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Association between type 2 diabetes and dietary patterns in Middle Eastern and North African populations (MENA): A systematic review

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ABSTRACT

Background: Examining diet from the perspective of combinations of food items and food groups rather than focusing on a single food item or a food group is defined as dietary patterns. Many studies have begun studying nutritional patterns and their associations to different chronic diseases, including type-two diabetes (T2D), a condition commonly found among the Middle East and North Africa (MENA) populations. *Materials and Methods:* PubMed, Web of Science, and Google Scholar were searched for studies that examined the associations between dietary patterns and having a diagnosis of T2D or with T2D laboratory parameters such as blood glucose or HbA1c levels. Data were extracted by summarising the features and outcomes of the included studies and, further, groups commonly identified similar dietary patterns together. *Results:* Overall, in the countries of the MENA region, 12 studies were identified. Among the commonly identified dietary patterns, three main groups are traditional, healthy, and fast food/Western. While evidence suggests a decreased association between healthy and traditional nutritional patterns and T2D, there was an increased association between fast food/Western nutritional patterns and T2D. *Conclusion:* The results of this systematic review suggest a relationship between dietary patterns and the risk of developing T2D. Such evidence could guide future research that can potentially inform the development of future evidence-based nutritional guidelines for better management and prevention of diabetes among MENA populations.

Keywords: Diet, Dietary Patterns, Type 2 diabetes, MENA

1. INTRODUCTION

World Health Organization's has estimated that 422 million adults are currently affected by diabetes, according to their 2016 report on the subject (Roglic, 2016). Among individuals diagnosed with Type 2 Diabetes (T2D),

70% originate from developing nations, which also includes the Middle East and North Africa (MENA) regions (Olokoba et al., 2012). According to Roglic, (2016), diabetes was the direct cause of death for 1.5 million adults in 2012. Additionally, there were 2.2 million deaths from conditions related to T2D, such as cardiovascular diseases. It is projected that the global population of individuals with diabetes will increase to 592 million by the year 2035. The majority of individuals who are diagnosed with T2D are typically aged between 45 and 64 years. However, there has been a rise in the occurrence of T2D among children and adolescents, which can be attributed to the growing problem of childhood obesity (Olokoba et al., 2012).

The etiology of type 2 diabetes (T2D), like other chronic non-communicable conditions such as hypertension, is multifactorial. It involves genetic and lifestyle factors (Ripsin et al., 2009). Modifiable risk factors linked to the development of Type 2 Diabetes (T2D) encompass dietary choices, excessive body weight, tobacco use, excessive alcohol consumption, and a lack of physical activity (Alhazmi et al., 2014). Fortunately, unlike the inherent genetic risk, numerous lifestyle risk factors, such as diet, can be modified. Studying the connection between diet and chronic diseases through dietary patterns, which involve combinations of foods and nutrients, is a relatively recent approach compared to the traditional method of focusing on specific nutrients or food groups (Cespedes and Hu, 2015; Moeller et al., 2007).

Nutritional epidemiologists have advocated this approach for various reasons. Typically, the various combinations of food people consume are likely to have interactive or synergistic effects (Cespedes and Hu, 2015; Moeller et al., 2007). In addition, the impact of individual nutrients may be too subtle to identify when combined with the overall impact of multiple nutrients in a dietary pattern. Furthermore, analyzing individual nutrients can be confounded by the impact of the overall dietary patterns (Moeller et al., 2007). In addition, the Dietary Guidelines Advisory Committee (DGAC) prioritized its recommendations in 2015 towards promoting healthy dietary patterns rather than individual dietary factors. The statement highlights the growing trend of using dietary patterns to educate the public about dietary recommendations rather than solely focusing on individual nutrients (Cespedes and Hu, 2015).

Various methods can be employed to identify the dietary patterns of a specific population, which can be classified broadly into investigator-defined and data-driven (Moeller et al., 2007; Previdelli et al., 2016). These two categories can also be merged and used together within a study (Moeller et al., 2007; Previdelli et al., 2016). In the investigator-defined (hypothesis-driven) approach, dietary patterns are established before the study occurs. Participants' adherence to a specific diet, such as the Mediterranean diet, can be assessed by categorizing them based on an index or score system. This allows for examining dietary patterns (Reedy et al., 2010). Dietary patterns are established data-driven by collecting dietary data from the participants. Various statistical techniques, such as cluster or factor analysis, can accomplish this task (Reedy et al., 2010).

Several recent studies have begun investigating the correlation between type 2 diabetes (T2D) and diet by analyzing dietary patterns rather than solely focusing on specific nutrients or individual dietary factors. This includes limited studies exploring the association between T2D and dietary patterns in MENA countries (Alhazmi et al., 2014; Emadian et al., 2015; Kennedy et al., 2005). Therefore, this systematic review aims to provide a concise overview of the existing evidence regarding the connection between type 2 diabetes (T2D) and dietary patterns in the MENA (Middle East and North Africa) regions.

2. METHODS

This systematic review investigates studies that analyze the correlation between dietary patterns and type 2 diabetes (T2D) in the Middle East and North Africa (MENA) regions. This section will analyze the methods employed in this systematic review, focusing on three primary categories: Search strategy, data extraction methods, and the quality assessment process for the studies included. The present systematic review has been officially registered in PROSPERO under the identification number CRD42017067576.

Search strategy

Inclusion criteria

The systematic review had five specific inclusion criteria: 1) the study had to be a primary study, 2) it had to be conducted in the MENA region, 3) the study had to examine well-defined dietary patterns as a factor of interest, 4) it had to include the diagnosis of T2D or related measures used to diagnose or monitor it as an outcome, and 5) it had to be published in English. Given that medical education in MENA countries is primarily conducted in English, all pertinent literature is anticipated to be released in English. The exclusion criteria encompass reviews and primary studies that failed to provide a clear definition of the diet based on dietary patterns, as well as studies that did not involve individuals with T2D or did not incorporate at least one blood test to assess glucose hemostasis in their outcomes.

Search method

The relevant literature was identified using two prominent search engines: PubMed via Ovid and Web of Science. The searches on both engines utilized an identical and all-inclusive collection of keywords and their combinations (Table 1). The references and citations of potentially relevant studies were also examined using Google Scholar to identify additional relevant studies. The studies were first screened based on their titles and abstracts. Subsequently, their complete text was evaluated to determine their eligibility.

Table 1 Keywords used for searches in PubMed and Web of Science and their combinations.

Concept	Terms
Outcome	diabetes mellitus, type 2/hyperglycemia/glucose intolerance/hyperinsulinism/ insulin resistance/metabolic syndrome x/
And	
Exposure	diet/diet, diabetic/diet, atherogenic/diet, carbohydrate-restricted/diet, fat-restricted/diet, high-fat/diet, Mediterranean/diet, paleolithic/diet, protein-restricted/diet, vegetarian/diet, western/ketogenic diet/food habits/food preferences/
And	
Region	The Middle East/Bahrain/Iran/Iraq/Israel/Jordan/Kuwait/Lebanon/Oman/Qatar/ Saudi Arabia/Syria/Turkey/the United Arab Emirates/Yemen/Africa, Northern/ Algeria/Egypt/Libya/Morocco/Tunisia/Djibouti/Somalia/Sudan/MENA/North Africa/

Data extraction

All the studies identified in this systematic review were summarized into a data extraction table (Table 2), which enables convenient observation and comparison of individual studies. Table 2 encompasses various variables, such as the year of the study, the primary author, the region, the type and size of the sample, the method used to identify dietary patterns, the specific dietary patterns examined, the statistical analysis methods employed, the results obtained, and the outcome of the study. The effect measures utilized for the outcomes will align with the specific measures employed by each study, such as linear regression or odds ratio**.** Meta-analysis was not employed due to the lack of standardization in the data collection methods used by each study, specifically through their food frequency questionnaire for the respective target population.

Quality assessment process

The literature included in this systematic review consisted of four types of study design: Cohort studies, case-control studies, cross-sectional, and clinical trial studies. The quality of all study types except the cross-sectional was assessed using checklists obtained from the Critical Appraisal Skills Program (CASP). The checklists for clinical trials and case-control studies consist of 11 questions, with nine of them allowing for responses of "yes", "no", or "cannot tell", while the remaining two are general inquiries about the outcomes. The checklist for cohort studies comprises 12 inquiries, with nine being amenable to a "yes", "no", or "cannot tell" response, while the remaining three are overarching inquiries about the outcomes.

The quality score for all the studies was determined based on nine binary questions, encompassing general and specific inquiries regarding the validity and applicability of the evaluated study findings. The cross-sectional studies quality was assessed using the tool obtained from the US National Institute of Health (NIH). The checklist comprises seven questions, excluding those irrelevant to cross-sectional studies. The questions can be responded to with "yes", "no", "cannot determine", or "not reported". The questions pertain to elucidating the study's objective, defining the study population, estimating the sample size and statistical power, assessing exposures and outcomes, and accounting for confounding variables.

3. RESULTS

The search results

The search conducted in PubMed using Ovid resulted in 154 studies, whereas the search in Web of Science yielded 1,182. After evaluating titles, 1,311 studies were deemed ineligible and therefore excluded. The remaining 57 studies were utilized for supplementary reference and citation searches in Google Scholar. Through screening reference lists and citations, nine potential supplementary studies were identified. Upon evaluation of the entire text for suitability, only 12 studies satisfied all the criteria for inclusion (Figure 1).

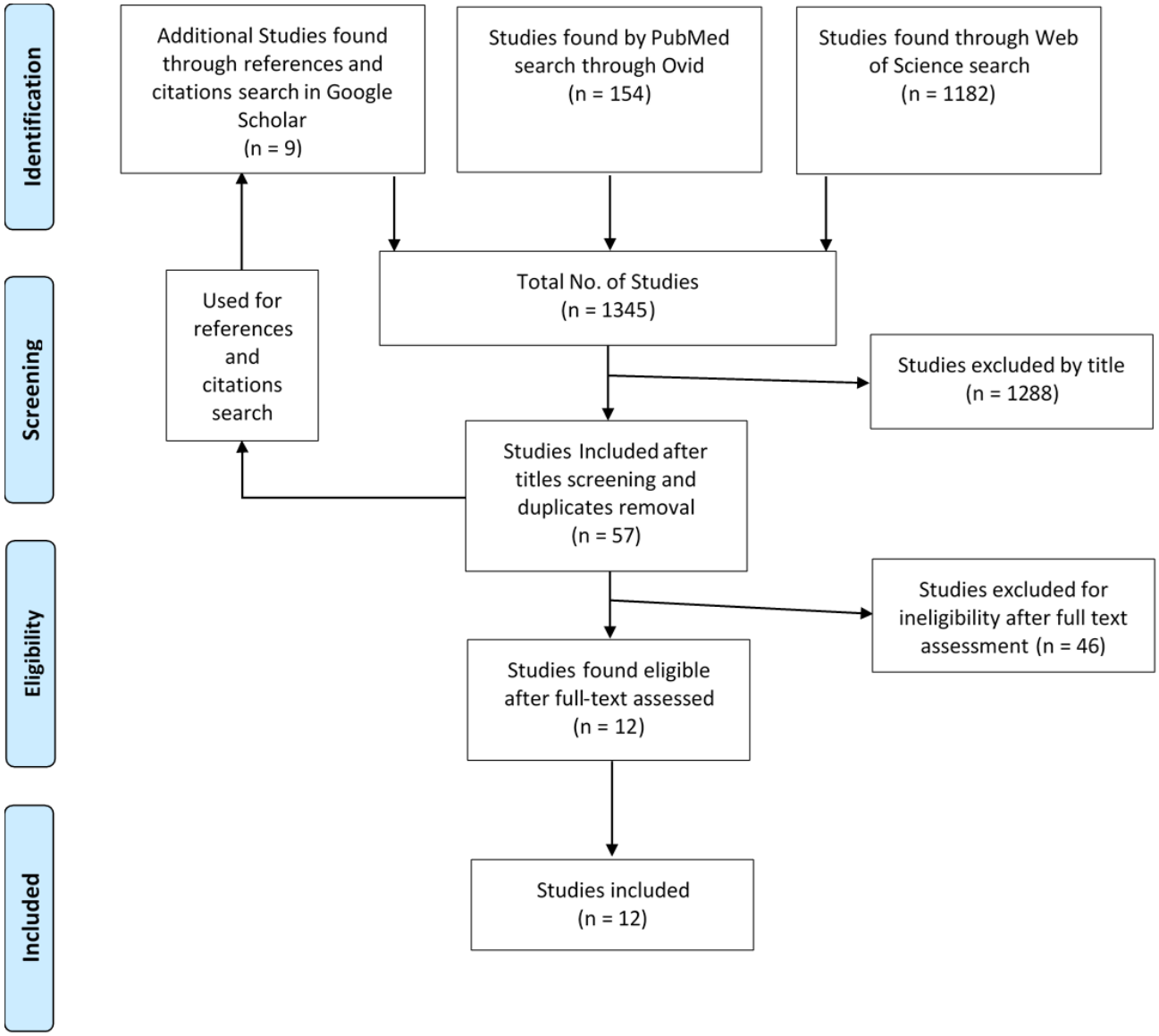

Figure 1 The flow diagram illustrating the search results of the systematic review

The first method of data extraction

Table 2 contains a comprehensive overview of the characteristics of each study, the analysis conducted, and the outcomes of the dietary patterns. This systematic review encompasses 12 studies that were published from 2007 to 2016. A total of 38 dietary patterns were examined in these studies. Iran was the setting for seven studies, while Lebanon, Algeria, Israel, and Saudi Arabia each served as the setting for two, one, one, and one study, respectively. There were seven cross-sectional studies, two case-control studies, one clinical trial, and one cohort study. Seven studies demonstrate a significant outcome indicating a positive or negative correlation between the dietary pattern and T2D or abnormal glucose blood tests. However, four studies did not find statistically significant associations between diet-related variables and the outcome measures.

Quality assessment results

Only two cross-sectional studies received a score as low as 5 out of 7, and one clinical trial received a low as 7 out of 9. The two cross-sectional studies received low scores due to their failure to investigate the impact of varying levels of adherence to dietary patterns on the outcome. The clinical trial received a low score due to a lack of completion by most participants (48 out of 84). The reasons for their loss of follow-up were not provided or accounted for.

Table 2 Studies that were identified through the systematic review

Study No.	First author and year	Region	Study design	Sample size and type	Method for identifying dietary patterns	Dietary patterns Studied	Analysis used	Results	Outcome	Study Quality
1	A. Elhayany, 2010 (Elhayany et al., 2010)	Israel	Clinical trial	259 overweight diabetic patients aged 30-65 years were recruited from 10 primary health clinics. 179 completed a 12-month follow-up.	Investigator defined	*low-carbohydrate Mediterranean **Traditional Mediterranean ***2003 American Diabetic Association diet	Generalized linear model analysis describing the 12-month changes in fasting blood glucose and HbA1c	Fasting blood glucose in mmol/l (+-SD) *baseline:10.26 (1.69) 12 months:7.19 (1.85) **baseline:10.07 (1.80) 12 months:6.57 (1.34) ***baseline:10.47 (2.00) 12 months:6.18 (0.84) p=<0.001 HbA1c in % (+-SD) *baseline:8.3 (0.8) 12 months:6.7 (0.9) **baseline:8.3 (1.0) 12 months:6.5 (0.8) ***baseline:8.3 (1.0) 12 months:6.3 (1.4) p=<0.001	Traditional Mediterranean and low-carbohydrate Mediterranean diets decreased fasting blood glucose and HbA1c more than the American Diabetic Association diet.	8/9
2	Parvane Saneei, 2015 (Saneei et al., 2015)	Iran	Cross-sectional	420 females nurses randomly selected from seven hospitals, all above 30 years old.	Investigator defined and diet score.	Dietary Approaches to Stop Hypertension (DASH diet)	odd ratio of abnormal glucose homeostasis among the DASH diet's lowest and highest adherent groups.	Multivariable adjusted: 0.71 (0.21–1.84), p= 0.38	The available evidence did not provide sufficient support to determine whether following the DASH diet was linked to an increased or decreased likelihood of abnormal glucose homeostasis.	6/7
3	F. Naja, 2013 (Naja et al., 2013)	Lebanon	Cross-Sectional	323 adults were selected randomly from the general population with no history of any chronic condition	Factor Analysis	*Fast Food / Dessert **Traditional ***High Protein	OR of having Hyperglycemia	*OR=3.81 (1.59–9.14), p= 0.001 **OR=1.44 (0.67–3.08), p=0.31 ***OR=1.60 (0.70–3.62), p=0.70	High adherence to Fast Food/dessert dietary patterns was associated with higher odds of having hyperglycemia. There was not enough evidence to conclude that Traditional and	6/7

									high-protein diets were associated with higher or lower odds of having hyperglycemia.	
4	Nasrin Darani Zad, 2015 (Zad et al., 2015)	Iran	Cross-sectional	400 T2D patients aged 40–60 years with no previous history of chronic disease other than T2D	Factor Analysis	*Vegetable & Poultry **Western ***Semi-healthy	The regression coefficient for abnormal HbA1c and fasting blood glucose	HbA1c: *b= -.007 (95%CI=-.013-.000) **b=-.0003 (95%CI=-.099-.099) ***b=.071 (95%CI=-.028-.171) Fasting blood glucose: *b=-.002 (95%CI=-.005-.000) **b=.014 (95%CI=.024-.003) ***b=-.003 (95%CI=-.005-.000)	There was insufficient evidence to conclude a relationship between HbA1c and all dietary patterns. There was an association between the Western dietary pattern and higher fasting blood glucose levels, but not enough evidence was found with other dietary patterns.	5/7
5	F. Naja, 2012 (Naja et al., 2012)	Lebanon	Case-control	58 T2D patients and 116 control selected from the adult general population	Factor analysis	*Refined grains & desserts **Traditional ***Fast Food ****Meat & Alcohol	Odds ratios of having T2D	*OR=3.85 (1.31–11.23) **OR=0.46 (0.22–0.97) ***OR=2.80 (1.41–5.59) ****OR=1.43 (0.83–2.46)	Refined grains and desserts and fast-food diets were associated with higher odds of having type 2 DM, while the Traditional Lebanese diet was associated with lower odds of having T2D. There was insufficient evidence to conclude an association between meat and alcohol diet and T2D.	8/9
6	A.M Fathia Khogali, (2013). (Fathia et al., 2013)	Saudi Arabia	Cross-sectional	170 diabetic patients recruited from a hospital, aged 30-79 years	Factor Analysis	*Transitional **Healthy ***Desirable fat ****Traditional *****Mousselines ******Snacking	Linear regression for HbA1c, glucose, postprandial glucose blood levels	HbA1c: *r=0.689(p=0.0001) **r=-0.574(p=0.014) ***r=-0.589(p=0.008) ****r=-0.558(p=0.020) *****r=0.013(p=0.862) ******r=0.055(p=0.477) Glucose: *r=0.703(p=0.0001)	The transitional pattern was positively associated with higher glucose levels, postprandial glucose, and HbA1c levels. The healthy, desirable fat and Traditional patterns were negatively associated with glucose and HbA1c levels.	5/7

								r=-0.661(p=0.0001) ***r=-0.514(p=0.03) ****r=-0.673(p=0.0001) *****r=-0.389(p=0.063) ******r=0.13(p=0.145) Postprandial: *r=0.662(p=0.001) **r=-0.391(p=0.062) ***r=-0.348(p=0.07) ****r=--0.347(p=0.07) *****r=-0.008(p=0.914) **** r=-0.105(p=0.173)	There was not enough statistical evidence for any further associations.	
7	Marsa Zaroudi, 2016 (Study, 2016)	Iran	Case-control	111 newly diagnosed T2D cases and 222 controlled aged 43-77 years	Factor Analysis	*Healthy **Transitional ***Traditional	Odds ratios for having T2D	*OR=1.18 (0.56–2.46) **OR=2.17 (1.0–4.50) ***OR=2.13 (1.03–4.41)	Both transitional and Traditional dietary patterns were positively associated with higher odds of having T2D.	9/9
8	Ahmad Esmaillzadeh, 2007 (Esmaillzadeh et al., 2007)	Iran	Cross-sectional	486 Tehrani females selected by multistage cluster random sampling method aged 40 – 60 years, with no history of chronic conditions	Factor Analysis	* Healthy ** Western *** Traditional	OR for having an abnormal glucose homeostasis (adjusted to BMI)	*OR=0.83 (0.49, 0.97) **OR=1.11 (0.95, 1.46) ***OR=1.19 (1.04, 1.59) *r=0.13 (p=0.11) **r=0.01 (p=0.81) ***r=0.08 (p=0.36)	A healthy dietary pattern was negatively associated with the odds of having abnormal glucose levels. All other results were statistically insignificant.	6/7
9	Nazanin Mosleh, 2016 (Moslehi et al., 2016)	Iran	Nested case-control study	178 T2D patients and 520 controls were recruited from one district in Tehran aged 32 – 56 years.	Factor Analysis	* Western ** healthy *** Traditional	Odds ratios of having T2D	*OR=1.10 (0.69–1.77) **OR=0.93 (0.57–1.49) ***OR=0.68 (0.41–1.11)	No statistically significant association was found after adjusting to BMI.	9/9
10	Tayebeh Doostvandi, 2016 (Doostvandi et al., 2017)	Iran	Cohort study with follow-up for three years.	802 adults recruited from Tehran with no history of T2D aged 28-50 years.	Factor Analysis with Varimax rotation	*Western **Traditional ***healthy	Odds ratios of having insulin resistance	*1.58 (0.89-2.73) **1.58 (0.89-2.73) ***0.19 (0.10-0.36)	being on a healthy dietary pattern is associated with lower odds of having T2D.	8/9

11	L. Bekkouche, 2014 (Bekkouche et al., 2014)	Algeria	Clinical trial	11 men and 73 women (84 in total) metabolic syndrome patients recruited from medical centers	Investigator defined diet	The Mediterranean diet	linear model analysis that describes the changes recorded prior to and after adopting the diet for fasting plasma glucose and HbA1c levels.	Fasting plasma glucose in mmol/l (SD) Prior: 11.41(1.92) After: 7.26(1.85) p= <0.05 HbA1c in % (+- SD) Prior: 89(17.63) After: 60.58(16.37) p=<0.05	There was a significant decrease in the fasting plasma glucose and HbA1c levels.	7/9
12	Massoud Amini, 2010 (Amini et al., 2010)	Iran	Cross-sectional	425 participants with impaired glucose levels aged 35 -55 years, all 1st-degree relatives of T2D patients.	Factor Analysis with orthogonal rotation	* Western ** Prudent *** Vegetarian **** High-fat dairy ***** Chicken and plant	OR of having high plasma glucose across tertile of significant dietary patterns scores	*OR=0.81 (0.44-1.47) p=.49 **OR=0.73 (0.39-1.37) p=.34 ***OR=2.26 (1.25-4.06) p=.006 ****OR=0.78 (0.43-1.38) p=.39 *****OR=0.89 (0.51-1.58) p=.7	A higher tertile of the vegetarian pattern was significantly associated with higher plasma glucose levels than the lower tertile.	

4. DISCUSSION

The primary objective of this systematic review was to provide a concise overview of the existing evidence regarding the correlation between T2D and dietary patterns in the MENA regions. The comprehensive electronic database search for this systematic review yielded a diverse array of study types that examined various dietary patterns, some of which had similarities. The earliest study identified was published in 2007, likely due to the recent emergence of interest in investigating the correlation between dietary patterns and diabetes, as opposed to focusing solely on individual foods or nutrients.

Dietary patterns across different regions and studies

While the studies did not have a standardized approach to defining dietary patterns, there was a strong resemblance in how the components of the overlapping dietary patterns, such as the "healthy" and "Fast Food/Western" patterns, were defined. This resemblance could be attributed to the fact that there is a considerable degree of similarity in food culture among the countries in the MENA region. In addition, the proximity of the studies ensures that any changes in food culture over time, such as the definition of food components for each dietary pattern in different countries, would have minimal to no impact. The resemblance in characteristics of these dietary patterns across the MENA countries can be attributed to both the shared traits of traditional cultures and the influence of globalization in these nations.

However, there were variations in the Traditional dietary patterns among certain countries. According to a study by Fathia-Khogali et al., (2013), the Traditional diet in Iran and Lebanon shared common elements like grains and vegetables. However, the Saudi Traditional diet stood out as it included breakfast cereal. Adding breakfast cereal to the Saudi Traditional dietary pattern may seem contentious. However, in this instance, the explanation lies in utilizing factor analysis to identify the dietary pattern, followed by the selection of names for the pattern based on its primary components.

Dietary patterns associated with glycemia or T2D diagnosis

The systematic review encompassed two clinical trials that primarily investigated the Mediterranean diet. One of the studies explored both the Traditional Mediterranean diet and a low-carbohydrate Mediterranean diet (Elhayany et al., 2010). Both diets protected against type 2 diabetes (T2D); however, the low carbohydrate diet demonstrated more excellent protection. The growing body of evidence supports the advantages of low carbohydrate diets in weight loss and improved management of T2D (Feinman et al., 2015).

Furthermore, when considering different dietary patterns, it was observed that the Fast-Food dietary pattern exhibited a positive correlation with T2D or abnormal glucose and HbA1c blood tests. This association remained significant even after

accounting for various potential confounding factors in the studies that examined this particular dietary pattern. One potential reason for this correlation is that Fast Food eating habits involve consuming foods rich in fat and carbohydrates and having high glycemic loads. These foods include processed meats and carbonated beverages. The Traditional and healthy dietary patterns exhibited a preventive impact on T2D, potentially due to their food constituents, such as vegetables and fish, which possessed elevated fiber and protein levels and lower glycaemic load compared to the food constituents of the Fast-Food dietary pattern (Thomas and Pfeiffer, 2012).

Strengths and weaknesses of this review

This systematic review is a unique study that aims to summarise the current evidence on the correlation between dietary patterns and Type 2 Diabetes (T2D) in the Middle East and North Africa (MENA) region. One of its notable advantages is its utilization of three distinct search engines to locate pertinent research, encompassing a diverse array of study types. Nevertheless, this systematic review may be limited in comprehensiveness due to the initial search being conducted solely through electronic databases and the inclusion criteria being restricted to English language papers. An additional constraint arising from the studies' diversity is the inability to combine the data for meta-analysis. This is due to the variation in study types, populations included, and the differences in diet and outcome measures used across the studies.

5. CONCLUSION

While dietary patterns are more commonly employed in dietary recommendations for diabetic patients, there is a limited amount of research investigating diet as dietary patterns, specifically in the MENA region. These studies indicate a correlation between dietary patterns and the likelihood of developing type 2 diabetes (T2D), as well as a connection between diet and the regulation of blood sugar levels (glycemic control). Additional investigation is required to examine the correlation between dietary patterns and T2D in particular populations, considering the cultural specificity of dietary patterns. This evidence has the potential to contribute to the creation of future evidence-based national dietary guidelines, which can be used to manage and prevent diabetes effectively.

Authors Contributions

Dr Fahad M Almutairi: Main Author and primary contributor
Prof. Elizabeth Goyder: Main Supervisor and secondary contributor
Dr Samantha Caton: Secondary Supervisor and secondary contributor

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This study was done as part of my Ph.D. thesis, which covers the scope of the association between diet and type 2 diabetes. It has also been deposited in the white Rose database system upon completion in compliance with the University of Sheffield regulation. (Almutairi, Fahad. "Association Between Dietary Patterns and Type Two Diabetes in Saudi Arabia" 2020, https://core.ac.uk/download/348897632.pdf.)

Informed consent

Not applicable.

Ethical approval

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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