Association between fatty acids and coronary heart disease: A scoping review

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ABSTRACT

Introduction: High intakes of total fat are long known as a risk factor for coronary heart disease (CHD), but the association between fatty acids and CHD remains unclear. This scoping review aims to collate and analyze the association between types of fatty acid and risk of CHD.

Materials and Methods: This review uses the methodological framework of Arksey and O'Malley. A total of 19 studies were selected from 9456 studies screened from the electronic databases.

Results: Majority of the studies reported no association between saturated fat (SFA) and monounsaturated fat (MUFA) with CHD. Meanwhile, seven out of 12 studies reported inverse association between polyunsaturated fat (PUFA) and risk of CHD whilst 67% of the studies found that trans-fat intake was positively associated with CHD risk.

Conclusions: This review finds that all the types of dietary fat have different effects on the risk of CHD. Nevertheless, intakes of healthy fat such as MUFA and PUFA in controlled amounts are expected to reduce CHD risk. In addition, the divergence of findings found between studies might be due to the methodological inconsistencies. More robust research is needed to determine the actual dietary determinants of CHD as it will provide important information for future development of dietary intervention.

KEYWORDS:
Type of fatty acid, dietary fat, fat intake, coronary heart disease

INTRODUCTION

In recent years, non-communicable diseases (NCDs) have become a global concern. The four main NCDs are cardiovascular diseases (CVDs), cancers, respiratory diseases and diabetes.[1] World Health Organization (WHO) 2017 has estimated that out of the 17 million premature deaths due to NCDs in 2015, 37% were caused by CVDs.[2] In the United States of America (USA), it was estimated that the annual cost of CVD in 2014-2015 was estimated at $351.2 billion.[3] Improved preventions of CVD can help to reduce the number of CVD incidence as well as their treatment cost globally. Of all CVDs, coronary heart disease (CHD) is the most common type of CVDs.

A number of risk factors have been associated with CHD, known as modifiable and non-modifiable risk factors. Apart from the non- modifiable risk factors such as age, sex and family history, the lifestyle risk factors of CHD such as smoking, poor lipid profile, physical inactivity and unhealthy dietary intake are the major contributing factors towards CHD.[4,5] Global clinical practice guidelines still advise that CHD treatments and prevention methods are based on underlying risk factors. Adherence to a healthy diet may reduce the mortality rate of CVD by eight to 45%.[6] Therefore, the main objective of Medical Nutrition Therapy is to reduce the intake of cholesterol, total fat, and saturated fat (SFA). It is believed that high SFA and trans-fat consumption may increase low-density lipoprotein (LDL) cholesterol levels which leads to CVD.[7] High LDL-cholesterol can increase lipids deposition in the arterial wall, leading to the build-up of plaque and narrowing the arteries, known as atherosclerosis process.[8]

However, the recent guidelines from USA Dietary Guidelines and Recommended Nutrient Intake (RNI) for Malaysia removed the cholesterol intake recommendation as there is insufficient evidence to show whether lowering cholesterol intake reduces LDL-cholesterol.[7] Previous studies found that the reduction of SFA consumption together with increased intake of unsaturated fatty acids would reduce the incidence of CHD.[9] Over the years, there are conflicting arguments on the association between fatty acids and CHD that may confuse the public and healthcare practitioners. Therefore, the association between fatty acids and CHD has to be examined continually and extensively using the most current evidence as the type of fatty acids in dietary intake have an important role in determining CHD risk.

Thus, this paper aims to collate, assemble and analyze previous literature on the association between fatty acids and the risk of CHD. The findings are important to provide a basis for the development of dietary intervention, particularly for at-risk patients.

MATERIALS AND METHODS

This review was conducted using the methodology outlined by Arksey & O'Malley.[10] The five stages included in this framework were (1) identification of research questions, (2) identification of related studies, (3) study selection, (4)

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charting of data and (5) collating, summarizing, and reporting the results. A flow diagram based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2009) from literature search to its final selection is shown in Figure 1.

Identifying the research questions
The research question to be addressed in this review was 'what is the association of type of fatty acids with the risk of CHD?'

Identifying relevant studies
Two databases were utilized in the search method i.e. Medline (via EBSCOHost) and SCOPUS. The initial selection criteria were broad to ensure that as many studies as possible were assessed according to the criteria of the studies. There was no restriction in the year of publication and this review included studies conducted in any country and published in English. All observational studies such as retrospective, prospective, case-control and cross-sectional studies which report on the association between fatty acids with CHD were included in the search. To be eligible for inclusion in this review, a study had to be conducted in the adult population (≥18 years) and only studies that employed validated dietary assessment (i.e. FFQ, 3-7 days diet diary, 24 hours diet recall, and food records) were included in this review paper. Key search terms used for searching articles are recorded in Table I.

Study selection
The selection of relevant studies was based on the research questions and eligibility criteria. Duplicates were removed, and the remaining titles and abstracts were screened by two independent reviewers following the eligibility criteria. Any abstract that did not meet the study criteria were excluded. Then, full texts were assessed by the reviewer according to inclusion/exclusion criteria independently. In addition, the exclusion was applied to non-relevant articles. Non-duplicated original articles from the review paper were checked and included.

Charting the data
The country(-ies), author(s), year of publication, type(s) and purpose(s) of study, characteristic of participants, dietary assessment method, fat intake, incidence and findings are described in Table II.

Collating, summarizing and reporting the results
Evaluations of the review on the association of type of fatty acids with risk of CHD are summarised in Table II.

RESULTS

Figure 1 illustrates the process of inclusion of the eligible studies for this scoping review. Initially, 9,456 articles were obtained, 1,300 from Scopus and 8,156 from Medline. After removing the duplicates of articles, 9,090 articles remained. Those articles were screened and only 101 full-text articles were assessed for eligibility. Finally, only 19 studies were included in this scoping review after excluding 82 articles with reasons. Out of 19 studies, 16 were observational prospective studies, two were case-control studies and one was cross-sectional study.

Nine studies were conducted in the United State of America (USA), two studies each were conducted in Denmark, Netherlands and Norway, and the remaining studies were from Finland, Italy, United Kingdom and Iran. The total number of participants involved in all studies was 869,608 ranging from 222 to 344,696. The duration of follow-up across the studies ranged from 4 to 30 years. The age range of the participants was eighteen to 86 years old. Three studies involved only female participants, five studies involved male participants, whilst eleven studies involved both sexes. Eleven out of 19 studies used a food frequency questionnaire (FFQ) to assess dietary intake, meanwhile, eight studies used other methods including dietary history interview, 4-day food recording, 7-day weighed food record, cross-check dietary history, and 24-hour diet recall.

The association between fatty acid intakes and CHD were reported in different ways between studies (Table II). Seventy-seven per cent of the studies reported that saturated fat (SFA) was not associated with CHD.[11–20] In contrast, Jakobsen et al. in their cohort study found a positive association between CHD and SFA intake among females with HR = 1.36 (0.98, 1.88).[21] However, no overall association between SFA and CHD was found among males in the same study. Posner et al. found that SFA intake had a marginally significant association with CHD.[22] Conversely, another study by Jakobsen et al. showed that there was a significant inverse association between polyunsaturated fat (PUFA) and risk of coronary events for each 5% substitution of SFA with PUFA with HR = 0.89 (0.50, 1.57) for females and HR = 0.80 (0.55, 1.15) for males.[23]

Six out of nine studies reported no association between monounsaturated fat (MUFA) and CHD.[12,14,15,18,19,21] However, a study by Virtanen et al.[17] showed that MUFA intake was positively associated with increased risk of CHD with HR=1.40 and 95% CI (0.90-2.20) whilst Posner et al.[22] found this association only among 45-55y people. In contrast, a case-control study conducted by Moghadam et al. showed a negative association between MUFA and CHD risk (OR=0.7, 95% CI 0.45-1.08).[20] In terms of PUFA alone, seven out of twelve studies reported an inverse association between PUFA and the risk of CHD.[14,15,17,19–21,24] Jakobsen et al. found that PUFA intake was inversely associated with risk of CHD among females, HR = 0.89 (0.50, 1.57).[21] Conversely, other five studies showed that PUFAs were not linked with CHD protection.[12,18,22,25,26]

Nonetheless, 67% of the studies included in this review found that trans-fat intakes were positively associated with CHD risk with a relative risk or hazard ratio between 1.20 to 3.3.[11,12,14,15,27,28] However, a study done by Smith et al. showed different finding between males and females.[28] The odds of CHD were smaller in the highest intake of total trans fatty acid (OR=0.59, 95% CI 0.35,1.00) among males, but trans fatty acid intake did not appear to influence odds of CHD (OR=1.24, 95% CI 0.64, 2.41) among females. The other three studies showed no association between trans-fat CHD risk.[17,18,29]

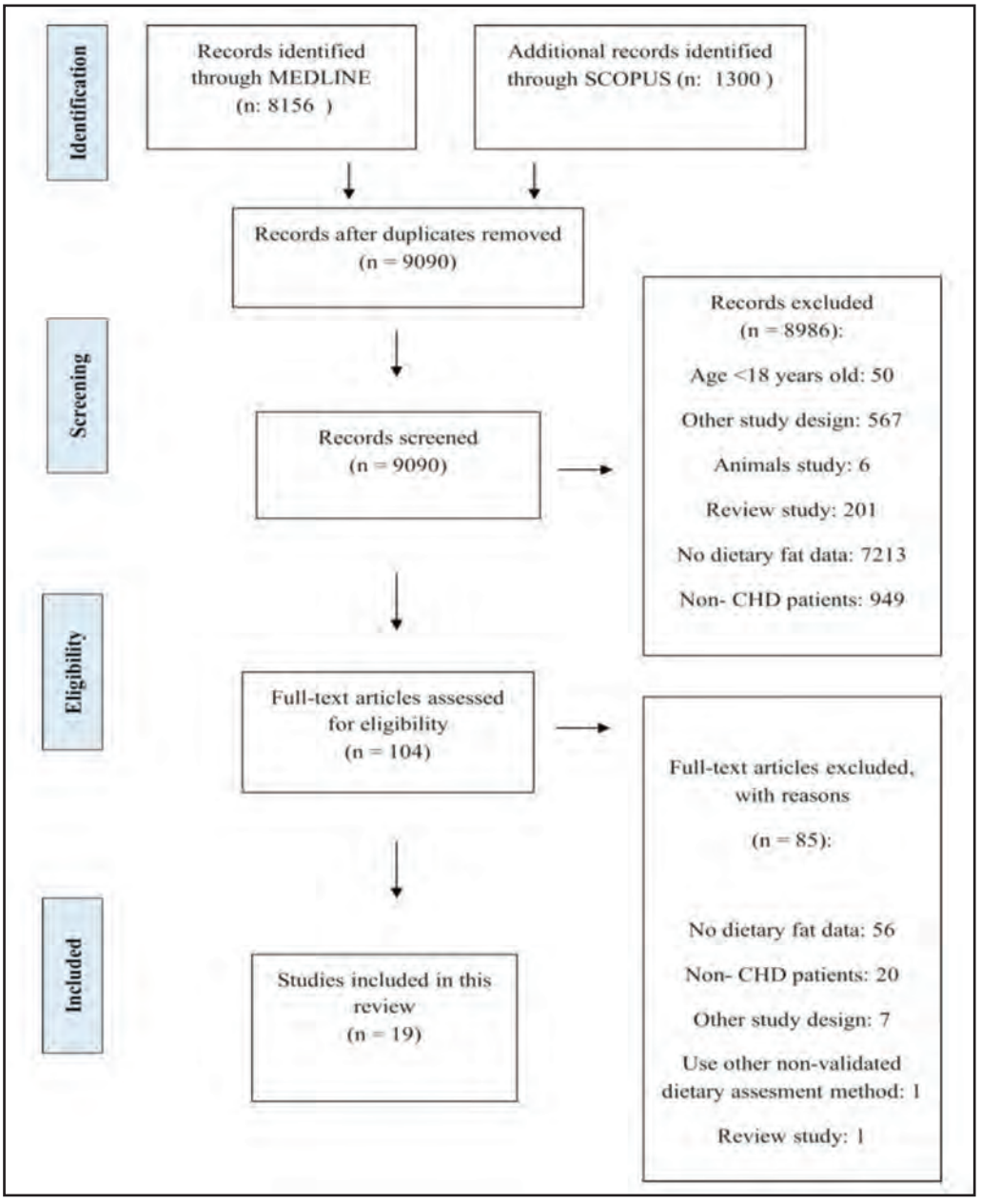

Fig. 1: PRISMA flow diagram of article screening and eligibility.

Table I: Key terms in the scoping review

Key Search Terms
"Dietary Fat" AND "Coronary Heart Disease" OR CHD
"Dietary Fat" AND "Coronary Artery Disease" OR CAD
"Fat Intake" AND "Coronary Heart Disease" OR CHD
"Fat Intake" AND "Coronary Artery Disease" OR CAD

DISCUSSION

Each type of fatty acid gives a different effect on blood cholesterol levels, either beneficial or adverse.[30] Most the dietary guidelines limit the intake of SFA as it has been believed that SFA increases CHD risk due to its potential effect in increasing low-density lipoprotein (LDL) cholesterol. The original American Heart Association (AHA) Step 1 suggested an ideal balance of dietary fat consumption by 1:1:1 for SFA: MUFA: PUFA to maintain a good plasma LDL/HDL level.[31] The current recommendation from the AHA indicates that a lower intake of saturated fat accompanied by higher intake

Table II: General characteristics and important findings of included studies

Country	Author (Year)	Types, Purpose of the study & Duration of follow up (years)	Participants' characteristic	Dietary assessment method	The intake of fat	Findings
Denmark	Jakobsen et al. (2004)	Prospective cohort study -to describe the associations between the energy intake from total dietary fat and the major types of dietary fat and risk of CHD -16 years of follow up	N= 3686 Age: 30-71 years Sex: Both CHD cases: 326	7-day weighed food record or a dietary history interview	Saturated fat Female: 19.5% Male: 19.7%	- A 5% greater energy intake from the consumption of SFA among females will increase the CHD risk by 36% (HR= 1.36, 95% CI 0.98, 1.88) - SFA and CHD was not associated among males, (HR=1.03, 95% CI 0.78, 1.37)
					MUFA Female: 15.2% Male:15.8%	- There was no association between MUFAs intake and the risk of CHD among females (HR= 1.01, 95% CI 0.56, 1.83) and males (HR=0.95, 95% CI 0.65, 1.40)
					PUFA Female: 6.5% Male:6.5%	There was an inverse trend between the percentage of energy derived from PUFA and risk of CHD but not significant among females (HR= = 0.89, 95% CI 0.50, 1.57) and males (HR= 0.80, 95% CI 0.55, 1.15)
US	Jakobsen et al. (2009)	Prospective cohort study - to investigate associations between energy intake from MUFA, PUFA and carbohydrates and risk of CHD and to clarify whether energy from unsaturated fatty acids or carbohydrates should replace energy from SFAs to prevent CHD. - 4-10 years of follow up	N= 344,696 Age: 37-76 years Sex: Both CHD cases: 5249	Dietary history interview/ FFQ	Saturated fat 10.1%	- PUFAs had a significant negative correlation with CHD risk, if replacing SFs with PUFAs by 5 percent, (HR=0.87, 95% CI 0.77-0.97) - Carbohydrates had moderate significant positive correlation with CHD risk, if replacing SFs with carbohydrate by 5 percent, (HR=1.07, 95% CI 1.01-1.14)
US	Posner et al. (1991)	Prospective cohort study -to examine the effect of major dietary lipid components on the longitudinal incidence of CHD in the Framingham cohort population - 16 years of follow up	N= 859 Age: 45-65 years Sex: Male CHD cases: 213	24-hour dietary intake	SFA 45-55y: 15.2% 56-65y: 14.8%	- SFA intake was marginally significant
					MUFA 45-55y: 16.2% 56-65y: 15.5%	- MUFA intake among 45-55y was positively associated with CHD and no association among 56-65y people
					PUFA 45-55y: 5.5% 56-65y: 5.4%	- PUFAs intake was not associated with CHD among 45-55y people and 56-65y people
US	Hu et al. (1999)	Prospective cohort study -to examine the associations between intakes of individual saturated fatty acids and their food sources and risk of CHD - 14 years of follow up	N= 80,082 Age= 34-59 years Sex: Female CHD cases: 939	FFQ	SFA Median intake of 4:0-10:0 (% of energy): 1st quantile: 0.87 5th quantile: 2.00 Median intake of sum of 12:0-18:0 (% of energy): 1st quantile: 9.5 5th quantile: 17.2	- No significant association between consumption of short to medium chain SFAs with CHD risk (RR= 1.07, 95% CI 0.89, 1.30) - Consumption of longer-chain SFAs were each separately correlated with a small risk increment (RR= 1.14, 95% CI 0.93, 1.39)

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US	Xu et al. (2006)	Prospective cohort study - to examine the associations between intakes of dietary fat and CHD incidence in American Indians - 7.2 years of follow up	N= 2398 Age: 47-79 years Sex: Both CHD events: 436	Cross-check dietary history method	SFA 1st quartile= 7.5% 4th quartile= 16.5%	- No association between SFA and its components with CHD incidence after the variable adjustments (HR= 1.15, 95% CI 0.81, 1.63)
					MUFA 1st quartile= 8.5% 4th quartile= 18.2	- In multivariate analyses, there were no statistically significant interactions for CHD incidence between quartiles of dietary fat intake and sex, diabetes, or age group - Intake of total fat and its components were not associated with CHD incidence after the analysis was controlled for other MUFA: HR (95% CI) = 1.23 (0.86, 1.76) PUFA: HR (95% CI) = 1.18 (0.81, 1.71) Trans fat: HR (95% CI) = 1.21 (0.85, 1.74)
					PUFA 1st quartile= 3.5% 4th quartile= 9.9%	
					Trans fat 1st quartile= 0.9% 4th quartile= 3.9%	
Finland	Virtanen et al. (2014)	Prospective cohort study - to examine the associations between dietary fatty acids with risk of CHD - 21.4 years of follow up	N= 1981 Age: 42-60 years Sex: Male CHD cases: 382	4-day food recording	SFA 1st quantile = 13.4% 4th quantile= 22.8%	- No association between SFA consumption and CHD risk (HR=1.05; 95% CI 0.70-1.57)
					MUFA 1st quantile = 8.6% 4th quantile= 13.4%	- MUFA intake was associated with increased risk (HR= 1.40, 95% CI 0.90-2.20)
					PUFA 1st quantile = 2.9% 4th quantile= 6.3%	- PUFA was associated with decreased risk of fatal CHD (HR= 1.00, 95% CI 0.64-1.56)
					Trans fat 1st quantile = 0.7% 4th quantile= 1.5%	- Trans fat intakes were not associated with CHD risk (HR= 0.94, 95% CI 0.70–1.26)
US	Oh et al. (2005)	Prospective cohort study - to examine the associations between dietary fat and specific types of fat with risk of CHD among US female initially free of CVD and diabetes - 20 years of follow up	N= 78,778 Age: 30-55 years Sex: Female CHD cases: 1766	FFQ	SFA 1st quantile = 10.1% 5th quantile= 17.6%	- No significant association between consumption of SFA with CHD (RR= = 0.97, 95% CI 0.74-1.27)
					MUFA 1st quantile = 10.6% 5th quantile= 18.0%	- MUFA were not statistically significant predictors of CHD after adjustments (RR= 0.82, 95% CI 0.62-1.10)
					PUFA 1st quantile = 4.1% 5th quantile= 7.4%	-PUFA intake was significantly associated with lower risk of CHD (RR= 0.75, 95% CI 0.60-0.92)
					TRANS FAT 1st quantile = 1.3% 5th quantile= 2.8%	- A significant direct association between consumption of trans-fat and CHD risk was found (RR= 1.33, 95% CI 1.07-1.66)

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Table II: General characteristics and important findings of included studies

Country	Author (Year)	Types, Purpose of the study & Duration of follow up (years)	Participants' characteristic	Dietary assessment method	The intake of fat	Findings
US	Hu et al. (1997)	Prospective cohort study - to examine the associations between dietary intake of specific types of fat and risk of CHD - 14 years of follow up	N= 80,082 Age: 34-59 years Sex: Female MI cases: 658	FFQ	SFA 1st quantile= 10.7% 5th quartile= 18.8%	- No association between SFA and CHD risk (RR= 1.07, 95% CI 0.77–1.48)
					MUFA 1st quantile= 11.0% 5th quartile=19.3%	- No association between MUFA and CHD risk (RR= 0.95, 95% CI 0.64–1.39)
					PUFA 1st quantile= 2.9% 5th quartile= 6.4%	- PUFA was not associated with CHD risk (RR= 0.68, 95% CI 0.53–0.88)
					TRANS UNSATURATED FAT 1st quantile= 1.3% 5th quartile= 2.9%	- There is a significant association between trans unsaturated fat and CHD risk (RR= 1.53, 95% CI 1.16–2.02)
US	Ascherio et al. (1996)	Prospective cohort study - to examine the association between fat intake and the incidence of coronary heart disease in men of middle age and older - 6 years of follow up	N= 43,757 Age: 40-75 years Sex: Male CHD cases: 505	FFQ	SFA 1st quantile= 7.2% 5th quartile= 14.8%	- SFA was correlated with increased myocardial infarction risk, but the correlation reduced after fibre intake adjustment (RR= 0.96, 95% CI 0.73 to 1.27)
					Trans Fat 1st quartile= 0.8% 5th quartile= 1.6%	- There was a positive association between trans fatty acids consumption with risk of myocardial infarction after adjustment for age and standard risk factors but reduced after further adjustment for fibre intake (RR= 1.21, 95% CI 0.93 to 1.58)
US	Li et al. (2015)	Prospective cohort study - to study associations between dietary saturated fats compared with unsaturated fats and different sources of carbohydrates in relation to CHD risk - 24-30 years of follow up	N=127,536 Age: 30-75 years Sex: Both CHD cases: 7667	FFQ	SFA Male: 1st quantile = 7.4% 5th quantile= 13.6% Female: 1st quantile= 9.6% 5th quantile=16.9%	- No association between SFAs with CHD among males (HR= 0.93, 95% CI 0.82–1.05)
					MUFA Male: 1st quantile = 9.0% 5th quantile= 15.1% Female: 1st quantile= 10.4% 5th quantile= 17.3%	- MUFAs were not associated with CHD (HR=1.00, 95% CI 0.87–1.13)
					PUFA Male: 1st quantile = 5.2% 5th quantile= 7.5% Female: 1st quantile= 4.9% 5th quantile= 7.4%	- Higher PUFA intake was associated with a lower risk of CHD (HR= 0.80, 95% CI 0.73–0.88)
					Trans fat Male: 1st quantile = 0.7% 5th quantile= 1.9% Female: 1st quantile= 1.1% 5th quantile= 2.6%	- Trans-fat intake was significantly associated with an increased risk of CHD (HR= 1.20, 95% CI 1.09–1.32)

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Table II: General characteristics and important findings of included studies

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Norway	Puaschitz et al. (2015)	Prospective cohort study -to examine the association between self-reported dietary SFA intake and risk of subsequent coronary events and mortality in patients with coronary artery disease - 4.8 years of follow up	N= 2412 Age: 27-86 years Sex: Both CHD cases: 292	FFQ	SFA 1st quartile= 8.4% 4th quartile= 15%	- Consumption of SFA was not significantly associated with coronary risk events (RR= 0.83, 95% CI 0.59, 1.16)
US	Hu et al. (2002)	Prospective cohort study - To examine the association between fish and long-chain omega-3 fatty acid consumption and risk of CHD in women - 16 years of follow up	N= 84,688 Age: 34-59 years Sex: Both CHD cases: 1513	Semi quantitative FFQ	Median intake of Omega-3 Fatty Acid (% of energy) 1st quintile= 0.03 5th quintile= 0.24	- There was a significant inverse association between dietary omega-3 fatty acids consumption and CHD risk. This inverse association stronger for fatal CHD than for nonfatal MI (RR= 0.69, 95% CI 0.57-0.84)
Norway	Manger et al. (2010)	Prospective cohort study - to examine the relation between dietary intake of n–3 LCPUFAs or fish and risk of future coronary events or mortality in patients with well-characterized CAD. - 4.75 years of follow up	N= 2412 Age: >18 years Sex: Both Coronary event: 292	FFQ	n-23 LCPUFAs (g) 1st quartile= 0.58±0.29 4th quartile= 2.64±1.18 * Mean ± SD	- There was no dose-response relation between quartiles of n–3 LCPUFAs (based on intake as percentage of total energy) and coronary events or separate endpoints (HR= 0.95, 95% CI 0.69, 1.31)
Nether-lands	Oomen et al. (2001)	Prospective cohort study - to examine whether dietary alpha-linolenic acid intake was inversely associated with risk of CAD. - 10 years of follow up	N= 667 Age: 64-84 years Sex: Male CHD cases: 98	Cross-check dietary history method	The mean (± SD) daily intake of α-linolenic acid was 1.32 ± 0.47 g	No association between consumption of α-linolenic acid and the CAD risk (RR= 1.68, 95% CI 0.86, 3.29)
Nether-lands	Oomen et al. (2001)	Prospective cohort study - to investigate the association between trans fatty acid intake and risk of CHD in the Zutphen Elderly Study - 10 years of follow up	N= 667 Age: 64-84 years Sex: Male CHD cases: 98	Cross-check dietary history method	Daily mean of trans fat intake, g/day: Year 1985= 10.9±6.3 Year 1995= 4.4±1.7	- Trans fatty acid intake at baseline was positively associated with the 10-year risk of coronary heart disease (RR= 2·00, 95% CI 2·07–3·75)
Denmark	Jakobsen et al. (2008)	Prospective cohort study -to describe the association between R-TFA intake and risk of CHD evaluating both the absolute and the energy-adjusted intake. - 18 years of follow up	N= 3686 Age: 30-71 years Sex: Both	7 day weighed food record	R-TFA intake (g/d) Female Q1= 0.7 (0.3,0.8) Q5= 2.7 (2.3, 3.8) Male Q1= 0.8 (0.4,1.0) Q5= 3.4 (2.8, 4.9)	- There were no overall associations between absolute R-TFA intakes and risk of CHD (HR= 0.98, 95% CI 0.92, 1.05)

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Country	Author (Year)	Types, Purpose of the study & Duration of follow up (years)	Participants' characteristic	Dietary assessment method	The intake of fat	Findings
Italy	Marangoni et al. (2013)	Case-control study -to examine the relationship between MI, whole blood fatty acids and the diet in Italian cohort.	N= 222 Age: 18-70 years Sex: Both Case: 119 Control:103	Semiquantitative FFQ	SFA Mean (SD) Cases: 28.6 (12.6) Control: 28.1(14.6)	- No significant association was detected between SFA and MI risk (OR=2.25, 95% CI 0.96-5.27)
					MUFA Mean (SD) Cases: 38.7(14.5) Control: 38.9(17.4)	- No significant association was detected between MUFA and MI risk (OR=1.95, 95% CI 0.77-4.90)
					PUFA Mean (SD) Cases: 9.3(3.9) Control: 9.2(4.4)	- MI risk significantly and steadily decreased with increasing levels of total PUFA (OR=0.14, 95% CI 0.05-0.40)
Iran	Moghadam et al., (2017)	Case- control study -to evaluate the association between nutrition factors and CHD among Armenians in Yerevan	N= 640 Age: more than 30 years Sex: Both Case: 320 Control: 320	Semiquantitative FFQ	SFA Mean (SD) Cases: 30.1(8) Control: 30.7(8.8)	- No significant association between SFA and CHD risk. (OR=0.84, 95% CI 0.54-1.31)
					MUFA Mean (SD) Cases:21.7(5.1) Control: 22.9(6.4)	- Higher intakes of MUFA were associated with a reduced risk of CHD (OR=0.7, 95% CI 0.45-1.08)
					PUFA Mean(SD) Cases: 13.1(4.5) Control: 15.1(5.6)	- Higher intakes of PUFA were associated with a reduced risk of CHD (OR=0.22, 95% CI 0.14-0.35)

of PUFA and MUFA is associated with a reduced rate of CVD.[9] In this review, only one study showed that gender may influence the association of SFA and risk of CHD. A study showed a positive association between SFA and CHD risk, in which the association was only found among women and no overall association was found among men.[21] There may be due to the production of postprandial hypertriglyceridemia by fat that increases triglycerides. High triglycerides level is one of the CHD mortality risk factors that is stronger in women compared to men.[21] This finding is in line with the study done by Naska et al. which found out that lipoprotein metabolism is faster approximately two-fold in women compared with men, due to the stimulatory effects of estrogen in women and the inhibitory effects of androgen in men, thus, a greater increment in CHD risk is associated with women.[32] However, other study showed no association between SFA and CHD in both sexes.[14] Besides, findings from a study done by Hu et al. showed that intakes of longer-chain SFA are associated with a small increase in CHD risk which may be related to postprandial responses to these fatty acids.[13] On the contrary, this review found an inverse association between SFA intake and risk of CHD, which could be due to the replacement of other macronutrients to maintain energy balance. A recent study also suggests that substituting SFAs with PUFAs instead of MUFAs or carbohydrates prevents CHD over a wide range of intakes.[23]

There were two studies that reported a positive association between MUFA and risk of CHD. Conversely, one study reported a negative association between MUFA and CHD incidence and other prospective studies of MUFA intake and CHD risk had a different conclusion, in which no association with higher intake of MUFA. An analysis by Posner et al. showed that a higher level of MUFA intake was associated with increased CHD mortality and morbidity in the younger male cohort.[22] These findings were contradicting with previous studies which showed a beneficial effect on CHD.[20] This might be due to the different sources of MUFA, in which in Posner et al. study, MUFAs were obtained from animal food products which high in both MUFA and SFA.[22] Meanwhile, it was suggested that previous studies obtained MUFA largely from vegetable sources.[22] Another recent study suggested that MUFAs were associated with an increased risk of CHD which might be due to underlying hepatic de novo lipogenesis activation.[33] However, Virtanen et al. explained that there was a probability that the incorporation of two highly correlated variables (PUFA and MUFA) in the same model has led to the greater CHD death risk.[17] Due to these mixed findings, further research on the impact of MUFA on the risk of CHD is highly required.

The majority studies reported an inverse association between PUFA and the risk of CHD. Virtanen et al. pointed out that PUFA has beneficial effects to reduce CHD risk factors, including blood total/high-density lipoprotein cholesterol ratio, insulin resistance, blood pressure, and vascular function.[17] Besides, higher PUFA intake will reduce the thickness of carotid artery wall. It is in line with the findings of a meta-analysis of randomised clinical trials (RCTs) which showed that each 5% energy greater in PUFA consumption in place of SFA reduced CHD risk by 10%.[34] Omega-3 and omega-6 are the two most biologically important PUFA classes. Several potential mechanisms of omega-3 fatty acids intake in reducing CVD risk are by lowering triglyceride levels, increasing HDL, lower resting blood pressure, decrease aggregation of platelet, reduce atherosclerosis, and reduce inflammation.[35] On the other hand, although many studies suggested that omega-6 fatty acid intakes reduce CHD risk, there was a concern that high omega-6 fatty acids intake might have a bad effect on cardiovascular health. However, the latest meta-analysis claimed that an intake of omega-6 fatty acid within the range as recommended by the AHA was not associated with CVD risk.[36]

In contrast, positive associations between intake of trans fatty acid and risk of CHD were reported in many studies in this review. The highest RR was 2.00 (95% CI 2.07, 3.75) which was related to the 10-year risk of CHD.[27] The findings were consistent with the result of most previous studies.[37] Trans fatty acid can contribute to increased risk of CHD by increasing the ratio of LDL: HDL, increased ratio of apolipoprotein B: apolipoprotein A, increased cholesterol content in both LDL and HDL particles in comparison to SFA, increased plasma triglyceride levels, which adversely affects the essential fatty acid metabolism.[38,39]

Apart from the biological variance such as gender differences, the inconsistency of findings between studies might be due to different methodological approaches. One of the most important reasons could be the self-reported method of dietary assessments. All studies in this review reported dietary intake based on self-reported measurements which are at risk of bias. Participants' inability to accurately recall their food intake could be the source of errors as it might limit the validity of the generated information.[32] Furthermore, the effect of changes in dietary habits could not be assessed if only baseline information regarding dietary habits was available.[21] It was noted that the majority studies in this review used a food frequency questionnaire (FFQ) as it can assess long-term dietary intakes in a relatively simple, cost-effective and time-efficient manner. Although FFQ might produce measurement error related to methodology, however, it is proven to be a valid method to assess dietary intake particularly in a large sample size.[40] Besides dietary factor, variability in lifestyle habits such as physical inactivity, intake of alcohol, cigarette use and waist circumference are well known to be strongly correlated with increased risk of CHD and may confound the results and explain the variation between studies, however, it was not reported in individual study. In addition, the difference in the duration of follow-up might produce inconsistent outcomes among these studies. Moreover, demography differences among different study population will lead to divergence in habitual diet which affect the findings of study.

CONCLUSIONS

In conclusion, this scoping review of nineteen observational studies found conflicting results regarding the association between types of fatty acid with the risk of CHD. The discrepancies of the results among the studies might be due to many factors particularly the inter-studies variability of biological factors such as age and gender of participants. Methodological inconsistencies may also contribute to the

divergence of findings between studies. Nevertheless, more than 50% of the studies suggested no association between SFA and MUFA intake with CHD, whilst 58% suggested an inverse association between PUFA intake with CHD. Sixty-seven percent of the studies showed a positive association between trans-fatty acid with CHD. Overall, this review may provide new insights into current dietary guidelines for CHD prevention. More robust longitudinal prospective research is required to evaluate the association between dietary fat and CHD risk to confirm these findings.

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