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Clustering of Hypertension, Abnormal Glucose Tolerance, Hypercholesterolaemia and Obesity in Malaysian Adult Population

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Summary

We determine the prevalence and determinants of clustering of hypertension, abnormal glucose tolerance, hypercholesterolaemia and overweight in Malaysia. A national probability sample of 17392 individuals aged 30 years or older had usable data. 61% of adults had at least one risk factor, 27% had 2 or more risk factors. The observed frequency of 4 factors cluster was 6 times greater than that expected by chance. Indian and Malay women were at particular high risk of risk factors clustering. Individuals with a risk factor had 1.5 to 3 times higher prevalence of other risk factors. Ordinal regression analyses show that higher income, urban residence and physical inactivity were independently associated with risk factors clustering, lending support to the hypotheses that risk factors clustering is related to lifestyle changes brought about by modernisation and urbanisation. In conclusion, risk factor clustering is highly prevalent among Malaysian adults. Treatment and prevention programme must emphasise the multiple risk factor approach.

Key Words: Hypertension, Blood pressure, Diabetes mellitus, Hypercholesterolaemia, Obesity prevalence, Risk factors clustering, Syndrome X, Cardiovascular risk factor cluster syndrome, Cross-sectional population survey

Introduction

Hypertension, abnormal glucose tolerance, hypercholesterolaemia and obesity are major risk factors for cardiovascular disease[1-6]. They are also highly prevalent in Malaysia[7-11]; hypertension and diabetes mellitus being especially common[7,8,11]. These risk factors also tend to cluster or aggregate in the same individual[12]. That is, patients with one risk factor tend to have a higher prevalence of the other risk factors. These clustering of risk factors have been described as syndrome X[12], deadly quartet[13], or more descriptively, the cardiovascular risk factor cluster syndrome[14].

The clustering of cardiovascular risk factors has important implications. Firstly, it suggests the risk factors may have common antecedent. The most frequently cited mechanism to explain the clustering is insulin resistance or hyperinsulinaemia[12,15]. Secondly, these factors are synergistic in their impact on risk of cardiovascular disease[16]. Finally, the clustering and their synergistic effect on cardiovascular risk underlie the common recommendation that detection of one risk factor ought to prompt screening for other risk factors, and treatment decision must be guided by an individual overall CV risk profile that takes into account other risk factors present.

For example, hypertension treatment guidelines of both the World Health Organisation-International Society of Hypertension[17] and the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure[18] emphasise such an approach.

We present here the prevalence and determinants of clustering of hypertension, abnormal glucose tolerance, hypercholesterolaemia and obesity among Malaysian adults using data from the National Health and Morbidity survey (NHMS) completed in 1996.

Materials and Methods

Sampling design and sample

The National Health and Morbidity Survey (NHMS) was a multi purpose survey designed to describe the health status, health related behaviour and health services utilisation for a representative sample of the population of Malaysia. An up to date and representative sampling frame for this population was provided by the frame used for the annual Labour Force survey conducted by the Department of Statistics[19]. The sampling frame was stratified by state and urban/rural residence. A stratified two- stage cluster sampling design with self-weighting sample was used to draw a sample of 17995 private dwellings. However, only 13025 (87%) dwellings were contactable or responded. All residents of sampled dwellings were included yielding a sample size of 59903 individuals. For NHMS component on blood pressure, blood glucose, blood cholesterol, body weight and height, 21708 individual age 30 or older (excluding other ethnic group) were eligible. 17392 (80%) of them agreed to have their measurements taken or have evaluable responses. Table I shows the composition of the sample.

Survey procedures

Details have been described elsewhere[7-11]. Briefly, during a home visit, the first hour was devoted to completing a questionnaire administered by an interviewer. The questionnaire included the following items on hypertension (or diabetes):

1. Are you known to have high blood pressure (or high blood sugar)?
2. Have you ever been told by a doctor or by other care health personnel that you had high blood pressure (or high blood sugar)?
3. Have you ever been on medication for treatment of high blood pressure (or high blood sugar)?
4. Are you still taking the medication now?

After the interview, respondent's blood pressure (BP), capillary blood glucose (BG) and cholesterol (BC), body weight and height was measured by a trained nurse. One of two calibrated electronic devices (Visomat® OZ 30 for obese subjects or OZ 2 for non-obese subjects) was used to measure blood pressure according to the manufacturer's guideline. Two BP measurements were taken with an interval of 3 minutes apart. Capillary blood glucose and cholesterol was measured using reflectance photometer (Accutrend, Boehringer Mannheim). For blood glucose measurement, all subjects without medical history of diabetes (negative response to question 2 above) were approached but only a small sub-sample of known diabetic had blood glucose measurement taken. The procedure was explained and verbal permission obtained from the respondent prior to the examination. 75 gram of glucose monohydrate powder was mixed with a glass of plain water and ingested by respondent. Respondent then fasted for 2 hours (only plain water allowed). Blood sample was then obtained by finger prick for blood glucose and cholesterol measurement by photometer. Body weight was measured in light indoor clothing without shoes to the nearest tenth of a kilogram using a bathroom spring balance. Height was measured without shoes to the nearest tenth of a centimetre using a measuring tape attached to a rigid wall. All nurses attended centralised training on standardised protocol for BP, BG, BC, body weight and height measurement. During field survey, supervisors conduct weekly check on compliance with measurement protocol.

Definitions

The mean of the two BP measurements is used for analysis unless only one measurement is available. Hypertension was defined as mean systolic blood pressure (SBP) >=140mmHg, mean diastolic blood pressure (DBP) >=90mmHg or current treatment for hypertension with medication[20]. Definition of abnormal glucose tolerance (impaired glucose tolerance or

diabetes) is based on WHO criteria[21]. Subjects with medical history of diabetes and currently on anti-diabetic medication were also classified as diabetic. Hypercholesterolaemia was defined by blood total cholesterol level >=5.2mmol/L according to the classification system recommended by the Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol[22]. Body mass index (BMI) is defined as ratio of weight in kilogram to square of height in metre. Overweight was defined by BMI >=25Kg/M^2 according to the classification system recommended by the WHO Expert Committee on Physical status[23]. Physical activity was graded active if a person engaged in a sporting activity at least 3 times a week each lasting at least 15 minutes or a person's daily activity including occupational activity was sufficiently rigorous to cause sweating. Otherwise physical activity was graded inactive. Residence in a gazetted area with population exceeding 10000 people is defined as urban; otherwise the residence is rural[19].

Statistical methods

Prevalence estimates and standard error were calculated by method appropriate to the complex sampling design[24,25]. The sampling weights were adjusted for household non-response using adjustment cells formed by state and urban/rural residence. Post stratification[26] was used to adjust the weighted sample totals to known population totals for age, gender and ethnicity based on 1996 census population projection. Prevalence estimates were standardised by the direct method to the age distribution of the 1996 adult Malaysian population.

Expected prevalence in Table III was calculated by applying the multiplication rule of probability for independent events and addition rule for mutually exclusive events. Thus, for 2 events A and B, the probability of A and B (denoted P (A and B)) is given by P(A) x P(B) if A and B are independent, and the probability of A or B is given by P(A) + P(B) if A and B are mutually exclusive. For example, for occurrence of hypertension (HT), abnormal glucose tolerance (AGT), hypercholesterolaemia (CHO) and overweight (OW) in a population, the expected prevalence of isolated HT is P(HT) x P(not AGT) x P(not CHO) x P(not OW). Similarly the expected prevalence of HT plus one other risk factor is P(HT and AGT and not CHO and not OW) + P(HT and not AGT and CHO and not OW) + P(HT and not AGT and not CHO and OW).

Proportional odds model[27,28] was used to estimate the effects of covariates on the cumulative probability of number (0 to 4) of risk factors present. The model included age, ethnic and gender interaction term, physical activity (active/inactive), urban/rural residence, household income and education. Interaction between ethnicity and gender was expected based on previous descriptive study in this population[7-11]. All quantitative covariates are categorised to avoid the possibly unjustified linearity assumption. In the first model, (Table VII) we assume there is no interaction between ethnicity-gender and the other covariates. Persistent ethnic and gender differences were observed after adjustment (Table VII). However, interaction between gender-ethnicity and other socio-demographic variables can be expected based on previous study in this population[11], as well as literature findings[29,30]. The regression analyses were therefore repeated separately for each ethnic-sex group. To account for the cluster sampling, we obtained robust variance estimates using the Huber's[31] or sandwich estimator. Probability weighted estimation were used to account for differential sampling probability. Proportional odds model[27,28] is a relatively new statistical technique and warrant further explanation. Such model is used for ordinal dependent variable. The dependent variable of interest here is the number of risk factors present, which is quantitative (count data) and could potentially be modelled, say, as a Poisson variate. However, it is preferable to treat it as ordinal for the following reasons:

1. Its range (0 to 4) is severely limited by design.
2. Regression coefficient from say Poisson model has limited interpretation in this context.
3. By treating the number of risk factors present as count data, we are implicitly assuming that one risk factor is as important or serious as another risk factor. This is clearly unjustified. For example, it is unjustified to assume that the cardiovascular risk of an individual with all 4 risk factors studied is twice that of one with any 2 risk factors combinations. The synergism among risk factors in their impact on cardiovascular risk justifies the rank ordering of number of risk

factors present. That is, one may justifiably regard an individual with greater number of risk factors is at greater risk than one with lesser number, without assuming quantitative differences in cardiovascular risk between number of factors present.

In proportional odds model, the cumulative probabilities for the ordinal dependent variable, after suitable transformation (logit transform), is modelled as a linear function of covariates. The regression coefficient has interpretation as cumulative odds ratio (OR) (after taking its exponent). We explain this by an example. In Table VI, the cumulative OR for the number of risk factors present for Chinese men compare to Malay men is 1.27. This means the odds for greater number of risk factors are 1.27 times higher for Chinese men than Malay men. In other words, the cumulative distribution for the number of risk factor for Chinese men is shifted to the right of Malay men. A key assumption for the model is the proportional odds assumption, that is, homogeneity of cut-point specific odds ratio. We assessed this informally by plotting the binary logistic odds ratio and its 95% confidence interval against the cut-points[32]. No obvious heterogeneity in cut-point specific odds ratio was apparent.

Statistical significance is accepted at 5% level. No attempt was made to adjust for multiple comparisons. The above methods were implemented using programs written in STATA[33] software package.

Results

Table I shows the characteristics of the sample. Other indigenous ethnic group and women were over-represented. All estimates are therefore corrected for the sampling bias.

Table II shows the distribution of number of risk factors (0 to 4) among adult Malaysians. Clearly, only a minority of adult Malaysians had no risk factor. 51% had one or two risk factors, and 1% had all 4 risk factors. The clustering of risk factors did not occur by chance as shown in Table III. Each risk factor, in isolation or together with one or two other risk factor, occurred less

Table I
Characteristics of Respondents Compared with Total Population of Malaysia Age 30 or Older in 1996

	% Respondents (unweighted) n=17392 No. (%)	% Malaysia Population Aged 30 or Older n=7.06 million %
Sex		
Male	8164 (47%)	49%
Female	9228 (53%)	51%
Age		
30 - 34	3351 (19%)	20%
35 - 39	3242 (19%)	19%
40 - 44	2801 (16%)	16%
45 - 49	2232 (13%)	12%
50 - 54	1653 (10%)	9%
55 - 59	1393 (8%)	8%
60 - 64	1122 (7%)	6%
65 - 69	748 (4%)	4%
> = 70	850 (5%)	6%
Ethnic		
Malay	8345 (45%)	48%
Chinese	4881 (28%)	34%
Indian	1218 (7%)	8%
Other indigenous	2948 (15%)	10%

Table II
Distribution of Number of Risk Factors (0 to 4) among Adult Malaysians

Number of Risk Factor(s)	Prevalence % (SE)
0	39 (0.5)
1	34 (0.4)
2	19 (0.3)
3	7 (0.2)
4	1 (0.9)

Table III
Observed and Expected Prevalence of Risk Factor in Isolation and with One or More Other Risk Factors

		All (%)	Isolated (%)	+1 other (%)	+2 others (%)	+3 others (%)
Hypertension	Observed	33.1	12.3	13.3	6.3	1.2
	Expected	-	15.7	13.7	6.4	0.2
Abnormal glucose tolerance	Observed	11.3	2.1	4.1	4.0	1.2
	Expected	-	4.0	5.0	6.4	0.2
hypercholesterolaemia	Observed	20.1	6.7	7.6	4.6	1.2
	Expected	-	8.0	8.9	6.4	0.2
Overweight	Observed	33.1	6.7	7.6	4.7	1.2
	Expected	-	15.7	13.7	6.9	0.2

frequently than expected by chance. In contrast, the clustering of all 4 risk factors occurred at a frequency 6 times greater than expected by chance.

Table IV shows prevalence and age adjusted prevalence of risk factor combinations in each ethnic-sex groups. Indian men had remarkably high prevalence of high blood pressure and abnormal glucose tolerance in association with high blood cholesterol or overweight. Malay women had high prevalence of high blood pressure, high blood cholesterol and overweight cluster. For all 4 risk factors, the most at risk groups were no doubt Indian men and women, and Malay women.

Table V compares the prevalence of other risk factors between subjects with and without a particular risk factor. Clearly, subjects with high blood pressure, abnormal glucose tolerance, high blood cholesterol and high BMI had about 1.5 to 3 times higher prevalence of other risk factors or combination of risk factors. The difference was particularly marked for 3-factor combination.

Table VI shows the mean and cumulative OR for the number of risk factors present by age, ethnicity, gender, physical activity (active/inactive), urban/rural residence, household income and education. There were marked ethnic and gender differences. Indian men and women, and Malay women had greater number of risk factors, while other indigenous men and women had less. Other observed differences in prevalence of risk factors cluster were expected. The elderly and the inactive, and individuals with lesser education, more income or residing in urban area had greater number of risk factors. The effects of each of these socio-demographic factors may not be independent of each other.

Table VII shows cumulative OR from proportional odds models predicting cumulative probability of number of risk factors. Clearly, ethnic and sex differences persisted after adjustment for other socio-demographic factors. The age and income trends in cumulative odds of number of risk factors were also obvious. The effect of education was less consistent. Effects of rural residence and physical activity remained favourable as expected.

Table VIII shows the cumulative OR from proportional odds models separately for each sex-ethnic groups. Age, rural residence and physical activity had consistent effect in all groups. However, the effects of education and income were heterogeneous across sex-ethnic groups. Education appeared to have opposite effect in men and women. Better-educated men had more risk factors while the reverse was true for women. Higher income was associated with more risk factors in all groups except in Chinese.

Discussion

Caution is warranted in interpreting the results of cross-sectional study. One cannot be certain that the socio-demographic factors studied actually preceded the occurrence of hypertension, abnormal glucose tolerance, hypercholesterolaemia and overweight. For example,

Table IV
Prevalence (SE) and Age Adjusted Prevalence of Risk Factor Combinations by Ethnicity and Gender**

	All	All Men	All Women	All Malay	All Chinese	All Indian	All Other Indig*	Malay Men	Malay Women	Chinese Men	Chinese Women	Indian Men	Indian Women	Other Indig Men	Other Indig. Women
N	17392	8164	9228	8345	4881	1218	2948	3952	4393	2245	2636	573	645	1394	1554
HT[a]	12.3	13.3	11.4	12.3	11.6	9	17.4	12.9	11.7	13.2	10.1	9.8	8.2	17.9	16.8
(SE)	(0.3)	(0.4)	(0.4)	(0.4)	(0.6)	(0.8)	(0.8)	(0.6)	(0.6)	(0.8)	(0.7)	(1.2)	(1.1)	(1.1)	(1.1)
Age-adjusted prevalence**	12.5	13.5	11.5	12.7	11.2	9.6	17.9	13.2	12.1	13	9.5	10.2	9.1	18.4	17.3
(SE)	(0.3)	(0.4)	(0.4)	(0.4)	(0.5)	(0.9)	(0.7)	(0.6)	(0.5)	(0.8)	(0.6)	(1.4)	(1.2)	(1)	(1)
AGT[b]	2.1	2.2	2	1.5	2.7	4.5	1.2	1.8	1.3	2.3	3	5.6	3.4	1.3	1.2
(SE)	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.7)	(0.2)	(0.2)	(0.2)	(0.4)	(0.4)	(1.1)	(0.8)	(0.3)	(0.3)
Age-adjusted prevalence	2.1	2.2	2	1.6	2.6	4.6	1.2	1.8	1.3	2.3	3	5.9	3.4	1.3	1.2
(SE)	(0.1)	(0.2)	(0.2)	(0.1)	(0.3)	(0.7)	(0.2)	(0.2)	(0.2)	(0.4)	(0.4)	(1.1)	(0.8)	(0.3)	(0.3)
CHO[c]	6.7	6.7	6.6	6.8	7.6	5.9	3.8	7.6	6.1	6.8	8.4	5.5	6.2	3.3	4.3
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.7)	(0.4)	(0.5)	(0.4)	(0.6)	(0.6)	(1)	(1)	(0.5)	(0.6)
Age-adjusted prevalence	6.6	6.7	6.6	6.8	7.5	5.7	3.8	7.5	6	6.8	8.3	5.1	6.1	3.3	4.3
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.7)	(0.4)	(0.5)	(0.4)	(0.6)	(0.6)	(0.9)	(1)	(0.5)	(0.5)
OW[d]	6.7	6.7	6.6	6.8	7.6	5.9	3.8	7.6	6.1	6.8	8.4	5.5	6.2	3.3	4.3
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.7)	(0.4)	(0.5)	(0.4)	(0.6)	(0.6)	(1)	(1)	(0.5)	(0.6)
Age-adjusted prevalence	6.6	6.7	6.6	6.8	7.5	5.7	3.8	7.5	6	6.8	8.3	5.1	6.1	3.3	4.3
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.7)	(0.4)	(0.5)	(0.4)	(0.6)	(0.6)	(0.9)	(1)	(0.5)	(0.5)
HT + AGT	6.3	5.9	6.8	5.7	7.3	9.1	3.9	4.7	6.7	7.2	7.4	10.9	7.4	3.2	4.7
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(1)	(0.4)	(0.4)	(0.4)	(0.6)	(0.6)	(1.5)	(1.1)	(0.5)	(0.6)
Age-adjusted prevalence	6.3	5.8	6.8	5.8	6.9	9.6	4.1	4.8	6.8	6.8	6.8	11.4	7.9	3.3	5
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.9)	(0.4)	(0.4)	(0.4)	(0.6)	(0.5)	(1.4)	(1.1)	(0.5)	(0.6)
HT + CHO	8.5	7.3	9.8	9.3	8.5	8.2	5.6	7.3	11.2	7.7	9.2	9.8	6.7	4	7.3
(SE)	(0.3)	(0.3)	(0.4)	(0.4)	(0.5)	(0.9)	(0.5)	(0.5)	(0.5)	(0.6)	(0.7)	(1.4)	(1)	(0.6)	(0.7)
Age-adjusted prevalence	8.5	7.2	9.7	9.4	7.9	8.5	5.8	7.3	11.4	7.2	8.5	9.9	7.3	4.1	7.5
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.9)	(0.5)	(0.5)	(0.5)	(0.6)	(0.5)	(1.3)	(1.1)	(0.6)	(0.7)
HT + OW	14.5	13.5	15.6	15.3	14.2	14.3	12.5	12.7	17.8	15.4	12.9	14.9	13.7	10.1	15
(SE)	(0.3)	(0.4)	(0.4)	(0.5)	(0.6)	(1.1)	(0.7)	(0.6)	(0.7)	(0.8)	(0.8)	(1.6)	(1.6)	(0.8)	(1)
Age-adjusted prevalence	14.4	13.3	15.4	15.1	13.5	14.7	12.7	12.6	17.6	15	12	15.4	13.9	10.3	15.2
(SE)	(0.3)	(0.4)	(0.4)	(0.4)	(0.5)	(1.1)	(0.7)	(0.6)	(0.6)	(0.8)	(0.7)	(1.8)	(1.4)	(0.9)	(1)
AGT + CHO	3.5	3.2	3.8	3.4	3.7	5.7	1.4	3.1	3.7	3	4.3	7.3	4.1	0.7	2
(SE)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.7)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(1.2)	(0.8)	(0.3)	(0.4)
Age-adjusted prevalence	3.4	3.1	3.7	3.5	3.4	5.8	1.4	3.1	3.8	2.9	4	7.2	4.4	0.7	2.1
(SE)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.7)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(1.2)	(0.8)	(0.3)	(0.4)

ACT + OW	5.7	5.3	6.1	5.5	5.8	9.6	2.8	5	6.1	6	5.7	8.8	10.3	2	3.6
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(1)	(0.4)	(0.4)	(0.4)	(0.6)	(0.5)	(1.3)	(1.4)	(0.4)	(0.5)
Age-adjusted prevalence	5.6	5.3	6	5.5	5.6	9.6	2.9	5	6.1	5.9	5.3	8.8	10.3	2	3.8
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(1)	(0.3)	(0.4)	(0.4)	(0.6)	(0.5)	(1.3)	(1.3)	(0.4)	(0.5)
CHO + OW	8.4	7.9	8.9	9.3	8	9	5.1	8.2	10.3	8.2	7.7	9.8	8.3	4.1	6.1
(SE)	(0.3)	(0.3)	(0.3)	(0.4)	(0.5)	(1.1)	(0.4)	(0.5)	(0.6)	(0.7)	(0.5)	(1.6)	(1.2)	(0.5)	(0.7)
Age-adjusted prevalence	8.3	7.8	8.8	9.2	7.7	8.9	5.1	8.1	10.2	8.2	7.3	9.3	8.3	4.1	6.1
(SE)	(0.2)	(0.3)	(0.3)	(0.3)	(0.4)	(0.9)	(0.4)	(0.5)	(0.5)	(0.6)	(0.5)	(1.3)	(1.1)	(0.5)	(0.7)
HT + AGT + CHO	2.1	1.7	2.5	2.1	2.2	3.2	1	1.6	2.6	1.7	2.7	4.1	2.3	0.5	1.5
(SE)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.6)	(0.2)	(0.2)	(0.3)	(0.3)	(0.4)	(1)	(0.6)	(0.2)	(0.3)
Age-adjusted prevalence	2.1	1.7	2.5	2.1	2	3.2	1	1.6	2.6	1.6	2.4	4	2.6	0.5	1.6
(SE)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.5)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)	(0.8)	(0.7)	(0.3)	(0.3)
HT + AGT + OW	3.5	3.1	3.8	3.4	3.7	4.9	2	2.9	3.9	3.7	3.8	4.9	4.9	1.2	2.8
(SE)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.7)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.9)	(0.9)	(0.3)	(0.5)
Age-adjusted prevalence	3.4	3.1	3.8	3.4	3.6	4.9	2	2.9	3.9	3.6	3.5	4.8	5	1.2	2.9
(SE)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.8)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(1)	(1)	(0.3)	(0.5)
HT + CHO + OW	4.2	3.5	4.9	4.6	4.1	3.6	2.6	3.6	5.7	3.8	4.5	3.7	3.5	1.9	3.4
(SE)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)	(0.6)	(0.3)	(0.3)	(0.4)	(0.5)	(0.5)	(0.9)	(0.8)	(0.4)	(0.5)
Age-adjusted prevalence	4.1	3.5	4.8	4.6	3.9	3.6	2.7	3.6	5.6	3.7	4.1	3.6	3.5	1.9	3.5
(SE)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.6)	(0.3)	(0.3)	(0.4)	(0.5)	(0.4)	(0.8)	(0.8)	(0.4)	(0.5)
AGT + CHO + OW	1.9	1.7	2.1	2	1.6	3.3	0.8	1.9	2.2	1.3	2	3.8	2.7	0.4	1.2
(SE)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.5)	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.8)	(0.7)	(0.2)	(0.3)
Age-adjusted prevalence	1.8	1.7	2	2	1.5	3.2	0.8	1.8	2.1	1.3	1.8	3.6	2.8	0.4	1.2
(SE)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.5)	(0.2)	(0.3)	(0.2)	(0.3)	(0.3)	(0.8)	(0.6)	(0.2)	(0.3)
HT + AGT + CHO + OW	1.2	0.9	1.4	1.2	1.1	1.8	0.6	0.9	1.5	0.8	1.3	2.2	1.3	0.3	0.9
(SE)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.4)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.7)	(0.5)	(0.1)	(0.3)
Age-adjusted prevalence	1.1	0.9	1.4	1.2	1	1.7	0.6	0.9	1.5	0.8	1.2	2	1.4	0.3	0.9
(SE)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.4)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.6)	(0.5)	(0.1)	(0.3)

[a] HT means hypertension, [b] AGT means abnormal glucose tolerance, [c] CHO means blood cholesterol>=5,2mmol/L, [d] OW means BMI>=25

** Other Indig. Means other indigenous ethnic groups*

*** Age adjusted to 1996 Malaysia population*

Table V
Comparison of the Prevalence (SE) of other Risk Factors between Subjects with and without a Risk Factor

Other Risk Factor (s)	Prevalence (SE) %	Age Adjusted* Prevalence %	(SE) %	Prevalence (SE)	Age Adjusted* Prevalence %	SE)
	Normotensives (n=11463)			**Hypertensives (n=5929)**		
AGT[b]	7.5 (0.3)		8.3 (0.3)	19.1 (0.6)		16.8 (0.6)
CHO[c]	17.3 (0.4)		17.8 (0.4)	25.8 (0.7)		24.1 (0.7)
OW[d]	27.7 (0.5)		26.6 (0.5)	43.8 (0.8)		46.8 (0.8)
AGT + CHO	2.1 (0.2)		2.3 (0.2)	6.3 (0.4)		5.5 (0.4)
AGT + OW	3.3 (0.2)		3.4 (0.2)	10.4 (0.5)		10.1 (0.5)
CHO + OW	6.3 (0.3)		6.3 (0.3)	12.6 (0.5)		12.6 (0.6)
AGT + CHO + OW	1.1 (0.1)		1.1 (0.1)	3.5 (0.3)		3.4 (0.3)
	Normal Glucose Tolerance (n=15485)			**Abnormal Glucose Tolerance (n=1907)**		
HT[a]	30.3 (0.5)		31.2 (0.4)	55.9 (1.3)		49.2 (1.4)
CHO	18.8 (0.4)		18.8 (0.4)	30.7 (1.3)		29.5 (1.4)
OW	30.9 (0.5)		30.5 (0.4)	50.2 (1.4)		53.2 (1.5)
HT + CHO	7.3 (0.2)		7.5 (0.2)	18.5 (1.0)		16.2 (1.0)
HT+ OW	12.5 (0.3)		12.5 (0.3)	30.6 (1.2)		29.4 (1.3)
CHO + OW	7.4 (0.2)		7.3 (0.2)	16.6 (1.0)		17.3 (1.1)
HT + CHO + OW	3.4 (0.2)		3.5 (0.2)	10.2 (0.8)		9.7 (0.9)
	Normocholesterolaemic (n=13935)			**Hypercholesterolaemic (n=3457)**		
AGT	9.8 (0.3)		10.0 (0.3)	17.3 (0.8)		16.1 (0.7)
HT	30.8 (0.5)		31.6 (0.4)	42.5 (0.9)		39.4 (0.9)
OW	30.9 (0.5)		30.6 (0.4)	41.8 (1.0)		42.1 (1.0)
HT + AGT	5.3 (0.2)		5.5 (0.2)	10.4 (0.6)		9.4 (0.5)
AGT + OW	4.8 (0.2)		4.8 (0.2)	9.3 (0.6)		9.0 (0.6)
HT + OW	13.0 (0.3)		13.1 (0.3)	20.8 (0.8)		19.5 (0.8)
HT + AGT + OW	2.9 (0.2)		3.0 (0.2)	5.8 (0.4)		5.3 (0.4)
	Not Overweight (n=11616)			**Overweight (n=5776)**		
AGT	8.4 (0.3)		8.3 (0.3)	17.2 (0.6)		17.8 (0.6)
CHO	17.5 (0.4)		17.3 (0.4)	25.4 (0.7)		25.4 (0.7)
HT	27.8 (0.5)		27.4 (0.4)	43.9 (0.8)		44.9 (0.7)
AGT + CHO	2.4 (0.2)		2.3 (0.1)	5.7 (0.4)		5.7 (0.4)
HT + AGT	4.3 (0.2)		4.2(0.2)	10.5 (0.5)		11.2 (0.5)
HT + CHO	6.5 (0.3)		6.4 (0.3)	12.7 (0.5)		12.9 (0.5)
HT + AGT + CHO	1.4 (0.1)		1.4 (0.1)	3.5 (0.3)		3.6 (0.3)

[a]HT means hypertension, [b]AGT means abnormal glucose tolerance, [c]CHO means blood cholesterol>=5,2mmol/L, [d]OW means BMI>=25
**Age adjusted to 1996 Malaysia population*

Table VI
Mean (SE) Number of Risk Factor and Cumulative OR (95% Confidence Interval) for Number of Risk Factors by Socio-demographic Variables

Socio-demographic Variables	N	Mean (SE)	Cumulative OR	(95% CI)
Ethnic-sex group				
Malay men (ref*)	3952	0.89 (0.02)	1	-
Chinese men	2245	1.01 (0.02)	1.27	(1.34, 1.20)
Indian men	573	1.15 (0.05)	1.63	(1.78, 1.50)
Other Indigenous men	1394	0.71 (0.03)	0.72	(0.77, 0.68)
Malay women	4393	1.10 (0.02)	1.48	(1.54, 1.42)
Chinese women	2636	0.94 (0.02)	1.07	(1.13, 1.01)
Indian women	645	1.04 (0.04)	1.33	(1.46, 1.22)
Other Indigenous Women	1554	0.88 (0.03)	0.99	(1.06, 0.93)
Age group (years)				
30 - 39 (ref*)	6593	0.70 (0.01)	1	-
40 - 49	5033	1.02 (0.02)	1.89	(1.96, 1.82)
50 - 59	3046	1.25 (0.02)	2.88	(3.02, 2.75)
60 - 69	1870	1.33 (0.03)	3.29	(3.47, 3.12)
>=70	850	1.21 (0.04)	2.72	(2.93, 2.53)
Educational attainment in years				
0 - 3(ref*)	5253	1.09 (0.02)	1	-
4 - 10	8022	0.99 (0.01)	0.82	(0.85, 0.79)
>10	4117	0.82 (0.02)	0.59	(0.62, 0.56)
Household income (1000 RM)				
<1 (ref*)	8139	0.95 (0.01)	1	-
1 - 2	4640	1.01 (0.02)	1.11	(1.15, 1.07)
>2	4613	0.98 (0.02)	1.03	(1.07, 0.98)
Urban-rural residence				
Urban (ref*)	9427	1.01 (0.01)	1	-
Rural	7965	0.93 (0.01)	0.89	(0.92, 0.85)
Physical activity				
Inactive (ref*)	11259	1.03 (0.01)	1	-
Active	6133	0.88 (0.01)	0.76	(0.78, 0.73)

**ref is reference category in calculating cumulative OR*

subjects with multiple risk factors may move to the city to access better medical care, thus producing spurious association between urban residence and risk factor clustering. This however is unlikely, and is mitigated by the high proportion of undiagnosed diabetics (37%) and hypertensives (67%) in the sample. On the other hand, subjects with multiple risk factors may be encouraged to exercise. This will lead to attenuation of the relation between physical activity and risk factors clustering.

This study has shown that the clustering of risk factors is indeed common among Malaysian adults and it did not arise by chance. Overall, 61% of adults had at least one risk factor and 27% of adults had 2 or more risk factors. This is of course not unique to Malaysia. Many other population studies had similarly found high prevalence of risk factors clustering[34-40]. Specific groups at particular high risk of risk factors clustering in this country were Indian and Malay women.

Table VII
Cumulative Odds Ratio (95% Confidence Interval) from Ordinal Regression (Proportional Odds) Model Predicting Cumulative Probability of Number (0 to 4) of Risk Factors Present

Factors	Cumulative OR	(95% Confidence Interval)
Sex-ethnic group		
Malay men(ref*)	1	-
Chinese men	1.09	(1.15, 1.03)
Indian men	1.57	(1.71, 1.44)
Other indigenous men	0.79	(0.85, 0.74)
Malay women	1.43	(1.50, 1.36)
Chinese women	0.88	(0.94, 0.83)
Indian women	1.22	(1.34, 1.12)
Other indigenous women	1.03	(1.11, 0.96)
Age group (years)		
30 - 39 (ref*)	1	-
40 - 49	1.88	(1.96, 1.81)
50 - 59	3.01	(3.16, 2.87)
60 - 69	3.47	(3.67, 3.27)
>=70	2.90	(3.13, 2.68)
Number of years of education		
0 - 3 (ref*)	1	-
4 - 10	1.11	(1.16, 1.06)
>10	0.92	(0.97, 0.87)
Household income (1000 RM)		
<1	1	-
1 - 2	1.20	(1.25, 1.15)
>2	1.12	(1.17, 1.07)
Urban-rural residence		
Urban (ref*)	1	-
Rural	0.85	(0.88, 0.81)
Physical activity		
Inactive (ref*)	1	-
Active	0.81	(0.84 0.78)

** ref is reference category in regression analysis*

As expected clustering of risk factors was associated with higher income, urban residence and physical inactivity. This is in keeping with the hypotheses that these risk factors had evolved in relation to changes in lifestyle brought about by urbanisation and modernisation[41,42]. And Malaysia has undergone remarkably rapid socio-economic development in the last 4 decades. Indeed, the prevalence of risk factors clustering is particularly high in societies in transition such as Australian Aboriginals[38], Polynesians[39,40] and Micronesians[39].

The high prevalence of risk factors clustering among Malaysian adults has important implications. The detection of any risk factor ought to prompt screening for other risk factors. This may be already widely accepted in medical practice in this country. More importantly, treatment of patients with any particular risk factor must emphasise the aggressive management of all risk factors present. Traditional approach, as implemented in Diabetes or Hypertension clinics in primary care setting, is probably still very much focus on specific condition. Such a narrow focus is undesirable. A recent authoritative paper[43] has challenged the concept that Non-insulin dependent diabetes (NIDDM) is a discrete disease state. NIDDM is more properly regarded as a risk factor state, a component of Chronic Disease Risk Factor syndrome that includes hypertension, central obesity and dyslipidaemia. These risk factors are linked through a common mechanism, possibly hyperinsulinaemia or insulin resistance[15]. Thus, these risk factors are manifestations of a much broader underlying disorder. Such a concept has important implications for the primary prevention of these risk factors. It suggests an integrated lifestyle approach to prevention aimed at addressing all of the risk factors would be more effective than tackling each condition separately[43,44]. Prevention programme must stress the importance of healthy lifestyle, good nutrition, weight reduction in the obese and increased physical activity[43,44].

In conclusion, risk factor clustering is common among Malaysian adults. Treatment and prevention programme for hypertension, abnormal glucose tolerance, hypercholesterolaemia and overweight must emphasise the multiple risk factor approach.

Table VIII
Cumulative Odds Ratio (Cum. OR, 95% Confidence Interval) from Ordinal Regression (Proportional Odds) Models Predicting Cumulative Probability of Number (0 to 4) of Risk Factors Present in 4 Ethnic Populations Stratified by Sex

	Malay		Chinese		Indian		Other Indig.	
	Cum. OR	(95% CI)	Cum. OR	(95% CI)	Cum. OR	(95% CI)	Cum. OR	(95% CI)
Men								
Age group (years)								
30 - 39 (ref*)	1	-	1	-	1	-	1	-
40 - 49	1.8	(1.96, 1.66)	1.67	(1.86, 1.5)	2.13	(2.59, 1.75)	1.61	(1.87, 1.39)
50 - 59	2.41	(2.67, 2.18)	2.05	(2.31, 1.82)	3.51	(4.64, 2.66)	2.17	(2.58, 1.83)
60 - 69	2.95	(3.31, 2.63)	2.73	(3.15, 2.36)	2.62	(3.38, 2.03)	2.47	(2.99, 2.04)
>=70	2.31	(2.74, 1.94)	1.95	(2.37, 1.61)	1.33	(1.93, 0.92)	3.14	(4.1, 2.41)
Number of years of education								
0 - 3 (ref*)	1	-	1	-	1	-	1	-
4 - 10	1.37	(1.5, 1.25)	1.12	(1.27, 0.99)	1.35	(1.75, 1.05)	1.83	(2.12, 1.59)
>10	1.57	(1.77, 1.39)	1.14	(1.32, 0.99)	0.95	(1.31, 0.69)	1.42	(1.78, 1.14)
Household income (1000 RM)								
<1	1	-	1	-	1	-	1	-
1 - 2	1.19	(1.29, 1.1)	0.88	(0.99, 0.78)	1.14	(1.39, 0.93)	1.71	(2, 1.46)
>2	1.27	(1.4, 1.15)	0.84	(0.94, 0.76)	1.48	(1.87, 1.18)	2.1	(2.57, 1.71)
Urban-rural residence								
Urban (ref*)	1	-	1	-	1	-	1	-
Rural	0.84	(0.9, 0.78)	0.95	(1.05, 0.86)	0.8	(0.98, 0.66)	0.89	(1.02, 0.78)
Physical activity								
Inactive (ref*)	1	-	1	-	1	-	1	-
Active	0.83	(0.89, 0.77)	0.83	(0.91, 0.76)	0.84	(0.99, 0.71)	0.73	(0.83, 0.64)
Women								
Age group (years)								
30 - 39 (ref*)	1	-	1	-	1	-	1	-
40 - 49	2	(2.16, 1.85)	2.04	(2.28, 1.83)	2.3	(2.77, 1.91)	1.97	(2.24, 1.73)
50 - 59	3.89	(4.32, 3.51)	5.09	(5.75, 4.52)	4.89	(6.48, 3.7)	2.45	(2.94, 2.03)
60 - 69	4.28	(4.83, 3.79)	5.93	(7.03, 5)	6.48	(9.25, 4.53)	2.33	(2.82, 1.92)
>=70	3.78	(4.34, 3.29)	5.21	(6.44, 4.21)	3.39	(4.97, 2.31)	2.61	(3.25, 2.09)
Number of years of education								
0-3 (ref*)	1	-	1	-	1	-	1	-
4-10	1.29	(1.4, 1.19)	0.86	(0.96, 0.77)	1.2	(1.45, 0.99)	1.19	(1.37, 1.04)
>10	0.85	(0.94, 0.76)	0.42	(0.48, 0.36)	0.77	(0.99, 0.6)	0.55	(0.7, 0.44)
Household income (1000 RM)								
<1	1	-	1	-	1	-	1	-
1-2	1.21	(1.3, 1.12)	1.05	(1.17, 0.94)	1.23	(1.52, 0.99)	1.69	(1.92, 1.48)
>2	0.95	(1.05, 0.86)	1.06	(1.17, 0.96)	0.91	(1.12, 0.74)	1.42	(1.69, 1.2)
Urban-rural residence								
Urban (ref*)	1	-	1	-	1	-	1	-
Rural	0.88	(0.94, 0.82)	0.9	(1.01, 0.8)	0.7	(0.87, 0.57)	0.74	(0.83, 0.66)
Physical activity								
Inactive (ref*)	1	-	1	-	1	-	1	-
Active	0.81	(0.88, 0.75)	0.86	(0.96, 0.78)	0.93	(1.1, 0.78)	0.85	(0.95, 0.77)

** ref is reference category in regression analysis*
*** Other Indig. Means other indigenous ethnic groups*

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