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Understanding Cultural Influences on Dietary Habits in Asian, Middle Eastern, and Latino Patients with Type 2 Diabetes: A Review of Current Literature and Future Directions

Natalie Mora[1] · **Sherita Hill Golden**[2]

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Abstract
Purpose of Review This review focuses on evaluating and identifying gaps in the current literature regarding culturally specific dietary influences for patients with type 2 diabetes. As this topic has previously been examined in African American populations, we chose to focus on four other distinct populations (Hispanic, Middle Eastern, Western Pacific, South Asian). Given the rapid increase in global rates of type 2 diabetes and high rates of diabetes among certain ethnic groups, it is important to understand how culturally adapted strategies in diabetes management have been described in different regions and populations.
Recent Findings The specific role of nutrition in controlling diabetes is tied to cultural habits and customs. Variation in cultural practices, including diet, create unique environments in which patients with diabetes must navigate.
Summary The role of family, particularly among Hispanics, is crucial to cultural adaptations of diabetes management. Incorporating alternative medicine, namely observed in Chinese and Indian populations, also guided diabetes care strategies. Language barriers, health literacy, and acculturation were all unique factors affecting cultural approaches to diabetes management in these four populations. Understanding such cultural determinants is crucial to addressing diabetes disparities and improving outcomes.

Keywords Type 2 diabetes · Nutrition · Hispanic · Asian · Western Pacific · Diet

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✉ Sherita Hill Golden
sahill@jhmi.edu

[1] Department of Medicine, University of Virginia School of Medicine, Charlottesville, VA, USA

[2] Department of Medicine, Division of Endocrinology, Diabetes, and Metabolism, Johns Hopkins University School of Medicine, 1830 E. Monument Street, Suite 333, Baltimore, MD 21287, USA

Introduction

The epidemic surge in type 2 diabetes (T2DM) over the past few decades has impacted numerous regions globally. Diabetes rates vary significantly by region and ethnicity and pose a significant public health and financial burden to local governments. According to the 2013 Diabetes Atlas, 366 million people worldwide are affected by type 2 diabetes [1]. The diabetes prevalence rate for non-Hispanic African Americans in the USA is 13.2% [2]. Approximately 36% of individuals with T2DM reside in the Western Pacific region [1] and diabetes prevalence rates vary from 10.7% in the Federated States of Micronesia to 47.3% in American Samoa [3]. Diabetes rates are higher in Hispanic individuals compared to non-Hispanic whites [4, 5]. In 2012, approximately 12.8% of Latino adults in the USA had diabetes, whereas 7.6% of non-Hispanic whites were affected [6]. Cardiovascular complications are disproportionately higher in Hispanics than whites [7] and renal impairment, and blindness are disproportionately higher in Hispanics, African Americans, and Native Americans than whites. [8]. The Middle Eastern region is estimated to have a diabetes prevalence of 9.3% [9]. Countries in the Arabian Peninsula, including Qatar, Kuwait, and Bahrain have estimated rates of 24, 12.8, and 22.1%, respectively [10]. Rates of diabetes in Iran have been reported to range from 2 to 8% in 2008 [11]. The prevalence of diabetes in South Asia, particularly India, has been increasing [12, 13]. Urbanized areas in India have reported rates as high as 16.8%

[12]. Compared to whites, South Asians are noted to develop T2DM at younger ages and lower body mass index (BMI), and have increased incidence rates of complications, including retinopathy and nephropathy [12, 14].

Diabetes often results in significant morbidity and mortality. Glycemic control is a fundamental principle in disease management, and is largely centered on self-care. Patients typically incorporate lifestyle changes and pharmacologic therapies to treat diabetes and minimize complications. In the context of increasing diabetes prevalence rates globally, there is a need to develop culturally tailored lifestyle interventions. Given the high rates of diabetes among certain ethnic populations, tailored programs may address the specific needs of these populations more appropriately. Such an emphasis on cultural understanding may in turn play a crucial role in optimizing disease education and self-management. Because prior reviews have focused on these issues in African American populations, this review will examine the cultural milieu surrounding other less studied populations contributing to the global burden of diabetes (e.g., South Asians, Pacific Islanders, those from the Middle East), and how this interplay influences dietary management of T2DM [8, 15].

Search Strategy

We conducted a comprehensive literature search in PubMed for relevant studies addressing specific populations, T2DM, and diet through July 2016. Our search included MeSH (medical subject headings) keywords for diabetes, diet, food, and specific populations (e.g., Hispanics). The search included terms specific to each population. The detailed search terms are detailed in the Appendix. Our search was limited to human subjects and studies published in English.

We included randomized controlled trials, observational, and descriptive studies evaluating culturally tailored nutrition-based approaches to T2DM care. The titles and abstracts of the publications retrieved by the search strategy were screened for relevance. Complete texts which met selection criteria were obtained and reviewed. Those articles that fulfilled previously outlined criteria were included in this review.

Results

Hispanic Populations

Description of Diet and Contributors to Dietary Choices Traditional Hispanic cuisine among Mexicans, Puerto Ricans, and Dominicans includes staples such as rice, beans, and tortillas. Brunt et al. reported daily consumption of rice and beans, as well as heavy utilization of cooking oil [16]. Lard, which is high in saturated fat, is commonly used in Mexican food preparation, though vegetable oil consumption has also been reported [17, 18]. Compared to the typical US diet, a classic Mexican diet was noted to be higher in total fiber, vegetable protein, and saturated fat [19], though one study cited a lower saturated fat diet among less-acculturated Hispanics [20].

Family is an influential factor in diabetes care for Hispanics. The concept of "family comes first" has been incorporated into diabetes interventions for this group, and has included techniques such as family-based sessions [7]. Family involvement has been associated with healthy dietary habits in Hispanics with diabetes [7]. Aponte et al. described how Puerto Rican and Dominicans with diabetes commonly defer to family members for support when adjusting to healthier behaviors [4], reinforcing the importance of involving family in interventions.

Hispanic culture plays a role in health-oriented behavior. General concern over exclusion of culturally specific dietary staples (e.g., rice and beans) as well as how to adapt to healthier cuisine (e.g., decreasing fried food intake) has been documented. Participants in focus groups for diabetes patients have expressed concern with dietary restrictions ("I can't eat anything I like and can't eat too much of anything") [4]. Hispanic populations often face significant language barriers when managing diabetes. Limited English fluency limits engagement with non-Spanish-speaking healthcare providers [21•]. Additionally, low health literacy levels can also hinder diabetes care, thus prompting the development of literacy-appropriate education materials [22]. Caribbean Latinos have cited social isolation, fatalistic viewpoints of diabetes, and doubt related to preventative measures as barriers to proper dietary management [16].

The process of acculturation is defined as the adoption of beliefs and customs of a new culture. Among Hispanics, acculturation into mainstream culture can lead to changes in dietary patterns. Often described as a complex, multifactorial process, duration of time in the USA and language preference are typical factors that influence integration into mainstream society [23]. Regarding health behaviors, acculturation in Latinos has been associated with higher fat and artificially sweetened beverage intake, as well as lower fruit and vegetable consumption [23]. The introduction of processed foods and sweets has also been reported [24]. Other studies have shown higher fruit intake among more accultured Hispanics compared to those less accultured, as well as lower consumption of starchy, root vegetables [23]. Less accultured Latinos are more likely to consume and adhere to diets high in fiber and low in saturated fat [20].

Dietary Intervention Approaches (Table 1) There were 11 articles that addressed culturally tailored dietary intervention approaches to diabetes management in Hispanic

Table 1 Hispanic population

Study	Population characteristics	Study design/intervention	Summary primary findings			
			Glycemic/glucometabolic	Dietary	Body fat	Other
Observational studies						
Salto et al. [25]	46 Mexican Americans	All subjects were enrolled in a culturally specific diabetes education program.	HbA1c and lipid profiles significantly improved.	Decreases in dietary cholesterol and fat intake	–	–
Porter et al. [22]	9 native Spanish-speakers interested in nutrition and diabetes	Evaluation of *Your Guide to Diet and Diabetes* for culturally accurate content	–	Carbohydrate-counting skills, and meal planning ability increased.	–	Improved diabetes knowledge
Randomized controlled trials						
Perez-Escamilla et al. [21•]	211 Latinos	DIALBEST trial randomized subjects to culturally tailored diabetes education group led by community health workers (CHW) or standard care	The CHW group showed a net reduction in HbA1c.	–	–	–
Wang et al. [6]	238 Latinos	Randomization to diabetes self-management group or usual care	Increase in glycemic index was positively associated with HbA1c levels.	–	Increase in glycemic index positively associated with waist circumference	–
Jimenez-Cruz et al. (2003)	36 subjects	Randomized, crossover design of lower– and higher–glycemic index (GI) Mexican-style diet	HbA1c lower in the low GI intervention group.	Low GI diet associated with low glycemic load and index	BMI lower in the low GI intervention group	
Vazquez et al. [26]	38 Caribbean Latinos	Randomization to culturally specific sessions on dietary intervention and self-management		Reduced intake of fat increased intake of fiber and carbohydrates		
Brown et al. [18]	252 Mexican Americans	Random assignment to a culturally sensitive diabetes education and management intervention	Intervention group had improved glycemic control.			No overall change in leptin levels
Hu et al. [7]	36 Hispanics and family members	Intervention consisted of bilingual family sessions on diabetes education and management		Significant improvement in diet scores		Significant improvement in diabetes self-efficacy, self-management and diabetes knowledge
Santiago-Torres et al. [19]	53 females of Mexican descent	Random assignment to crossover design of traditional Mexican diet or US diet	Fasting blood glucose levels were not different between diets. Mexican diet associated with a slight improvement in insulin sensitivity.			No difference in biomarkers of inflammation between the two diets
Fernandez et al. [24]	252 Caribbean Latinos	Randomization to *Latinos En Control* diabetes management intervention	Significant change in HbA1c over 12 months	Intervention subjects had improvement in dietary behaviors		
Rosal et al. [5]	252 Caribbean Latinos	Subjects randomized to a culturally tailored diabetes self-management program	Significant change in HbA1c saturated fat and fat consumed over 12 months	Intervention group had significant change in dietary quality and kilocalories, % saturated fat and % fat consumed		

BMI body mass index, *T2DM* type 2 diabetes

populations—two were observational studies and 9 were interventional trials.

Observational Studies In the study by Salto et al., 46 Mexican Americans were enrolled in a 3-month culturally specific diabetes education program. There was a significant improvement in HbA1c and lipid profiles as well as a decrease in dietary cholesterol and fat intake [25]. In another culturally tailored dietary education intervention, there was an improvement in carbohydrate-counting skills and meal planning using the plate method [22].

Clinical Trials Among the intervention studies, seven, five, and two examined the impact of dietary interventions on glycemic control and glucometabolic outcomes, dietary outcomes, and measures of body fat, respectively. Interventions that led to improvement in glycemic control included culturally tailored diabetes education groups including dietary goals with and without a community health worker and Mexican-style low glycemic index diet. Culturally tailored diabetes education also resulted in reduced intake of total and saturated fat [5, 26], increased intake of fiber and carbohydrates [26], and overall improvement in dietary choices [7, 24]. Wang et al. found that increased glycemic index during intervention was positively associated with waist circumference and Jimenez-Cruz et al. showed that a low glycemic index Mexican dietary intervention resulted in a lower body mass index. Interventions did not change leptin levels [18] or inflammatory biomarkers [19].

Western Pacific Populations

Description of Diet and Contributors to Dietary Choices Western Pacific dietary patterns have been described based on region. The Singapore Chinese Health Study described two main dietary patterns—vegetable/fruit/soy (VFS) and dim sum/meat/rice/noodles (DSM)—in relation to diabetes. The DSM pattern was positively associated with T2DM in never smokers [27]. A "more fruit, fish, and vegetables" pattern described by Yu et al. in a longitudinal study was associated with a 14% lower T2DM risk, whereas the "more meat and milk" pattern was associated with a 39% higher risk [28]. Dietary assessments have highlighted rice, porridge, steamed bun, and noodles as staple foods [29]. In Taiwan, night markets and roadside food stands often feature thickened, starchy soups, noodles, rice, and tofu dishes [29]. Chinese populations reportedly have higher rates of fiber intake compared to Western groups [30]. According to Ma et al., consumption of rice accounts for 30% of daily energy in Chinese. Rice has become increasingly more refined in recent years, and contributes to a heavy glycemic load in the Chinese diet. Studies have suggested that patients with the highest rice intake were at greater risk of developing T2DM compared to those with lower rice intake [31].

Individuals with diabetes of Western Pacific origin often face challenges related to family structure and context. The family unit plays an important role in T2DM management. Chesla et al. highlighted several factors that affect family dynamics in diabetes care—"symptoms challenged family harmony, prescribed diet challenged cultural beliefs and practices, and challenges to family roles and responsibilities" [32]. Family members often attributed specific behaviors and emotions to diabetes (e.g., irritability, emotional lability) rather than the individual. These behaviors were concerning for family members in relation to Chinese social and cultural values, including suppression of negative emotions. Dietary restrictions led to social and cultural isolation for individuals with diabetes, as they were no longer able to share a similar diet to their family and acquaintances [32]. Moreover, large family celebrations and gatherings made it difficult for patients with diabetes to adhere to food restrictions [32].

Expectations about the role of family members, including spouses, in understanding dietary management were inconsistent. Aitaoto et al. describes how the concept of self merges with a collectivism model for family and community in the Pacific region. For the Chuukese population in Micronesia, health and self-management are reflected in the priority of the group rather than that of the individual [3]. Thus patients with diabetes reported not wanting to break with the collective entity and eat a different meal than the rest of the family [3].

In China, traditional Chinese medicine is often used in combination with antidiabetic drug therapies. Herbal formulations targeting diabetes have been documented, including ginseng, bitter melon, and membranous milkvetch root [33]. Though the exact mechanisms are unclear, invigorating, nourishing, stasis reduction, and heat-clearing functions are often attributed to symptom and complications management of diabetes for traditional herbal preparations [33]. Studies have suggested that integration of traditional therapies with Western medicine may be done without seeking medical advice [34].

For the Chinese population, dietary restrictions for diabetes may interfere with common cultural beliefs that food must be balanced (i.e., "hot and cold"). The cultural belief of balance is an important factor for Chinese patients with diabetes and may be overlooked by providers [32]. Additionally, the Chinese consider rice as a mainstay for nourishment and well-being. Studies have cited "significant suffering" if rice is restricted, as rice is commonly viewed as a symbol of vital health [32].

Western Pacific populations may require nutrition education that addresses the mind, body, and spirit [3]. Cultural adaptation of nutrition, relationships with family, and spiritual faith help to support health-related behaviors for these patients with diabetes [3]. Braginsky et al. highlighted the importance of eating behaviors in many Asian cultures. Food is not meant

to be wasted, as this could cause considerable shame for one's family [35]. For Chinese populations, individuals with diabetes are often urged to consume certain foods that promote well-being (e.g., bitter melon), and elimination of these specific foods may be upsetting for families [34].

Patients with diabetes living in the Western Pacific region face difficulties including language barriers and access to healthy foods. Language barriers are complicating factors in healthcare management for less assimilated groups [34]. Limited English skills may ultimately put these groups at higher risk for health disparities [34]. Additionally, in the Chinese population, there are numerous dialects which complicate the translation of diabetes education materials [34].

Low-income individuals often have limited access to healthy food selections. Poverty has been documented as a frequent hindrance to acquiring and preparing healthy foods [3]. Ho et al. emphasized the role of economic hardship on medication compliance and blood glucose monitoring in Chinese Americans, similar to other groups with diabetes and minimal financial resources [34].

Increasing urbanization in regions of the Western Pacific, namely China, has led to a population shift in nutrition and physical activity. In China, daily caloric intake has remained stable over the past few decades, which suggests that dietary patterns and decreased exercise may contribute to increasing diabetes prevalence [31]. The rapid growth of urban China has paralleled the increased intake of fat, animal foods, and refined grains [31]. Lifestyle changes and increasing rates of diabetes have been documented in the setting of urbanization [31].

Dietary Intervention Approaches (Table 2) There were three interventional trials that described culturally specific dietary approaches to populations with T2DM.

Clinical Trials In the intervention studies in this population, nutrition interventions were assessed in relation to glycemic and lipid control, as well as insulin sensitivity. Liu et al. showed how incorporation of the traffic light diet (TLD), in which patients designate foods into three categories (red, yellow, green) based on nutritional value, significantly reduced glucose and cholesterol levels [36•]. Insulin and glucose levels, in addition to insulin sensitivity, improved with high dietary intake of almonds [37]. Nutrition knowledge, practice, and awareness was also noted to significantly change with intervention [38].

South Asian Populations

Description of Diet and Contributors to Dietary Choices South Asian cuisine usually includes starchy foods such as rice, roti flat bread, and potatoes, as well as desserts, or *metai* [39, 40]. Meals are often fried or prepared with oil [40]. Curry,

Table 2 Western Pacific population

Study	Population characteristics	Study design/ intervention	Summary primary findings		
			Glycemic/ glucometabolic	Dietary	Other
Randomized controlled trials					
Liu et al. [36•]	117 Chinese	Randomization to diabetes management sessions	Significant reduction in fasting blood glucose, HbA1c, triglyceride and cholesterol levels in the intervention group	Decrease in caloric intake in intervention group	
Wang et al. [38]	162 Chinese	Random assignment to nutritional intervention	Glycemic control improved	Increased consumption of grains, fruits, vegetables, and dairy	Nutrition knowledge, practice, and awareness significantly improved
Li et al. [37]	20 Chinese	Randomization to control or almond diet	Significant improvement in fasting insulin, fasting glucose, and insulin sensitivity		

T2DM type 2 diabetes

a dietary staple, is typically cooked using oil and salt [39]. Boiling and roasting, as well as boiling and frying, have been reported as common cooking methods [41]. Flatbreads are offered in several varieties including plain (high glycemic index) and bran (low glycemic index) [42]. Ground cereals and unleavened bread are frequently consumed in rural, lower socioeconomic groups, whereas fried snacks, potatoes, lentils, or legumes are eaten among wealthier populations [43]. Sugar intake from both traditional sources (e.g., k*handsari*, jaggery) and sugar-sweetened beverages (SSB) has increased in India within the past decade [44]. Availability of SSBs in both rural and urban areas, including small shops and roadside stands, has contributed to this rise [44].

Dietary surveys involving self-care of individuals with T2DM in southern India showed that 75% reported not eating sweets within the past week. Approximately 44% ate fresh fruits and vegetables for > 50% of their meals, and 86% reported consuming < 25% of fats and fried foods within the past 7 days [45]. However, data from the Study to Assess the Dietary Carbohydrate Content of Indian Type 2 Diabetes Populations (STARCH study) demonstrated how carbohydrates accounted for 64.1% of energy intake in Indian patients with T2DM. Consumption of carbohydrates in individuals with T2DM was higher than the recommended amount [13]. According to Mohan et al., total carbohydrate consumption, glycemic index, and glycemic load were associated with an increased risk of T2DM in Asian Indians [46]. In contrast, fruits, vegetables, fiber, and dairy had a negative association with T2DM [46].

Certain specialty foods have cultural significance for Indians and Pakistanis, and may be served almost daily for more affluent subgroups. Traditional sweet desserts and dishes prepared with butter (*ghee*) are routinely offered as gifts for special occasions and social gatherings [39]. Owing to community and family activities, South Asian individuals with T2DM have reported consuming traditional meals (e.g., *roti*, *metai*/desserts) despite understanding the adverse health implication of these foods on their diabetes disease management [39].

Social support can be derived from interactions within the family. Studies have included family members of individuals with T2DM when implementing healthcare management programs, as family relationships are important factors that affect dietary behavior [40]. Meal planning and cooking for the family impacts how patients with T2DM manage their condition [47•]. Findings by Kapur et al. suggest that dietary compliance for south Asians with diabetes is higher when healthy meals are prepared for the entire family [48]. Dietary interventions, as described by Wallia et al., have included family members in cultural adaptations for diabetes programs [47•].

In southeast Asian populations, health-related behaviors frequently incorporate the use of traditional therapies [14]. The application of traditional medicine in diabetes management creates an important connection between culture and biomedical practice [49]. Ayurvedic medicine is a traditional form of alternative medicine practiced in India. Ayurveda specialists focus on treating medical conditions with natural, non-biomedical therapies. India has numerous Ayurvedic hospitals and pharmaceutical companies that produce Ayurvedic therapies [49]. Ayurvedic medicine is an example of such an overlay between traditional cultural practices and conventional medicine, and is used for diabetes treatment throughout India [49]. Ayuverdic medicine is generally perceived to be safer and have less side effects compared to the biomedical approach [49].

Additionally, among Asians living in western countries and India, common beliefs related to exercise (e.g., exercise depletes energy levels) and family (e.g., desire to "keep families well fed") have been noted [14]. Nicolaou et al. described how leisure physical activity was uncommon in Indian culture, with the exception of young men and soccer [40].

For Southeast Asians, language and communication barriers can impact diabetes education and management. Though translation accommodations are available, the use of services on a routine basis is limited [14]. Patients may often be reluctant to utilize translators from the same community and/or family, which may create challenges for the delivery of care [14].

Access to dieticians in India, including urban areas, may also impact diabetes self-management as described by Patel et al. [41]. Of the participants in a western Indian survey study, 73% were currently on a diabetic diet that had been recommended by either a physician or dietician. Seventy-seven percent reported obtaining dietary information from their family physician compared to only 4% from a dietician [41].

Dietary Intervention Approaches (Table 3) Among the culturally tailored studies, one interventional and one descriptive study were focused on nutritional aspects of T2DM management.

Observational Studies To examine the impact of high carbohydrate dietary staple, *chapatti* flatbread, on postprandial hyperglycemia, levels of insulin, blood glucose, and ghrelin were tracked for patients with and without T2DM [42]. Prolonged hyperinsulinemia was most elevated with the high GI index flatbread (plain *chapatti*) compared to the lower GI flatbread (bran *chapatti*). Ghrelin levels were suppressed with low GI flatbread. These effects were noted to be more significant for patients with T2DM [42].

Clinical Trials Balagopal et al. described how lifestyle intervention, including emphasis on diet and exercise, significantly improved HbA1c levels for patients with T2DM and prediabetes [43]. Community health workers (CHWs) were involved in carrying out these interventions, including data

Table 3 South Asian population

Study	Population characteristics	Study design/ intervention	Summary primary findings	
			Glycemic/ glucometabolic	Dietary
Observational studies				
Balagopal et al. [43]	1683 rural Indians	Intervention essions focused on healthy diet and physical activity.	Intervention group showed decreased blood glucose levels.	Lower SES group consumed ground cereals and unleavened bread, rice. Higher SES group ate whole wheat flour, rice, vegetables, potatoes, lentils or legumes, fried snacks. Post-intervention fruit and vegetable intake improved.
Khawaja et al. [42]	22 Indian patients	Examined impact of different dietary flatbreads on satiety and metabolic parameters	Prolonged hyperinsulinemia noted with high GI flatbread. Ghrelin levels were significantly lower for the low GI flatbread. The difference for each parameter was greater for participants with T2DM.	

GI glycemic index, *SES* socioeconomic status, *T2DM* type 2 diabetes, *DIALBEST* Diabetes Among Latinos Best Practices Trial

collection and conveying basic health information. Participants engaged in ten face-to-face encounters and written materials were provided in Gujarati. Community-based intervention strategies resulted in successful lowering of HbA1c and blood pressure, as well as improvement in diabetes knowledge [43].

Middle Eastern Populations

Description of Diet and Contributors to Dietary Choices

Middle Eastern diets encompass a variety of foods. A cross-sectional study by Ghane et al. identified fish, vegetables, legumes, and low-fat dairy as a part of a healthy Middle Eastern diet, whereas unhealthy food items included processed meats (e.g., sausages), red meat (e.g., ground beef, hamburger, beef, veal, mutton), refined grains, and sugar [50]. Standard Arab diets include heavy protein intake, often greater than 300 g daily [10]. Specific to the Iranian diet, refined grains (e.g., white rice and bread) are a major dietary staple and carbohydrates account for a large portion of calories [50]. Saturated fat and cholesterol intake have been linked to mortality rate and cerebrovascular complications in Iranians with diabetes with known coronary artery disease (CAD) [51]. Additionally, individuals with diabetes and known CAD who reported healthy nutrition habits (e.g., higher fruit and vegetable intake) had significantly less adverse cardiac and cerebrovascular events [51]. Among Middle Easterners, potato consumption, refined grains, and fast food all contribute to an increased risk of T2DM [9]. In contrast, a traditional Lebanese diet (e.g., olives, whole wheat bread) has been associated with significantly lower rates of T2DM. Studies involving Saudi Arabians have shown a positive relationship between fish consumption and T2DM; however, traditional cooking style (e.g., fish frying) may potentially explain this link [9].

Ethnic variation in Middle Eastern cuisine has been documented. For example, Jewish populations living in Israel typically consume central/northern European-style foods, whereas Arab diets generally follow a Mediterranean pattern. Though Jewish subjects were noted to have healthier diets, individuals with T2DM in both groups demonstrated healthier eating habits compared to those without diabetes [52]. Participants reported making dietary changes to address health-related concerns, specifically development of a chronic medical condition [52].

Table 4 Middle Eastern population

Study	Population characteristics	Study design/intervention	Summary primary findings: Glycemic/glucometabolic	Dietary	Body fat	Other
Randomized controlled trials						
Parham et al. [54]	48 Iranians	Randomized crossover design involving pistachio servings	Significant decrease in both HbA1c and fasting blood glucose in the pistachio group			
Hosseinpour-Niazi et al. [55]	31 Iranians	Randomized, crossover study to assess legume-free vs. legume-rich diet	Legume-based diet participants had significantly decreased fasting insulin, fasting blood glucose, triglycerides and LDL cholesterol.			
Mohamed et al. [10]	430 patients in Qatar	Intervention of culturally sensitive diabetes management program	Intervention group demonstrated significant improvement in HbA1c, FBG, BMI, urine albumin-to-creatinine ratio.			Diabetes knowledge, practice and attitude were also significantly increased.
Negarandeh et al. [53]	127 Iranians	Randomization to diabetes education intervention				Intervention group had significant differences in knowledge, medication and diet adherence.
Al-Shookri et al. [56]	170 patients in Oman	Randomized assignment to nutrition counseling intervention	Intervention group demonstrated changes in HbA1c, FBG, and weight. Also showed improvement in triglycerides and LDL cholesterol.		Waist circumference was significantly decreased in the intervention group.	

T2DM type 2 diabetes

Family is an important factor affecting diabetes management for Middle Easterners. Tol et al. described how patients with T2DM reported family influence as the key factor affecting dietary habits [11]. Family members may serve as barriers to optimal diabetic care, a concept emphasized by the need for social support for motivation to follow the proper diet [11].

Low health literacy is a major barrier in Middle Easterners, and has been found to be severe in patients with chronic diseases in developing counties, including Iran [53]. Specific diabetes intervention programs have been designed to fulfill the need for this group, with emphasis on literacy-appropriate materials and strategies for diabetes self-management [53]. The use of graphic illustrations and teach back methods are described by Negarandeh et al., which demonstrated that these techniques enhanced diabetes knowledge, as well as diet and medication compliance [53].

Language barriers also present a complex challenge in diabetes care. Application of Arabic-based diabetes education sessions in Qatar has been one technique to reinforce cultural sensitivity of T2DM management [10]. The adaptation of the diabetes Idaho plate method to local cuisine also highlights how cultural barriers can be addressed and overcome [10].

Dietary Intervention Approaches (Table 4) There were 5 culturally sensitive intervention studies that addressed dietary impact on patients with T2DM.

Clinical Trials Two of these trials emphasized randomized crossover designs to assess how specific food items influenced blood glucose parameters [54, 55]. Parham et al. described that patients with T2DM who received 50 g of pistachios for 12 weeks had significantly lower HbA1c and fasting blood glucose (FBG) concentrations [54]. Iranian patients with non-insulin T2DM on a legume-based diet had significantly decreased insulin and FBG levels [55].

Among the clinical intervention studies, Mohamed et al. and Negarandeh et al. described how diabetes management affected glycemic control. Implementation of a culturally sensitive diabetes intervention resulted in significant improvement in HbA1c and FBG [10]. Culturally tailored methods emphasizing low health literacy populations resulted in increased diet adherence, diabetes knowledge, and medication compliance [53]. Al-Shookri et al. found that nutrition counseling intervention resulted in significant decreases in FBG, HbA1c, triglycerides, low-density lipoprotein (LDL), and waist circumference [56].

Future Directions and Conclusions

As described in this review, approaches to culturally adapted dietary approaches for T2DM management has

been documented in different international regions and populations [5, 7, 10, 18, 21•, 25, 26, 38, 40, 53]. Culturally tailored therapies applied in randomized control trials demonstrated an effect of these interventions on reducing hemoglobin A1c and body fat. These culturally specific implementation strategies not only improved glucometabolic measures but also improved barriers to care. Such barriers addressed included educational knowledge gaps, language, low health literacy, and the role of family [5, 7, 10, 11, 18, 21•, 25, 26, 43, 53].

There are several limitations to our review. First, relative to the high rates of T2DM in multiple world regions described in this review, there was a lack of randomized control trials describing the impact of culturally tailored nutritional interventions on diabetes clinical outcomes in the literature. The few published trials were very small despite the large number of individuals with T2DM in those respective countries. Second, it is unclear whether the included studies used evidence-based intervention materials. Third, it was unclear how non-traditional treatment modalities impacted T2DM care as these approaches were not used in the interventions. In several populations (e.g., Indian, western Pacific), alternative therapies are used in addition to standard medical care [33, 49]. It is therefore important to perform future studies to understand the potential impact of non-traditional therapies on glycemic control and how these therapies influence T2DM management in these cultures. Fourth, we did not include studies of Africans and Afro-Caribbeans in our review—populations for which diabetes prevalence is growing. While beyond the scope of this review, a comparison on the effect of culturally adapted dietary approaches to diabetes management in African and Afro-Caribbeans compared to African Americans is warranted in a future review. Finally, the studies did not elaborate on the nutritionist resources available in these countries, which is important for broader population dissemination. It is uncertain to what extent patients with T2DM are meeting International Diabetes Federation (IDF) recommended guidelines regarding access to nutritionists and individualized dietary recommendations. According to IDF 2012 Global Guideline for T2DM, lifestyle modification, including eating habits, is recommended for patients with T2DM [57]. The IDF guidelines also emphasize access to a nutrition specialist and outline the need for individualized dietary recommendations based on food preferences and culture [57]. The emphasis on dietary guidelines for patients with T2DM mainly focused on fasting practices during religious holidays, namely Ramadan for the Middle Eastern population, and do not focus on specific culturally adapted dietary recommendations.

In the context of increasing diabetes rates worldwide, the role of culturally specific lifestyle interventions will continue to grow in importance and incorporation of culturally sensitive methods into T2DM dietary management is a reasonable approach to improve glycemic control and overall patient outcomes. Future studies are needed in larger, ethnically diverse populations to generate a stronger evidence base for which culturally adapted dietary recommendations are most effective in improving cardiometabolic outcomes in at-risk minority populations.

Compliance with Ethical Standards

Conflict of Interest Natalie Mora and Sherita Hill Golden declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Appendix

Table 5 Search methods

Population	Search terms	Number of hits (searched July 2016)	Selected articles
Hispanic	("hispanic americans" [MeSH Terms] OR latino [Title/Abstract] OR Mexican [Title/Abstract] OR Mexicans [Title/Abstract] OR Puerto Rican [Title/Abstract] OR Puerto Ricans [Title/Abstract] OR Dominican [Title/Abstract] OR Dominicans [Title/Abstract] AND ("diet" [MeSH Terms] OR diets [Title/Abstract] OR dietary [Title/Abstract] OR food [Title/Abstract]) AND ("diabetes mellitus, ype 2" [MeSH Terms] OR diabetics [Title/Abstract] OR diabetic [Title/Abstract])	242	18
Middle Eastern	("middle east" [MeSH Terms] OR middle east [Title/Abstract] OR middle easterner [Title/Abstract] OR middle easterners [Title/Abstract] OR saudi arabia [Title/Abstract]	177	18

Table 5 (continued)

Population	Search terms	Number of hits (searched July 2016)	Selected articles
	OR saudi arabian [Title/Abstract] OR saudi arabians [Title/Abstract] OR Iran [Title/Abstract] OR Iranian [Title/Abstract] OR Iranians [Title/Abstract]) AND ("diet" [MeSH Terms] OR diets [Title/Abstract] OR dietary [Title/Abstract] OR food [Title/Abstract]) AND ("diabetes mellitus, type 2" [MeSH Terms] OR diabetics [Title/Abstract] OR diabetic [Title/Abstract])		
Western Pacific	("western pacific" [MeSH Terms] OR western pacific [Title/Abstract] OR pacific island [Title/Abstract] OR pacific islander [Title/Abstract] OR pacific islanders [Title/Abstract] OR China [Title/Abstract] OR Chinese [Title/Abstract]) AND ("diet" [MeSH Terms] OR diets [Title/Abstract] OR dietary [Title/Abstract] OR food [Title/Abstract]) AND ("diabetes mellitus, type 2" [MeSH Terms] OR diabetics [Title/Abstract] OR diabetic [Title/Abstract])	280	15
South Asian	(south asian [Title/Abstract] OR south asians [Title/Abstract] OR southeast asia [Title/Abstract] OR southeast asian [Title/Abstract] OR southeast asians [Title/Abstract] OR India [Title/Abstract]) AND ("diet" [MeSH Terms] OR diets [Title/Abstract] OR dietary [Title/Abstract] OR food [Title/Abstract]) AND ("diabetes mellitus, type 2" [MeSH Terms] OR diabetics [Title/Abstract] OR diabetic [Title/Abstract]) AND "humans" [MeSH Terms] AND "humans" [MeSH Terms])	182	13

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