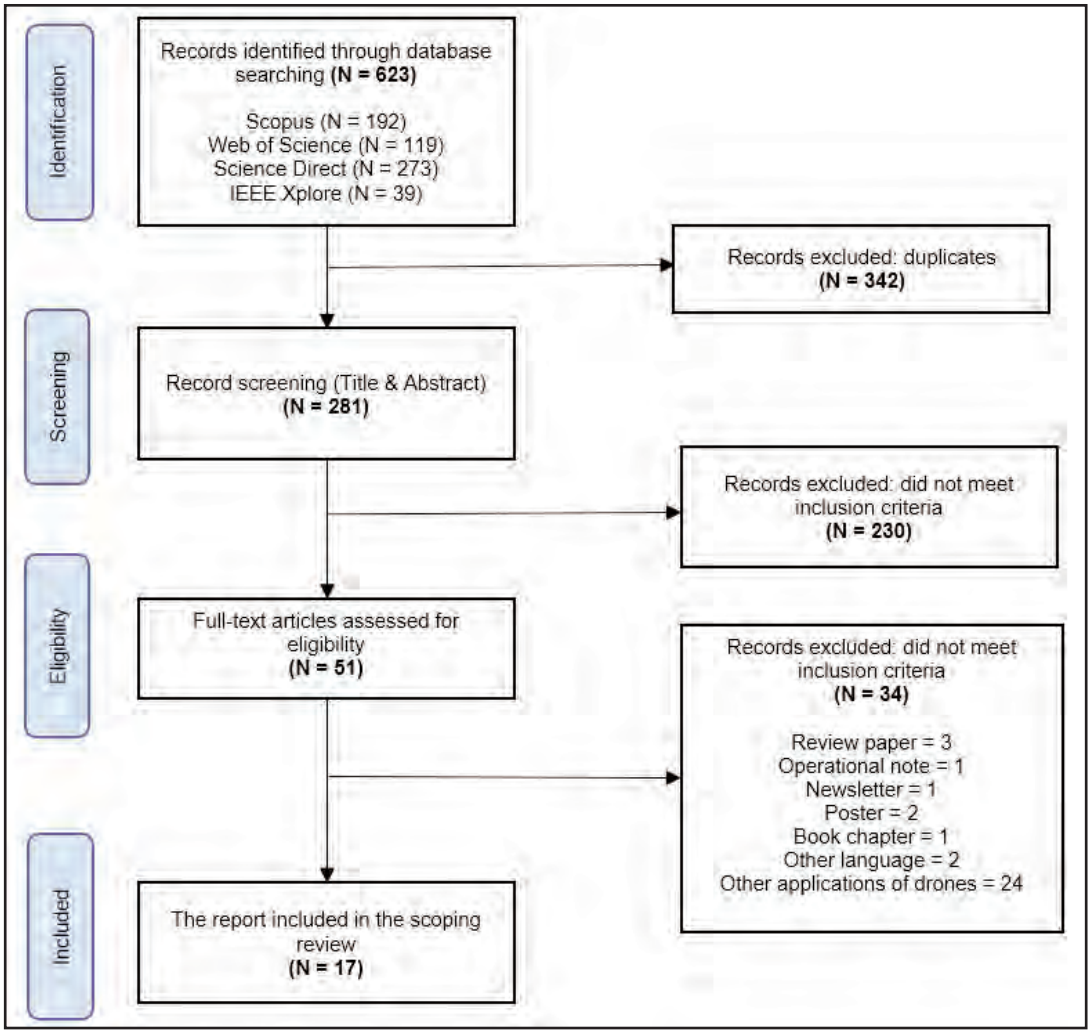

Fig. 3: PRISMA flowchart of the study collection

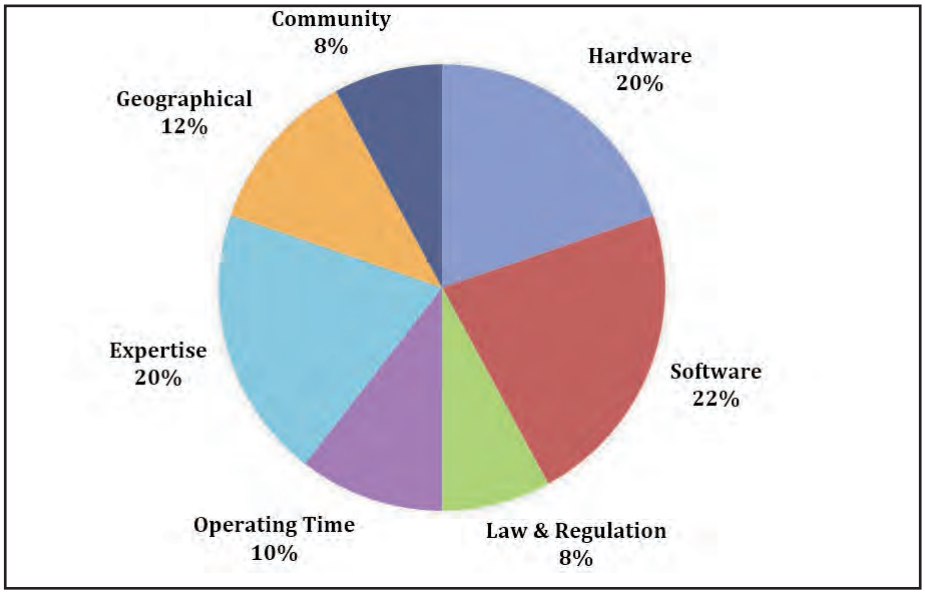

Fig. 4: Issues, challenges and limitations of using drone

base station.[33] However, there is a need for additional consultations between experts and stakeholders in the fields of drones, image analysis, and vector control to develop more specific recommendations for how this technology can be utilized most effectively.[10]

CONCLUSION

The feasibility of drone technology being used in mosquito breeding control programs should be further explored, as it could complement the conventional method of larval habitat inspection, which is a more labor-intensive approach. Even though the current data is scarce and lacks evidence, the literature search shows growing interest. The advancement in drone technology and collaboration with government agencies and the community will give strong evidence for a new dimension to dengue prevention and control programs in Malaysia and other endemic regions.

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SYSTEMATIC / NARRATIVE REVIEW ARTICLE

Metabolites alterations associated with obesity: A scoping review

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ABSTRACT

Introduction: Obesity can be considered a major public health concern throughout the world. Various studies have been conducted to combat the rising number of cases of this health problem. Therefore, identifying the roots of the disease is critical in developing the desperately needed treatment approaches. However, in order to fully understand the origin of this disease, figuring out the metabolites present, and the alterations that occurred in a particular metabolism are crucial, and the information regarding the metabolites involved is limited. The aim of this study is to analyse the literature relevant to the metabolites involved in obesity conditions through a scoping review.

Materials and Methods: This review utilises three databases (SCOPUS, Science Direct, and PubMed). The search phrases used are (Metabolomic* OR Metabolite*) for metabolomic study, (3T3-L1 OR Adipocyte OR "Adipose Tissue") for experimental design, and (Obesity) for obesity condition. Each of the search keywords was separated by an "AND" term in the databases. Other terms related to obesity, such as insulin resistance, heart disease, type 2 diabetes, muscular disorders, respiratory problems, and psychological problems were omitted because they did not contribute to the total number of studies discovered.

Results: A total of 27 research publications were included in this scoping review. Most of the study focuses on metabolomics in obesity. Metabolites detected were found in various metabolic pathways including amino acids, carbohydrates, lipids as well as other metabolisms. Most of these metabolites discovered in obese conditions showed an alteration when compared to the level of the metabolite in normal conditions.

Conclusion: Unfortunately, these studies had some limitations in which the metabolites detected varied between the articles and the information concerning the relationship between the technique or instrument utilised and the metabolites detected in the samples were not well described. Therefore, using the findings obtained in this study, it can help to determine the direction of the study in the future.

KEYWORDS:
Metabolism, metabolites, metabolomics, obesity, review

INTRODUCTION

Obesity can be considered a major public health concern throughout the world. According to the World Health Organization (WHO), obesity and overweight are characterised as abnormal or excessive fat accumulation that is harmful to one's health.[1] Obese patients are at a higher risk of developing a variety of comorbid conditions, such as cardiovascular disease (CVD), gastrointestinal disorders, type 2 diabetes mellitus (T2DM), joint and muscular disorders, respiratory problems, and psychological problems, all of which can have a significant impact on their daily lives and increase mortality risks.[2,3] Various research had been done to address the rising cases of this health issue. Therefore, understanding the roots of the disease is critical in developing the desperately needed treatment approaches. Principally, this condition is linked to an increase in the size of adipocytes,[4] which arise from fat cell multiplication through adipogenesis and increased cytoplasmic triglyceride accumulation.[5]

Adipogenesis is the process through which fat-laden cells (adipocytes) grow and deposit as adipose tissue at numerous locations throughout the body, including subcutaneous fat and depots.[6,7] This complex multi-step process involves coordinated changes in shape, hormone sensitivity, and adipogenic gene expression.[5]

The primary functions of these adipocytes are to store energy as fat when energy intake exceeds expenditure and to utilise this stored energy when energy expenditure exceeds intake.[6] During adipogenesis, countless metabolites from various metabolism including amino acids, carbohydrates, and lipids such as isoleucine, valine, lysine, phenylalanine,[8] betaine, carnitine, choline,[9] lactate, acetate, and succinate[10] were analysed. In order to detect these metabolites, metabolomic profiling should be performed.

The analysis of various small molecule metabolites in biological samples such as body fluids (urine, blood, saliva), tissues, etc., is also known as metabolomic study. In comparison to genomics, transcriptomics, and proteomics, metabolomics is seen as a relatively new addition to the "omics" platforms, but its roots lie in the old theory of analytical biochemistry.[11] In actuality, metabolites exist in a wide range of quantities and chemical diversity, making it impossible to assess all of the metabolites in a single assay with a single set of equipment. Instead, to get extensive

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coverage of metabolic space, practitioners of this approach typically use a suite of instruments, most often combining different combinations of liquid or gas chromatography coupled with mass spectrometry.[12]

The most common methods for metabolomic profiling are nuclear magnetic resonance (NMR) and mass spectrometry (MS). Individual analytes in the sample are separated based on their magnetic resonance shift or mass/charge ratio, resulting in a separation spectral profile.[11,13] NMR spectroscopy is a universal metabolite detection technology that allows samples to be evaluated directly with minimal processing and various classes of small metabolites to be detected at the same time. However, the major limitations in NMR for metabolomics include poor sensitivity and spectrum complexity, with signal superimposition at particular spectral regions compromising precise identification. While MS spectroscopy is more sensitive and specific compared to NMR spectroscopy, it usually necessitates a prior separation step, such as gas chromatography (GC), high-performance liquid chromatography (HPLC), or ultra-performance liquid chromatography (UPLC), and capillary electrophoresis (CE). Separation procedures in combination with MS are critical for reducing sample complexity and minimising ionisation suppression effects, hence increasing detection sensitivity and metabolome coverage.[2] Thus, in this scoping review, the studies focusing on the metabolomic study of obesity will be discussed and summarised. This review will also identify the research gaps in the particular subject, which then may serve as a roadmap for future research.

MATERIALS AND METHODS

This study investigated literature relevant to metabolomic studies in obesity through a scoping review. By including many types of study, scoping reviews are considered a beneficial tool for swiftly identifying research trends and outcomes connected to the research topic, as well as for quickly discovering usable basic resources and core concepts of corresponding domains. The scoping review was conducted in the order of the five research steps suggested by Arksey and O'Malley.[14]

Identify Research Question

This review aimed to investigate the diversity of metabolites related to obesity. This research question was created using the recommendation of Arksey & O'Malley[14] to start with a broad review topic to determine the data available before refining the search. The current authors are currently employing a metabolomic technique to investigate the metabolites related to obesity and are gathering further information from past correlated studies and published research. The development of research topics was critical for determining the direction of the review and the method for identifying and selecting relevant articles. Hence, the research questions for this review are: [1] What are the metabolites involved in obesity condition? [2] What are the metabolites altered in obese samples compared to normal?

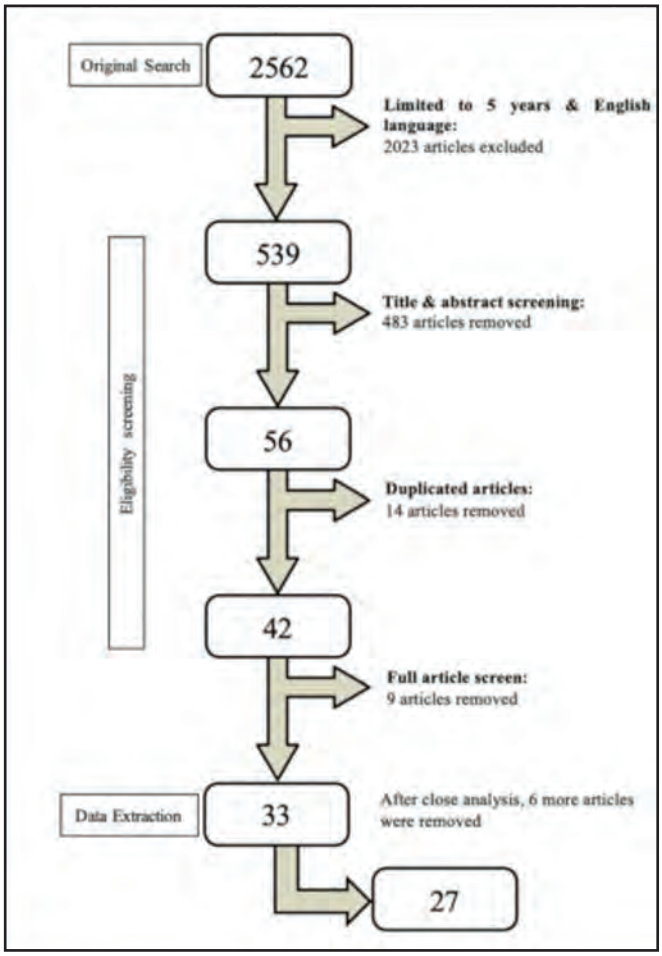

Fig. 1: Study selection for the scoping review. Articles identified from Scopus (n=203); Science Direct (n=2176); PubMed (n=183)

Identify Relevant Studies

Search Terms

To discover studies relating to the research questions outlined, key phrases were chosen. The following were the search phrases used: (Metabolomic* OR Metabolite*) for metabolomic study, (3T3-L1 OR Adipocyte OR "Adipose Tissue") for experimental design, and (Obesity) for obesity condition. Each of the search keywords was separated by an "AND" term in the databases. Other terms related to obesity, such as insulin resistance, heart disease, type 2 diabetes, muscular disorders, respiratory problems, and psychological problems were omitted. English language and articles published between 2017 and 2021 were chosen as the inclusion criteria. Older publications were eliminated or excluded because the goal of this scoping review was to find the most recent and relevant literature.

Databases

Based on the topic area, three databases were used in this study: SCOPUS (life and health sciences), ScienceDirect (science and medicine), and PubMed (life sciences and biomedical topics). Three databases were believed to be sufficient to rule out bias and would be able to access all the relevant papers within the area of interest. Using the above search criteria and databases, 2,562 articles were discovered.

Study Selection

In the study selection for this scoping review, out of the 2,562 articles discovered in three databases, articles published before 2017 until 2021 and languages other than the English language were removed, leaving 539 articles to be screened. All 539 titles of articles were read, and blatantly irrelevant papers were eliminated (e.g., Metabolomic profiling for the identification of novel biomarkers and mechanisms related to common cardiovascular diseases form and function), narrowing the total number of papers to 147. Next, the remaining abstracts were carefully evaluated and those that were irrelevant (n=91) were removed, leaving 56 publications for full-text screening. Then, duplicate titles (n=9) were discarded, leaving 42 articles to evaluate. The following stage was to read the full report, focusing on the methodology portion in particular. All the remaining articles were evaluated, resulting in a total of 33 articles. After close analysis during data extraction, a final 27 articles were selected to be included in the review. The flowchart of the study selection for this review is illustrated in Figure 1.

Data Charting

All the data from the chosen articles were collected and organised in the fourth research step of the scoping review framework. The gathered data points were title, author(s), year of publication, sample(s), experimental design, metabolomic technique used, and significant metabolites in obese conditions. The collected data points were summarised in Table I. While extracting and compiling the data for Table I, after close analysis was performed, six more publications were eliminated from this study because other metabolic syndromes were included (n=3), measurement of metabolites from other obese-related samples (n=2) and did not include metabolite in obesity condition (n=1).

Collating, Summarizing and Reporting Results

The final research step suggested by Arksey & O'Malley[14] was to organise the relevant findings into themes, sorting and prioritising the findings based on their relevance to the research objectives and putting a strong emphasis on the intervention type. The sample, experimental design, methodology, and outcomes were all covered in the study. The executive summary in Table I contain all the information.

RESULTS

Based on the Arksey & O'Malley[14] methodology and the inclusion criteria described above, 27 peer-reviewed papers related to the study topic were discovered. Considering the experimental design of all the related publications, the majority of the studies were conducted in mice (n=16, 59.3%), while eight (29.6%) in human serum, plasma, or urine and one (3.7%) each in adipocyte, hamster, and rabbit. Of all the experimental designs, the samples were divided into serum (n=6, 22.2%), plasma (n=4, 14.8%), adipose tissue (n=6, 22.2%), adipocyte (n=2, 7.4%), liver (n=4, 14.8%), urine (n=3,11.1%) and faecal (n=2, 7.4%). The interventions and data collection techniques are detailed in Table I. The metabolites analysed were further grouped by the type of metabolism it took place which are carbohydrate metabolism, amino acid metabolism, and lipid metabolism.

Carbohydrate Metabolism

According to the studies related to the metabolites in obesity, the majority of metabolites discovered involved in carbohydrate metabolism include glucose, lactate, succinate, citrate, fumarate, and 2-oxoglutarate. Most of these metabolites can be found in glycolysis and the tricarboxylic acid (TCA) cycle. Significant increases were reported in glucose and fumarate.[10,15,16] However, some studies found that glucose and fumarate metabolites were decreased when compared to normal conditions.[8,17,18] Besides, out of 27 studies discovered, four papers stated that there was an increase in lactate,[8–10,16] while one paper showed that lactate was decreased.[19] Moreover, although some publications identified a notable decrease in citrate,[10,15,17,19,20] there were also papers that demonstrated that citrate was increased compared to normal.[16,21] Several other papers also found a few metabolites such as aconitate, hippurate, galactose, pyruvate, mannose, maltose, glutathione, sucrose, acetyl-CoA, and alpha-ketoglutarate were related to obesity. Pyruvate,[9,20] hippurate,[19] alpha-ketoglutarate,[22] and acetyl-CoA[23] were some of the elevated metabolites that were revealed in obese samples. Remarkable decreases were also shown in aconitate,[20] galactose,[21] mannose,[24] sucrose,[19] maltose, and glutathione.[10]

Amino Acid Metabolism

Based on the papers related to the study, the most common metabolites found involved in amino acid metabolism are tyrosine, phenylalanine, isoleucine, leucine, alanine, lysine, valine, glutamine, and glycine. In obese conditions, the result for tyrosine, phenylalanine, and valine showed a significant increase when compared to normal.[8–10,18,19,25,26] In addition, a notable increase was also revealed in isoleucine and leucine.[9,18,25–28] However, even though multiple papers demonstrated a significant increase in these metabolites, according to Airaksinen, et al.,[29] these metabolites were lower when compared to the normal group. Meanwhile, glycine is one of the metabolites in amino acid metabolism that was found to be markedly decreased.[17,21,24,25,30] Other than these commonly analysed metabolites that are involved in amino acid metabolism, there were also studies reported that in obese subjects or samples that were induced with a high-fat diet, the results exhibited an increase in creatinine,[9,19] 2-oxoisocaproate,[9,16] glutamate,[10,17,19] and histamine.[10] On the other hand, several studies showed that aspartic acid,[24,31] cystine, and anserine[10] were significantly reduced. Apart from the variety of results reported among the metabolites found in amino acid metabolism, carnitine however, exhibited quite inconsistent results where there was an increase[9], decrease[29], and no remarkable change[31] observed when compared to the normal condition.

Lipid Metabolism

In accordance with 27 peer-reviewed papers related to the study topic, most of the metabolites detected that were related to lipid metabolism are comprised of betaine, choline, and taurine. Four studies found that betaine was one of the decreased metabolites when compared to the normal group.[8,10,19,29] In contrast,[9,16] showed that betaine was increased in the serum sample. Choline, however, exhibited an elevation based on the studies done by Wang, et al.,[8] Duft, et al.,[9] Guo, et al.,[16] and Osawa, et al.[30] but conversely, it was decreased in research done by Airaksinen, et al.[29] In addition

Table I: The sociodemographic among respondents

Author	Sample	Metabolomic Technique	Significant Metabolites Observation in Obese Condition
Wang et al.[8]	Liver	Proton nuclear magnetic resonance (^{1}H NMR analysis)	Isoleucine, Valine, Lysine, Phenylalanine, Lactate, Alanine, Acetate, Glutamine, Succinate, Taurine, Choline, Tyrosine, Uridine, 3-Hydroxybutyrate, Betaine, A-Glucose, Glycogen, Formate, Fumarate and Adenosine
Duft et al.[9]	Serum	Proton nuclear magnetic resonance (^{1}H NMR analysis)	Tyrosine, Histidine, 2-Oxoisocaproate, Pyruvate, Phenylalanine, Isoleucine, Choline, Betaine, Carnitine, Lysine, Glucose, Creatinine, Ornithine, Valine, Alanine, Leucine, Glutamine, Asparagine, 2-Aminobutyrate, Lactate
Sun et al.[10]	Serum and liver	Proton nuclear magnetic resonance (^{1}H NMR analysis)	1. Serum Low-density lipoprotein (LDL), Very low-density lipoprotein (VLDL), Isoleucine, Leucine, 3 Aminoisobutyrate, 3-Hydroxybutyrate, Valine, Lipid, Lactate, Alanine, Lysine, Acetate, Glutamate, Glutamine, Succinate, Citrate, Creatinine, Glucose 2. Liver Isoleucine, Leucin, Valine, Lactate, Alanine, Acetate, Glutamate, Glutamine, Glutathione, Succinate, Aspartate, Trimethylamine (TMA), Betaine, Trimethylamine oxide (TMAO), Taurine, Maltose, Glucose, Cystine, Inosine, Anserin, Uridin, Fumarate, Tyrosine, Histamine, Phenylalanine, 3-Methylxanthine, Nicotinamide adenine dinucleotide (NAD), Nicotinamide adenine dinucleotide phosphate (NADP), Nicotinurate
Bugáňová et al.[15]	Urine	Nuclear magnetic resonance (NMR-based metabolomics)	Hexanoylglycine, 2-Oxovalerate, N-Isovalerylglycine, Lactate, Putrescine, Vinyl Acetylglycine, Acetate, N-Acetyls of Amino Acids Derivatives, N-Carbamoyl-B-Alanine, Succinate, 2-Oxoglutarate, Citrate, Methylamine, Dimethylamine, Trimethylamine, N, N-Dimethylglycine, Creatine, Creatinine, Cis-Aconitate, Ethanolamine, Carnitine, Taurine, Glycine, N-methyl-4-pyridone-5-carboxamide (4PY), Ascorbate, Trigonelline, 1-Methylnicotinamide, Glucose, Galactose, Allantoin, Urea, Fumarate, N-methyl-2-pyridone-5-carboxamide (2PY), Phenylacetylglycine, 3-Indoxyl Sulfate, Hippurate, Nicotinamide-N-Oxide, Formate, Nicotinurate
Guo et al.[16]	Serum	Proton nuclear magnetic resonance (^{1}H NMR analysis)	2-Hydroxybutyrate, 2-Hydroxyisovalerate, 2-Oxoglutarate, 2-Oxoisocaproate, 3-Hydroxybutyrate, 3-Hydroxyisobutyrate, 3-Methyl-2-Oxovalerate, Alanine, Betaine, Choline, Citrate, Fumarate, Glucose, Glutamine, Lactate, Myo-Inositol, O-Acetylcarnitine, Proline, Tryptophan, Lysine, Arginine
Nishitani et al.[17]	Adipose and liver tissue	Capillary electrophoresis–mass spectrometry (CE-MS analysis)	1. White Adipose Tissue (Wat) Glycolysis- Glucose 6-Phosphate (G6P), Fructose 6-Phosphate (F6P), Fructose 1,6-Diphosphate (F1,6P), 3-Phosphoglycerate (3-PG), 2-Phosphoglycerate (2-PG), Phosphoenolpyruvate (PEP) TCA- Citrate, Cis-Aconitate (Cis-Aco), Succinate, Fumarate, Malate 2. Liver Glucose 6-phosphate (G6P), Fructose 6-phosphate (F6P), Citrate, Fumarate, Malate, Amino Acids, Alanine, Glycine, Glutamate, And Glutamine
Yde et al.[18]	Fecal	Nuclear magnetic resonance (NMR spectroscopy)	1. Short-Chain Fatty Acid (Acetate, Formate, Propionate, Isobutyrate, Valerate) 2. BCFA (2-Methyl Butyrate, 3-Methyl-2-Oxovalerate) 3. Alcohols 4. Amino Acids (Arginine, Isoleucine, Leucine, Lysine, Phenylalanine, Tryptophan, Tyrosine, Valine) 5. Metabolism (Glutarate, Malate, Fumarate, Glucose, Ribose, Succinate) 6. Others (Cadaverine, Trimethylamine)
Chen et al.[19]	Urine and fecal	Proton nuclear magnetic resonance (^{1}H NMR analysis)	1. Urine Acetoacetate, Creatine, Creatinine, Allantoin, Phenylacetate, Hippurate, Phenylalanine, Succinimide, N-Acetyl-Beta-D-Glucosaminidase (NAG), N-Acetylglutamate, Uracil, Valine, Levulinate, Alanine, 2-Methylglutarate, 4-Cresol, Leucine, Trimethylamine, 2-Hydroxybutyrate, N-Phenylacetylglycine and Glycogen, Phosphorylcholine, Ornithine, N-Nitrosodimethylamine, Glycerol, Citrate, Betaine, Sucrose, Glycine, Glycerophosphocholine, Propylene Glycol 2. Fecal Imidazole, Urocanate, 3-Phenylpropionate, Glutamate, Phenylacetate, Tyrosine, 2-Oxoglutarate, Cadaverine, Valine, Leucine, 5-Aminovalerate, Uracil, Arginine, Creatine, Malonate, α-Ketoisocaproate, Threonine, Lactate, α-Arabinose

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Table I: The sociodemographic among respondents

Author	Sample	Metabolomic Technique	Significant Metabolites Observation in Obese Condition
Sundekilde et al.[20]	Liver	High-Resolution Magic Angle Spinning (HRMAS) NMR Methods	Acetate, Glucose, Pyruvate, Fumarate, Cis-Aconitate, Citrate, Malate, Succinate, Taurine, Oxaloacetate, Oxoglutarate
Zhuang et al.[21]	Urine	Gas chromatography-mass spectrometry (GC-MS)	Glycine And Serine, Glutamine, L-Proline, L-Alanine, Glutamate, Acetic Acid, Lysine, D-Galactose, Citrate
Candi et al.[22]	Adipose tissue	Extensive gas chromatography/mass spectrometry (GC/MS) and liquid chromatography/mass spectrometry (LC/MS/MS) analyses	1. Ceramide and Sphingolipid Metabolism Behenoyl Sphingomyelin, Tricosanoyl Sphingomyelin, Lignoceroyl Sphingomyelin 2. Plasmalogens and Lysoplasmalogens 1-(1-Enyl-Palmitoyl)-GPE, 1-(1-Enyl-Oleoyl)-GPE and 1-(1-Enyl-Stearoyl)-GPE), 1-(1-Enyl-Palmitoyl)-2 Palmitoyl-GPC, 1-(1-Enyl-Palmitoyl)-2-Arachidonyl-GPC, 1-(1-Enyl-Palmitoyl)-2-Arachidonyl-GPE, and 1-(1-Enyl-Stearoyl)-2-Arachidonoyl-GPE) 3. Phospholipids and Lysolipids Glycerol Phosphorylcholine (GPC), Glycerol Phosphoethanolamine, 1,2-Dipalmitoyl-GPC, 1-Stearoyl-2-Arachidonoyl-GPC, 1-Palmitoyl-2-Arachidonoyl-GPC, 1-Steroyl-2-Arachidonoyl-GPI, 1-Steroyl-2-Arachidonoyl-GPE, 1-Palmitoyl-2-Steroyl-GPC, 1-Stearoyl-2-Oleoyl-GPG, and 1-Stearoyl-2-Linoleoyl-GPS), 1-Palmitoyl-GPC, 1-Stearoyl-GPC, 1-Palmitoyl-GPE, 1-Stearoyl-GPE, 1-Stearoyl-GPI, and 1-Stearoyl-GP) 4. Glucose Related Metabolites
Li et al.[23]	Liver	Chromatographic separation was performed by using an Acquity UPLC HSS T3 column	Acetyl-Coa, L-Glutamic Acid, N-Acetyl-D-Galactosamine, 1,1,1-Tri-Fluoroacetone, 1-Linoleoyl-Sn-Glycero-3-Phosphocholine, 2-C-Methylerythritol 4-Phosphate, Bis(2-Ethylhexyl) Phthalate, Methyl 3,3,3-Tri-Fluoro-2-Oxopropanoate, Muramic Acid, Taurine, Isoleucine, L-Phenylalanine, Methionine, Spermidine
Ammar et al.[24]	Serum	Gas chromatography/mass spectrometry (GC/MS)	Aminobutyric Acid, Butyric Acid, Glycine, Phenylethanolamine, Urea, D-Glucopyranose, Ethanol Hydroxybutyric Acid, D-Glucose, L-Alanine, L-Aspartic Acid, L-Glutamine, D-Mannose (Glucose-2-Epimer)
Dadson et al.[25]	Serum	High-throughput (HTP) nuclear magnetic resonance (NMR) metabolomic	Apob/Apoa-1, Glycine, Isoleucine, Leucine, Valine, Phenylalanine, Tyrosine, GlycA
Brennan et al.[26]	Plasma	Liquid Chromatography Triple Quadrupole Mass Spectrometry (LC-MS/MS)	Lactic Acid, Hypoxanthine, Pyruvic Acid, Inosine, Alpha-Ketoglutaric Acid,2-Ketoisovaleric Acid, Ketoisocaproic Acid, Xanthosine, Kynurenine, Anthranilic Acid, Indole-3-Carboxylic Acid, Allantoin
Jokinen et al.[27]	Plasma	Liquid Chromatography Triple Quadrupole Mass Spectrometry (LC-MS/MS)	Leucine, Propionylcarnitine, Isobutyrylcarnitine, Valine, Isovalerylcarnitine, Isoleucine
Piro et al.[28]	Adipose tissue	Samples were divided into five fractions: -Two for analysis by two separate reverse phases (RP)/UPLC-MS/MS methods with positive ion mode electrospray ionisation (ESI) -One for analysis by RP/UPLC-MS/MS with negative ion mode ESI -One for analysis by HILIC/UPLC-MS/MS with negative ion mode ESI -One sample was reserved for backup	Leucine, Isoleucine, Valine, 4-Methyl-2-Oxopentanoate, 3-Methyl-2-Oxovalerate, 3-Methyl-2-Oxobutyrate, 2-Methylbutyrylcarnitine

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Table I: The sociodemographic among respondents

Author	Sample	Metabolomic Technique	Significant Metabolites Observation in Obese Condition
Airaksinen et al.[29]	Adipose tissue	Liquid chromatography quadrupole time-of-flight mass spectrometry (LC-QTOF-MS)	1. Subcutaneous Adipose Tissue (SAT) L-Carnitine, Hydroxybutyrylcarnitine, Hydroxyhexanoylcarnitine, Hydroxy-Isovaleryl-Carnitine, Isobutyryl-Carnitine, Methylmalonylcarnitine, Hexadecenoyl Carnitine, Citrulline, L-Histidine, L-Leucine, L-Isoleucine, L-Lysine, 1-Methylhistamine, L-Methionine, Pantothenic Acid, L-Phenylalanine, Proline, Uric Acid 2. Visceral Adipose Tissue (VAT) Butyryl-Carnitine, Hexanoylcarnitine, Palmitoyl-L-Carnitine, Choline, Propionylcarnitine, Pantothenic Acid, Tetradecanoylcarnitine, Hexadecenoyl Carnitine, Histidine, Lysine
Osawa et al.[30]	Adipocyte	Capillary electrophoresis time of flight mass spectrometer (CE-TOF/MS)	Choline, Cystathionine, Threonine, Glycine, Citrulline, Hypoxanthine, 5-phosphoribosyl 1-diphosphate (PRPP)
Li et al.[31]	Fecal	The ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UHPLC/Q-TOF-MS)	1. Amino Acids (Leucine, Phenylalanine, Tryptophan, Glycine, Methionine, Proline, Lysine, Citrulline, Isoleucine, Aspartic Acid, Ornithine) 2. Short Chain Fatty Acids 3. Unsaturated Fatty Acids 4. Sphingolipids 5. Carnitines
Shao et al.[32]	Adipose tissue	Ultrahigh-performance liquid chromatography-tandem mass spectrometry (UHPLC–MS/MS) Analysis	Glycerophospholipids, Polyketides, Sterol Lipids, Arachidonic Acid (AA), L-Dopa, Cholecalciferol, Hydrocortisone, Pyridoxamine
Jang et al.[33]	Plasma	Ultra performance liquid chromatography-mass spectrometry (UPLC MS)	3-Methoxybenzenepropanoic Acid, 3-Oxodecanoic Acid, 4-Aminobutyraldehyde, 4'-Apo-B-Carotenal, Lysopc (18:4), MG (0:0/18:2/0:0), N-Arachidonoyl, Retinyl Ester
Luo & Liu.[34]	Serum	Ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UPLC-QTOF-MS)	Thyroxine, Phosphatidylcholine (PC), Triglycerides (TG), Lysophosphatidylcholine (Lysopc), Lysophosphatidylethanolamine (Lysope), Glucosylceramide, 1D-Myo-Inositol 1, 3,4,6-Tetrakisphosphate, Alpha-Linolenic Acid, Cholesterol Sulfate, 1-Arachidonoyl glycerophosphoinositol), Arachidonic Acid, Glycerophospholipid, Glycosphingolipid, Linoleate, Omega-3 Fatty Acid, Phosphatidylinositol Phosphate, Tyrosine
Eniafe & Jiang.[35]	Plasma	Ultra-performance liquid chromatography/quadrupole time-of-flight mass spectrometry (UPLC-Q-TOF/MS) analysis	Avenoleic Acid, 2R-Hydroxy-Oleic Acid, PC 16:0/18:2(9Z,12Z), 20:3 Cholesteryl Ester
Herman et al.[36]	Adipose tissue and serum	The ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UHPLC/Q-TOF-MS)	21 Amino Acids, 5 Carbohydrate, 2 Energy, 67 Lipid, 2 Xenobiotics, 3 Cofactors and Vitamins, 6 Nucleotides
Hsieh et al.[37]	3T3-L1 adipocyte	Liquid Chromatography–Time of Flight Mass Spectrometry	Hydroxyphenyllactic Acid, 2-Hydroxycaproic Acid, Creatine, Lactate, Ketoleucine or 2-Ketohexanoic Acid, Alanine or Beta-Alanine, Lysine, Arginine, Isoleucine or Alloisoleucine or Norleucine
Qiu et al.[38]	Liver	Ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UPLC-QTOF-MS)	1. Fatty Acid Metabolism 2. PPAR Signalling Pathway 3. AMPK Signalling Pathway 4. Insulin Signalling Pathway 5. Fatty Acid Degeneration

to the differential results shown in betaine and choline, taurine also exhibited an inconsistent alteration which resulted in significant elevation,[8] decrease,[15,23] and no change[10] when compared to the sample of normal condition. Other than that, there were also a few metabolites discovered in lipid metabolism when analysed in obesity conditions which are short-chain fatty acids, unsaturated fatty acids, sphingolipids,[31] sterol lipids, and glycerophospholipids.[32]

Other Metabolism

According to the obesity-related publications that were reviewed, there were few metabolites reported involved in energy metabolism and these include nicotinamide adenine dinucleotide (NAD), nicotinamide adenine dinucleotide phosphate (NADP), trimethylamine (TMA), and trimethylamine N-oxide (TMAO). Out of 27 papers identified, only one study discussed the metabolites involved in energy metabolism. Sun, et al.[10] found that in the liver, there was a significant increase in NAD+, TMAO, and a slight increase in NADP+. However, TMA in the liver sample showed a notable reduction when compared to the normal group. In proportion to the 26 refereed journals related to the metabolomic study of obesity, seven papers reported that metabolites associated with nucleotide metabolism were altered and these include allantoin, urea, uric acid, hypoxanthine, inosine, and uridine. Among these observed metabolites, allantoin showed an elevation when compared to the normal condition.[15,19] On the contrary, urea[24] and uric acid[29] were demonstrated to be at a lower level in obesity samples. However, even though uridine was found in a high-fat diet-induced sample, there was no significant difference as opposed to the normal diet.[10] Furthermore, a study conducted by Brennan, et al.[26] also found that there was a notable change in allantoin, hypoxanthine, and inosine. Other than that, metabolites resulting from the metabolism of cofactors and vitamins which are retinyl ester[33] and nicotinurate[10] were also reported to be slightly reduced and increased respectively.

DISCUSSION

This scoping review analysed 27 peer-reviewed research articles related to the metabolomic study of obesity. The main finding from these papers was the metabolites found in obesity conditions. Based on the papers reviewed, there were abundant metabolites analysed including metabolites that are discovered in carbohydrate, amino acid, lipid, energy, and nucleotide metabolism, also, most of these observed metabolites were varied in each article. However, in all of the articles included, the information regarding the relationship between the technique or instrument used and the metabolites detected in the samples was not properly discussed in detail. Within these metabolites examined, there were several elements particularly related to obesity that should be thoroughly investigated.

Carbohydrate Metabolism

Through its nuanced actions at both the organ and systemic levels, adipose tissue plays a critical role in controlling whole-body energy and glucose homeostasis.[34] Glycolysis, gluconeogenesis, TCA cycle, and pyruvate metabolism are among the pathways involved in carbohydrate metabolism. According to the scholarly articles reviewed, a large number of metabolites were discovered in this metabolism, however, these 27 studies provided contradicting results were inconsistent levels of metabolites were demonstrated. According to Sundekilde et al.,[20] the TCA cycle is a critical metabolic mechanism that links carbohydrate, protein, and fat metabolism by converting pyruvate to energy and carbon dioxide. An increase in TCA metabolites indicates the increase of gluconeogenesis consistent with pyruvate-driven gluconeogenesis, and higher TCA cycle flux, both of which have been seen as a result of diet-induced obesity. Thus, these explain the elevated metabolites involved in carbohydrate metabolism. Similarly, research done by Sun, et al.[10] also reported that in reaction to hyperlipidemia, glucose levels were increased.

Even so, some findings have indicated that when compared to normal conditions, some metabolites commonly found in the TCA cycle which are responsible for the generation of cellular energy[35] such as citrate, sucrose, and aconitate were lowered. This is owing to the fact that HFD may obstruct the entrance of TCA intermediates into the cycle, resulting in lipid build up in both serum and liver samples.[16] This view was also complemented by Chen, et al.[19] when the study explained that in obese conditions, energy consumption is reduced, resulting in an energy surplus and fat formation. The excess energy storage in the body suppresses the metabolism in the TCA cycle. Several other papers have also reported the downregulation of metabolites in carbohydrate metabolism.[10,15,17,19–21,24] In other words, the reductions observed in carbohydrate metabolism may reflect the body's energy metabolism level.[19]

Amino Acid Metabolism

From the data collected and evaluated from these 27 peer-reviewed articles, metabolites involved in amino acid metabolism were the most abundant metabolites exhibited. The relevance of these findings was supported by Herman, et al.36 that highlights while adipose tissue is well-known for its role in glucose and lipid homeostasis, it is less well-recognised for its role in systemic protein and amino acid metabolism. In vitro and in vivo experiments suggested that adipose tissue can metabolize large amounts of branched-chain amino acids (BCAAs). In obesity, most of the amino acid metabolites such as tyrosine, phenylalanine, valine, isoleucine, leucine, 2-oxoisocaproate, glutamate, and histamine showed increasing levels when compared to the normal group. These elevated results were supported by a study done by Duft, et al.[9] that stated obese individuals have increased BCAA levels and breakdown products in their blood. In the same vein, Mccormack, et al.[39] additionally reported that obesity and insulin resistance are linked to increased levels of BCAAs in the bloodstream. On top of that, She, et al.[40] mentioned that BCAA levels may be higher in obese people simply because they eat more food, and this is also influenced by the impairment of the BCAA catabolic pathway.[41] She, et al.[40] also stated that increase protein catabolism as a result of insulin resistance is another plausible cause for the rise in BCAAs in obesity.

On the contrary, there were also some metabolites, when compared to the normal diet showed a lower level of amino

acid metabolites. According to Ammar, et al.,[24] the study of obesity in rats revealed the amino acid metabolic pathway was found to be highly altered in obese rats, resulting in reduced levels of several amino acids such as glycine, aspartic, alanine, and glutamine. Similarly, Etxeberria, et al.[42] also stated that obese rats were found to have reduced levels of amino acids. Amino acid depletion was observed in HFD-fed obese mice, implying a disruption in energy metabolism. Furthermore, the lower glycine level may have contributed to the occurrence of a catabolic state, in which muscle tissue secretes glutamine to help the liver maintain glucose homeostasis.[24]

Lipid Metabolism

Lipid metabolism can be defined as the synthesis of structural and functional lipids such as phospholipids, glycolipids, sphingolipids, cholesterol, prostaglandins, etc. The metabolism is always in a dynamic equilibrium condition which means that some lipids are constantly oxidised to meet the body's metabolic needs, while others are synthesised and stored in adipocytes as triglycerides.[43] Lipids or fat are predominantly stored in white adipocytes. In white adipocytes, triglycerides are formed through the esterification of energy-rich fatty acids and glycerol. Triglyceride hydrolysis (lipolysis) releases fatty acids from fat cells into the bloodstream.[44] These released products are considered as metabolites. As reported by Park, et al.,[45] metabolite profiling has demonstrated substantial changes in lipid profiles linked to HFD, obesity, and obesity-related diseases in a variety of animal and human research. Even though various metabolites linked to lipid metabolism were discovered both in the normal and in the obese group, the level of metabolites in the obese group was altered when compared to the normal group. Choline was discovered to be one of the upregulated metabolites in four studies when compared to the normal group. Betaine, on the other hand, was reduced. Likewise, Wang et al.[8] also reported an increased level of choline and the downregulation of betaine. These results indicate that the HFD may have blocked the choline to betaine pathway. Supposedly, choline is converted to betaine, which adds a methyl group to homocysteine to produce methionine and dimethylglycine.[46] Hence, in HFD, when the choline to betaine pathway is blocked, the choline cannot be metabolised into betaine, eventually leading to an elevation of the choline level and reduction of the betaine. Moreover, Wang, et al.[8] draw on the work of Lever & Slow[47] who suggested that alterations in betaine, together with taurine and choline changes, suggested that these metabolites changes occurred may be due to the abnormal fatty acid metabolism.

LIMITATION AND SUGGESTION

The major shortcoming of the scoping review methodology is the absence of quality assessment of the papers evaluated. This is because the purpose of a scoping review is to simply identify research that has been done, not necessarily to assess the quality of the papers. According to Arksey & O'Malley,[14] the scoping study does not intend to examine the quality of evidence and hence cannot identify whether particular research yields robust or generalizable findings. Although quality assessment may not be a purpose of the study, the quality should be taken into account before using the findings to evaluate the metabolites related to obesity. Moreover, only three databases were utilised for article searching and the results are further limited as only papers published in English from the year 2017 until 2021 were selected. Therefore, these criteria may cause some bias in reviewing the results.

Concerning the articles analysed that were included in this review paper, one of the gaps discovered is that there were some variations in the metabolites analysed. Even though several metabolites detected were similar, the concentrations of each metabolite were different. Thus, this will limit the understanding of metabolites study in obesity as the changes in normal conditions and obese conditions remain unsettled. This particular knowledge is very useful as it may help researchers identify a possible obesity biomarker. Moreover, another limitation noted was the information regarding the relationship between the metabolites detected and the technique utilised. The instrument may play some crucial roles in the spectrum of the metabolites analysed. Hence, the lack of explanation concerning this relationship limits the information with regard to the metabolomic study in obesity.

CONCLUSION

In conclusion, this scoping review sheds light on the metabolomic study in obesity. According to current research, metabolomic profiling has been done to analyse the abundance of metabolites present in obesity conditions. All of these discovered metabolites were found mainly in carbohydrate, amino acid, lipid, energy, and nucleotide metabolism. Nevertheless, in discussions involving metabolisms, the pathways usually are always interconnected with each other. Thus, this review has evaluated and summarised the published literature concerning the majority of the metabolites found in obesity which may be a potential biomarker reference that might help in the future clinical management of obese patients.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

AUTHORS CONTRIBUTION

Conceptualisation and drafting of the manuscript: AA, NH; review of the manuscript: NH, EM, MIMY, MRS; All of the authors have read and approved the final manuscript.

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SYSTEMATIC / NARRATIVE REVIEW ARTICLE

Motor control on gait performance among individuals with lower crossed syndrome: A scoping review

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ABSTRACT

Introduction: Lower Cross Syndrome (LCS) is a prevalent condition that manifests as muscular tension due to the asymmetry in the strength of the lower extremity muscles. This imbalance could be due to the tautness of the iliopsoas, rectus femoris, tensor fascia latae, adductor group, gastrocnemius, and soleus muscles. LCS causes a postural imbalance in the individual, which triggers low back pain (LBP). When LCS is present alongside LBP, may cause the upper body to sway more in the transverse plane and at the lumbar level, making walking and termination of gait (GT) more difficult. However, the evidence of motor control and gait performance is scarce with inconclusive findings. Thus, this study aimed to review motor control on gait performance among individuals with lower crossed syndrome. This review is conducted to determine the motor control on gait performance in patients with LCS and how the conditions affect gait.

Materials and Methods: The databases Google Scholar, Science Direct, ResearchGate, PubMed, and Scopus were searched to identify potentially relevant documents. The keywords used for the search included "motor control" OR "motor learning" OR" core stability" AND "lower crossed syndrome" AND "gait". The search includes articles published between 1970 and 2022 and written in English. It is excluded when the paper is not a full-text article. After finding the articles, the information was extracted, including author, year of publication, country, objective, type of study, and motor control analysis summary.

Results: There were 107 articles retrieved from the search. but only seventeen articles were included for analysis. The finding demonstrates that LCS may associate with LBP and reduces the motor control of the core muscle stability which indirectly influences gait performance.

Conclusions: This study suggests that individuals with LCS will have an alteration in their gait. However, there is still insufficient information on motor control in gait performance among lower crossed syndrome. Further research is needed to find what factors that may contribute to the adaptation of motor control in gait among LCS population

KEYWORDS:
Lower crossed syndrome, low back pain, motor control, gait

INTRODUCTION

Lower Cross Syndrome (LCS) is a common disorder characterised by muscle tension caused by an imbalance in the strength of the muscles in the lower extremities[1] and further clarified that LCS is a musculoskeletal imbalance characterised by specific muscle weakness patterns[2], which is also known as pelvic cross syndrome.[3] LCS results from the imbalance of muscle strength in the lower extremities, which is affected by muscle tightness on the iliopsoas, rectus femoris, tensor fascia latae, adductor group, gastrocnemius, and soleus.[1] Due to the muscle imbalance, a person with LCS may develop lower back pain later in life.[2]

Lower Back Pain (LBP) is a prevalent condition affecting people worldwide, among the poor and wealthy people. Also, it affects people in both age groups, from children to the elderly. Individuals experiencing chronic LBP may exhibit variations in muscle size, composition, and coordination that deviate from those who do not report pain.[4] Individuals experiencing chronic LBP may also exhibit diminished control over gait smoothness and stability at higher levels. This may be attributed to a decrease in muscle excitability, which can result in reduced control over trunk movements.[5] On the other hand, gait considers a fully autonomic task that interacts extensively with motor control.[6] Gait is also classified as an act and way of walking that involves the complex motor skill that facilitates locomotion. Lesions or dysfunctions in the central, peripheral, and musculoskeletal systems can cause gait disorders.[7]

Gait performance is influenced by motor control of the involved muscles in the trunk and extremities. It is said that, to initiate movement, the individual requires good motor control which associated with motor learning. Motor control is the ability to regulate or direct the mechanisms necessary for movement, while motor learning is the investigation of movement acquisition and modification. While motor control is concerned with understanding the control of previously acquired movement, motor learning is concerned with understanding the acquisition and modification of movement.[8] Therefore, having good motor control and learning is essential to enhance better gait performance and training in individuals with LCS.

However, it is imperative for an individual to possess proficient motor control and aptitude for learning. The question of whether individuals with a lower cross syndrome condition are more likely to experience low back pain has

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been raised. The purpose of this study was to investigate the potential relationship between lower extremity muscle strength in LCS and gait. The occurrence of gait pattern disorders can be ascribed to a decrease in the musculature of the lower extremities. Therefore, it can be inferred that the decline in muscle quality and strength is potentially responsible for the motor control and balance deficiencies that ultimately result in falls and unfavourable outcomes.[9]

Thus, the motor control of the trunk and lower extremities of an individual with LCS might influence the gait performance, which could also be associated with low back pain in reference to structures involve due to the LCS.

Lower Cross Syndrome and Low Back Pain
Individuals with LCS may present with a postural imbalance, which leads to LBP at any point of time in their life. In the presence of inhibited and weakened gluteal muscles, overactivity and tightness of the erector spinae muscle may alter the hip extension pattern by changing the order in which the muscles are more activated.[2]

In this case, the lower back erector spinae may fire first, followed by the gluteus. As a result, the lower spine becomes overloaded, compressed, and hypermobile, particularly in the L4-5 and L5-S1 joints. Excessive loading of the lumbar spines and hip joints can cause stiffness, irritation, and inflammation of the joints and the surrounding soft tissues, including the discs. Then, the pain eventually sets in, usually in the L5-S1 and L4-5 regions thus, develop LBP.[10]

Lower Cross Syndrome Affecting Gait
LCS may affect the gait due to the various patterns of back muscle activation, such as heightened co-contraction of flexor and extensor muscles during trunk movements, the heightened activity of the obliquus externus abdominis during standardised shoulder movements, and the heightened activity of the erector spinae during the swing phase of the gait cycle.[11]

When LCS is present together with LBP, the upper body can sway more in the transverse plane and at the lumbar level, making walking and termination of gait (GT) more difficult. Changes in the neuromuscular control of the upper body appeared to be task-dependent, and these changes are exacerbated by the necessity of a rapid cessation of gait in response to an environmental visual stimulus.[12] The potential correlation between the decline of the muscles in the lower extremities and the manifestation of irregularities in an individual's gait pattern is a subject of interest. It suggests that the loss of muscle quality and power may be the underlying cause of the motor control and balance impairments that result in falls and adverse consequences.[9]

MATERIALS AND METHODS

This scoping review used Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA).[13]

Eligibility Criteria
In searching for articles to be included in the review, the papers need to explain lower extremities pain, posture, and core stability. The papers should also emphasise the conceptual framework (e.g., lower crossed syndrome, gait, low back pain, lower extremities pain, and posture). This study also included peer-reviewed and systematic review papers published between 1970 and 2022 and written in English.

Exclusion Criteria
The paper was excluded when it did not align with the conceptual framework and involved neurological conditions.

Information Sources
The researchers searched the following databases to identify potentially relevant documents: Google Scholar, Science Direct, ResearchGate, PubMed, and Scopus.

Search Strategy
In the process of searching the papers, the keywords used were:
1. "Motor Control and Motor Learning" AND "gait" AND "lower crossed syndrome"
2. "Motor Control" AND "gait" AND "lower crossed syndrome"
3. "Motor Control" AND "gait" AND "low back pain"
4. "Gait" AND "low back pain"
5. "Gait" AND "lower crossed syndrome"
6. "Lower crossed syndrome" AND "lower back pain"
7. "Low back pain"
8. "Motor control and motor learning"

Data Extraction
During data extraction, a few article characteristics (e.g., motor control and motor learning, lower crossed syndrome, gait) and engagement characteristics and contextual factors need to be highlighted (e.g., structure affected, muscle involvement, how that affects gait).

The studies were organised and summarised based on the type of behaviour analysed: Authors (Year), Study design, Sample, Duration, Intervention, and Main Result. The studies for review were chosen after a thorough search and screening.

Ethics Approval and Infprmed Consent
This review does not require ethical approval.

RESULTS

There were 107 articles retrieved from the search. After removing duplicates, 90 articles were eliminated through the eligibility based on title, abstract, and full text. This selection process finally resulted in seventeen articles being included for further review. The details of the selected articles are illustrated in Figure 1.

The design of the study found in the eight reviewed articles included cross-sectional (n=1), Randomized Control Trial

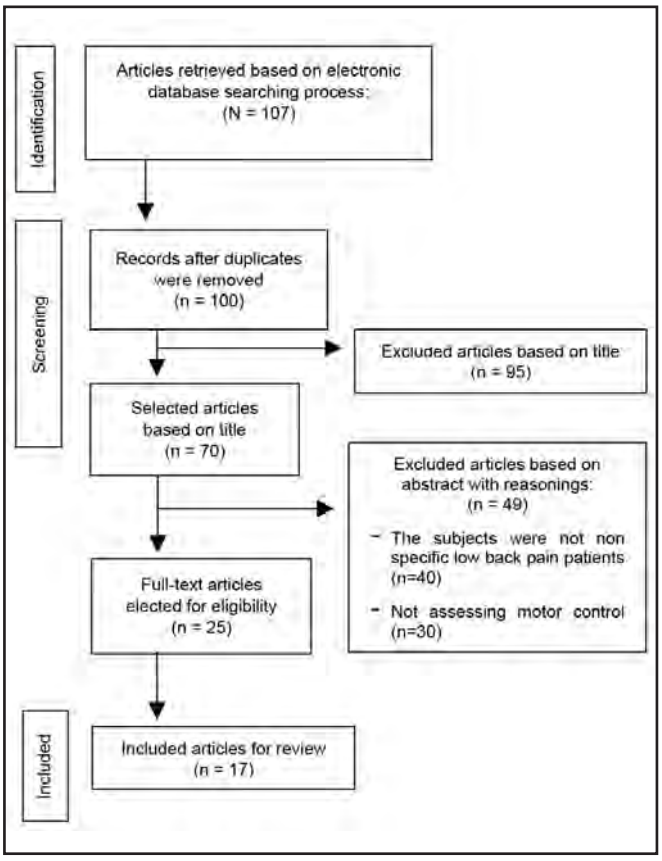

Fig. 1: Articles Selection Process Flowchart

(n=6), systematic review (n=3), Experimental study (n=6), and Stepped Wedge Intervention (n=1). Their study objectives vary but included one or more of the following: (1) identifying lower crossed syndrome, (2) gait, (3) motor control changes, (4) motor learning, and (5) low back pain.

DISCUSSION

The aim of this review was to conduct a thorough analysis of research related to individuals who suffer from LCS or LBP that affects their gait. The current investigation comprised a collective of seventeen articles that met the predetermined standards for analysis. The present study shows the enduring effects of motor control alterations following training, alongside the acquisition of automatic postural control strategies through motor learning.[27]

The therapeutic impact of core stability on individuals with non-specific CLBP is noteworthy, as it leads to a reduction in pain intensity, functional disability, and an improvement in quality of life, core muscle activation, and thickness.[24] The implementation of stabilisation exercises in individuals with LBP has the potential to mitigate pain and reduce disability. It may not be deemed imperative to prescribe exercises that are purported to reinstate motor control of specific muscles.[31]

This intervention is appropriate for individuals experiencing LBP. Nevertheless, there is a lack of evidence to suggest that stabilisation exercises are superior to other forms of active exercise in the long term.[32] Most studies included subgroups of people with LBP that associated with gait problems, however, display little studies that aimed specifically at people with the LCS who demonstrated with gait problem. The lack of amount of lower cross-syndrome-related research proves this.

A limited number of related studies were retrieved, with the majority being focused on the topic of lumbar pain. This scoping review criteria excluded gait-related studies pertaining to neurological conditions, which were the focus of most of the studies. The available evidence is inadequate to establish a conclusive differentiation between LCS and gait. A study conducted on musculoskeletal disorders revealed that there was no discernible distinction in pain, low back disability, lower body flexibility, kinesiophobia, gait characteristics, and quality of life.[17] Nonetheless, a comparable investigation contrasting the effects of core stability exercise (CSE) and myofascial relaxation technique (MRT) with those of core stability exercise alone revealed that the former combination of interventions yielded advantageous outcomes. The combination of CSE and MRT may provide greater benefits for individuals suffering from chronic LBP or LCS conditions over an extended period. Nevertheless, no scholarly investigation has explicitly contrasted this phenomenon with individuals who exhibit LCS. While these studies provide additional context regarding core stability interventions for this specific population, further clarification is required regarding the influence of lower crossed syndrome on gait performance. This limitation restricts the scope of conclusions that can be drawn from the available evidence.

There is a lack of literature that establishes the motor control and motor learning aspects related to LCS and gait in physiotherapeutic intervention in a manner that is replicable. The studies under consideration indicated the inclusion of motor control and motor learning in the intervention; however, many of them did not provide detailed description of the said component. The authors use the term "exercises" to denote the intervention, implying that it is a standalone treatment rather than a comprehensive label for diverse potential treatment methodologies.

This implies that there is insufficient evidence to guide physiotherapists in deciding what intervention to prescribe, supported by the systematic reviews in this study. One study found that people with LBP and pronated feet may benefit from corrective exercise programmes, but it did not include motor control components. Nonetheless, the two randomized control trials (RCT)[15,17] concluded that the core stability intervention improved people with low back pain and gait.

Comprehending the encounters of individuals afflicted with the LCS, a condition that impacts both gait and motor function, is deemed an essential component in the administration of any intricate intervention. The study's strengths lie in its comprehensive search approach and rigorous screening and data extraction methods. It is important to acknowledge that our focus was solely on musculoskeletal disorders within the scope of physiotherapy practice, thereby limiting our exploration of broader techniques that may be employed by physiotherapists in the context of neurological disorders.

Table I: Table of Evidence

Authors (Year)[Ref no]	Study Design	Sample	Duration	Intervention	Main Result
Steele, Bruce-Low, Smith, Jessop, & Osborne, (2016)[14]	Randomized Controlled Trial	24 people with non-specific CLBP	12 Weeks	Isolated lumbar extension exercise intervention (1x/week, performing a single set to momentary muscular failure with a load equal to 80% of maximum tested torque) or non-training control period.	Implementing a resistance exercise intervention that focuses on isolated lumbar extension can decrease gait variability. The results indicate that performing lumbar extension exercises in isolation may have a targeted effect on reducing variability in the sagittal plane. This suggests that the exercise may enhance the ability to replicate motor patterns in this particular plane of movement, potentially due to the exercise's use of this specific movement plane.
Kim, Park, & Kwon, (2020)[15]	Randomized Controlled Trial	39 patients who displayed the lumbar Ext Rot pattern were subjected to randomisation, with 19 patients assigned to the experimental group and 20 patients assigned to the control group.	6 weeks	Experimental group: classification-specific treatment (included an exercise to control or prevent lumbopelvic motion during lower-extremity movement) Control group: encouraged to perform general exercises and were educated about LBP.	Pain intensity, disability, fear-avoidance beliefs-physical activity score, and Erector Spinae muscle activity during walking all had significant time-by-group interaction effects. After the intervention, the group had significant effects on pain, disability, and fear-avoidance beliefs-physical activity score. Erector Spinae muscle activity decreased significantly during walking in the experimental group, but this was not an all-events decrease.
Madadi-Shad, Jafarnezhadgero, Sheikhalizade, & Dionisio, (2020)[16]	A double-blind, randomized controlled trial	30 older adults with both back pain and pronated feet	-	-	Higher walking speed, lower pain, lower LBP disability, comparable vertical loading rate and free moments, and lower muscle activities in the experimental group after CEP demonstrate improved gait efficiency.
Ozsoy et al., (2019)17	A randomized, controlled, single-blind study	45 participants	6 Weeks	Core stabilisation exercises (CSE) group: A core stabilisation exercise program CSE+MRT group: Core stabilisation exercises, myofascial relaxation technique with a roller massager	The results indicate that the CSE+MRT group exhibited more significant improvements in core stability endurance ($p=0.031$) and spinal mobility in the sagittal plane ($p=0.022$) compared to the CSE group. The study found no statistically significant difference between the two groups concerning pain about ability, lower body flexibility, kinesiophobia, gait characteristics, and quality of life ($p>0.05$).
Cai, Yang, & Kong, (2017)18	A randomized, controlled, single-blind study	84 recreational runners	8 Weeks	1)Lower limb (LL) exercises, 2) Lumbar extensor (LE) exercises 3)Lumbar stabilisation (LS) exercises.	Lower limb exercise therapy has shown promise in the clinical management of non-specific LBP in recreational runners. Lower limb exercise therapy was more effective than traditional back exercises in improving key rehabilitation outcomes such as self-rated running capability, knee extension strength, and running step length. All exercise therapies reduced running-induced pain and improved back muscle function equally well.
Koch & Hänsel, (2018)[19]	Systematic Review	-	-	The researchers compared neuromuscular and biomechanical parameters during walking or running in healthy adults and adults with chronic non-specific LBP.	Although there is limited scientific proof for any individual parameter, a comprehensive elucidation can be achieved by integrating biomechanical and neuromuscular parameters. The manifestation of compromised motor control while walking is evident in escalated erector spinae activity, leading to rigidity in the lumbar-pelvic area.

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Table I: Table of Evidence

Authors (Year)[Ref no]	Study Design	Sample	Duration	Intervention	Main Result
Martinikorena et al., (2016)[20]	Experimental Design	22 institutionalised frail elderly	-	Walked 7 meters in a straight line with no obstacles at a self-controlled pace.	An increase in the quantity of high-density fibres, particularly in the quadriceps femoris muscle, has been associated with enhanced gait performance in terms of step time variability, regularity, and symmetry. Moreover, there was a correlation between gait variability and muscle power.
Brach et al., (2015)[21]	Randomized Controlled Trial	40 Adults	12 Weeks	Both interventions included task-oriented motor learning, a standard exercise programme, and strength training.	There is preliminary evidence that task-oriented motor learning exercise improves motor control of walking, whereas standard exercise does not.
Lin, Halaki, & Leaver, (2023)[8]	Cross-sectional study	16 participants	-	The study employed an instrumented treadmill (FDMT Lido, Noraxon, USA) equipped with a deck comprising 2560 capacitive sensors (MyoPressure-T, Noraxon, USA) to measure gait parameters.	The absence of noteworthy inter-group disparities in gait parameters may suggest that individuals with low levels of LBP exhibited unmodified gait patterns after adjusting for gender, age, and height.
Rum et al., (2021)[12]	Experimental Design	22 participants	-	Walk straight at their own pace while keeping their gaze fixed on a black visual target displayed on a screen at the end of the 10-meter walkway.	Compared to individuals without chronic low back pain, those with CLBP exhibited an increased transverse range of motion in the lumbar region while engaging in walking and GT activities. The individuals with chronic low back pain (CLBP) showed a higher degree of sagittal range of motion (ROM) compared to their healthy counterparts during the termination phase of gait (GT). During ambulation, the group diagnosed with chronic low back pain exhibited greater variability in the transverse plane, while the group diagnosed with gluteal tendinopathy showed greater variability in lumbar frontal motion.
Nakisa, Ghasemzadeh Rahbardar, Sokhangouei, & Afsharmand, (2021)[22]	Quasi-experimental and applied research	15 male elite soccer players	8 Weeks	For eight weeks, core stability-based corrective exercises were performed thrice weekly, and changes in gait parameters (pre- and post-intervention) were measured.	By performing core stability-based corrective exercises during the study period, gait parameters in the post-intervention outperformed the results in the pre-intervention in most parameters. As a result, it is proposed that core stability-based corrective exercises are a safe and effective method for improving function in those with the middle-crossed syndrome. They could be used as therapy to assist players with this finding.
Leung, Mendis, Stanton, & Hides, (2015)[23]	Stepped-wedge intervention	46 AFL players participated	7 or 8 Weeks	The motor control training consisted of two 30-minute sessions per week overseen by qualified physiotherapists with experience in the motor control training programme.	The present study reveals that the size of the piriformis muscle in elite Australian Football League (AFL) players increases during the season and is impacted by lower back pain (LBP) and injuries to the lower limb. The size of the piriformis muscle in individuals with lower back pain (LBP) can be improved through motor control training.
Frizziero et al., (2021)[24]	Systematic Review	-	-	-	In patients with non-specific chronic low back pain, core stabilit has a significant therapeutic effect, reducing pain intensity and functional disability and improving quality of life, core muscle activation, and thickness.
Shih, Van Dillen, Kutch, & Kulig, (2021)[25]	Experimental Design	20 young adults	-	Participants were then given 3 minutes to become acquainted with the treadmill before completing a 30-second treadmill walking trial at 1.25 m/s to determine the preferred step width (PSW).	The exacerbation of unusual motion during the reduction of symptoms may suggest that modified trunk regulation in patients with recurrent low back pain is attributable to movement patterns or anatomical factors that predated the evaluated painful occurrence.

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Table I: Table of Evidence

Authors (Year)[Ref no]	Study Design	Sample	Duration	Intervention	Main Result
Xiao et al., (2022)[26]	Systematic Review	30 participants	-	For the actual testing, the participants completed 40 trials.	Older people with LBP had lower ankle proprioception than healthy peers, indicating impaired central proprioceptive processing.
Tsao & Hodges, (2008)[27]	Experimental Design	Nine people	4 Weeks, the follow-up was done after six months	During the initial and subsequent two-week sessions, the participants underwent training involving repeated isolated voluntary contractions of the transversus abdominis (TrA) muscle with the aid of real-time ultrasound imaging feedback. Over a month, the home regimen consisted of two daily training sessions.	The persistence of motor control changes after training is demonstrated, as is the motor learning of automatic postural control strategies.
Hall, Tsao, MacDonald, Coppieters, & Hodges, (2009)[28]	Experimental Design	Ten people	Single session	A single training session that included three tasks: "abdominal curl up," "side bridge," and "birdog."	After a single session of training, co-contraction training of the trunk muscles does not restore
Waters, (2014)[29]	Randomised controlled trial	Thirty people	4-week period	6-sessions of Bruegger's exercise and/or SM were administered to each group over the course of 3-week.	Bruegger's exercise, SM, and the combination of Bruegger's exercise+SM are all effective treatment protocols for improving hip and lumbar ROM, reducing the degree of lumbar lordosis, and relieving pain and disability. However, no treatment strategy is superior to others. Overall improvements in pain, disability, hip and lumbar ROM, and lumbar lordosis were greatest with SM alone, suggesting that SM alone is the most effective treatment for CLBP associated with LCS. After the full effects of the SM have set in and the muscles are in their optimal state for exercise, Bruegger's exercise may be added to the treatment plan to further assisting in some cases.
Niemier et al., (2019)[30]	prospective, rater-blinded, cross-sectional controlled multicenter study	31 Participants	-	The study's doctors or PT were given training in advance, and they all stay to the same exam schedule. They observed signs of secondary muscle strain in the postural muscles (TRPs), examined spontaneous and directed movements, postural patterns, movements, or postures thought to provoke special postural reactions. Janda classified muscles as predominantly tonic (tensing/ shortening) or phasic (weakening/ stabilizing), and thus the examined postural patterns were derived from the crossed syndromes.	A higher proportion of patients with CLBP exhibited LCS. However, there was no statistical significance difference observed. This could be due to the limited sample size of participants in this study.

CLBP=chronic low back pain; LBP=low back pain; CSE=Core stabilization Exercises; ROM=Range Of Motion; GT=Termination of Gait

CONCLUSION

This scoping review has demonstrated that individuals with LCS and concurrent LBP exhibit gait alterations. The reason for this phenomenon is that there exists a correlation between motor control among patients with LCS. Therefore, it is imperative to implement a thorough evaluation of motor control and a rehabilitation regimen focused on functional goals for individuals with LCS. Further investigation is required to determine the variables that potentially influence the adjustment of motor regulation in locomotion among individuals with LCS.

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CONFLICT OF INTEREST

No conflict of interest.

FUNDING

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The road less taken: A scoping review of the utilisation of hand assessments in individuals with diabetes mellitus

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ABSTRACT

Introduction: Diabetic peripheral neuropathy (DPN) is one of the most prevalent chronic complications of diabetes mellitus (DM) that can significantly result in disability and impaired quality of life. The DPN of the foot has been extensively studied in diabetes care. Nevertheless, the DPN of hand has been the road less taken in research and clinical practice. Thus, a scoping review was conducted to identify all available standardized hand assessments which have been used, developed, or tested in individuals with DM.

Materials and Methods: This scoping review was reported in alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). Studies were identified through searches of five databases: Cochrane, Scopus, ProQuest, MEDLINE, and Web of Science (WoS).

Results: Of the 294 articles initially identified, 20 studies were included and analysed thematically after removing duplicates. The majority of these assessments measure body function and structure such as grip and pinch strength while the rest are measuring the activity and participation domain. Most of the hand assessments were performance-based measurements. It is suggestible to employ both types of assessments to obtain a comprehensive understanding of hand conditions in individuals with DM. While some validated hand assessments were identified, only the Duruöz Hand Index (DHI) has been validated as a reliable tool specifically for evaluating hand function in individuals with DM.

Conclusion: There is a need to evaluate the measurement properties of existing instruments for assessing the hand function in individuals with DM, or to develop hand assessments specifically for the DM population. This scoping review was forging a new path, by discovering diabetes care through the utilisation of hand assessments.

KEYWORDS:
Diabetes mellitus, hand assessment, hand function problems, International Classification of Functioning (ICF)

INTRODUCTION

Diabetes Mellitus (DM) is a pervasive metabolic disorder affecting millions of people globally, which requires the government to necessitate a multifaceted strategy for optimal management. It is estimated that by 2030, approximately 578 million people would be affected by DM, and this number is expected to increase by 51% (700 million) in 2045.[1] Diabetic peripheral neuropathy (DPN) is one of the most prevalent chronic complications of DM that can significantly result in disability and impaired quality of life.[2–5] With the progressive increase in the prevalence of DM, there would be a parallel increase in the occurrence and severity of complications as well. DPN can develop in both the lower and upper extremities, leading to physical function limitations across different body areas.[6–8] Hence, DPN could impact not only the feet but also the hands and fingers in terms of functional difficulties.

The DPN of the foot has been extensively studied in diabetes care. Comparatively, the DPN of the hand has been the road less taken in research and clinical practice. Despite the significant impact of hand neuropathy on functional ability and quality of life, it has been sometimes overlooked in diabetes care, both in research and clinical practice.[9–11] Standard approaches in diabetes care like blood glucose monitoring, medication, and lifestyle modifications are well-established as described in the literature.[12–14] Amidst neglect, the less explored frontier, namely the employment of hand assessments holds the promise of unveiling novel insights in the literature on DM. Exploring the DPN, particularly in the hands would lead to interventions to improve hand function, enhance patient education on DM, and minimize disability risks.[4,11,15,16] Early diagnosis and comprehensive management are essential for alleviating symptoms, preserving hand function, and preventing complications. Focusing on DPN in the hands would facilitate optimal functional outcomes and promote the overall quality of life for individuals living with DM.

The hand is the most active and important component of the upper extremity.[17] The specific scale in evaluating hand function is undetermined as it could not be assessed directly because of its structure and various functions. Thus, hand function is always illustrated to be assessed based on its components such as precision accuracy, grasp, pinch and

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coordination. Hand function is also defined as the ability to perform daily activities using hands.[18,19] Previous literature mentioned the ability of the hand to perform precise movements, known as dexterity and hand strength which included both pinch and grip strength are part of the functional characteristics of the hand.[20,21] In the realm of hand rehabilitation, hand assessments are an essential component of our practice. They are fundamental to evaluation and intervention approaches in hand rehabilitation, serving as a crucial element in addressing hand-related issues in individuals.

As regards to DM, hand assessments could play a valuable role in the management of DM by identifying potential hand-related complications and developing optimal strategies for hand rehabilitation. DPN could lead to various issues like pain, reduced hand strength, impaired sensory and motor abilities, decreased tactile sensitivity, and compromised hand dexterity.[22,23] Additionally, a study highlighted substantial challenges faced by individuals suffering DPN, including struggles with activities of daily living such as fastening buttons, handling utensils, opening doors, sleeping problems, navigating stairs, walking, and efficiently performing work or household chores.[24] This emphasises the necessity of assessing the hand function as it directly impacts the overall quality of life and daily activities. As in the literature, hand assessments would be able to detect symptoms and assess hand strength, hand dexterity and other hand dysfunctions that would affect functional ability in individuals with DM.[7,8,25–28]

The International Classification of Functioning, Disability and Health (ICF) framework is internationally understood and applies to many health professions as ICF established a common language and framework in integrating knowledge of health conditions across disciplinary and geographic boundaries.[29] Undoubtedly, ICF might seem like a basic health classification but could be employed for a variety of purposes.[30] This framework provides a comprehensive way to understand the impact of health conditions on an individual's functioning and participation in society. Therefore, the consideration of the constructs being assessed was conducted with reference to the ICF.

Motivated by the important role played by hands in daily activities, which might be affected by DM and the fact for the lack of a review on hand assessment in this population, this review aimed to (1) identify all available standardized hand assessments which have been used, developed or tested in individuals with DM and (2) map the dimension/ construct(s), types of the assessments, and (sub)scale(s) of the assessments involved using a framework focusing on human functioning.

MATERIALS AND METHODS

Study Design

This review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist.[31] The process involved five phases delineated as: 1) determining eligibility criteria, 2) identifying relevant literature, 3) studies selection, 4) data retrieval and charting, and 5) analysis and presentation of data.

Determining Eligibility Criteria

Scoping review employs a systematic approach to exploring the evidence related to the identified topic area.[31] This scoping review aimed to map out the relevant studies related to the utilisation of hand assessments in individuals with DM. Studies were included based on the following criteria: (1) peer-reviewed studies involved measurement instruments in assessing hand condition among individuals with DM, (2) studies were published between January 1, 2014, and March 31, 2023, (3) studies reported in English, and (4) the population focuses on individuals with DM type 2.

To avoid the impact of confounders, this study would focus on individuals with DM type 2 only as individuals with DM type 1 have distinct etiology and management. Studies were also excluded if they were focusing on conditions other than DM, applying different assessments other than hand assessments, grey literature published as editorial letters, dissertations, reviews, and conference abstracts, studies reporting non-standardised measures, and studies that are published before 2014.

Identifying Relevant Literature

Based on the eligibility criteria, the search for studies that meet the requirements began. Multiple electronic databases were searched namely Cochrane, Scopus, ProQuest, MEDLINE, and Web of Science (WoS). The keyword term for this topic was based on the medical subject heading (Mesh). The search keywords, terms and Boolean operators used in the database search strategy were; ("hand function* assessment" OR "hand assessment" OR "hand evaluation" OR "hand measurement" OR "hand therapy assessment" OR "hand dysfunction" OR "hand function" OR "hand disorder" OR "diabetic hand") AND ("diabetes mellitus" OR "type 2 diabetes mellitus" OR "diabetic" OR "non-insulin-dependent diabetes mellitus" OR "adult-onset diabetes" OR "Type-2 diabetes" OR "type 2 diabetes" OR "DM"). The identification process is shown in Figure 1. The identification of the relevant literature was carried out by two reviewers.

Study Selection

Two reviewers performed the selection of the studies. This stage includes a thorough analysis of the articles obtained from the five databases. Firstly, the articles were identified and retrieved from the selected databases, based on the search criteria and keywords used. Data extraction was considered to be thorough when the searches yielded no further articles beyond those newly identified ones through the searches. In all 294 articles were identified and retrieved from the databases (Figure 1). Then, a meticulous review was conducted by two reviewers to eliminate any articles that are deemed irrelevant or not applicable to the research topic. Following the removal of 5 duplicate articles, 289 articles were screened. Should a disagreement arise between the two reviewers, a third reviewer decided regarding the inclusion of the article. Initially, a title screening was conducted to quickly scan the article titles and determine their potential alignment with the research topic.

Next, a more comprehensive title and abstract screening were conducted to further evaluate the articles based on the abstracts. This allowed for a deeper assessment of the articles' suitability for the research, considering both the title and a summary of their content. Of the 51 articles, only 21 articles left for a thorough full-text screening. A total of 30 articles were excluded as the studies are not using the standardized assessment for hand conditions, focusing on other conditions other than DM, applying different assessments other than hand assessments, articles published as dissertations and the studies published before 2014. This involved a meticulous evaluation of the complete content of the articles, including the introduction, methods, results, and conclusion sections. The full-text screening enabled a detailed evaluation of the articles' relevance and alignment with the research objectives. After reviewing the full-text articles, 1 article was excluded as the study is focusing on other conditions other than DM. Eventually, this study encompassed a comprehensive selection of 20 articles, which were deliberately chosen for inclusion in this study.

Data Retrieval and Charting

The data retrieved from a comprehensive review of 20 articles were extracted and outlined and summarised in Table I according to the author, year, names of hand assessments involved in the study, dimension/ construct(s) to be assessed, type of hand assessment, (sub)scale(s) or the number of items and the dimension of hand assessment within the ICF framework.

Data Interpretation and Presentation

The articles were thoroughly reviewed by two reviewers, and the results were summarized in Table I by employing thematic analysis, based on themes associated with the contents of those hand assessments in identified articles. The findings were thoroughly analysed and deliberated in light of the components of ICF, and the approach employed in evaluating the hand function. The ICF uses a hierarchical coding system with three levels. The first level broadly categorizes into 'body functions and structures' and 'activities and participation', describing the impairments in body systems and structures, and covers limitations in an individual's ability to perform activities and participate in life situations. The second level provides more specific details within the first-level categories, while the third level offers even greater granularity. Nonetheless, this review exclusively relied on the first-level coding for the analysis as it provides high-level overview.

Ethics Approval and Informed Consent

Ethics approval was not required for this study.

RESULTS

There are two major themes derived from the qualitative review. One is the dimension of hand assessment within the ICF framework, and the other is the type of hand assessment involved. Each was discussed in detail below.

Dimension of Hand Assessment within ICF Framework

Across the included papers, a total of 20 hand assessments were identified. The hand assessments were grouped into two distinct categories (either 'body function and structure' or 'activity and participation'), depending on the published description of each assessment's intended scope of the evaluation. The most prevalent form of assessment is related to body function and structure domain within the ICF framework, as they focused on evaluating various physical parameters of hand function, such as grip strength, pinch strength, range of motion, and tactile sensation. The hand assessments that are extensively employed and mostly cited encompass the ones that evaluate grip and pinch strength,[7,8,37–39,15,16,26,32–36] which constitute a significant proportion of 60% of the utilised assessments, followed by Semmes-Weinstein monofilament (55%).[6,7,40,8,16,26,27,35,37–39] Included in the category of body function and structure assessments are a total of two evaluations that measure tactile acuity, namely static two-point discrimination (S2PD) (15%)[6,38,40] and moving two-point discrimination (M2PD) (10%).[6,40] As for the remaining assessments, each of them is utilised in a relatively small proportion of 5% among the overall assessments employed, namely goniometer, grip force control, pinch proprioception test and on-off vibration test.[8,35,37,39]

As for hand assessments related to the activity and participation domain within the ICF framework, the focus is on evaluating an individual's ability to engage in activities that require hand use and participation in everyday life tasks. Within this category, the most used assessment is Purdue Pegboard Test (40%), [7,11,16,22,32,33,38,40] followed by Michigan Hand Outcomes Questionnaire (MHQ) (20%),[11,22,32,40] Nine-hole peg test (20%),[8,15,32,35] the Duruöz Hand Index (DHI) (15%)[28,34,41] and Jebsen-Taylor Hand Function Test (JTHFT) (15%).[8,35,38] Other assessments namely the Patient Neurotoxicity Questionnaire (PNQ),[37] the Minnesota Manual Dexterity test,[15] the Keitel Functional Test (KFT),[42] The Arthritis Hand Function Test (AHFT),[42] and Disabilities of Arm, Shoulder and Hand Questionnaire (DASH)[3] were infrequently utilised in the studies conducted, with each assessment being employed in only 5% of the research, indicating a low prevalence in the literature. Table I provides information on the characteristics of the measurement instruments that were extracted and categorized based on the components framed within the ICF framework.

Type of Assessment

In the context of assessments, the term "type of assessment" refers to the methods or approaches used to measure or evaluate the intended constructs. It comprises numerous procedures for administering assessments, which might affect the validity, reliability, and fairness of the assessment outcomes. In this review, the hand assessments were categorized into two primary groups namely performance-based measurement and self-reported measurement. These two categories provide different approaches to assess hand function, with performance-based measurement focusing on objective measurements of capacity or actual/best performance, and self-reported measures capturing individuals' subjective perceptions of their hand function or actual performance. Most (80%) of the hand assessments used were classified as performance-based measurements, while only a limited number of four assessments (20%) were categorized as self-reported measurements that are the Disabilities of Arm, Shoulder Hand Questionnaire (DASH), Patient Neurotoxicity Questionnaire (PNQ), Michigan Hand

Table I: Articles summary

Hand Assessments Utilised in the Study	Author/s, Year	Dimension/ Construct(s)	Type of Assessment	(Sub)scale(s) and number of items	Dimension of Hand Assessment within ICF Framework
Grip and pinch strength Assessment of Hands [44]	Q. Zhang et al., 2021 [16] Y. Zhang et al., 2021 [7] Wani et al., 2019 [15] Gundmi et al., 2018 [32] Kamal et al., 2021 [8] Win et al., 2020 [37] Kender et al., 2022 [33] De Carvalho E Silva et al., 2014 [34] Lima et al., 2017 [35] Akpinar et al., 2017 [28] Ochoa et al., 2014 [26] Gorniak et al., 2014 [38]	Measurement of the maximum force that an individual can exert with their hands during grip and pinch tasks	Performance-based	Measures related to grip and pinch strength	Body function and structure
Pinch Strength Assessment of Hands [44]	Yahya et al., 2019 [39]	Measurement of the maximum force force that an individual can exert with their hands during pinch tasks	Performance-based	measures related to pinch strength	Body Function and Structure
Grip force control assessment	Lima et al., 2017 [35]	Measurement of hand grip force control during object manipulation	Performance-based	Measures related to grip and pinch strength	Body function and structure
Pinch proprioception testing [39]	Yahya et al., 2019 [39]	Measurement of the pinch proprioception using a modified goniometer with its fulcrum fixed on top of a small cardboard.	Performance-based	Single measurement of pinch proprioception	Body Function and Structure
Pinch-Holding-Up Activity (PHUA) Test [56]	Kuo et al., 2019 [40] Chiu et al.. 2014 [6]	Measurement of the ability of an individual to hold an object between the thumb and index finger and lift it up to a target height.	Performance-based	Single measurement of hand function to determine the features of sensorimotor control in the hand	Body function and structure
Semmes-Weinstein monofilament (SWM) [57]	Kuo et al., 2019 [40] Gorniak et al., 2014 [38] Q. Zhang et al., 2021 [16] Y. Zhang et al., 2021 [7] Chiu et al., 2014 [6] Ochoa et al., 2014 [26] Lima et al., 2017 [35] Gorniak et al., 2020 [27] Kamal et al., 2021 [8] Yahya et al., 2019 [39] Win et al., 2020 [37]	Measurement of the touch threshold test in the hands.	Performance-based	Single measurement of the touch-pressure threshold test with 20 nylon filaments with of varied thickness	Body function and structure
on–off vibration tests (128 Hz tuning fork)	Win et al., 2020 [37]	Measurement of vibratory sensation as rapid screening for diabetic neuropathy	Performance-based	Single measurement of individual's ability to perceive vibration at 128 Hz.	Body function and structure
Static two-point discrimination (S2PD)	Chiu et al., 2014 [6] Lima et al., 2017 [35] Kuo et al., 2019 [40]	Measure of tactile spatial acuity, or the ability to distinguish two closely spaced points applied to the skin at the same time	Performance-based	Single measurement of tactile spatial acuity	Body Function and Structure

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Table I: Articles summary

Hand Assessments Utilised in the Study	Author/s, Year	Dimension/ Construct(s)	Type of Assessment	(Sub)scale(s) and number of items	Dimension of Hand Assessment within ICF Framework
Moving two-point discrimination (M2PD)	Chiu et al., 2014 [6] Kuo et al., 2019 [40]	Measure of tactile spatial acuity, similar to static two-point discrimination (S2PD), but with the added dimension of movement	Performance-based	Single measurement of tactile spatial acuity	Body Function and Structure
12" plastic goniometer	Kamal et al., 2021 [8]	Measurement of total active motion of the wrist	Performance-based	single measurement of range of motion	Body function and structure
Purdue Pegboard Test [58]	Kuo et al., 2019 [40] Gorniak et al., 2014 [38] Q. Zhang et al., 2021 [16] Y. Zhang et al., 2021 [7] Yang et al., 2015 [11] Yang et al., 2018 [22] Gundmi et al., 2018 [32] Kender et al., 2022 [33] Yang et al., 2018 [22]	Measurement of hand dexterity	Performance-based	Four subtests (right hand left hand, both hands and assembly), each of which measures a different aspect of manual dexterity. The four subtests include tasks that involve using the right hand (RH), left hand (LH), both hands (BH), and assembly.	Activity and participation
Nine-Hole Peg Test [59]	Lima et al., 2017 [35] Wani et al., 2019 [15] Gundmi et al., 2018 [32] Kamal et al., 2021 [8]	Measurement of hand dexterity	Performance-based	Two subtests: measurement of the time taken for a subject to place and remove nine pegs in a hole on pegboard.	Activity and participation
Minnesota Manual Dexterity test [60]	Wani et al., 2019 [15]	Measurement of individual's ability to perform simple, rapid eye-hand coordination and arm-hand dexterity (gross motor skills)	Performance-based	Five subtests: Placing test, Turning test, Displacing test, One-hand Turning and Placing test, and the Two-hand Turning and Placing test	Activity and participation
Jebsen-Taylor Hand Function Test (JTHF) [61]	Gorniak et al., 2014 38 Lima et al., 2017 35 Kamal et al., 20218	Measurement of hand function using simulated ADL, including speed, dexterity, and coordination	Performance-based	Seven subtests/activities, which assess different functional activities of the hand namely writing a twenty-four letter sen- tence, card turning ability, lifting small common objects, stacking checkers, simulated feeding, lifting large light objects (e.g., empty cans), and lifting large heavy objects (e.g., lifting cans of approximately 0.45 kg).	Activity and participation

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Table I: Articles summary

Hand Assessments Utilised in the Study	Author/s, Year	Dimension/ Construct(s)	Type of Assessment	(Sub)scale(s) and number of items	Dimension of Hand Assessment within ICF Framework
Patient Neurotoxicity Questionnaire (PNQ) [62]	Win et al., 2020 [37]	Measurement of the presence of difficulties in ADL-related areas	Self-reported	3 subscales that identify the incidence and severity of sensory and motor disturbances and the types of activities of daily living , which need to be ticked if they have difficulties	Activity and participation
Keitel Functional Test (KFT) [63]	Poole et al., 2016 [42]	Measurement of functional performance	Performance-based	24 items assessing joint range of motion and muscular activity. 3 groups: hands and wrists (9 items), shoulders (2 items) and lower limbs (13 items).	Activity and participation
The Arthritis Hand Function Test (AHFT) [64]	Poole et al., 2016 [42]	Measurement functional status of the hand	Performance-based	11 tasks assess hand strength, dexterity, applied dexterity, and applied strength while performing activities associated with self-care, work, and leisure.	Activity and participation
Disabilities of Arm, Shoulder and Hand Questionnaire (DASH) [65]	Joshi et al., 2021 [3]	Measurement of physical function and symptoms in patients with any or several musculoskeletal disorders of the upper limb	Self-reported	30 items that assess upper extremity physical function and symptoms	Activity and participation
Michigan Hand Outcomes Questionnaire (MHQ)[66,67]	Kuo et al., 2019 [40] Yang et al., 2015 [11] Gundmi et al., 2018 [32] Yang et al., 2018 [22]	Measurement of patients' perceptions of functional hand performance	Self-reported	37 items questionnaire, which are grouped into six subscales (overall hand functioning, activities of daily living, pain, work performance, aesthetics and patient satisfaction with hand function)	Activity and participation
The Duruöz Hand Index (DHI)[51,68]	De Carvalho E Silva et al., 2014 [34] Poole et al., 2016 [42] Akpinar et al., 2017 [28]	Measurement of the functional status of the hand in patients with hand and wrist disorders.	Self-reported	18 items that assess various hand functions, including hand ability in the kitchen, during dressing, while doing personal hygiene, office tasks, and other general items.	Activity and participation

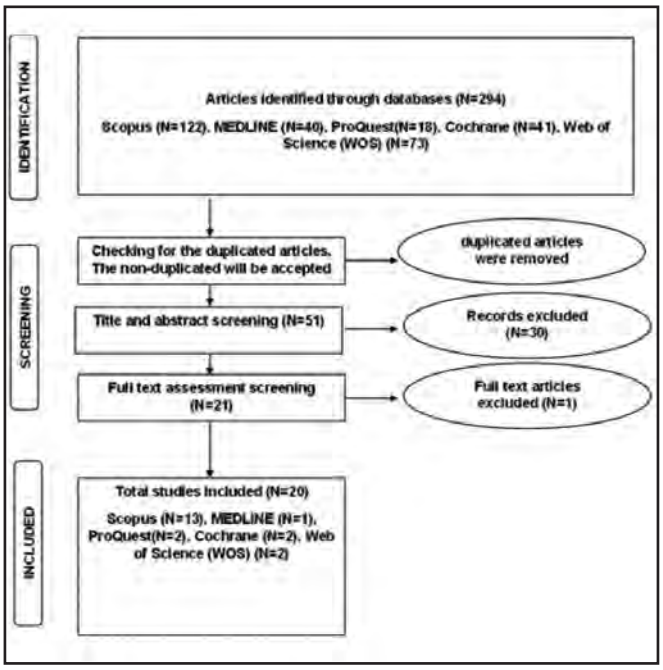

Fig. 1: The search processes

Outcomes Questionnaire (MHQ), and The Duruöz Hand Index (DHI).

DISCUSSION

This scoping review sought to comprehensively explore and synthesize the available hand assessment that have been used, tested, or developed for individuals with DM, providing a novel contribution to the existing literature in this area of study. This review is akin to navigating uncharted territory by exploring diabetes care through hand assessments as the findings of this study are based on fairly limited literature. The findings could be used to identify potential research gaps or areas of hand assessment in individuals with DM for further development. In an effort to ensure that the study reflects the most current research, the researchers have decided to exclusively focus on studies conducted within the past 10 years. This aligns with the concept of research field maturity highlighted in previous literature, as it facilitates a comprehensive evaluation due to the ample availability of a significant number of published studies.[43]

In this review study, the ICF framework was used to categorize the utilisation of hand assessments as it provides a conceptual clarity which would enhance the quality and comparability of hand assessments used. The hand assessment categorization was done by aligning them with the relevant domains within the ICF framework, considering the published descriptions that specify the intended purpose of each hand assessment. The two domains within the ICF framework involved were 'body function and structure' and 'activity and participation'. These two domains within the ICF framework could be a guiding principle when determining appropriate treatment approaches.

This study sheds light on the fact that hand assessments in patients with DM were dominated by the body function and structure domain than the activity and participation domain. This is unsurprising, as measures of body functions and structures domain have been extensively validated for their psychometric properties and are widely integrated into clinical practice.[44,45] As a systemic condition, DM could affect numerous physiological functions and structures within the body. This is exemplified in a study that illustrated the inclusion of a wide range of body-function categories in both the Comprehensive ICF Core Set and the Brief ICF Core Set for DM.[46] The Comprehensive ICF Core Set for DM encompassed a total of 99 categories, comprising 85 at the second level and 14 at the third level. This classification encompassed 36 categories related to body functions, 16 associated with body structures, and 18 concerning activities and participation. As for the Brief ICF Core Set, it comprised a total of 33 second-level categories, with 12 addressing body functions, 6 focusing on body structures, and 5 relating to activities and participation.[46]

More than half research studies (60%) incorporated the evaluation of the activity and participation domain alongside the evaluation of the body functions and structures domain. This integrated approach could view a holistic picture of hand function, encompassing not only the physiological aspects (body functions and structures) but also the functional aspects (activity and participation) in a more comprehensive manner. In some cases, even minor impairments in hand can result in significant limitations in a person's ability to perform activities or participate in various aspects of life, such as self-care, work, and leisure activities. These limitations may arise from the cumulative effects of multiple minor impairments that collectively hinder an individual's functional abilities. In contrast, major impairments of body functions, such as severe muscle weakness or sensory loss, may not always directly translate into limitations in activities or participation, as individuals may adapt or compensate using alternative strategies. Yang et al11 mentioned that diabetic patients commonly find ways to adapt their hand deficits in performing their daily activities. Hence, it is essential to assess not only body functions and structures, but also activities and participation, to gain a comprehensive understanding of how hand conditions would influence an individual with diabetic overall functional status and engagement in meaningful activities. Other than that, healthcare providers would be able to better tailor interventions and treatment plans to address the specific challenges and needs of the individual.

Throughout reviewed studies, grip and pinch strength evaluations are commonly utilised for assessing body functions and structures domain of the hand. Grip and pinch strength are assumed as key indicators of hand function that provide insight into the overall health and capabilities of the hand. The pinch gauge achieved the highest accuracy at ±1%, and reliability (ICC=0.98) while the Jamar dynamometer was found to be highly reliable (ICC = 0.98) and valid (ICC= 0.99) (42,44). Even so, there is a lack of consistency and variability observed in the findings of various studies when it comes to the association between DM and hand strength.[32] Different research studies have reported

conflicting results, with some indicating a correlation between DM and hand strength, while others show no significant association. [36,47–49] Also included in the body functions and structures domain are assessments of sensory function, tactile acuity, range of motion, and proprioceptive function. Given that DM could cause nerve damage and result in diminished sensory perception, tactile sensation, proprioceptive function, and limited joint mobility, it was expected for the researchers to evaluate these components.[8,32,47,50]

To achieve a comprehensive understanding of hand condition, it is essential to not solely focus on improving body functions and structures but also to thoroughly evaluate and address issues related to hand performance skills. Studies have revealed that DM would affect activities of daily living.[4,49] Thus, it was predicted that the studies would assess the activity and participation domain as well. This review suggests that a variety of hand assessments have been used in individuals with DM. Purdue Pegboard Test (PPT) and Nine-Hole Peg Test are using pegboard test in evaluating the coordination of the hands while the Michigan Hand Outcome Questionnaire (MHQ), Duruöz Hand Index (DHI), Disabilities of Arm, Shoulder and Hand Questionnaire (DASH), and Patient Neurotoxicity Questionnaire (PNQ) would assess general performance skills in ADL and/or participation.

As for Keitel Functional Test (KFT), Minnesota Manual Dexterity test, and Jebsen-Taylor Hand Function Test (JTHF); these assessments would evaluate fine motor skills and the functional capacity of the arm. This review revealed that hand assessments were used to evaluate different aspects of activities. Considering the complexity of hand function and the wide range of variables that can impact it, there is currently no consensus on a single assessment method that can be recommended to be the most effective hand function assessment. Nevertheless, among the various assessments used, only the Duruöz Hand Index (DHI) has been validated as a reliable tool specifically for evaluating hand function in individuals with DM.[51]

Throughout the reviewed studies, the researchers utilised two different approaches in evaluating the hand condition of individuals with DM, namely self-reported measurement and performance-based measurement. Most of the research conducted on evaluating hand condition in individuals with DM has primarily employed performance-based measurement as the main approach for evaluation. Performance-based measurement involves objective measurements of the physical capabilities and function of the hand. The individuals need to demonstrate their skills or performance through tasks or activities assigned to them. This could include tests or assessments that measure grip strength, range of motion, tactile sensitivity, dexterity, or other physical parameters related to hand health. Performance-based measurement provides a more objective and quantitative evaluation of the actual physical abilities and functional limitations of the hand in individuals with DM.[28,34]

On the other hand, the self-reported measurement would allow individuals to provide their own appraisal of their feelings or abilities related to their condition. This could include questionnaires, interviews, or surveys that asked individuals to report on their hand-related symptoms, functional limitations, pain, discomfort, or overall perception of their hand health. Self-reported measurement could provide insights into how individuals perceive their own hand condition and how it impacts their daily activities and quality of life.[52,53]

Generally, both self-reported and performance-based measurement approaches have pros and cons. Despite that, the assessment of hand condition in individuals with DM might be differently represented when using self-reported or performance-based measures, and this variation may be influenced by various patient-related factors.[25] Factors such as age, gender, the severity of DM, the presence of comorbidities, and individual perceptions of symptoms and function can impact the outcomes of self-reported and performance-based measures.

According to Poole et al.[10] the self-reported measurement could cover a wider range of skills than performance-based measurement. This is in line with a study by Coman et al.[54] that mentioned self-reported measurement has been demonstrated to be reliable as performance-based measurement. Literature also suggested that measuring functional limitations through self-reported measurement or performance-based measurement is likely to yield similar results, implying that both methods are potentially valid and reliable measures of function.[54] Nonetheless, the accuracy of self-reported measurement might be questionable as patients are more likely to report being capable of performing a task despite actually being unable to do so.[25,55] Generally, performance-based measurement is designed to assess the capability to perform a specific task within the construct of functional limitation, but it might not fully capture the real-life context of hand use in everyday activities like self-reported measurement. Thus, employing both self-reported and performance-based measurements would be advantageous, as they allow the practitioners to obtain a comprehensive understanding of hand conditions in individuals with DM.

LIMITATIONS

Though this scoping review was planned and conducted in accordance with applicable criteria by Tricco et al.,[31] some limitations must be highlighted. It did not attempt to evaluate the quality of the included hand assessments as per scoping review methodology. Yet the articles included were published in peer-reviewed journals; opinion pieces, narrative reviews, non-English articles, and grey literature were eliminated. Future studies should assess the psychometric qualities of the hand assessments involved in individuals with DM. The search was confined to five databases (Cochrane, Scopus, Web of Science (WoS), ProQuest and Medline) only. While these five databases are commonly acknowledged as the primary repositories for indexing healthcare publications, it is possible that articles

related to hand assessments in DM may have been indexed in other databases, but unintentionally missed in the search process. It is worth noting that there may be also a limitation as articles in languages other than English were not included.

CONCLUSION

The objective of the scoping review was to identify relevant literature utilising hand assessments for evaluating hand conditions in individuals with DM. Among the 20 hand assessments identified, most measure body function and structure such as grip and pinch strength, while a smaller proportion of the assessments measure the activity and participation domain. Only the Duruöz Hand Index (DHI) has been validated as a reliable tool specifically for assessing hand function in individuals with DM. There is a need to evaluate the measurement properties of the other identified instruments for individuals with DM. Additionally, this review recognized two main types of assessments: self-reported measurement and performance-based measurement. Both assessments have the potential to provide valuable information about hand function but might measure different aspects of hand function. Performance-based measurement is more commonly used; however, self-reported measurement offers advantages such as ease of use, efficiency, accessibility, and minimal resource requirements. Currently, there is a lack of performance-based measurement and self-reported measurement tools for hand function specifically designed for individuals with DM. However, the Duruöz Hand Index has been validated as a practical and efficient self-reported measurement tool that can accurately assess hand dysfunction in diabetic patients. Hence, this reflects that self-reported measurement would be a good way to measure how well individuals with DM could use their hands.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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Occupational therapy interventions in promoting social communication skills among children with autism spectrum disorder: A scoping review

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ABSTRACT

Introduction: Children with Autism Spectrum Disorder (ASD) often face significant challenges in verbal communication, social interaction, and exhibit repetitive behavioral patterns. These challenges persist across various developmental stages, particularly impacting their social communication abilities. This scoping review aims to explore the range of occupational therapy interventions that are employed to enhance social communication skills in children with ASD.

Materials and Methods: A literature search was conducted independently on scientific databases: Scopus, Google Scholar, Science Direct, and Web of Science (WOS). The process was carried out according to the PRISMA guidelines.

Result: Of the 195 studies identified, 8 articles involving 185 participants, aged 17 months to 12 years old, across six countries met the inclusion criteria. The majority of studies indicate significant improvement in social communication abilities, while one study demonstrates insignificant results and another study presents mixed outcomes, utilising two different assessment tools.

Conclusion: Occupational therapy has showed promise in improving social communication in children with ASD. Nonetheless, this review emphasises the need for greater in-depth study and long-term evaluation to better explain and sustain these benefits. More research is needed to develop OT interventions that are both effective and evidence-based.

KEYWORDS:
Social communication, autism spectrum disorder, occupational therapy, scoping review

INTRODUCTION

Children diagnosed with autism spectrum disorder (ASD) encounter various challenges, for instance, challenges in social interaction, verbal communication, and behavioural routines that are repetitive.[1] According to the CDC, the prevalence of ASD among 8-year-old children in the US was 1 in 54 in 2016.[2] Global estimates suggest a greater range of 50 to 70 cases per 10,000 individuals.[3] The diagnosis of ASD is significantly more common in boys compared to girls, with boys being diagnosed at a rate four times higher than girls.[4,5] In contrast, the available data on ASD prevalence in Malaysia is minimal. However, a preliminary study conducted by the Ministry of Health Malaysia in 2006, using the M-CHAT assessment, found that the incidence of ASD in toddlers was 1.6 per 1,000.[6]

Numerous researchers have revealed that children with ASD face difficulties in behaviour requests, social interaction, as well as shared attention, all of which are critical components of social communication abilities. Children who have ASD are more likely to exhibit those deficits in comparison to normal health children and children with forms of developmental issues. Social communication is one of the common difficulties among children with ASD at all developmental stages.[7] The difficulties in social communication linked to ASD have a substantial impact on both the children and their parents. Parents frequently face issues in efficiently identifying their children's needs.[8] These children often encounter challenges in articulating their needs and opinions, particularly in educational settings, resulting in reduced academic achievement and frequent disruptions in peer interactions caused by unrelated interruptions. This issue results in challenging behaviours in school and at home, limiting their opportunity or ability to execute independently in instrumental activities of daily living (IADLs) and activities of daily living (ADLs).

Tomchek et al.[9] highlight the critical role of occupational therapy (OT) in enhancing involvement in social communication for individuals, with a specific emphasis on its relevance in the context of ASD. Despite the fact that there remains a notable gap in the literature, current reviews do not adequately explore OT interventions aimed at enhancing social communication skills in children with ASD. This shortfall highlights an urgent need for comprehensive research to support the development and refinement of targeted services, thereby advancing our understanding and effectiveness of OT interventions in fostering social communication competencies

MATERIALS AND METHODS

This study is based on the PRISMA Extension for Scoping Review (PRISMA-ScR).[10]

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Table I: Databases and search strategies utilised

Databases	Search strategy January 2022 to April 2022
SCOPUS	TITLE-ABS-KEY (("social communication" OR "social skills" OR "communication skills" OR "social interaction") AND ("occupational therapy" OR "occupational therapy intervention") AND ("autism spectrum disorder" OR "ASD"))
Web of Science (WoS)	("social communication" OR "social skills" OR "communication skills" OR "social interaction") AND ("occupational therapy" OR "occupational therapy intervention") AND ("autism spectrum disorder" OR "ASD")
Science Direct	("social communication" OR "social skills" OR "communication skills" OR "social interaction") AND ("occupational therapy" OR "occupational therapy intervention") AND ("autism spectrum disorder" OR "ASD")
Google Scholar	("social communication" OR "social skills" OR "communication skills" OR "social interaction") AND ("occupational therapy" OR "occupational therapy intervention") AND ("autism spectrum disorder" OR "ASD")

Search Strategy

A comprehensive search of the published literature was conducted on online scientific databases: Science Direct, Google Scholar, Web of Science (WoS), and SCOPUS. The search terms, social communication, occupational therapy, spectrum disorder, and autism, together with the Boolean operators AND, and OR, was utilised across all the reviewed sources. Table I presents the search techniques that were applied across all the databases.

Review Criteria

All publication that met the inclusion criteria was considered. The type of studies included experimental studies, non-randomised control trials randomised control observational studies, case reports, pilot studies, quasi-experimental studies, and other trials. This study falls under levels 2, 3, and 4 of the evidence hierarchy with regards to Oxford Centre for Evidence-Based Medicine.[11] Children diagnosed with ASD, below 12-year-old, OT interventions that focus on social communication, research published between 2011 and 2021, full text article and research published in English were the other inclusion criteria.

The Selection of Studies

The screening procedure was carried out after all the papers were entered into Mendeley; duplicates were removed. Aside from eliminating duplicates, we deliberately omitted studies categorised as literature reviews, systematic reviews, or meta-analyses. We conducted this action to concentrate our analysis exclusively on original research articles, ensuring that our study was based on primary research data and findings, rather than on secondary summarises or interpretations. In addition, we eliminated studies that did not include OT interventions. It refers to interventions that are not carried out by occupational therapists (OTs) or are not grounded in the principles of OT. The exclusion was essential in order to precisely concentrate our investigation on the specific influence and function of OT. The titles, abstracts, and full text of the screened articles were reviewed to determine their eligible criteria.[10] To ensure a comprehensive and unbiased initial gathering of literature, no date filter was applied at this stage. This methodology enabled us to incorporate a diverse range of studies, including influential and fundamental research that may have been conducted in the past but remains pertinent.

Extraction and Synthesis of Data

A table for charting data was constructed so that critical information from the articles could be extracted and charted. The following data were extracted: the authors' name, type of study, year of publication, type of intervention, participants' details, study outcomes, type of evaluation, information on the sessions, duration of the intervention, and the intervention managers, main result, main limitations, funding sources, and a declaration of interest. The extracted data was entered into the charting form. Since scoping review aims to give a research's comprehensive overview that was previously conducted regardless of the quality of the evidence, the quality of the studies was not taken into consideration during the review process.[12]

RESULTS

Search Results

Eight intervention studies were included in this review, data were extracted and synthesis. The selection procedure is depicted in PRISMA Flow diagram [Figure 1].

Descriptive Overview of Studies Contained

Table II provides an overview of the included studies. Out of the eight studies, three were conducted in the United States of America (USA), three in Asia (Iran, South Korea, and Taiwan), and two in Europe (Spain and Portugal). All studies were conducted on children diagnosed with ASD. The number of participants in the studies range from three to 43.[17,19]

Study Design

Three of the studies included were pilot studies,[13,15,20] three were randomised control trials,[14,18,19] one was an empirical study, and one was a single-subject design.[16,17] A control group was only included in three of the experiments that received the usual therapy.[14,18,19]

Assessment Tools for Social and Communication Skill

A range of assessment tools were employed to examine the social communication issue in children with ASD, where a variety of instruments was used. The assessment tools included were Vineland Adaptive Behaviour Scales (VABS),[13-15,19,20] Autism Diagnostic Observation Schedule (ADOS),[15,19] Paediatric Evaluation of Disability Inventory (PEDI),[14] Mullen Scales of Early Learning (MSEL),[10] Bayley Scales of Infant Development,[15] Differential Ability Scales (DAS),[15] Brief Observation of Social Communication Change (BOSCC),[15]

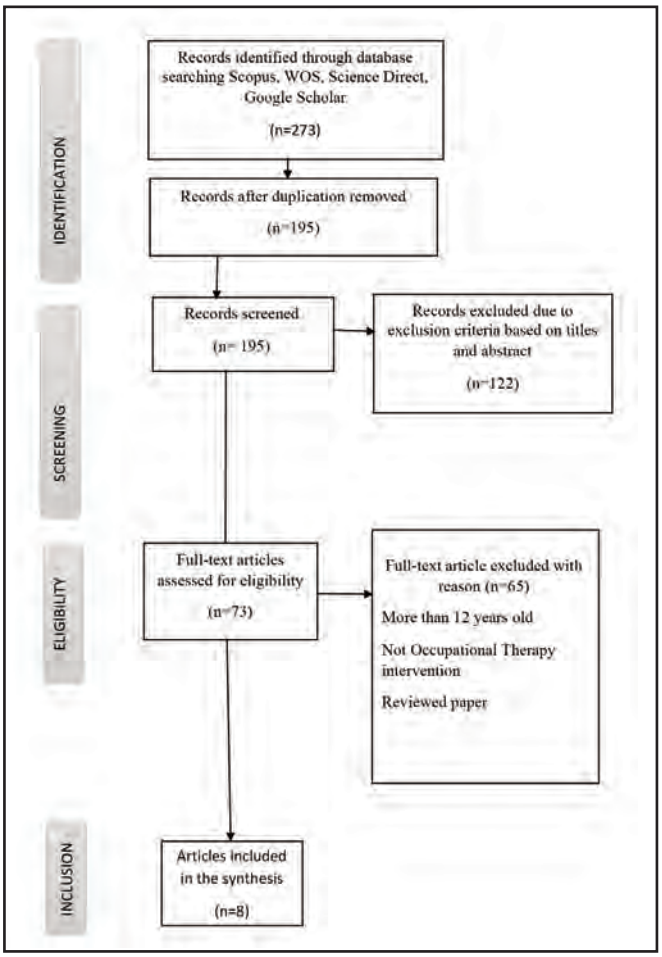

Fig. 1: PRISMA flow diagram

Assessment Scale of Children with ASD Social Communication Dimension,[15] M-CHAT,[17] Evaluation of Social Interaction,[17] and Reynell Developmental Language Scale (RDLS).[19]

Types of Intervention

The study results were classified based on the numerous intervention possibilities that were investigated. Notably, three distinct studies [15,16,20] utilised social skills training as a common intervention method. Two studies [13,19] explicitly investigated the use of animal-assisted intervention, while another study[17] coupled modifications to the environment with instruction in social skills. In addition, a study examined the effects of sensory integration [14] as well as a combined strategy involving behavioural control and environmental modification[15]. The DIRFloortime programmes was utilised as an intervention technique in two of the studies, [20].

Outcomes

Most of the articles reported positive outcomes of social communication abilities. However, one study found no significant improvement in social communication skills,[13] while another study by Swain et al.[15] found mixed results with two different outcome measures, where social communication skills in BOSCC showed more significant improvements than ADOS-2.

Main Limitation of Included Studies

Table IV displays the primary limitation identified by the authors of the included studies, as well as other factors that may impact the interpretation of the obtained outcome.

The primary limitation in the included studies is the small sample size, which was documented in five of them. Three studies reported challenges in maintaining ongoing monitoring of treatment responses and skill retention after the intervention, with the ages of the participants ranging from.[13,14,17,18,20] Furthermore, difficulties were observed in maintaining a consistent approach to administering therapy and utilising reliable tools to assess changes during a 10-week intervention period.[14] While three studies identified limitations in maintaining continuous monitoring of treatment responses and skill retention post-intervention.[15,18,19] In addition, four studies did not include a control group,[13,16,17,20] and one study did not properly examine the practicality and acceptability of the proposed models.[15] Furthermore, the studies did not assess whether the benefits of interventions persisted after the intervention ended.[15]

DISCUSSION

This scoping review conducted a systematic analysis of data from eight intervention studies to examine the effectiveness of OT interventions in improving social communication skills in children with ASD.

The geographical distribution of the eight studies which covered United States, Asia and Europe suggest as worldwide acknowledgment of the need and interest in social communication intervention. There is a variation of sample size between studies ranging from three to forty-three participants. The inclusion of different type of study such as pilot studies, randomized control trials, an empirical study, and a single-subject design, demonstrates the progressive development of studies in this area.

Despite this diversity, the majority of the studies had an insufficient number of respondents, and the research designs that are considered to be the gold standard, such as randomised controlled clinical trials, were uncommon. This may have been due to the people's characteristics participating in the research, such as the fact that they were living with conditions or disabilities that had specific or varying effects. Other than that, the setting may have had an influence, as it was not possible to have a large number of participants in rehabilitation or community settings.

A variety of assessment tools are utilised to evaluate social communication issues, including VABS,[13-15,19,2] ADOS,[15,19] PEDI,[14] MSEL,[10] Bayley Scales of Infant Development,[15] DAS,[15] BOSCC,[15] Assessment Scale of Children with ASD Social Communication Dimension,[15] M-CHAT,[17] Evaluation of Social Interaction,[17] and RDLS [19] shows the complex and diverse nature of ASD. Other than that, it is also indicates that there is lack of consensus on the most effective method to assess the results of interventions, particularly in relation to social communication skills.

It was noted that in all eight intervention studies, each intervention for social communication focused on a distinct

Table II: Main characteristic of the included studies

Author, Year	Study design	Sample size, country	Participants	Intervention/ comparator	Evaluation	Assessment Tools Used	Study Outcomes
Ajzenman et al. (2013)[13]	Pilot study, single group pre-post design	7, United States	ASD, 4 boys and 3 girls Age: 5- 12 years old	HPOT is an intervention method that makes use of the horse's movement to help individuals achieve functional goals.	Pre and post evaluation Nonparametric statistic Wilcoxon signed-rank	Force Plates and Video Motion Capture to capture centre-of-pressure (COP) and centre-of-mass(COM) Vineland Adaptive Behaviour Scales-II (Parent/Caregiver Rating Form). Child Activity Card Sort	Force Plates and Video Motion Capture are used to evaluate changes in postural control Vineland Adaptive Behaviour Scales-II (Parent/Caregiver Rating Form) is employed to evaluate adaptive behaviour and performance of the children in daily living activities. Child Activity Card Sort to evaluate changes in involvement in everyday activities.
Schaaf et al. (2014)[14]	Randomised control trial	32, United States	ASD, 26 boys and 6 girls Age: 4.0 to 7.11	Manualised OT/SI intervention followed as outline by Jean Ayres.	Pre and post evaluation Two-tailed independent sample t-test Wilcoxon Rank Sum test	Goal attainment scaling (GAS) The Paediatric Evaluation of Disability Inventory (PEDI). Pervasive Developmental Disorders Behaviour Inventory (PDDBI). The Vineland Adaptive Behaviour Scales II (VABS II).	GAS is employed to assess the functional result of parent's claimed individual goal of achievement. PEDI examines a child's mobility, social skills, as well as capacity to take care of themselves and domains of Sensory/Perceptual. PDDBI to assess Ritualistic/Resistance to change as well as Arousal Regulation. VABS II are employed to evaluate participation in school, family, as well as community activities.
Swain et al. (2020)[15]	Pilot study	34, United States	ASD, 27 boys and 7 girls Age: 17 months to 33 months	Augmented naturalistic developmental behavioural intervention	Pre and post evaluation Levene's test Independent sample t-test Generalized Linear Mixed Models (GLMM)	Mullen Scales of Early Learning (MSEL) Bayley Scales of Infant Development. Differential Ability Scales, Second Edition-Early Years (DAS-II). The Autistic Diagnostic Observation Schedule, 2nd Edition (ADOS-2). Brief Observation of Social Communication Change (BOSCC). Vineland Adaptive Behaviour Scales, 2nd and 3rd Editions (VABS II and VABS III) The Measure of NDBI Strategy Implementation-Caregiver Change (MONSI-CC)	MSEL, Bayley Scales of Infant Development, as well as Differential Ability Scales, DAS II to assess cognitive skills and developmental capacities. ADOS-2 is employed to evaluate the severity of a child's autism symptoms. BOSCC to assess improvements in social communications skills. VABS II and VABS III are employed to evaluate the adaptive functioning of children. MONSI-CC used to evaluate the effectiveness and appropriateness of NDBI startegies.
Reis et al. (2018)[16]	Empirical study	25, Portugal	ASD, 17 males and 8 females	DIR Floortime Program	Pre and post evaluation t-test for paired sample	Assessment Scale of Children with ASD.	Assessment Scale of Children with ASD to evaluate Social Communication (SC), Repetitive Behaviour and Restricted Interest (RBRI), as well as Sensory Processing (SP), social interaction and sensory regulation.

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Table II: Main characteristic of the included studies

Author, Year	Study design	Sample size, country	Participants	Intervention/ comparator	Evaluation	Assessment Tools Used	Study Outcomes
Park et al. (2020)[17]	Single subject design, ABA	3, South Korea	ASD Age; 24 to 36 months	Family-centred early intervention	Pre and post evaluation, follow up phase Linear graph and 2 standard deviation (2SD)	Toddler Autism Modified Checklist, Revised, with Follow-Up (M-CHAT-R/F). Social Interaction Evaluation, 2nd Edition.	M-CHAT-R/F to evaluate infants at risk of ASD. Social Interaction Evaluation, 2nd Edition to evaluate social interaction measures how well a person interacts with others in "actual" situations
Kahjoogh et al. (2020)[18]	Randomized control trial	30, Iran	ASD Age: 4 to 6 years old	Son-Rise program for intervention group while control group received traditional occupational therapy, which includes sensory integration therapy	Baseline Pre and post evaluation Paired t-test Wilcoxon sign ranked test Independent-t test Mann-Whitney	Gilliam autism rating scale (GARS-2). Vineland Social Maturity Scale.	GARS-2 to assess communication skills and social interactions skills. Vineland Social Maturity Scale to assess social developmental age.
Hernández-Espeso et al. (2021)[19]	Randomized control trial	43, Spain	ASD Age: 4 to 5 years old	Dolphin Assisted therapy	Pre and post evaluation Mann-Whitney U-test Wilcoxonntest ANOVA	The Autism Diagnostic Observation Schedule-Generic (ADOS-G). The Reynell Developmental Language Scale (RDLS). The Vineland Adaptive Behaviour Scales-Second Edition.	ADOS-G to evaluate communicative and social skills. RDLS to assess comprehensive and expressive language VABS II to assess communication and localization skills
Liao et al. (2014)[20]	Pilot study	11, Taiwan	ASD Age: 45 to 69 months	Homebased DIR/ Floortime intervention program	Pre and post evaluation Wilcoxon signed-rank.	Functional Emotional Assessment Scale (FEAS) The Vineland Adaptive Behaviour Scales-Second Edition. The Parenting Stress Index-Short Form (PSI/SF; Abidin, 1990)	Functional Emotional Assessment Scale to assess changes in the children's emotional functioning in the context of their connection with their caregiver VABS II to track changes in the children's adaptive behaviours. PSI/SF was employed to evaluate perceptions of stress experienced by mothers.

Table III: Characteristic of the interventions conducted in the included studies

Author, year	Interventions	Duration (w)	Sessions	Intervention managers	Main result
Ajzenman et al. (2013)[13]	Numerous mounted positions, which includes forward sitting (astride), supine, prone, backward sitting (astride), standing, quadruped, kneeling, as well as side sitting. Applying half halts further examined trunk stability and attentional skills, changing speed within the walk, as well as intermittently stopping and starting as respondents followed complicated directions which involves changes in tasks and games, obstacle courses, as well as positioning which requires the use of the upper extremities.	12	Once a week, 45 minutes	OTs	The study found notable improvements in postural control post-HPOT. Significantly, there was a 12% decline in the variability of COP sway area (p = .028), a 102% drop in the mean Anterior-Posterior (AP) velocity of the COM (p = .046), and a 20% reduction in the Medial-Lateral (ML) velocity of the COM (p = .046). Nevertheless, there were no significant differences seen in COP AP and ML velocity, as well as COM sway area variability. Furthermore, there were significant decreases observed in the COM normalised sway area (with a 40% change, p = .046) and sway path length (with a 7% change, p = .028), as well as in the COP normalised sway area (with a 48% change, p = .046) and sway path length (with a 24% change, p = .028). In addition, there were substantial decreases in both mean (33% change, p = .028) and minimum displacement (77% change, p = .028) between COM and COP post-HPOT, with large effect sizes. Researchers revealed statistically significant changes in the overall adaptive behaviour composite score for children with ASD following HPOT, hence having a small effect size. Significant improvements in the receptive communication (p=0.026) content categories of listening, following 2-step instructions, and following if-then instructions were observed (p=0.046). Significant changes in acceptable social caution, notably avoiding harmful behaviours, occurred as a means of coping. There were no significant changes in interpersonal skills, written communication, expressive communication, or time spent playing as well as relaxing. Researchers discovered no significant distinct in domains of daily life as well as motor skills. There is a significant increase in area of self-care (p=0.027), low-demand leisure (p=0.042)and social interaction (p=0.027) post-HPOT.
Schaaf et al. (2014)[14]	Intervention group; Manualised OT/ SI intervention; Usual care group (Control group); Speech and language services, educational program, behavioural interventions as well as other therapies	10	1 hour, Three times per week	OTs	There is a significant difference between the UC and treatment groups on the GAS with the treatment group attaining significantly greater scores (p= 0.003). Both the Self-Care Care-Giver Assistance subtest (p=0.008) including the Social Function Care-Giver Assistance subtest (p= 0.039) show a significantly larger change for the treatment group in comparison to the UC control group. Notably, the treatment group also demonstrated significant advancement on the Self-Care Functional Skills subtest (p=0.28) as well as the Social Functions subtest (p=0.097). Despite changes in the treatment group reached significance in the Sensory Perceptual Behaviorus Subscale (p=0.064), there exists no differences in autism behaviours between the groups in the post-treatment stage. There were no significant improvements in adaptive behaviours, despite the fact that the treatment group outperformed the UC Controls across the subscales.

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Table III: Characteristic of the interventions conducted in the included studies

Author, year	Interventions	Duration (w)	Sessions	Intervention managers	Main result
Swain et al. (2020)[15]	Child-focused services is divided to group-based instruction and parent- mediated special instructions. NDBI strategies, which includes choice or child-initiated teaching episodes, broadening of attentional focus, imitation of child language, play, and behaviour, modelling, balanced turns, prompt fading, prompting, natural reinforcement, shared control, environmental arrangement, as well as three-part contingency child were employed for group-based intervention. Caregivers will get 60 minutes of caregiver support group, 60 minutes of psychoeducation group, and 30 minutes of individual visits with a Social Worker as needed for caregiver-focused services.	24	13 hour per week	Board-Certified Behavior Analyst (BCBA), a Special Education Teacher, OT, Social Worker, SLP PSY, Post-Doctoral Fellows in Psychology, and research assistants.	Children depicted significant improvement in VMA (Verbal mental age)($p<0.001$) as well as NVMA (Non-verbal mental age)($p<0.001$) of MSEL, BAYLEY and DAS-II. Significant drop in social communication symptoms were noted on the BOSCC ($p=0.05$). No significant changes in social communication symptoms when assessed by ADOS 2. Significant improvement in age equivalents (AEs) for social skills ($p=0.034$), daily living skills ($p=0.009$) as well as communication abilities ($p<0.001$). Caregivers depicted significant increases in total usage of NDBI strategies employing the MONSI-CC, but only two domain which is show significant changes which is Environmental Set-up ($p=0.04$) and Child Guided Interaction ($p=0.03$).
Reis et al. (2018)[16]	The Floortime sessions were managed by a psychologist and aimed at improving joint attention and social interaction between the parents and children. During sensory integration sessions, the therapist employed play activities and sensory-enhanced interactions to evoke the adaptive responses of a child. The therapist designed activities that included the child and developed his or her motor planning and sensory processing skills. The objective of the child's individual speech therapy intervention, which was monitored by Speech Language and Pathologist was to equip the child with pre-symbolic and symbolic communication methods while expanding their communicative intentions to unused pragmatic categories.	40	30 minutes, Once or twice a week	OTs, PSY, SLP	SC dimension had statistically significant differences ($p<0.001$) with SP ($p\leq0.001$), and RBRI dimension, is not statistically significant.
Park et al. (2020)[17]	Family-centred early intervention programs, which includes task and feedback, play video recording and training, home environment modification, as well as related information training. Tasks were conducted daily, and their responses were recorded in the task notes. The assigned researcher contacted the caregiver via daily messages to verify the assignment's performance.	6	12 times	OTs	There were significant changes in social interaction quality for participants 1 (most noticeable changes were looks, turns toward, produces speech, regulates, as well as replies), participant 2 (most noticeable changes were looks, turns toward, as well as gesticulates), and participant 3 (most noticeable changes were looks, turns toward, gesticulates, regulates, produces speech, questions, as well as replies). The Risk of ASD of M-CHAT-R/F score changed, with Participant 1's score moving from high to middle risk, Participant 2's score moving from high to middle risk, and Participant 3's score moving from high to low risk.

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Table III: Characteristic of the interventions conducted in the included studies

Author, year	Interventions	Duration (w)	Sessions	Intervention managers	Main result
Kahjoogh et al. (2020)[18]	The primary methods of the program were imitating stereotyped movements, responding quickly and naturally to the child's interactive behaviours, communicating with the child, increasing the child's responsiveness, as well as engaging in new activities.	24	45 to 60 minutes per session	OTs	There exists a significant difference between the mean of pre- and post-test raw scores with regards to social interaction ($p<0.001$) as well as communication ($p=0.027$) in both groups. As per GARS-2 questionnaire, the reducing mean signifies increase in the social communication and interaction of the study's respondents. There exists a significant difference between the two groups with regards to social interaction ($p=0.001$), and no significant difference was made with respect to communication ($p=0.53$). Moreover, social interaction scores reduce in the intervention group, signifying that the intervention possessed a positive impact on social interaction.
Hernández-Espeso et al. (2021)[19]	Intervention Group (DAT) The games were designed employing different materials (for example, numbered diving sticks, frisbees, baskets, balls, as well as colorful rings), so that the children had to utilize both comprehensive and expressive communication skills. The sessions were designed and applied in a similar way for all the children, although individual characteristics were taken into consideration. Activities included: simulating their medical treatment; asking the dolphins questions that could be answered with "yes" or "no"; petting and naming different parts of the dolphin's body; as well as asking the coach for fish and giving it to the dolphins, among others. Control group (TWD): The sessions were similar to the DAT group sessions, but there was also a water component. Children engaged in recreational activities on the pool's edge and in the water, interacting with the therapist and the dolphin trainer. At the end of the session, these children participated in a relaxing water activity.	10	45 minutes, 18 sessions	Dolphin trainer, OTs, PTs, PSY	ADOS-G: Both groups demonstrated a significant improvement in the "Communication" dimension from the pre-test to the post-test ($p<0.001$). The statistical analysis did not find a significant interaction between the variables "Time" and "Type of Therapy", suggesting that both therapy methods (DAT and TWD) yielded similar results. Analysis at the item level demonstrated significant effects of "Time" ($p < 0.05$) and its interaction with "Type of Therapy" ($p < 0.05$) on the frequency of vocalizations directed towards others. A strong association was seen between the "Time" variable and the "Type of Therapy" variable in relation to the scores of the "Gestures" item ($p < 0.05$). However, no significant correlation was discovered between the "Time" variable and the overall effect. Comprehension Scale, RDLS: Both groups demonstrated an improvement in comprehension skills due to the statistically significant main effects of the "Time" factor ($p<0.001$). Nevertheless, the statistical analysis did not reveal a significant improvement between "Time" and "Type of Therapy," indicating that the benefits of both interventions are equivalent. Expression Scale, RDLS: Both groups demonstrated significant improvement in expression skills($p<0.001$). However, the statistical analysis did not reveal a significant improvement between "Time" and "Type of Therapy," Communication scale, VABS II: Results demonstrates that both treatment modalities (DAT and TWD) were equally effective in enhancing non-verbal and verbal communication skills. The "Time" factor was significant ($p<0.01$), but the "Type of Therapy" interaction was insignificant, leading to a conclusion that both modalities are equally effective. Socialisation scale, VABS II: Both treatment modalities (TWD and DAT) were equally effective at improving social skills, with no significant difference between the two. The "Time" factor was significantly improve ($p<0.01$) than the "Type of Therapy".
Liao et al. (2014)[20]	To learn more about the DIR/Floortime model, each mother took a 3-week one-on-one training course at the research lab. The mothers received training on how to pay attention to the cues given by their child, follow their lead as well as use age-appropriate play techniques.	10	10 hour per weeks	OTs as facilitator	Significant improvements were observed in the overall score of FEAS ($p<0.05$) and in the engagement and relating area ($p<0.05$), as well as in two-way purposeful emotional interaction ($p<0.01$) and social problem solving ($p<0.05$). There is a significant improvement observed in the VABS II assessment in the areas of communication ($p<0.05$), daily living skills ($p<0.05$), and social abilities ($p<0.05$). The parent-child dysfunctional interaction score experienced a significant decrease ($p<0.05$).

Table IV: Items related to risk of bias of included studies

Author, year	Main limitations	Funding sources	Declaration of interest
Ajzenman et al. (2013)[13]	Small sample size, parental biases due to parent-report measure assessment tools, and unknown degree of consistency among therapists in their application of the HPOT therapy progression plan	Not stated	Not stated
Schaaf et al. (2014)[14]	Small sample size, a limitation of validated instruments to assess change during the duration of 10-week intervention.	Autism Speak Foundation Treatment Grant	Not stated
Swain et al. (2020)[15]	Monitoring the fidelity of clinician treatment provision in a classroom setting is not always feasible. Only 50% of providers responded when questioned for their feedback on the model's feasibility and acceptability by the researchers. Although the researcher assessed the treatment's endpoint results, they did not continuously monitor treatment response or skill maintenance at the follow-up.	The Louis and Rachel Rudin Foundation	Not stated
Reis et al. (2018)[16]	The impact of maturation as well as other supports and services could not be evaluated because there was no control group. Unable to control how normal development and other confounding factors may affect results.	Funded by CIEd – Research Centre on Education, projects UID/CED/1661/2013 and UID/CED/1661/2016, Institute of Education, University of Minho, through national funds of FCT/MCTES-PT.	Not stated
Park et al. (2020)[17]	Lack of sample size.	Not stated	No stated
Kahjoogh et al. (2020)[18]	There exists no follow-up in the research to address the intervention effects' stability as well as small sample size.	No conflict of interest	Not stated
Hernández-Espeso et al. (2021)[19]	After a brief intervention, it is difficult to identify subtle changes in specific aspects of communication and social skills due to the use of developmental milestones in diagnostic instruments. Not examined whether the intervention's benefits continued after the intervention ended.	No conflict of interest	No stated
Liao et al. (2014)[20]	Small sample size	Not stated	No conflict of interest

aspect of social communication skills. The majority of the studies analysed in this review found that OT interventions for social communication mostly concentrate on social skills training, including imitation skills, play skills, and joint attention. The study also examined animal-assisted intervention, contextual change, sensory integration, and behavioural control. These findings demonstrate the adaptability and originality of OT interventions in enhancing social communication abilities.

Although the majority of studies indicate positive outcomes, this analysis also identified variations in effectiveness.[14,16-20] This review also discovered variety in effectiveness with on study showing no significant improvement[13] and another reporting mixed result.[15] This suggests that the success of interventions for ASD may be as unpredictable as the disorder itself.

Small sample sizes were highlighted as a primary limitation of the reviewed studies, limiting the generalizability of the findings and emphasising the need for larger-scale research. Furthermore, numerous studies have challenges with continued follow-up and consistent application of therapy, emphasising the importance of consistent protocol and long-term follow-up to determine the sustainability of intervention results

The absence of a control group in numerous studies hinders the direct observation of the improvements resulting from the intervention, underscoring the imperative for more stringent study designs in future research. Furthermore, the lack of assessment on the long-term effects of intervention, as well as their feasibility and acceptance, highlights specific areas where OT research should extend and enhance.

LIMITATIONS

This study has certain restrictions since the small number of research that were eligible for inclusion depending on the criteria that were incorporated.

CONCLUSION

In conclusion, while OT interventions shows promise in prompting social communication skills in children with ASD, this scoping review emphasises the need for additional research in several areas. Future research should aim to undertake more extensive studies with bigger and diverse samples, as well as incorporate longitudinal follow-up to assess the enduring effects of OT interventions. The effectiveness and practicality of evidence-based occupational therapy interventions for children with ASD can only be enhanced through rigorous research.

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Strengthening exercise and motor control among football players with ankle sprain: A scoping review

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ABSTRACT

Introduction: The ankles and feet of footballers are the most commonly affected areas by acute and chronic injuries, especially sprains. The durability of changes in motor control for the sprained injury strongly suggests that central motor commands have been reorganized and restructured involving the sensorimotor system. Indirectly, providing strength training improves muscular strength and benefits cardiometabolic health, coordination, sensorimotor, and motor performance. Thus, this study aimed to identify the effects of strengthening exercises on motor control among footballers with sprained ankles.

Materials and Methods: This scoping review selected studies published from January 2002 to November 2022. The articles were searched through PubMed Central, BMJ Journal, Science Direct, and Scopus using "motor control", "ankle sprain" and "strengthening exercise" as the keywords. After finding the articles, the information extracted included author, year of publication, country, objective, type of study, and motor control analysis summary. The literature search strategy used Preferred Reporting Items for Systematic Review and a meta-analysis (PRISMA) where studies that are related to strengthening exercise and motor control were selected.

Results: From the initial search, 50 articles were found. After processing, only ten articles were further reviewed. The findings demonstrated strengthening exercises provide changes in neurophysiological parameters with motor performance, improved motor control, strength, balance, pain, and functional movement in footballers with sprained ankles.

Conclusion: This review suggests the application of strengthening exercise interventions not only improves motor control, but strength, balance, pain, and functional performance among footballers with sprained ankles.

KEYWORDS:
Ankle sprain, football, strengthening exercise, motor control, ankle stability

INTRODUCTION

Sprains in the ankle joint are more frequent in physically active people, notably in sports, where they account for at least 14% of all emergency hospital visits.[1] Injury to the lateral ligament complex of the ankle joint results in ankle sprain. Football players' feet and ankles are among the most often affected areas by acute and chronic injuries. Although not life-threatening, the injury frequently negatively impacts participation in sports where the running, jumping, kicking, and changing directions of players are restricted.1 Ankle sprains were among the most common diagnoses during the 2010 FIFA World Cup; and of those, about 50% restricted participation in practice or competition.[2] Additionally, a recent study of an English Premier League (EPL) team found that 20% of injuries for four years were to the foot and ankle, with a resulting mean return to sport time of 54 days.[3]

Ankle sprain causes pain, swelling, and other peripheral damage. The durability of changes in motor control for the sprained limbs supports the idea that central motor commands have been rearranged. As a result, sensory inputs are changed, which prompts the restructuring of the sensorimotor system that results in modifications of movement planning and execution.[4,5] Individuals with chronic ankle sprain will have differences in segmental motor strategies during walking, running, and jump landing, affecting the player's motor control and performance during all activities.

A deficiency in muscular strength may be directly related to the types of ligament injury at the ankle.[6] This will affect the degree of instability and result in different functions in muscle strength, where the muscle that controls the movement will have changes in the axes of motion and produce excessive stress on the surrounding tissues.[7] Dynamic stabilization of the ankle joint will be achieved by the strength of simultaneous activation of muscles on opposite sides of a joint of the muscle surrounding the joint. As a result, due to their inability to properly dissipate these forces in a coordinated manner, athletes who lack or have imbalances in this muscle ability may experience reduced motor control and performance.

Muscle-strengthening exercise, often known as strength/weight/resistance training or exercise, is a voluntary activity that involves using weight machines, exercise bands, handheld weights, or one's body weight.[8]

Muscle-strengthening exercises serve a variety of functions, such as increasing moderate-to-vigorous intensity aerobic physical activity, physical therapy (e.g., injury rehabilitation), conditioning for sports performance, and

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Table I: Table of Evidence

Author (Year)	Study Design	Objective of study	Study Characteristics	Outcome Measure	Groups and Intervention	Results
Duncan et al.[11]	Study Design	To identify the differences of sport performance of motor control after strengthening exercise	Sample size (26). Gender (Male), Age (60-80 years old).	Measure with the International Physical Activity Questionnaire (IPAQ)	Control Group: Maintenance of habit exercise for 12 weeks Experimental Group: Specific Sports Exercise (strength and endurance for 12 weeks (twice a week)	- The experimental group shows improvement in the 30-second chair stand (0.038), 8 feet timed up and go (0.001) but no improvement in strength. - There is a significant difference in the sports performance for the experimental group.
Forte et al.[12]	Experimental Study	To identify the motor control and performance after strengthening exercise.	Sample size (38). Gender (Male), Age (60-65 years old).	Measure with Romberg and Tandem positions on a force platform, maximal isometric handgrip strength, maximal knee flexor, and extensor strength.	Control Group: Gross Motor Skill exercise - Twice sessions per week for 12 weeks Experimental Group: Strengthening exercise Twice sessions per week for 12 weeks	- The experimental group shows improvement in balance, strength, and motor control. - There is a significant difference in motor control and performance in the strengthening exercises group.
Chen et al.[13]	Experimental Study	To identify the effects of integrated motor control strengthening exercise on individuals sport performance.	Sample size (38). Gender (Male), Age (20-60 years old).	Measured with two arm goniometers for AROM and VAS for pain.	Control Group: Conventional Physical Therapy - 5 days per week (week 1), 1 day per week (week 2-4) for 4 weeks Experimental Group: Integrated Motor Control Strengthening exercise - 5 days per week (week 1), 1 day per week (week 2-4) for 4 weeks	- The experimental group shows improvement in balance, strength, and motor control. - There is a significant difference in motor control and performance in the strengthening exercises group.
Ha et al.[14]	Experimental Study	To identify the dynamic balance of individuals with ankle sprain after motor control and strengthening exercises.	Sample size (30). Gender (Male (8), Female (22)), Age (19-25 years old).	Cumberland Ankle Instability Tool (CAIT), ankle's active joint position sense tests (Dualer Digital Inclinometer), Functional Reach Test (FRT)	Control Group: General Ankle Instability Exercise - 40 minutes of general exercises per session Experimental Group: Ankle strengthening exercise applied on the unstable supporting surface 40 minutes of ankle strengthening exercise on a supporting surface per session	- The experimental group had improvement in dynamic balance, static balance, and proprioception sense. - There is a significant difference in dynamic movement, balance, and motor performance ($p<0.05$).
Rabelo et al.[15]	Experimental Study	To identify the effects of pain, performance and function on motor control and strengthening exercise.	To identify the effects of pain, performance and function on motor control and strengthening exercise.	Measure with Numerical Pain Rating Scale (NPRS) and handheld manual dynamometer	Control Group: Strengthening Exercise - 40 min (week 1-3) and 60 minutes (week 4), 3 sessions per week for 4 weeks. Experimental Group: Motor Control Strengthening Exercise - 40 min (week 1-3) and 60 minutes (week 4), 3 sessions per week for 4 weeks.	

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Table I: Table of Evidence

Author (Year)	Study Design	Objective of study	Study Characteristics	Outcome Measure	Groups and Intervention	Results
Smith et al.16	Experimental Study	To identify the differences of strengthening exercise on motor control and performance in individuals with ankle sprain.	Sample size (40). Gender (Male (20), Female (20)), Age (20-25 years old).	Measured with modified ankle instability instrument and using load cell to measure strength and force sense	Control Group: Conventional Physical Therapy exercise for 6 weeks Experimental Group: Specific strengthening exercise (Multiaxial Ankle Exerciser) 3 days per week for 6 weeks	- There is an increase in strength (p=0.01) after 6 weeks of interventions but no relation to proprioception improvement. - There is a significant difference in muscle strength (inversion and eversion) and improved motor control and performance during functional movement.
Horschig et al.17	Single-Case Study	To identify the effects of periodization strengthening exercise on motor control.	Sample size (1). Gender (Male). Age (17 years old).	Measure with Star Excursion Balance Test (SEBT) and lateral step-down excursion test	Single Case Study: Strengthening exercises: 3 weeks 6 sessions, twice a week - Different Repetitive Maximum (RM) – 3RM, 6RM, AND 10RM 2 weeks 5 sessions for 2 weeks - Reduction of resistance for each RM	- It is safely and effectively increasing strength in both healthy populations and individuals recovering from injury during short-term strength training cycles. - There is an improvement in strength and functional movement after periodization strengthening training.
Bleakley et al.18	Experimental Study	To identify the pain, strength, motor performance after strengthening exercise among individuals with ankle sprain.	Sample size (101). Gender (Male), Age (16-65 years old).	Lower Extremity Functional Scale and Sports Ankle Rating Score	Control Group: Conservative Physical Therapy - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks Experimental Group: Ankle Rehabilitation Exercise (Strengthening exercise, neuromuscular training, and sport-specific exercise) - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks	- The experimental group had a favorable overall treatment effect (p=0.0077). - There is a significant difference in pain, strength, and motor performance after accelerated rehabilitation.
Jensen et al.19	Cross-sectional, Correlation Study	To identify the changes of neurophysiological, motor performance an strength with strengthening exercises.	Sample size (24). Gender (Male (13), Female (11)), Age (25-30 years old).	Measured with strength test (1RM), electrophysiological testing, and peripheral nerve stimulation	Measured with strength test (1RM), electrophysiological testing, and peripheral nerve stimulation	- The experimental group shows improved skills performance significantly (p<0.001) - There is a significant correlation between changes in neurophysiological parameters and motor performance for skill learning but not in strength.
Flanagan et al.20	Experimental Study	To identify the effects of strengthening exercise on ankle strength and motor performance.	Sample size (25). Gender (Male), Age (6-12 years old).	Measure with specific activities (Two hands Medicine Ball Put, Standing long jump, and Shuttle Run)	Measure with specific activities (Two hands Medicine Ball Put, Standing long jump, and Shuttle Run)	- Experimental group shows an improvement in motor performance in Two hand Medicine Ball Put, Standing long jump, and Shuttle Run - There is a significant difference in strength and motor performance after strengthening interventions.

strength-related sports proposed that there is a positive effect on motor control and performance of movement after giving strengthening exercises before an injury at the joint.[9] With an injury toward the ankle area, strength training helps increase muscular strength and provides benefits to cardiometabolic health, coordination, sensorimotor, and motor performance.[10] It plays an essential role in preserving the continued independence, physical functions, and maximum performance level of the athletes with an ankle sprain. Hence, does strengthening exercise help improve motor control and performance in athletes with an ankle sprain?

This review investigates the implementation of strengthening exercises on motor control and performance and reports the effects of strengthening training on the individual with an ankle sprain to provide the base knowledge that can guide research to advance in the field and provide the best and most effective treatment.

MATERIALS AND METHODS

This is a scoping review study of articles searched through four electronic databases, PubMed Central, BMJ Journal, Science Direct, and Scopus. The search keywords were "motor control", "ankle sprain", "motor performance" and "strengthening exercise". The article's inclusion criteria are as follows: (1) the study population were patients with ankle sprain; (2) analysing strength training on motor control and performance ; (3) no limitation on the type of study

The exclusion criteria were: (1) Lack of strengthening interventions; (2) Diagnosis other than ankle sprain (3) full text is unavailable, which is only available in the form of abstract, dissertation, conference proceeding, editorials, opinion pieces, review papers, letters, single-case study, short communication, or technical notes.

The extracted information from each article included: author, year of publication, country, objective, type of study, and motor control analysis summary. Screening of articles that are not related to motor control, ankle sprain, and strengthening exercise is excluded and different findings of the articles are considered in order to identify the effects of strengthening exercise on individuals with ankle sprained.

RESULTS

The search process from four databases resulted in 50 articles. After removing duplicates, 40 articles were to be eliminated through the eligibility based on title, abstract, and full text. This selection process finally resulted in ten articles being further reviewed herein. The details of the articles' selection process can be seen in the flow chart in Figure 1.

Among ten articles that are eligible for further review, the types of study found are cross-sectional, literature review, systematic review, and case-control. The objectives are identifying strength training on motor control, motor performance effect after strength training, motor control impairment, and motor control training on motor performance in the ankle sprain population. The data extraction from the reviewed article is demonstrated in Table I.

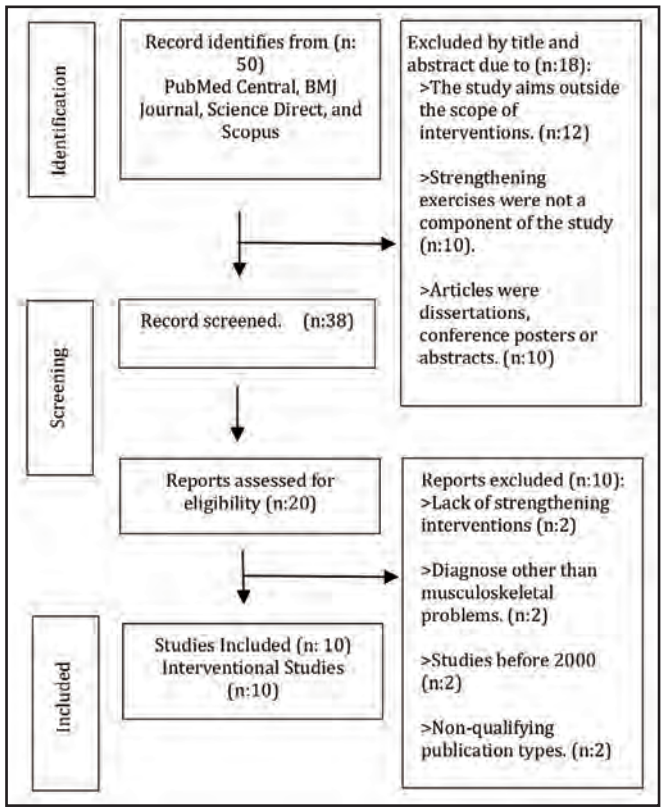

Fig. 1: Article Selection Process Flowchart

DISCUSSION

The findings of this scoping review indicate that the application of strengthening exercise demonstrates potential benefits for improving motor control and performance of functional and specific movement in individuals with an ankle sprain and soft tissue injury. This analysed ten published studies dating from 2002 to 2022, involving a total of 379 individuals aged 8 to 78 years. The strengthening exercise given were varied and different types of strengthening exercises (bodyweight exercise, machine-trained exercises, multiaxial strengthening exercise, specific resistance training, and combination of strengthening training with motor control or visuomotor training) and regime (different types of resistance, repetition maximal and surface) were implemented.

Strengthening exercises were found to improve motor control and performance in individuals with an ankle sprain. Three studies reported that the contribution of strengthening exercise shows a significant difference in motor control and performance compared to the conservative physical therapy treatment in individuals with an ankle sprain or instability.[16,18,20] Combinations of neural factors and hypertrophy through the development of muscular strength help to enhance motor performance and the ability of functional control when individuals perform the movement. The integration of motor control with strengthening training helps to provide feedback to the participants to enhance motor learning by improving temporal muscle activation of motor tasks.[13] Increased muscle activation after sprain or injury consumed higher muscle effort in performing the tasks.

Furthermore, Resistance training helps to reduce muscle activation through neural adaptation or muscle economy and prevents an imbalance of muscle where minimal motor units are required to perform a motor task. Achieving a motor task with smaller muscle activation indicates the participants consumed less muscle effort for the task. It is reported that through strengthening exercises, participants are conscious of controlling the alignment of the joint during movement to increase the performance of the motor movement, but longer training periods for nerve reinnervation and the recruitment of motor units are necessary to produce the significant change.

Injury in the soft tissue structure increases the stress level and causes a deficit in dynamic alignment with weakness of the muscle.[15] Improvement in symptoms by strengthening exercise promotes more significant effects in generating the kinematic changes in the structure. With techniques like the repetition of the task and the movements, motor learning can change how movements are performed. However, the studies identify that a combination of motor control training with strengthening exercise did not provide significant differences compared to the group that only received strengthening training. A slight change in the ankle muscle movement can influence the direction of the movement and the power of the ankle joint and the vector of power in other ankle muscles can show the presence of instability of the ankle joint. Therefore, performing strengthening exercises helps maintain the power balance for coupled activation of normal muscle and stability of the ankle joint.[23]

Implementation of motor control theory in the rehabilitation process shows a great benefit in improving functional motor control and performance. Based on the motor theory, movement regulation is a distributed process resulting from various systems and factors interacting to create and manage movement. It focuses on how the environment and goal-directed actions interact to organize the movement.[21] A previous study conducted with 30 adults with ankle instability shows an increase in motor control after 40 minutes of strengthening exercise on an unstable surface.[14]

The implementation of motor theory (System and Ecological Theory) in this study described the body as a mechanical system with a huge number of joints and muscles that need to be controlled in all movement tasks. The central nervous systems control, organise and coordinate the various degrees of freedom and the effects of gravity in movement through interaction with the environment and task factors. Hence, the contribution of motor control theory in strengthening exercise helps to improve the participant's proprioception, balance, and motor performance.

The effect of strengthening exercise on motor control is doubtable among the elderly population since reductions of muscle strength start between the fourth and fifth decade of life and are more severe when assessed at higher movement velocities. The reduced coactivation of the antagonist's muscle and impairment or dysfunction in a particular structure is caused by the cumulative effects of a wide range of molecular and cellular damage over time and naturally occurring deterioration of several body systems (neuromuscular, cardiovascular, and muscular systems).[22] Even denervation of fibers innervated by alpha motoneurons results from the gradual loss of these neurons in the elderly; two studies on elderly populations with ankle instability show that there are significant differences in motor control and performance after a strengthening exercise.[11,12] A study reported that 12 weeks of training helped in the improvement of dynamic movement and dynamic movement in the participants ($p<0.05$) through augmentations of muscle cross-sectional area, maximum and explosive strength, neuromuscular activation, and muscle power.[12] They show an increase in motor performance during a recreational football game by the participants.

Most of the study should have stated the suitable timing for the application of strengthening exercises after an ankle sprain since it led to pain, loss of function, and atherogenic muscle inhibition through injury of the ligament compartment and microtrauma of the structure. A study conducted on accelerated rehabilitation programs (muscle strengthening, neuromuscular training, and sports-specific functional exercises) on function after acute sport-related ankle sprain shows improvement in participants' strength and motor performance in most of the participant's daily activities.[18] Early reactivation of the ankle musculature, functional movement patterns, and a reduction in the influence of atherogenic muscle inhibition are all recommended in the early stages of injury. Strengthening exercise in the acute stage of ankle sprain also shows improvement in the enhancement of proprioception, which is crucial for ankle rehabilitation and may help improve postural control and movement. The results of the present study show that the biomechanical movement of the ankle joint increase after strengthening exercise since it give feedback about the ankle joint movement where individuals with ankle sprain recognize their motion making the movement of the ankle joint to be in a proper movement and decreasing the imbalance of the muscle to function.[23]

CONCLUSION

The rehabilitation process to improve functional motor control and performance is increasingly becoming focused on exercise through strengthening exercises to gain optimal skills in functional actions. It takes both the capacity to create muscular forces and the capacity for muscle activations to regulate intricate musculoskeletal relationships to restore skilled performance. This review identifies numerous understudied intervention elements that could have a significant impact on motor control and performance with strengthening training for

individuals with an ankle sprain. It emphasizes that strengthening exercises can be implemented in various ranges of ages, populations, and different types of injury. By the application of motor control theory in strengthening exercise, physiotherapy interventions for patients with motor-control deficiencies may benefit from a clinical strategy that acknowledges the impact of the task, the environment, and the individual on the execution of a particular functional movement activity. Separating strength training from achieving improvement of motor control

acknowledges the barriers and strategies that are unique to strength training participation.

More research is required to further investigate the optimal parameters, dosage, and impact of strengthening exercises on motor control for individuals with an ankle sprain to produce a better-strengthening intervention to improve motor control and performance in all populations in their functional activity. With various research focusing on strength training behaviour change specifically, population participation in meeting both strength and motor control guidelines help to improve and optimize population health outcomes in the future.

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ETHICS APPROVAL AND INFORMED CONSENT

This review did not require ethical approval.

CONFLICT OF INTEREST

No conflict of interest.

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AUTHORS CONTRIBUTION

Conceptualization: ZZ, AMT, SAB; data search: AMT; data extraction and editing: AMT, ZZ; methodology: ZZ, AMT, SAB; writing draft: AMT; writing review and editing: ZZ, AMT, SAB.

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Larvicidal potential of plant-based extracts against dengue vector: A short review

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ABSTRACT

Introduction. Dengue fever, a vector borne disease transmitted primarily by Aedes albopictus and Aedes aegypti mosquitoes, has triggered a significant global resurgence. While many vector control programs depend on the use of chemical insecticides to curb outbreaks, its heavy reliance raises environmental concerns and the risk of insecticide resistance. Alternatively, botanically derived insecticidal agents with larvicidal properties offer an eco-friendlier option. This review aims to analyze scientific reports that described the effectiveness of plant-derived extracts for vector control.

Materials and Methods: A literature search was performed to analyze studies that focused on plant-based extracts used for larvicidal purposes using databases such as Science Direct. Springer, PubMed, and Scopus. The inclusion criteria for publications were larvicidal effects, published in English from the year 2017 and availability of full-text articles. The available literature was further characterized by the value of larvicidal activities of LC50 and LC90 (< 50 ppm), of 22 different parts of plant species from 7 plant families namely Apiaceae, Asteraceae, Lauraceae, Magnoliaceae, Myrtaceae, Piperaceae and Rubiaceae.

Results: When comparing the values of LC50, 12 plants species (Artemisia vulgaris, Crassocephalum crepidioides, Echinops grijsii, Melaleuca leucadendra, Neolitsea ellipsoidea, Pavetta tomentosa, Piper betle, Piper caninum, Piper Montium, Piper muntabile, Piper ovatum, Tarenna asiatica) showed promising larvicidal efficacies with LC50 < 10 ppm.

Conclusion: This review emphasizes the effective alternatives of plant extracts for the potential production of larvicides. Piper betle extract and chloroform extract of Tarenna asiatica reported the most significant larvicidal activity (LC50 < 1 ppm) against mosquito vectors. Further reviews focusing on the mode of actions of its phytochemically constituents are essential for the future development of potentially significant plant-based larvicides.

KEYWORDS:
Plant extract, larvicide, dengue, mosquito

INTRODUCTION

The incidence of dengue has increased precipitously, with a 30-fold increase in incidence during the past five decades.[1] New emerging outbreaks continue to pose threats in endemic countries, exerting catastrophic burdens on populations, health systems and economies.[2,3] The Ministry of Health Malaysia has documented a total of 19,450 cumulative dengue fever cases in the first two months of 2023, which demonstrates an alarming increase of 212% (6229 cases) compared to the same period in 2022. Similarly, to date, a total of 15 dengue-related fatalities have been reported in Malaysia in the first few months of 2023, compared to two deaths during the same period in the previous year.

At present, a licensed and commercially available vaccine for public health use against dengue remains elusive. Reducing dengue transmission is therefore dependent on sustainable vector control approaches, including various environmental, biological, plant-based and chemical control strategies.[4] Chemical control using synthetic formulation is predominantly one of the primary means to combat dengue, which has adversely resulted in the development of insecticide resistance, target site and metabolic resistance.[5] As such, reports of resistance against malathion, dieldrin, pyrethroid DDT and temephos, of local mosquitoes have been documented in the local settings.[6,7]

The rampant use of insecticides has been associated with detrimental ecological impacts including agrochemical poisoning, the death of non-target organisms, reduced biodiversity, and ecosystem functions as well as endangering public health.[8]

Studies utilizing various natural products suggest the utilization of botanical insecticides as a safer and eco-friendly alternative measure of vector control.[9,10,11] Plant-derived phytochemicals constitute a rich source of bioactive insecticidal compounds such as alkaloids, alkamides, sesquiterpenes, triterpenes, sterols, flavonoids, coumarins,

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anthraquinones, xanthones, acetogenonins and aliphatics. Such compounds can act as biodegradable larvicides, insect growth regulators, repellents and ovipositional attractants based on ethnomedical evidence.[12,13] Pavela et al.[12] reviewed numerous plant species for their larvicidal efficacy against major vectors belonging to the genera Anopheles, Aedes and Culex. Similarly, Pani et al.[13] reviewed fifty (50) medicinal plants for larvicidal properties against various mosquitoes namely *Anopheles stephensi, Aedes aegypti* and *Culex quinquefasciatus, Phlebotomus duboscqi, An. gambiae* and *An. fluviatilis.* This study aims to further review the larvicidal activities of different plant extracts specifically against dengue vectors *Ae. albopictus* and *Ae. aegypti.*

MATERIALS AND METHODS

Methods and Criteria for Literature Selection

The review is based on original articles obtained by searching online literature in major scientific database such as Science Direct, Springer, PubMed, and Scopus. The selected research studies focused on larvicidal activity of plant extracts against dengue vectors *Aedes albopictus* and *Aedes aegypti*. The terms ("plant extract"), ("larvicidal"), ("mosquito"), *("Aedes albopictus"),* and *("Aedes aegypti")* were considered as a means of selecting articles from 2017-2020. The keywords were used as is or in combination with other terms, using an "and" "or" during the search. In the initial screening process, an analysis of the information available in the title, running head, abstract and keywords was performed. Articles that failed to match the theme were excluded. Articles were then read in full text to elucidate the year, object, method of larvicidal assay and research fundings. Articles in languages other than English, and unpublished data were excluded. This study was conducted to compare the result of LC_{50} and LC_{90} of the numerous plant extracts as larvicide agents, with a reading value of < 50 ppm. A total of twenty-two (22) different parts of plant species from 7 families namely Apiaceae, Asteraceae, Lauraceae, Magnoliaceae, Myrtaceae, Piperaceae and Rubiaceae were selected for this study.

RESULTS AND DISCUSSION

Various factors including differences in plant components, chemical composition, bioactive compound concentration, extraction methods, age, maturity, and inherence chemistry may influence larvicidal potential. Plant extracts can be classified as strong larvicidal agents (LC_{50}< 50 ppm), a moderate (50 ppm < LC_{50} < 100 ppm) or a weak larvicidal agent (LC_{50} > 100 ppm).[14].Table I summarizes the different parts of 22 selected plants from 7 families namely Apiaceae, Asteraceae, Lauraceae, Magnoliaceae, Myrtaceae, Piperaceae and Rubiaceae that exhibited larvicidal properties (LC_{50} < 50 ppm) against dengue vector, *Ae. albopictus* and *Ae. aegypti.*

Apiaceae

Apiaceae (formerly Umbelliferae) is one of the largest plant families in the order Apiales. Apiaceae species are a valuable source of secondary metabolite compounds with a broad spectrum of biological activities including antithrombotic, antioxidant, hypotensive, antibacterial, antifungal and insecticidal abilities.[32,33] A study conducted by Sheng et al.[22] screened 53 essential oil for their larvicidal activity, the results of which demonstrated the ability of Foeniculum vulgar essential oil in exerting 100% mortality at the concentration of 100 ppm against 4th instar larvae of Ae. albopictus. Moreover, fennel was also recorded as the most potent essential oil from all the plants tested with the value of LC_{50} 27.50 ppm and LC_{90} at 33.90 ppm. In another study, Balasubramani et al.15 explored the larvicidal activities of Artemisia vulgaris essential oil against 3rd instar larvae of *Ae. aegypti,* with an LC50 at 6.87 ppm and LC_{90} at 59.10 ppm. Such activities could be attributed to the actions of photoactive compounds in *Ar. vulgaris* such as β-caryophyllene, α-humulene, and β- caryophyllene oxide.

Asteraceae

The genus *Echinops* belongs to the Asteraceae family. Many species contain a plethora of secondary metabolites and have been used traditionally as therapeutic agents with ethnomedicinal claims, mainly in Asian and African countries.[34] Zhao et al.[19] extracted essential oils from the roots of Echinops grijsii via hydrodistillation, and bioassay results demonstrated an LC_{50} at 2.65 ppm and LC90 at 4.65 ppm against *Aedes albopictus* larvae. Moreover, researchers also isolated main constituents from this herb plant, 5-(3-buten-1-yn-1-yl)-2,2′-bithiophene (5-BBT) and 5-(4-isovaleroyloxybut-1-ynyl)-2,2′-bithiophene (5-IBT) which revealed effective larvicidal activity against the fourth instar larvae of *Aedes albopictus* with LC50 values of 0.34 ppm and 0.45 ppm. In another study, petroleum benzene crude extract of *Acanthospermum hispidum* leaves showed larvicidal activity of LC_{50} values at 15.22 ppm and LC90 at 27.75 ppm.[16] Hung et al.[18] tested the crude extracts of Crassocephalum crepidioides against both dengue vector larvae, *Ae. albopictus* and *Ae. aegypti.* The result implied that 3rd instar larvae of *Ae. aegypti* showed higher larvicidal impacts compared to *Ae. albopictus* with LC_{50} values at 4.95 ppm and 14.4 ppm, respectively.

Lauracaea

The genus *Cinnamomum* is classified in the family of Lauraceae. Dai et al.[17] screened the larvicidal activity from the essential oil of five species of *Cinnamomum* against *Ae.s aegypti.* and *Ae. albopictus*. From the overall findings, *Cinnamomum ovatum* leaves essential oil showed notable larvicidal activity against *Ae. aegypti* larvae with the LC_{50} at 13.76 ppm and LC_{90} at 30.17 ppm, In the same study, it was found that *Cinnamomum polyadelphum* leaf essential oil exhibit larvicidal toxicity with the LC_{50} at 20.66 ppm and LC_{90} at 37.21 ppm against *Ae. albopictus*. In a study reported by Chau et al.[23], essential oil from 11 species of Lauraceae family were analysed for their larvicidal efficacy. The results are indicative of strong larvicidal activities of *Machilus grandifolia* essential oil with LC_{50} of 16.48 ppm against *Aedes albopictus* while the LC_{50} values is slightly higher, 20.23 ppm when tested with *Aedes aegypti* larvae. Moreover, Neolitsea ellipsoidea essential oil displayed the greatest larvicidal activity against *Ae. aegypti* with LC_{50} 6.59 ppm and LC90 at 14.00 ppm particularly after being exposed for 24 hours. *Neolitsea ellipsoidea* is deemed to be rich in (E)-β-ocimene (87.6%), a bioactive compound that could be directly correlated with its strong larvicidal efficacy.

Magnoliaceae

Several taxa of the genus Magnolia (family Magnoliaceae) have long been used traditionally especially in the Far East, due to its wide concoction of biologically active compounds

Table I: Plant extracts with potential larvicidal activity

Plant	Family	Part	Solvent	Host /stages	LC_{50} (ppm)	LC_{90} (ppm)	References
Artemisia vulgaris	Apiaceae	Leaf	Distilled water	Ae.aegypti (3rd instar)	6.87	59.1	Balasubramani et al. [15]
Acanthospermum hispidum	Asteraceae	Leaf	Petroleum benzene	Ae.aegypti (4th instar)	15.22	22.75	Vivekanandhan et al. [16]
Cinnamomum ovatum	Lauraceae	Leaf	Distilled water	Ae.aegypti (3rd instar)	13.76	30.17	Dai et al.[17]
Cinnamomum polyadelphum	Lauraceae	Leaf	Distilled water	Ae. albopictus /Ae.aegypti (3rd instar)	20.66/ 23.41	37.21/ 36.69	Dai et al.[17]
Crassocephalum crepidioides	Asteraceae	Stem & Leaf	Distilled water	Ae.albopictus /Ae.aegypti (3rd instar)	14.3/ 4.95	20.86/ 10.28	Hung et al.[18]
Echinops grijsii	Asteraceae	Root	Distilled water	Ae.albopictus (4th instar)	2.65	4.65	Zhao et al.[19]
Eucalyptus camaldulensis	Myrtaceae	Leaf	Distilled water	Ae.aegypti (3nd and 4th instar)	33.7	-	Manh et al.[20]
Eucalyptus nitens	Myrtaceae	Leaf	Distilled water	Ae.albopictus / Ae. Aegypti (3rd instar)	28.19/ 50.83	-	Costa et al.[21]
Foeniculum vulgare	Apiaceae	Seed	Acetone	Ae.albopictus (4th instar)	27.5	33.9	Sheng et al.[22]
Machilus grandifolia	Lauraceae	Leaf	Distilled water	Ae.aegypti/ Ae.albopictus	20.23/ 16.48	29.29/ 25.00	Chau et al.[23]
Magnolia coco	Magnoliaceae	Leaf	Ethanol	Ae.albopictus /Ae.aegypti	11.01/ 46.46	-	Chung et al.[24]
Manglietia Dandyi	Magnoliaceae	Leaf	Ethanol	Ae.albopictus	29.57	46.21	Ban et al.[25]
Magnolia kobus	Magnoliaceae	Flower	Acetone	Ae.albopictus (3rd instar)	45.06 (Early) 22.63 (Full bloom)	-	Kim et al.[26]
Melaleuca leucadendra	Myrtaceae	Fruit	Distilled water	Ae.albopictus /Ae. aegypti	19.17/ 13.90	39.08/ 31.76	Giang An et al.[27]
Melaleuca leucadendra	Myrtaceae	Leaf (Old)	Distilled water	Ae.aegypti	7.40	8.29	Giang An et al.[27]
Neolitsea ellipsoidea	Lauraceae	Leaf	Distilled water	Ae.aegypti (3rd instar)	6.59	14.00	Chau et al.[23]
Pavetta tomentosa	Rubiaceae	Leaf	Ethanol/ hexane	Ae.aegypti (4th instar)	1.03/ 1.43	1.44/ 1.97	Pratheeba et al.[28]
Piper betle	Piperaceae	Leaf	Distilled water	Ae.aegypti (4th instar)	0.72	-	Vasantha-Srinivasan et al.[29]
Piper caninum	Piperaceae	Leaf & Stem	Distilled water	Ae.aegypti (3rd instar)	1.38	2.42	Huong et al.[30]
Piper montium	Piperaceae	Leaf & Stem	Distilled water	Ae. aegypti (3rd instar)	1.93	3.18	Huong et al.[30]
Piper muntabile	Piperaceae	Leaf & Stem	Distilled water	Ae. aegypti (3rd instar)	1.85	2.70	Huong et al.[30]
Piper ovatum	Piperaceae	Root	Ethanol	Ae .aegypti (3rd instar)	2.57	3.8	Kanis et al.[31]
Tarenna asiatica	Rubiaceae	Leaf	Acetone/ methanol	Ae. aegypti (4th instar)	1.29	1.99	Pratheeba et al.[28]
Tarenna asiatica	Rubiaceae	Leaf	Chloroform	Ae. aegypti (4th instar)	0.952	-	Pratheeba et al. [28]

such as lignans, neolignans, alkaloids and terpenoids.[35] Such compounds have been associated with its cytotoxic antitumor, antioxidant, antimicrobial and insecticidal effects and activities.[36] The acetone extract from the flower of *Magnolia kobus*, collected in Korea has been shown to exhibit higher larvicidal activity with an LC_{50} value of 22.63 ppm in full bloom floral compared to early bloom floral stage, with an LC_{50} value of 45.06 ppm against *Ae. albopictus* third instar larvae.[26] This study also reported efficacy in terms of adulticidal activity and fumigant toxicity of *Magnolia kobus* flower extract against adult female *Ae. albopictus*. Similarly, Chung et al.[24] isolated essential oils of Magnolia coco leaves and tested them on both dengue vectors. The bioassay for larvicidal activity revealed susceptibility against *Ae. albopictus* with an LC_{50} value of 11.01 ppm. In comparison, the larvicidal activity for *Ae.s aegypti* was observed to be slightly lower (LC_{50} 46.46 ppm) following 24 hours of exposure. Moreover, the essential oil showed 100 % mortality at 50 ppm against *Ae. albopictus* larvae while for *Ae. aegypti* at 100ppm.

In another study, Ban et al.[25] tested the ethanolic extract of *Manglietia dandyi* leaves against fourth instar larvae *Ae. albopictus* and it exhibited larvicidal efficacy with LC_{50} 29.57 ppm and LC_{90} at 46.21 ppm after 24 hours.

Myrtaceae

Eucalyptus is a genus belonging to the Myrtaceae family that is cultivated globally in countries with Mediterranean and subtropical climates. The genus displays a broad spectrum of actions including antioxidant, anti-inflammatory, wound healing and antiviral properties.[37] Costa et al.[21] reported Eucalyptus nitens leaves extracts showed higher toxicity against larvae of *Ae. albopictus* than *Ae. aegypti* with the value of LC_{50} 28.19 ppm and 52.83ppm respectively. Another genus, *Eucalyptus camaldulensis* essential oil reported a 50% mortality rate of 300 Aedes aegypti larvae tested at 33.7 ppm concentration. In a separate study performed by Giang et al.[27], four species of Myrtaceae namely *Baeckea frutescens, Callistemon citrinus, Melaleuca leucadendra, Syzygium nervosum* were evaluated, against larvae of dengue virus transmission vectors, *Ae. aegypti* and *Ae. albopictus*. The larvicidal activity of these plant was evident with LC_{50} values < 50 ppm. From the study, the essential oil of *Melaleuca leucadendra* fruit showed LC_{50} values at 19.17 ppm and LC_{90} at 39.08 ppm against larvae of *Ae. albopictus Ae. albopictus*. However, the result reported for the mortality of *Ae. aegypti* larvae showed lower value of LC_{50} and LC_{90} compared to *Ae. albopictus* with readings of 13.9 ppm and 31.76 ppm respectively. Among tested plants, essential oil of *Melaleuca leucadendra* showed potent larvicidal activity with LC_{50} at 7.40 ppm against *Ae. aegypti* larvae after 24 hours.

Piperaceae

Piper species belonging to the Piperaceae family are aromatic plants that are widely cultivated in tropical and subtropical countries. This includes *Piper betle* L. which is well known for its medicinal properties. Piper plants are rich with secondary metabolites in the leaves, seeds, stems, roots, and branches are associated with a wide range of health benefits, and has documented to possess anti-inflammatory, antioxidant, antibacterial, antifungal, and antimalarial properties.[38-39] Huong et al.[30] investigated the larvicidal activity of essential oil from 13 species of piper against third instar larvae of *Ae. aegypti*. Findings indicated that Piper caninum essential oil has substantial larvicidal promising capabilities with an LC_{50} value of 1.38 ppm and LC_{90} of 2.42 ppm after 24 hours of contact. *Piper montium* extracts from leaves and stems also demonstrated high mortality rates of larvae with LC_{50} at 1.93 ppm and LC_{90} at 3.18 ppm. Ethanolic extracts of *Piper ovatum* extracted from the root against larvae of *Aedes aegypti* displayed LC_{50} at 1.93 ppm.[31] Moreover, Vasantha-Srinivasan et al.[29] isolated the volatile crude oil from *Piper betle* leaves shows promising potency among their species with LC_{50} 0.72 ppm and 0.64 ppm against laboratory and wild strains of *Ae. aegypti* larvae respectively.

Rubiaceae

Anti-dengue capabilities of *Pavetta* tomentosa and *Tarenna asiatica from the Rubicea family leaf extracts* were studied by Pratheeba et al.[28] using five different types of solvent against *Ae. aegypti.* From the study, the hexane extract of *Pavetta tomentosa* leaves displayed a more effective larvicidal activity compared to the *Tarenna asiatica* with LC_{50} 1.43 ppm and 1.70 ppm respectively. Nevertheless, the acetone and the methanolic extract of *Tarenna asiatica leaves* showed promising larvicidal activity with the value of LC_{50} 1.29 ppm and 1.99 ppm upon exposure of 24 hours. From the overall solvent, the chloroform extract of *Tarenna asiatica* revealed the greatest larvicidal activity compared to five other different solvents, which displayed the lowest value of LC_{50} at 0.952 ppm. Moreover, the phytochemical tested in both plants showed the presence of saponins, flavonoids and alkaloids in all experimented extracts.

CONCLUSION

Concerns associated with the extensive usage of synthetic compounds have increased substantially over the past years, necessitating the search for alternative control measures for dengue vectors. Botanical or plant-based extracts shows promise as natural larvicides; one that is non - toxic and biodegradable. This short review summarizes the larvicidal abilities of plant-based extracts 2017-2020 which includes the plant species from seven families: Apiaceae, Asteraceae, Lauraceae, Magnoliaceae, Myrtaceae, Piperaceae and Rubiaceae that have demonstrated potential larvicidal properties with LC50 documented to be <50 ppm. Within all these family, extracts of 12 plants showed potent larvicidal activity with LC50 < 10 ppm. Among the plants with great larvicidal efficacy is the Piper genus (Pipiracea). Extracts of *Piper betle* and chloroform extract of *Tarenna asiatica* plant displayed the most effective larvicidal capabilities with 0.72 ppm and 0.952 ppm respectively (LC_{50} < 1 ppm). Similarly, many species of the Piperaceae family displayed larvicidal activities with LC50 < 10 ppm, rendering them potential candidates for the development of new eco-friendly bio-insecticidal formulations and the possibility for further investigations in the control of *Ae. Albopictus* and *Ae. aegypti.*

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

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Factors that influence motor control in individuals with nonspecific low back pain: A scoping review

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ABSTRACT

Introduction: One of the most common musculoskeletal pain that causes disability in healthcare settings is low back pain that presents without a specific cause and is known as nonspecific low back pain (NSLBP). NSLBP can cause impairment in motor control, which is the ability of the body to execute a precise and stabilized movement in space. Many factors affect motor control dysfunction and lead to different physical impairments, consequently requiring different approaches in clinical settings. However, the study regarding the alteration of motor control and the factors coming with NSLBP are still limited. Thus, this study is aimed to determine the factors affecting motor control in NSLBP conditions.

Materials and Methods: This is a scoping review of articles published from January 2012 to November 2022. This review follows the PRISMA guideline. The articles were searched through Scopus and Web of Sciences using the keywords "motor control" and "nonspecific low back pain". After finding the articles, the information was extracted, including authors, year of publication, country, objective, type of study, and motor control analysis summary.

Results: The search retrieved 1318 articles; however, after a thorough selection process, only eight articles were included for further review. The factors that affect motor control were related to trunk neuromuscular adaption, the precision of trunk control, motor control changes, motor abundance, and motor control impairment in the LBP population with or without comparison to healthy subjects.

Conclusion: Motor control in NSLBP is affected by various factors. The pain can lead to changes in motor behavior, alignment, postural control, proprioception, and stability strategy. If the changes happen for a long time, it will cause further structural and core control changes as an adaptation.

KEYWORDS:
Nonspecific low back pain, motor control, posture, stability

INTRODUCTION

Low back pain (LBP) is one of the most common disabling symptoms worldwide, with multiple known and unknown causes affecting all age groups. The most often found type of LBP is nonspecific.[1] Nonspecific low back pain (NSLBP) is frequently diagnosed when there is no known exact cause, such as infection, tumor, osteoporosis, fracture, structural deformity, an inflammatory disorder, radicular syndrome, and cauda equina syndrome.[2] NSLBP can be a complicated biopsychosocial problem with various manifestations (e.g., structural and functional cortical reorganization, the alteration or changes of muscle activity in the lumbopelvic), leading to chronic pain.[3]

The lifetime prevalence of LBP has reached up to 84%, with an estimated percentage of 23% chronic LBP, and 11 to 12% of the population has been disabled.[3] LBP has been an issue for both developed and developing countries, where in industrial countries 84% of the population complains of LBP at least once in their lifetime, and 85% are classified as nonspecific.[4] Moreover, LBP has been an issue globally and was in the top 10 causes of years lived with disability (YLDs) in 188 assessed countries based on the 2016 Global Burden of Disease Study.[5] In Malaysia, the main burden of musculoskeletal complaints was related to pain in the knee (9.3%) and lower back (11.6%).[6] Even for the developed country like the United Kingdom, the number of patients registered for LBP consultation was up to 417 from 10,000 registered patients each year, varying in the age group from 0 to 14 years old (30 from 10,000) until 45 to 64 years old in every 536 cases from 10,000 total cases.[2] Meanwhile, the Japanese population has the higher rates of LBP compared to other parts of the world with point prevalence up to 37.7%.[7]

LBP is suggested to be associated with muscular control of body function.[8] Understanding motor control is derived from studying each movement's nature and control. In short, motor control can be defined as regulating or directing the mechanisms essential for each movement.[9] Motor systems are responsible for generating sufficient coordinated forces of inappropriate muscles in controlling the oriented and stable body position during a movement.[9] This includes systems involved in higher-level planning, coordination, and generation of forces that produce movements and can effectively control the body's position in space.[9]

MATERIALS AND METHODS

Numerous factors contribute to the ability to maintain stability and ensure the postural sway is within the base of support (BOS).[10-12] In order to minimize gravitational force, body alignment held a vital role in maintaining a good erect posture as a part of the biomechanical process of the trunk.[10-

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[11] Good body segmental alignment is crucial because it can decrease stress on body structures, including bones, ligaments, muscles, and tendons. It can also improve body functions and, at the same time, decrease the amount of muscle energy needed to keep the body upright.[11] The other factor is muscle tone which is able to keep the body from collapsing as a response to the pull of gravity.[10]

Besides good body segmental alignment, the automatic activation of the lumbopelvic musculature, particularly core muscles, is essential in dynamically stabilizing and helping the spine function.[12] In order to prevent musculoskeletal injuries, precise control of body posture and balance is needed during activities of daily living and higher levels of physical activity.[12] This control and balance are obtained through the afferent input from the visual, vestibular, and proprioceptive systems delivered toward the CNS, resulting in motor output.[12]

During a task with high precision demands, motor control will be challenged since signal-dependent neuromuscular noise causes errors, and proprioceptive feedback is required for optimal performance. Meanwhile, pain may affect proprioception, muscle activation patterns, and kinematics.[9] Thus, motor control in LBP condition is generally altered to protect damaged tissue from further injuries in the acute phase via load redistribution. While this alteration may sound good, it could affect tissue health and the restoration of normal function in the future.[13] Furthermore, low-level co-contraction of trunk muscles has been found in patients with LBP even at rest, showing that even spine compression is still going on during recovery.[8]

These factors can lead to different mechanisms of motor control changes and also different physical interpretations of NSLPB.[8] Understanding the intricate dynamics influencing motor control in individuals with low back pain is essential for delivering comprehensive and effective care. This knowledge will help physiotherapists in prescribing individualized treatment strategies that target the underlying causes of motor control issues, manage the pain, and comprehend functional recovery.[8] However, there is still limited study that directly explains the alteration of motor control in those populations and the factors affecting the changes. Thus, this review will investigate the factors affecting motor control in nonspecific low back pain patients.

MATERIALS AND METHODS

This scoping review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline by 14 in The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. The search was conducted in two electronic databases, Scopus and Web of Science, available from the university's library. These databases were chosen because of their accessibility and ability to provide broader results. Meanwhile, the search from other databases, such as Cochrane and PubMed, did not show any results and thus did not included in this study. The search keywords were "low back pain", "nonspecific low back pain", "motor control", and "motor control impairment". The search included Boolean operators such as "low back pain" OR "nonspecific low back pain" OR "lower back pain" AND "motor control" OR "motor control impairment" OR "postural control".

The articles included in this study were those published from January 2012 to November 12th, 2022. An article was included when it met the following criteria: (1) the study population was patients with nonspecific low back pain; (2) analyzing motor control in nonspecific low back pain condition. Meanwhile, the article was excluded when: (1) designed as a study protocol; (2) full text is unavailable, which is only available in the form of abstracts, dissertations, conference proceeding abstracts, editorials, opinion pieces, review papers, letters, single-case studies, short communication, or technical notes. The information was extracted from each article, including author, year of publication, country, objective, type of study, results, factors, and conclusion.

Ethics Approval and Informed Consent

This review does not require ethical approval.

RESULTS

There were 1318 articles retrieved from the two databases. After removing duplicates, 1281 articles were removed through the eligibility based on title, abstract, and full text. Finally, only eight articles were included for further review. The details of the articles' selection process are illustrated in the flow chart in Figure 1.

The design of the study found in the eight reviewed articles included cross-sectional (n=4), literature review (n=2), systematic review (n=1), and case-control (n=1). Their study objectives vary but included one or more of the following: (1) identifying trunk neuromuscular adaption, (2) the precision of trunk control, (3) motor control changes, (4) motor abundance, and (5) motor control impairment in the low back pain population with or without comparison to healthy subjects. Further information about the reviewed article is demonstrated in Table I. Among eight articles, two studies assessed the precision of trunk control, two identified motor control changes, and the rest assessed trunk neuromuscular adaptation, motor abundance, and motor control impairment.

DISCUSSION

This review investigates the factors affecting motor control in patients with nonspecific low back pain. All eight studies demonstrated alteration of motor control in the LBP population and primarily compared with the healthy population, except for one study.[17] The identified factors are muscle endurance[15], pain intensity[4,8,10,15,17,18,19], neuromuscular changes[4,8,15,18,19], fear of mevement[8,16], speed and the complexity of the task given[4,17,16,18,19], environmental condition[17] (e.g. predictable and unpredictable perturbation8), changes in muscle structure (muscle type, muscle atrophy, fatty infiltration of the muscle)[8], and changes in body alignment and unstable lumbal segment.[8]

The most common factors that found in the studies are pain intensity and neuromuscular changes. The pain will lead to

Table I: Table of Evidence

Author (Year); Countryref. no.	Type of Study	Objective	Result	Factors	Conclusion
Abboud (2014); Canada[15]	Cross-sectional	Identify and characterize trunk neuromuscular adaptations during sustained isometric muscle contractions in patients with CLBP compared to healthy adult participants	After a trunk muscle fatigue protocol, both groups showed increased muscle variability, but a tremendous increase was found in the healthy group. Increased muscle variability as a response to muscle fatigue suggests the adaptation of motor control strategy in order to maintain the optimum task performance. However, due to the pain in LBP groups, there are motor control strategy changes to avoid pain and possible further tissue damage.	• Muscle endurance • Pain intensity • Neuromuscular changes	Patients with LBP showed less motor variability compared to healthy participants after a trunk muscle fatigue protocol.
Alsubaie (2021); United Kingdom[16]	Cross-sectional	Assessing the precision of trunk control during repetitive flexion-extension tasks with varying speeds in people with and without NSCLBP	There is a significant positive correlation between the tracking variability of the lumbar segment and the FABQ-PA score during slow-speed tasks. During faster movements, both groups showed an anticipatory response, but the response of the LBP group tended to be delayed compared to the healthy group.	• Fear of movement • Speed of the task	People with LBP showed more delayed responses compared to healthy participants. There is an association between tracking variability of the lumbar segment and the degree of fear of movement during slow-speed tasks.
Dieën (2019); Netherland[8]	Literature review	Finding the differences in postural control parameters between people with and without NSLBP during quiet standing	Three highlighted parameters were discussed in this study (CoP displacement, postural control strategy, and muscle activation pattern). Higher CoP sway in LBP groups during standing with higher demands was found compared to the healthy population. There was higher dependence on ankle proprioception in LBP, and the reliance on proprioception of the lower back and thigh muscles was restricted. Meanwhile, muscle activation patterns showed higher bilateral co-activation of GM in persons with back pain during prolonged standing.	• Predictable and unpredictable perturbation • Changes in muscle structure (muscle type, muscle atrophy, fatty infiltration of the muscle) • Changes in body alignment and unstable lumbal segment • Neuromuscular function • Pain and fear	There were differences in postural control between individuals with and without NSLBP in quiet standing, which became more evident in situations with higher demands.
Koch (2019); Germany[7]	Systematic review	To identify the differences in motor control between individuals with and without LBP during quiet standing	The procedure of quiet standing was performed in three conditions: standing on a stable surface with eyes open (EO), on a stable surface with eyes closed (EC), and on a foam surface with eyes open (FO) by assessing the muscle activity (EMG) and CoP. The result showed a main effect in each condition but no significant differences between groups. CoP sway was higher during the FO condition.	• Pain intensity • Neuromuscular changes • Task demands	During quiet standing, there are no motor control differences between individuals with and without LBP. The findings suggest that the populations may assume the task is manageable.
Koch (2022); Germany[17]	Case-control	To identify the differences in motor control between individuals with and without LBP during quiet standing	The procedure of quiet standing was performed in three conditions: standing on a stable surface with eyes open (EO), on a stable surface with eyes closed (EC), and on a foam surface with eyes open (FO) by assessing the muscle activity (EMG) and CoP. The result showed a main effect in each condition but no significant differences between groups. CoP sway was higher during the FO condition.	• Pain intensity • Task demands • Environmental condition	During quiet standing, there are no motor control differences between individuals with and without LBP. The findings suggest that the populations may assume the task is manageable.

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Table I: Table of Evidence

Author (Year); Countryref. no.	Type of Study	Objective	Result	actors	Conclusion
Liew (2020); United Kingdom[18]	Cross-sectional	Assessing the difference of motor abundance during low load lifting tasks between LBP and healthy subjects	The IMA was significantly greater during lowering than lifting for pelvic and trunk displacement in the LBP population, indicating worse motor variability compared to the control group which has higher motor abundance during lifting. However, current or previous LBP does not influence motor abundance (meaning there is no correlation between LBP status with control of the pelvis and trunk).	• Task demands • Pain intensity • Neuromuscular changes	LBP subjects had similar overall motor abundance, but different muscle activation profiles and modes compared to the control group during a low-load lifting task.
Sheikhhoseini (2016); Iran[10]	Literature review	Review studies relating to MCI in athletes with LBP	This study reviewed the MCI in cricket, cycling, football, golf, judo, hockey, and tennis athletes with LBP. Among these sports, the most common MCI finding is shown by muscle imbalance, reduction of ROM, increased muscle stiffness, and kinematic changes. In dance, no conclusion can be drawn because of limited sources.	• Pain intensity	Athletes with LBP show MCI while performing functional and non-functional tasks, like non-athletes.
Willigenburg (2013); Netherland[19]	Cross-sectional	Assessing the precision control of trunk movement in patients with LBP using a tracking task	The increased tracking errors with a vibration indicate an adequate proprioceptive function. However, subjects with severe LBP performed worse on the tracking task by showing a slight but not significantly decreased tracking error score (0.422° to 0.409) compared to the control, which showed significantly increased tracking errors with a vibration (0.332° to 0.367°). Hence, the vibration only influenced the control group, indicating an altered proprioception function in the LBP population.	• Pain intensity • Neuromuscular changes • Task demands	LBP is associated with proprioceptive impairments.

CLBP=chronic low back pain; LBP=low back pain; NSCLBP=non specific chronic low back pain; MCI=motor control impairment; FABQ-PA=fear-avoidance beliefs questionnaire-physical activity, CoP=center of pressure, GM=gluteus medius, IMA=index of motor abundance

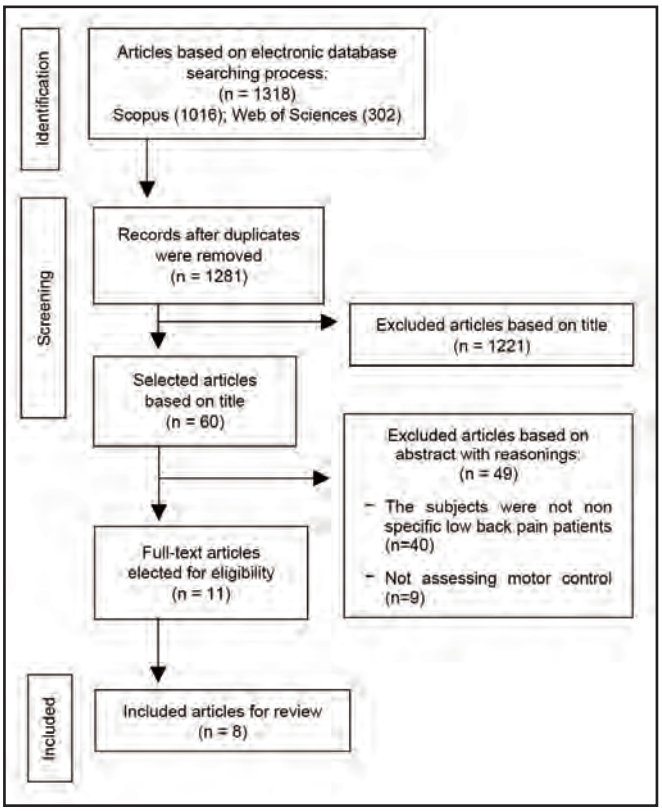

Fig. 1: Articles Selection Process Flowchart.

neuromuscular changes and affect the control of the movement.[15] The movement control is identified in the form of motor variability in two studies.[8,15] Higher motor variability indicates better motor control and neuromuscular function, therefore, less motor variability was found in the LBP population compared to control or healthy participants.[15]

There was one study[17] which unable to identify the difference between groups in assessing the center of mass and muscle activity through electromyography, contrary to the previous systematic review[4] that stated there is a difference in postural control between individuals with and without LBP in quiet standing. It is explained that in quiet standing, there is a higher reliance on ankle strategy for maintaining balance because of impaired hip flexion through a higher co-activation of gluteus maximus (GM) in subjects with LBP. The reliance on ankle strategy was also supported by a study,[15] which found a dominant ankle extensor and upper limb pattern in load-lifting tasks in patients with LBP compared with healthy subjects with a dominant trunk extensor pattern. However, the previous study[17] could not identify any difference in motor control activation between LBP, and the control group, which may be caused by quiet standing was not considered a highly demanding task.

The changes in the structure, such as type of muscle fiber, muscle atrophy, and fatty infiltration of the muscle, also can change motor control in patients with NSLBP.[4,8] Reduced muscular function and muscle weakness can result from fatty accumulation in the muscles, which can lead to muscular atrophy (loss of muscle mass).[7] Weakened muscles are less capable of supporting and stabilising the spine during movement, and might cause compensatory patterns that impair motor control and interfere with the alignment of muscle groups.[7] This changed muscle quality can impair the ability of muscles to contract effectively and worsen problems with motor control.[7]

Besides the structural changes, drastic changes in motor behavior were also found in one study[15] as protection from pain and further tissue damage. The pain-related changes also had been demonstrated by another study[8] that mentioned trunk stiffening found in patients with LBP is correlated with the changes in motor control as a purposeful strategy to avoid pain, leading to alignment changes as well as slower trunk movement compared with healthy subjects. This finding aligns with a study by a study[13] stating that poor coordination of muscles due to a disorder followed by low muscle activities, compromised joint laxity, muscle fatigue or other sensory function problems can lead to spinal instability. This spinal instability is correlated with the alignment change and drastic changes in motor behavior to avoid pain and possible further tissue damage.[15] The changes in muscle activities and motor behavior will lead to a higher risk of muscle fatigue and lesser motor variability, showing the inability to quickly search in motor strategy to maintain optimal task performance in individuals with LBP.[15] However, this study also presents the ability of the muscle to adapt to new behavior in patients with chronic LBP.[15]

Two studies[16,19] found proprioception deficits in the population with LBP, especially in high-precision demand conditions, such as load-lifting. Because in this task, proprioception is needed for optimal performance.[9] One of the studies[19] found that the vibration given in the LBP population did not affect the tracking performance since it was not remarkable even before the vibration, in contrast with the healthy subjects, who came with significant changes in tracking performance after the vibration, marking excellent proprioception function. The tracking performance result explained the altered proprioceptive function in the LBP condition, affecting motor control during task performance.[19]

Injury or nociceptive input and pain are potent causes of altering motor control.[8] The existing injury, pain, and fear of movement will change the excitability of motor pathways and muscle activation as a protective response to further tissue damage.[15] The other impact is the changes in proprioception, and the motor control will represent a purposeful strategy of protection instead of precision for functional tasks.[20] This condition can be seen when there is an injury to the spinal structure, the paraspinal muscles and the nociceptors will be stimulated and induce pain. Consecutively, this will cause an individual to be afraid to move and develop less function of the spinal muscles. Indirectly, this scenario alters the motor control of spinal movements.[8]

The motor control of deep core muscles (i.e. transverse abdominus, multifidus) can provide the appropriate movement needed for certain tasks in a specific environment.[20] Thus, it is essential to reeducate the muscle activities toward the physiological function so the body can

maintain steady-state stability and keep the postural sway within the base of support.[20] Correcting postural control and motor behavior will slowly return the proprioceptive function and give the correct strategy for stability.[8] Consecutively, a better muscle control strategy will improve the task performance as well.

CONCLUSION

This scoping review showed that numerous factors affecting motor control in patients with NSLBP correlated with one another. The identified factors are muscle endurance, pain intensity, neuromuscular changes, fear of movement, task variability, environmental conditions, perturbations, and structural changes. In the end, the pain-induced adaptation of the motor control will affect daily task performance as the pain will also cause changes in other factors. Thus, it is essential to establish a comprehensive motor control assessment and functional-aimed rehabilitation program. Further research is needed to find the other factors that may contribute to the adaptation of motor control in the LBP population.

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CONFLICT OF INTEREST

No conflict of interest.

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Knowledge and practices of radiation protection among Malaysian radiographers working in nuclear medicine: A preliminary study

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SUMMARY

This study is aimed to determine knowledge and practices on radiation protection among radiographers in nuclear medicine department. A cross-sectional survey was conducted among radiographers in nuclear medicine departments in four health institutions in Malaysia. A set of questionnaires was distributed to 17 respondents using convenience sampling. Approximately more than 75% and 44% - 56% of the radiographers have good knowledge of radiation protection and frequent adherence to radiation protection practices, respectively. Levels of education and length of service were statistically correlated with radiation protection knowledge and practices attributes ($p < 0.05$), respectively. More training is necessary for knowledge and practice improvement.

KEYWORDS:
Knowledge, practice, radiation protection, radiographers, nuclear medicine

INTRODUCTION

Nuclear medicine is a part of radiological imaging studies using a wide range of radiopharmaceuticals for diagnostic and therapeutic purposes. Two common nuclear medicine procedures are Single Photon Emission Computed Tomography (SPECT) using a gamma emitter e.g., technetium -99m and Positron Emission Tomography (PET) using a positron emitter e.g., fluorine-18. The properties of radiopharmaceuticals administered into the body facilitate to indicate the function of tissue and organ. Approximately 37 million nuclear medicine procedures are carried out globally each year.[1] Ionizing radiation exposure could result in cancer, genetically induced mutations, aberrant development, and degenerative disorders.[2] Thus, it is obligatory to ensure the safe practice of ionizing radiation exposure while minimizing its associated risk.

Radiological staff should possess adequate knowledge and good practice in radiation protection. Continuous training and courses should be provided from time to time for radiological staff to enhance their knowledge and practice on the safety of ionizing radiation. Several studies on the level of knowledge, awareness and practice in radiation protection and safety among medical personnel in nuclear medicine departments in several countries have been reported.[3,4] However, there is insufficient evidence of the knowledge and practices in radiation protection among Malaysian radiographers particularly those practicing in nuclear medicine presently. Therefore, this study is aimed to determine the level of knowledge and practices on radiation protection among radiographers in the nuclear medicine department and their correlations with demographic factors.

MATERIALS AND METHODS

Questionnaire Instrument

A cross-sectional survey was conducted among radiographers in the Department of Nuclear Medicine at four health institutions in Malaysia from July until December 2022.

A self-administered questionnaire which was adapted and adopted from previous studies [3,4] was employed in this study. The questionnaire consisted of three sections: demographic information in section A (four questions), knowledge of radiation protection in section B (eight questions) and practice of personnel in radiation protection in section C (seven questions). With regards to the practice attributes, three questions were addressed on personal protection and patient protection, respectively while one question addressed on protection of the environment.

A pilot study was conducted among ten radiographers to test the reliability of the questionnaire. The results of the pilot study showed acceptable Cronbach's alpha values of 0.828 and 0.928 for the questionnaire of knowledge and practice, respectively.

Sample Collection

The questionnaire was constructed using Google Forms and was distributed through WhatsApp and Telegram apps using convenience sampling method. The consent of the respondents was obtained before answering the questionnaire. A total of 17 samples was estimated following

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sample size calculation with a 95% confidence level using the Raosoft sample size calculator. Trainee radiographers were excluded from the samples.

Statistical Analysis
Descriptive and inferential statistical analyses were performed using Statistical Package for Social Science (SPSS) version 26.0 for Windows (SPSS Inc., USA) with a p-value < 0.05 was considered statistically significant.

Ethics Approval
Ethics approval was granted by the Research Ethics Committee of Faculty Health Sciences, Universiti Teknologi MARA (FERC/FSK/MR/2022/0153).

RESULTS

Demographic Characteristics
A total of 16 out of 17 radiographers responded to the survey (94.1%). The demographic data of the participants showed 62.5% were females and 37.5% were males. Most of the radiographers were aged between 30 – 39 years (62.5%) while 25% were between 20 – 29 years and 12.5% were between 40 – 49 years. Most of the radiographers were diploma holders (93.8%) with 6 - 10 years of service in the nuclear medicine department (50%) while 25% of them with less than 5 years and 11 – 15 years of service, respectively.

Level of Knowledge of Radiation Protection among Radiographers
Table I shows the level of knowledge of radiation protection of the radiographers in nuclear medicine. The results showed most of the radiographers had a good level of knowledge of radiation protection in nuclear medicine. It was found that 100% of the respondents were aware of the basic terms of radiation protection including ALARA, time, distance and shielding and TLD badge as well. It was noticed that 75% of them were familiar with radioactive materials' half-life. Furthermore, most of the radiographers were aware of radiation risks at the workplace (75%) and radiation protective equipment (81.3%).

Level of Practices of Radiation Protection among Radiographers
From the point of view of radiation protection practices, the results revealed frequent adherence to radiation protection in personal protection (50% – 56.3%), patient protection (43.8% - 87.5%) and protection of the environment (100%) as shown in Table II.

Particularly, only 56.3% of the radiographers frequently wear their dosimeter during working, 50% read thermoluminescent dosimeter badge and 56.3% frequently keep enough distance from the radiation source. Similarly, only 43.8% of the respondents frequently check all information about radiopharmaceuticals before administration to the patients and 56.3% of the respondents frequently use minimal exposure time when handling radiopharmaceutical-injected patients. However, better practice has been observed as 87.5% of the respondents asked about the pregnancy status of female patients. Moreover, all the respondents (100%) frequently have the radiation symbol light working in their practice.

Correlation of Knowledge and Practices with Demographic Factors
Furthermore, Pearson Chi-square correlation analysis showed the level of education was significantly correlated with the knowledge attribute of the annual limit on the effective dose for a radiation worker, X2 (1, N=16) =7.467, $p = 0.006$ (Table III). Interestingly, length of service in the nuclear medicine department was significantly correlated with most practice attributes including wearing a personal dosimeter during working, X2 (4, N =16) = 9.667, $p = 0.046$, reading a TLD dosimeter badge, X2 (4, N=16) = 9.714, $p = 0.046$ and checking information about radiopharmaceuticals before administration to the patient, X2 (2, N=16) = 8.382, $p = 0.015$.

Table I: Knowledge attributes of radiation protection

Knowledge attribute	n (%)
The annual limit on the effective dose for a radiation worker set by Act 304 under Basic Safety Radiation Protection 2010 is 2 mSv **(K1)**	
Yes	2 (12.5%)
No	14 (87.5%)
Do you know what the TLD badge is? **(K2)**	
Yes	16 (100%)
No	0 (0%)
Are you familiar with radioactive materials' half-life? **(K3)**	
Yes	4 (25%)
No	12 (75%)
Are you familiar with the term ALARA? **(K4)**	
Yes	16 (100%)
No	0 (0%)
Are you familiar with the terms; stochastic and deterministic effects? **(K5)**	
Yes	6 (37.5%)
No	10 (62.5%)
Do you have an idea about the radiation risks you are exposed to at the workplace? **(K6)**	
Yes	12 (75%)
No	4 (25%)
Are you familiar with the terms; Time, Distance, Shielding? **(K7)**	
Yes	16 (100%)
No	0 (0%)
Do you have an idea about the various protective equipment? **(K8)**	
Yes	13 (81.3%)
No	3 (18.8%)

Table II: Practice attributes of radiation protection

Practice attribute	n (%)
Personal protection	
Do you wear the personal dosimeter during work? **(P1)**	
Rarely	1 (6.3%)
Sometimes	6 (37.5%)
Often	9 (56.3%)
Personal protection	
Do you read your thermoluminescent dosimeter badge? **(P2)**	
Rarely	1 (6.3%)
Sometimes	7 (43.8%)
Often	8 (50%)
Patient protection	
Do you check all information about radiopharmaceuticals before administration to the patient? **(P3)**	
Rarely	0 (0%)
Sometimes	9 (56.3%)
Often	7 (43.8%)
Patient protection	
Do you use minimal exposure time when handling radiopharmaceutical-injected patients? **(P4)**	
Rarely	0 (0%)
Sometimes	7 (43.8%)
Often	9 (56.3)
Personal protection	
Do you keep enough distance from the radiation source? **(P5)**	
Rarely	3 (18.8%)
Sometimes	4 (25.0%)
Often	9 (56.3%)
Patient protection	
Do you ask about the pregnancy status of female patients? **(P6)**	
Rarely	0 (0%)
Sometimes	2 (12.5%)
Often	14 (87.5)
Protection of the environment	
Do you have the radiation symbol light working? **(P7)**	
Rarely	0 (0%)
Sometimes	0 (0%)
Often	16 (100%)

Table III: Correlation of knowledge and practice attributes of radiation protection with demographic factors of the radiographers

Attribute	Gender	Age	Level of education	Length of service
K1	0.242	0.504	0.006*	0.565
K2	-	-	-	-
K3	0.551	0.202	0.074	0.264
K4	-	-	-	-
K5	0.182	0.808	0.182	0.202
K6	0.074	0.202	0.551	0.368
K7	-	-	-	-
K8	0.247	0.171	0.620	0.158
P1	0.159	0.255	0.660	0.046*
P2	0.212	0.240	0.587	0.046*
P3	0.091	0.202	0.242	0.015*
P4	0.147	0.202	0.362	0.090
P5	0.837	0.310	0.660	0.070
P6	0.051	0.633	0.696	0.565
P7	-	-	-	-

* $p < 0.05$
- no statistics are counted because the variables (K2, K4, K7 and P7) are constant.

This study revealed gender and age demonstrated no significant correlation with any attributes of knowledge and practice of the radiographers in nuclear medicine ($p > 0.05$).

DISCUSSION

The results showed that most of the radiographers have a good level of knowledge of radiation protection in nuclear medicine. More than 75% of the respondents had knowledge of radiation protection in nuclear medicine including the annual dose limit for radiation workers, TLD badge, radiation risk, methods of radiation protection and radiation protection equipment. However, only 25% and 37.5% of them familiar with radioactive materials' half-life and biological effects of radiation, respectively. This finding is in accordance with a previous pilot study on radiation safety awareness among Malaysian nurses in the nuclear medicine department.[5]

On the contrary, only 44% - 56% of the radiographers had practiced frequently most of the attributes of good practice of radiation protection in nuclear medicine including wearing a personal dosimeter during work, reading a TLD dosimeter badge, using minimal exposure time when handling radiopharmaceutical-injected patients and keeping enough distance from the radiation source. Remarkably, 87.5% and 100% of the radiographers had practiced frequently on querying the pregnancy status of female patients and working on radiation symbol light, respectively. The results are in accordance with the previous report on the practice of radiation safety among Egyptian healthcare workers.[6] As a result of the present findings, strict measures on radiation protection and safety are substantially necessary for the department to ensure that radiographers are complying with the standard safety measures.

On the other hand, this study showed the level of education significantly correlated with the knowledge of the annual dose limit for radiation workers. The result may prove that higher education levels would lead to improved knowledge radiographers which fosters feelings of self-assurance, personal growth, self-realization, and professional achievement. These characteristics would lead to greater professional satisfaction, which is crucial for delivering high-quality medical care.[3] Similarly, the length of service of the radiographers significantly correlated with most attributes of radiation protection practice. It means that the level of radiation protection practice is directly proportional to the radiographers' working years of service. An Iranian study on radiation protection knowledge, attitude and practice in interventional radiology reported that the radiation protection practice score was significantly higher among radiological staff with more than 15 years of practice age as compared to those with less than 15 years of practice.[7] Exposure to radiation protection training and experience-based learning by radiographers could be the potential factors leading to good radiation protection practice. Over time, radiographers are exposed to various situations, equipment, protocols, and procedures, which provide the opportunity for learning and self-improvement. It is also important to note that ongoing education and training in radiation protection and safety is crucial to update knowledge and practice as radiation protection regulations and guidelines are constantly evolving.

There are several guidelines should be adhered by the radiographers and health personnel for radiation protection and safety in radiology and nuclear medicine. These guidelines include Act 304 (Atomic Energy Licensing Act 1984) and Guidance Document for Occupational Radiation Protection, which addressed the protection of health and safety of radiation workers. Furthermore, Ministry of Health Malaysia has published Operational Policy in Nuclear Medicine Services as an important national policy document to provide a general guideline for nuclear medicine personnels for delivering nuclear medicine services in Malaysia.[8] This document has been developed based on the needs of latest requirements under the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010. To ensure the current knowledge and skills of the health personnels in nuclear medicine are updated, they should attend continuous medical education (CME) in the service initiated by the authorized organization such as Ministry of Health Malaysia at least 6 hours per year.[9] Some of the training modules include Radiation Safety Awareness in Nuclear Medicine, Update in Nuclear Medicine Technology and others. The training is also essential for the renewal of radiation worker status.

The present study is limited by the small sample size of respondents which may lead to average bias.[10] More sample sizes with a greater population of radiographers practicing in the nuclear medicine department in the public, private and teaching hospitals in Malaysia are recommended for future study.

CONCLUSION

The radiographers in the nuclear medicine department generally have good knowledge of radiation protection and moderate adherence to radiation protection practices. Level of education and length of service are the important factors contributing to radiation protection knowledge and practice, respectively. Hence, more knowledge acquisition programs and training are necessary to improve the knowledge and practice of radiation protection among radiographers in nuclear medicine.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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