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State-of-the-Art Review

Cardiovascular disease in Arab Americans: A literature review of prevalence, risk factors, and directions for future research

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ABSTRACT

Cardiovascular disease (CVD) is the leading cause of mortality worldwide. Recent evidence suggests Arab Americans, individuals with ancestry from Arabic-speaking countries, have an elevated risk for CVD compared to other ethnicities in the US. However, research focusing specifically on CVD in this population is limited. This literature review synthesizes studies investigating CVD prevalence, risk factors, and outcomes in Arab Americans. Multiple studies found higher rates of coronary heart disease, cerebrovascular disease, and hypertension compared to non-Hispanic White participants. The prevalence of type 2 diabetes, a major CVD risk factor, was also markedly higher, ranging from 16 % to 41 % in Arab Americans based on objective measures. Possible explanations include high rates of vitamin D deficiency, genetic factors, and poor diabetes control. Other metabolic factors like dyslipidemia and obesity did not consistently differ from general population estimates. Psychosocial factors may further increase CVD risk, including acculturative stress, discrimination, low health literacy, and barriers to healthcare access. Smoking, especially waterpipe use, was more prevalent in Arab American men. Though heterogenous, Arab Americans overall appear to have elevated CVD risk, warranting tailored screening and management. Culturally appropriate educational initiatives on CVD prevention are greatly needed. Future directions include better characterizing CVD prevalence across Arab American subgroups, delineating genetic and environmental factors underlying increased diabetes susceptibility, and testing culturally tailored interventions to mitigate CVD risks. In summary, this review highlights concerning CVD disparities in Arab Americans and underscores the need for group-specific research and preventive strategies.

1. Introduction

Cardiovascular diseases (CVD) remain the leading cause of worldwide mortality for decades, affecting all races and ethnicities around the globe [1]. Despite this, the World Health Organization (WHO) estimates indicate that over 75 % of cardiovascular diseases are preventable or manageable with the right resources [2]. To maximize effectiveness, preventive efforts should be tailored to suit the various subgroups in a community and even the individuals within. Many studies have demonstrated that racial differences in CVD risk factors, prevalence and complications can be significant, warranting special attention be given to particular groups [3–5].

Arab Americans (ArA), or those who report direct ancestry from one of the 22 countries participating in the League of Arab States (LAS) [6] are a growing population in the United States. In 2018, the number of Arab Americans in the United States was estimated at 3.7 million by the Arab American Institute, with over 60 % of them residing in the states of California, Michigan, New York, Florida, Texas, New Jersey, Ohio, Pennsylvania, and Virginia. A large portion of Arab Americans trace their ancestry back to one of 5 countries: Iraq, Lebanon, Syria, Palestine, and Egypt [7]. Even though they represent a significant portion of the US population, government databases and census forms still do not distinguish Arab Americans as a separate ethnic category, classifying them as White in most cases [8,9]. This has led to some large-scale epidemiological studies failing to segregate them from non-Hispanic White Americans [5] in their data collection. This poses challenges for personalization of treatment.

Several studies have suggested that the chronic disease risk profile in

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Arab Americans differs from that of other individuals classified as "White". For example, a Michigan study that collected Arab American mortality data from 1990 to 2007 found that life expectancies were 2 years lower than in other demographics, with chronic diseases classifying among the top 3 causes of death [10]. Another 12-year study based on National Health Interview Survey (NHIS) data found that Arab Americans were the group that was most likely to have comorbid diseases, such as both diabetes and heart disease, rather than singular diseases [11]. Therefore, a comprehensive review of the literature on Arab Americans and the leading cause of mortality in the United States, cardiovascular disease, was conducted. Additionally, the distribution of various risk factors including metabolic, social and psychological factors germane to CVD in Arab Americans was evaluated.

2. Methods

A comprehensive literature review was conducted on October 1st, 2023 to identify scientific articles that tackle the cardiovascular health of ArAs, as defined above. The search encompassed three databases, namely PubMED, MEDLINE and Google Scholar. The following key words were used: "Cardiovascular disease", "Heart disease", "CVD", "Hypertension", "Coronary artery disease", "Stroke", "Diabetes", "Obesity", "Dyslipidemia", "Hypercholesterolemia", "Smoking", and "Metabolic syndrome". To specify the population of interest in the query, the following key words were added: "Arab Americans", "Arabian Americans", "Middle eastern Americans", "Middle East Americans", "North African Americans". The two groups of keywords were combined with AND, and the individual keywords in the groups were separated by OR. Duplicates were identified and removed, after which two investigators, H.L. and G.L., screened the papers for relevancy. Specifically, the investigators determined whether ArAs or a subset of them were indeed a distinct population of interest in the study, and whether cardiovascular diseases and/or their comorbidities were part of the outcomes of interest. All the papers that were found to be relevant were included in this review.

3. The prevalence of cardiovascular diseases in Arab Americans

Cardiovascular diseases (CVD) include all diseases of the heart and blood vessels, such as coronary heart disease, rhematic heart disease, hypertension, and cerebrovascular disease among others. The literature on the burden of these diseases in Arab Americans is sparse but still informative and is summarized in Table 1. Many of the studies were conducted in Michigan, which is the state with the second highest Arab American population, at over 220,000 [12]. A large-scale study that collected Michigan death certificate data from 1999 to 2001 found that age-adjusted heart disease death rate (per 100,000) for ArA men was 582.7 (95 % CI 483.8 - 698.3), which was higher than that in White men (521.6, 95 % CI 514.7 - 528.5). For women, the rate was 289.3 (95 % CI 241 - 343.6) in ArA and 352.4 (95 % CI 347.7 – 357.1) in non-Hispanic White participants. Heart diseases included in this study were classified using International Classification of Disease (ICD) codes. As for cerebrovascular disease, the prevalence in ArA men was greater than that in White men, though also not statistically significant (109.4, 95 % CI 69.1–167.8 and 93.5, 95 % CI 90.5–96.5 respectively). Once again, in women, the rate was lower in ArA but short of statistical significance. For both heart disease and stroke, the death rate in ArAs was lower than in Black Americans [13]. A similar study was conducted using death certificate data in California, the state with the largest ArA population, from 1989 to 1999. The results indicated that proportionate mortality ratios (PMRs) for CVD were significantly increased in Arab Americans compared to non-Hispanic White participants, after adjusting for age. The PMR for coronary heart disease was 1.28 (95 % CI 1.20–1.36) for ArA men and 1.32 (95 % CI 1.22–1.42) for ArA women compared to non-Hispanic White men and women, respectively [14].

Another Michigan study from 2015 used electronic health records to estimate the prevalence of various CVDs in ArAs. The age-adjusted prevalence ratio (PR) of heart disease (as defined by ICD codes) in ArA men was borderline different from White men, at 1.06 (95 % CI 1.00–1.13). For women, it was also borderline at 1.03 (95 % CI 0.98–1.09). Lastly, the PR for atherosclerosis was not significantly different in either men or women, at 0.81 (0.55 - 1.21) and 1.00 (0.72 – 1.38), respectively [15]. A smaller scale study based on a convenience sampling method from communities in Michigan found that the self-reported prevalence of heart disease was around 7 % in Arab Americans and 2 % in Black Americans [16]. Recently, a cross-sectional study conducted by Maki et al. in 2023 examined electronic medical record (EMR) data from over 26 healthcare systems, encompassing 70 million patients. This study found that the odds ratio (OR) of stroke in ArAs compared to non-Arabs was 1.62, (95 % CI 1.46–1.80), 1.64, (95 % CI 1.54–1.74) for coronary artery disease, 1.58, (95 % CI 1.45–1.72) for myocardial infarction, and 1.57 (95 % CI 1.45–1.69) for heart failure. These results were especially significant in elderly patients (>65 years old) compared with their age-matched cohort from other ethnicities [17].

Conflicting results were observed in other studies. A study based on 12 years of NHIS data on 213,644 adults found that the age-adjusted OR of heart disease in ArAs was 0.46 (95 % CI 0.33 – 0.65) compared to White individuals. This study also found, however, that ArA patients with one chronic condition, such as diabetes mellitus, were 18 % more likely to have comorbid heart disease [11]. A second study conducted in 2023 with EMR data from 3 Michigan hospitals found that among patients admitted for heart failure, ArA patients, particularly those with Middle Eastern ancestry, had lower rates of all-cause mortality. However, on average, they were significantly younger than their counterparts (74.7 years and 77.6 years, p-value <0.001) [18].

4. Comorbidities and classic metabolic risk factors for CVD

4.1. Hypertension

Hypertension is a key risk factor for CVD [19]. The 2015 Michigan study found that the age-adjusted prevalence ratio (PR) is significantly higher in both ArA men and women compared to their White counterparts (1.07, 95 % CI 1.04 – 1.10 and 1.04, 95 % CI 1.01 – 1.08, respectively). The paper determined hypertensive status via electronic medical records, and the prevailing definition at the time was a blood pressure over 140/90 mmHg. [15,20] In southern California, Tailakh et al. studied prevalence rates of hypertension (blood pressure >140/90 mmHg) in a sample of 126 Arab Americans and found that 37 % of participants had hypertension and 40 % had pre-hypertension (blood pressure 120–139/80–89 mmHg) with a higher prevalence in men versus women (46 % and 23 %, respectively; $P = .029$) [21]. Notably, among those with hypertension, only 67 % were aware of their hypertension status, and only 52 % were on antihypertensive medication. Blood pressure was controlled in only 46 % of medicated participants. Participants with higher body mass index (BMI) were often hypertensive hypertension (blood pressure >140/90 mmHg) compared to their normal BMI counterparts (mean BMI amongst hypertensive participants = 28.37 kg/m; $P = .01$) [22]. The prevalence of hypertension in this study is similar to the national prevalence in individuals aged 40–59 years according to the Center for Disease Control (CDC), Which also used a cutoff of 140/90 mmHg, is 33.2 %. However, the average age of ArA was 41.8 years which is on the lower end of the 40–59 years old range used by the CDC, so the data may not be fully comparable [23]. Meanwhile, in the large 2023 study by Maki et al., the odds ratio of hypertension (blood pressure >130/80 mmHg) in ArAs compared to non-Arabs was 1.65 (95 % CI 1.55–1.75) [17].

Conflicting reports were also present on hypertension. A 2015–2016 study based on EHR data from northern California found that the prevalence hypertension (blood pressure >140/90 mmHg) was significantly lower in ArA men and women compared to their gender matched

Table 1
Studies of cardiovascular risk among Arab Americans.

Study title	Date of sampling	Methods	Study Population	Control Population	Sample size from study population	Relevant findings
Mortality rates among Arab Americans in Michigan	1999–2006	Age-adjusted **Mortality rates (MR)** were calculated. Numerator came from Michigan death certificate data; denominator from Public-use microdata samples. ArA status determined by name/surname, Arab ancestry, birthplace, or language spoken at home.	ArAs in Michigan over 25 years old	Other non-Hispanic White (NHW) Michigan residents over 25 years old	2801	**Heart disease MR per 100k:** Males: 582.7 (95 % CI 483.8–698.3) compared to 521.6 (95 % CI 514.7 - 528.5) in controls Females: 289.3 (95 % CI 241.9–343.6) compared to 352.4 (95 % CI347.7–357.1) in controls **Stroke MR per 100k:** Males: 109.4 (95 % CI 69.1–167.8) compared to 93.5 (95 CI 90.5–96.5) in controls Females: 70.7 (95 % CI 48.5–100.0) compared to 87.3 (95 % CI 84.9–89.7) in controls
Mortality in First Generation White Immigrants in California, 1989–1999	1989–1999	Age-adjusted **Proportional mortality ratios (PMR)** were calculated from death certificate data, which contains information on country of birth.	Residents of California born in Arab Middle Eastern countries	US-born NHW residents of California	4597	**Coronary artery disease PMR:** Males: 1.28 (95 % CI 1.20–1.36) Females: 1.32 (95 % CI 1.22–1.42) **Stroke PMR:** Males: 1.02 (95 % CI 0.85–1.21) Females: 0.99 (95 % CI 0.83–1.18)
A Health Profile of Arab Americans in Michigan: A Novel Approach to Using a Hospital Administrative Database	2012	Sex specific, age-adjusted **prevalence ratios (PR)** were computed from data extracted from a large health system database in Detroit, Michigan. ArA status determined using an algorithm that relies on surname in addition to, in some cases, first name.	ArAs in Detroit, Michigan over 18 years old	Other NHWs in Detroit, Michigan over 18 years old	5399	**Heart disease PR:** Males: 1.06 (95 % CI 1.00–1.13) Females: 1.03 (95 % CI 0.98–1.09) **Hypertension PR:** Males: (1.07, 95 % CI 1.04–1.10) Females: 1.04, 95 % CI 1.01–1.08
Self-reported heart disease among Arab and Chaldean American women residing in southeast Michigan	2005	Age-adjusted **Odds ratio (OR)** was computed from self-reported rates of heart disease (diagnosed by a doctor) in southeast Michigan. This was achieved by distributing surveys in community centers such as mosques, churches, and marketplaces.	ArAs in southeast Michigan over 18 years old	African residents of southeast Michigan over 18 years old	812	**Heart disease adjusted OR:** 2.30 (95 % CI 0.66–7.99)
Prevalence, Awareness, Treatment, and Control of Hypertension Among Arab Americans	2012	Subjects were to fill out questionaries and have their blood pressure measured. Flyers were posted in community centers such as mosques and marketplaces. **Prevalence (P)** of hypertension was one of the outcomes.	ArA residents of southern California, over the age of 18	N/A	126	**Hypertension prevalence:** Males: 45.9 % Females: 23.2 %
Cardiovascular risk profile of Arab Americans in The United States: an aggregated electronic medical record study	Not specified, assumed to include records spanning years	Aggregate electronic medical record spanning 70 million patients was used to compute age-adjusted **odds ratios (OR).** ArAs were identified as those that spoke Arabic.	ArAs over 18 years old	Non-Arab patients over 18 years old	19,480	**Hypertension OR:** 1.65 (95 % CI 1.55–1.75) **Stoke OR:** 1.62, (95 % CI 1.46–1.80) **Coronary artery disease OR:** 1.64, (95 % CI 1.54–1.74) **Myocardial infarction OR:** 1.58, (95 % CI 1.45–1.72) **Heart failure OR:** 1.57 (95 % CI 1.45–1.69)
Disparities in Chronic Disease Prevalence Among Non-Hispanic Whites: Heterogeneity Among Foreign-Born Arab and European Americans	2000–2011	Data from the National Health Interview Survey (NHIS) was used. ArA status was determined by birth in an Arab country. **Prevalence (P)** and age-adjusted **Odds ratios (OR)** were computed.	ArAs over the age of 18	Other NHWs over the age of 18	463	**Heart disease OR:** 0.46 (95 % CI 0.33 – 0.65) **Prevalence of comorbid heart disease:** 18 %
Mortality and Hospital Readmission Rates for Heart Failure Among Patients of Middle Eastern Ancestry Compared to Non-Middle Eastern Whites in Southeast Michigan	2008–2015	Data was obtained from a healthcare system in southeast Michigan. Patients with heart failure were selected, and age-adjusted **odds ratios (OR)** for readmission and age-adjusted **hazard ratios (HR)** for death were computed. Middle eastern patients were identified by self-identification and/or an	Middle Eastern individuals in Michigan, over 18 years old	Other NHW individuals in Michigan, over 18 years old	642	**Adjusted HR for death:** 0.790 (95 % CI 0.677–0.921) **Adjusted OR for hospital readmission at 30 days:** 0.683 (95 % CI 0.329–1.418) **Adjusted OR for hospital readmission at 90 days:** 0.712 (95 % CI 0.425–1.194)

(*continued on next page*)

Table 1 (*continued*)

Study title	Date of sampling	Methods	Study Population	Control Population	Sample size from study population	Relevant findings
		algorithm that relies on surname in addition to, in some cases, first name.				
Health Risks and Chronic Health Conditions among Arab American and White Adults in Northern California	2015–2016	Electronic health record data from northern California was collected. ArA status was determined by documentation present in the EHR, preferred language being Arabic, and/or the surname algorithm mentioned above. Prevalence and **prevalence ratios (PR)** were calculated.	ArA in southern California, over 35 years of age	Other NHW individuals in southern California, over 35 years old	18,072	**Hypertension PR:** Males: 0.93 (95 % CI: 0.90–0.95) Females: 0.93, (95 % CI: 0.90, 0.96)
Self-reported diabetes and hypertension among Arab Americans in the United States	2000–2003	Data from the National Health Interview Survey (NHIS) was used. ArA status was determined by birth in an Arab country. Age-adjusted **Odds ratio (OR)** was computed.	ArAs over the age of 18	Other NHWs over the age of 18	425	**Hypertension OR:** 0.84 (99 % CI 0.42–1.71).
Hypertension, overweight/obesity, and diabetes among immigrants in the United States: an analysis of the 2010–2016 National Health Interview Survey	2010–2016	Data from the National Health Interview Survey (NHIS) was used. ArA status was determined by birth in the Middle East. Age-adjusted **Prevalence Ratio (PR)** was computed.	ArAs	Other NHWs	870	**Hypertension PR:** Males 1.16 (95 % CI 0.97–2.38) Females: 0.88 (95 % CI 0.74–1.04)

White counterparts (31% vs. 33 % in men, respectively, and 26 vs 28 % in women, respectively) after age-standardization [24]. A second study used nationwide NIHS survey data and found that the fully adjusted odds ratio of hypertension (blood pressure >140/90 mmHg) for ArAs compared to non-Hispanic White participants in 2000–2003 was 0.84 (99 % CI 0.42–1.71) [25]. Lastly, a cross-sectional study of the NHIS database by Commodore-Mensah et al. revealed that the age-adjusted PR of a self-reported hypertension diagnosis in Middle eastern Americans (a subset of ArAs which does not include those with ancestry from North African Arab countries such as Tunisia and Morocco) was not significantly different from that in European Americans. The PR for men was 1.16 (95 % CI 0.97–1.38) and for women, it was 0.88 (95 % CI 0.74–1.04) [26].

4.2. *Diabetes mellitus*

A study by Jaber et al. tested a randomly selected sample of ArAs and found the age-adjusted prevalence of metabolic syndrome to be 23 % by the Adult Treatment Panel-III (ATP-III) criteria [27]. While this estimate is low compared to national averages [28], separate components of the metabolic syndrome may have varying levels of significance in ArAs. Type-2 diabetes mellitus (DM) is among the metabolic risk factors that have been studied more extensively in this population. Most studies have documented that ArAs have a significantly higher prevalence of DM compared to the general American population, though there are some inconsistencies. For example, the ArA prevalence of DM in the 2000–2003 NHIS study was only around 5 % [25]. Notably, this study relied on self-reported diagnoses, and raises the possibility of under-reporting especially when other studies, discussed below, report much higher prevalence figures [29–31] Another study using self-reported estimates of DM found that the prevalence of DM in both ArAs and White individuals was 7 % [32]. Additionally, a study from southwest Brooklyn revealed that only 11 % of ArAs viewed diabetes as a health concern [33], while a similar study from southwest Chicago put that number at 35 % [34], a study by Jaber et al. found that 50 % of ArA participants with diabetes in Michigan were not aware of their diagnosis [29]. The low self-reported incidence of DM in ArA as well as the prevailing view that it is not a community concern highlights the disparities in diabetes education and awareness among various communities across the United States. The issue of diabetes awareness is significant, as a study from Michigan found that perceived risk was positively correlated with willingness to partake in diabetes-preventing activities such as diet and excercise [35].

Studies that relied on objective measures to diagnose diabetes, such as glucose tolerance tests reported prevalence figures ranging from 16 % to 41 % [29–31]. In 2003, Jaber et al. found that age-adjusted prevalence of DM was 16 % (95 % CI 12 %–19 %) and 20 % (95 % CI 15 %–25 %) in ArA women and men, respectively [31]. The 2015–2016 northern California EHR study reported that both ArA men and women had significantly higher prevalence of DM compared to their gender-and age-matched non-Hispanic White counterparts (17% vs 13 % in men, 11% vs 9 % in women) [24]. Interestingly, both ArA men and women had a lower prevalence of obesity than their White counterparts, which points to possible pathogenesis of DM through other non-obesity related mechanisms. The 2015 Detroit EHR study found that the age-adjusted prevalence ratio (PR) of DM in ArAs was 1.40 (95 % CI 1.29 – 1.52) for men and 1.49 (1.38 – 1.60) in women compared to non-Hispanic White individuals [15]. Also, the 1990–2007 Michigan study found that the diabetes age-adjusted mortality rate per 100,000 in ArA men was 52, compared to 27 in White men, and 32 in ArA women compared to 21 in White women [10].

A Detroit study found that ArAs were 38 % more likely to have HbA1C values >7 % compared to non-Hispanic White individuals. Furthermore, the OR of missing an eye exam for ArA with diabetes was 1.62 (95 % CI 1.21–2.17) [36]. Additionally, a small study with 53 participants found that ArAs were less likely to be receiving insulin than non-Hispanic White individuals (17% vs 27 %) and instead received more oral hypoglycemic agents (81% vs 65 %) [37]. Berlie et al. studied a group of 542 ArAs from Dearborn MI and found that 26 % had HbA1c levels over 9.5 %, compared to 18 % of the general population, with the majority of them being undertreated compared to American Diabetes Association (ADA) recommendations [38]. Regarding the last two studies, neither involved age standardization.

ArAs may have a higher burden of risk factors predisposing them to DM. A 2021 systematic review by Theik NWY et al. found that Vitamin D insufficiency is significantly associated with glucose intolerance [39],

though a 2023 review was less conclusive [40]. Vitamin D levels are uniformly low in a sample of ArA women in Michigan [41]. In a cross sectional study of 542 ArAs with metabolic syndrome, insulin resistance or glucose intolerance, the prevalence of Vitamin D deficiency was 75 %. Additionally, Vitamin D levels were lower among men with glucose intolerance compared to those with normoglycemia [42]. ArAs of lower educational attainment may be at higher risk of Vitamin D deficiency, according to one study [41]. Further longitudinal studies with control groups are needed to better elucidate the relationship between DM in Vitamin D insufficiency in ArAs.

Another risk factor that has been studied is acculturation, which is defined as degree of assimilation of a new cultural identity into one's personality scaffold in terms of cultural practices, values, traditions and language, among others. A Michigan study found an association between glucose intolerance, as diagnosed by glucose tolerance tests and/or having a prior diagnosis of DM, and lesser integration with American society. There was also an association with older age at immigration and unemployment [43]. El Masri et al. also found a similar relationship between unemployment, lack of social integration and support and DM [37]. Lastly, another survey-based study in Michigan found that all ArA participants viewed lack of chronic disease education and support as important barriers to proper diabetes management [44].

4.3. Dyslipidemia

Dyslipidemia is prevalent among individuals of Arab ethnicity, with a prevalence reaching 73 % in some Arab countries [45]. In a survey of ArAs living in southwest Chicago, 26 % identified high cholesterol as a community health concern [34], meaning it is a fairly large concern in the community. In a Michigan study that offered free health screening, the mean cholesterol concentration in ArAs over 40 years was 210 mg/dl and the mean High-density lipoprotein (HDL) was 48 and 38 mg/dl for women and men respectively [46]. In another Michigan study, only 36 % of ArA with comorbid diabetes were able to meet the LDL goal of <100 mg/dl [38]. Additionally, in the large cohort study based on EHR data in northern California, both ArA men and women had a higher prevalence of hyperlipidemia compared to their sex-matched counterparts (41% vs 35 % and 32% vs 28 %, respectively) [24]. However, a study with 6622 participants found no significant difference in LDL levels between ArAs and non-Hispanic White individuals [36].

4.4. Obesity

A 2000–2011 study based on NHIS data (n = 213,644) found no significant difference between prevalence of obesity in ArA (n = 463) and US-born White participants (adjusted OR 0.86, 95 % CI 0.62 – 1.18). These results are not representative of US-born ArAs, however, as only those born in foreign countries were included [11]. In another large study with 2363 ArA participants from the Behavioral Risk Factor Surveillance System (BRFSS), there was no significant difference was found between the ArA and White individuals (31 % and 33 %, respectively) [47]. Similar results were reported in two other studies, including one systematic review [24,48]. There was some conflicting data, though, with a study on ArAs over the age of 35 years finding that the prevalence of obesity was higher compared to non-ArA subjects [46]. However, this study collected data from advertised free health screening, which may have induced some selection bias.

5. Demographic factors and CVD risk in Arab Americans

5.1. Age

Generally, as age increases, the burden of CVD increases [49]. The 1999–2001 Michigan mortality study by Dallo et al. discovered that the increased mortality rate with age among ArA is higher compared to both White and Black participants. The ArA death rate is initially lower but then exceeds White Americans at 45–49 years of age and that of Black Americans at 75–79 years of age. At 85+ years, ArAs had the highest death rate at 27, 602 compared to 15,867 and 14,718 per 100,000 in White and Black Americans, respectively [13]. As CVD is a leading cause of death, particularly with older age, it is reasonable to assume that this discrepancy is due to higher rates of CVD mortality in older ArA. However, studies are needed to specifically investigate rates of CVD deaths in different age groups in ArA compared to other ethnicities.

5.2. Sex

Female ArAs tend to have a lower prevalence of CVD and related comorbidities than ArA men, as highlighted in some of the studies above. It is well described that women have lower CVD risk at younger ages, but this may be more prominent in ArA. A possible theory is that women are exposed to strict cultural messaging regarding body image [50] and are thus more inclined to have lower BMI. In fact, a cross-sectional study published in 2021 found that in a population of ArA women in Michigan, self and health satisfaction were positively correlated with lower CVD risk scores. Specifically, a correlation was found between health promoting behavior and self, health and life satisfaction (r = 0.54, 0.45, 0.41 respectively, $P < .0001$). Self, health and life satisfaction were further negatively correlated with CVD risk (r = −0.17, −0.18, −0.27 respectively $P<.05$). Self and health satisfaction accounted for a combined 32 % of the variance in health-promoting behavior in this population (F = 7.568, $P < .0001$) while age and life satisfaction comprised 50 % of the variance in CVD risk score (F = 58.28, $P < .0001$) [51]. Thus, culturally induced standards of self-satisfaction are expected to directly impact CVD risks.

While sex-segregated obesity data is widely available for other ethnicities, data is sparse for ArAs. A small study conducted in Michigan by Khoury and Alzouhayli found that among 534 women and 360 men, the mean BMI was 27.4 and 28.1, respectively [43]. This is similar to nationwide averages of BMI for women and men (26.5 and 26.6, respectively). Additionally, Abuelezam et al. found that the prevalence of obesity (BMI>30) in ArA was 31 % and 34 % in women and men, respectively. In the state of Michigan overall the rate of obesity is around 34 % for both men and women. These limited studies point to a difference in BMI between ArA women and their sex matched counterparts, which further supports the social programming hypothesis.

5.3. Country of origin

It is important to note that ArA are in themselves a diverse group, and that estimates of disease burden may differ among sub-demographics. A study by Abuelezam et al. separated ArAs into 4 different subgroups: Gulf, African, Levant and other Arabs. They found that the prevalence of obesity, dyslipidemia and hypertension were highest among Levant Arabs, while the prevalence of diabetes was highest in Gulf Arabs. They also found that diabetes was least prevalent in African Arabs [52]. Another study by Sewali et al. supported these findings and found that the rate of diabetes in Somali Americans was relatively low [53]. Additionally, the previously mentioned study on diabetes in Arab Americans by Jaber et al. found a prevalence of 14.5 % (95 % CI 11.1–17.9 %) in Lebanese Americans, which was low compared to that of Yemeni and Iraqi Americans, at 26.2 % (95 % CI 17.4–33.7 %) and 26.2 % (15.3–37.1 %), respectively [31]. These results suggest that it may not be sufficient to simply separate ArA from non-Hispanic White patients, and that further designation of subgroups may be necessary to accurately measure disease burden.

6. Social and behavioral risk factors for CVD in Arab Americans

6.1. Acculturation and acculturative stress

Lack of acculturation, or the extent to which an individual has

integrated themselves in a new environment, is known to have psychological effects on minority groups [54,55], and may influence CVD risk. Chatkoff and Leonard investigated whether, due to acculturative stress, ArAs exhibited higher cardiovascular reactivity (CVR) due to perceived stressors [56]. However, in their small sample of 27 ArA college students and 27 matched controls, they found no significant difference in CVR. In 2021 Merizian et al. found that acculturative stress contributed to poor cardiovascular health behaviors (CVHBs) in a cohort of second-generation ArAs from Washington DC. Interestingly, the study also found that most participants had poor (46 %) or intermediate (45 %) overall CVHBs [57]. In a study by Dallo et al. on hypertension in Chaladean American women, there was a negative correlation between acculturation and waist-to-hip ratio [58]. Jaber et al. had similar findings in his study on DM and acculturation, in which degree of acculturation was assessed via a questionnaire and an aggregate score was computed. The odds ratio for less accultured ArAs to develop DM compared to their more accultured counterparts was 4.76 (95 % CI 1.06 – 20.0) [43]. Another study by Tailakh et al. had somewhat conflicting results, reporting a significant positive association between acculturation and BMI (correlation coefficient 0.31, $p < 0.05$) as well as exercise frequency (0.38, $p < 0.05$) [21]. In another study, acculturative stress and spending more time with ethnic peers was correlated with increased nicotine dependance [59], and this may be due to cultural factors influencing the perception of smoking which are discussed below. Once again, this calls for tailored care pertaining to disease prevention in this sociodemographic group.

6.2. Discrimination, socioeconomic status, education, and language barriers

Discrimination is an important consideration for minority health, and can impact the wellbeing of victims through stress and consciousness of disadvantages [60]. In a 2010 survey, 25 % of ArA respondents reported that they have been affected by religious or cultural discrimination after the September 11 attacks. Perceived discrimination was found to have an impact on health status and outcomes [61]. Studies on other ethnic minorities support the notion that discrimination has adverse effects on physical health and risk for CVD [62]. Another effect of systemic discrimination is that it can worsen economic potential and socioeconomic status of victims [60].

Socioeconomic status is an important factor influencing health outcomes, including CVD [63]. In ArAs, socioeconomic status appears to be on average higher than the rest of the US population [64]. However, even independent of socioeconomic status as represented by income and insurance coverage, racial minorities may have less access to healthcare. This might be partially explained by ethnic identity factors as well as language barriers [65].

Education about the basics of a disease, treatment, and prevention modalities can positively impact health outcomes [66]. A prior study noted that perceived risk directly correlated with willingness to adopt preventive lifestyles [43]. Unfortunately, chronic disease education that would increase perception of risk seems to be lacking in of ArA communities. In an ArA focus group study by Bertran et al., participants had misconceptions regarding the etiology of diabetes and its treatment, citing folklore in their explanations [67]. One study focusing on Yemeni-Americans found that many endorsed religious explanations of illness, which may prevent them from receiving appropriate care [68]. In another study, many ArA participants believed that cultural barriers, including stigma, influenced diabetes self-management [69]. An additional barrier is language, with 15 % of respondents in the Brooklyn studies citing this as an obstacle to health care [33].

6.3. Behavior and habits

Among various habits, smoking is one of the most impactful on cardiovascular health. In the survey of ArAs in Chicago, 30 % reported that smoking is a concern in their community [34]. Indeed, high rates of smoking in ArA communities have been reported by other studies [70–72]. The northern California study reports a borderline significantly higher rate of smoking among ArA men compared to non-Hispanic White men, at 42% vs 41 %, with the age adjusted prevalence ratio of smoking in ArAs coming out as 1.02 (95 % CI 1.00 – 1.05). However, for women, the opposite was true with smoking rates of 25 % compared to 35 % in non-Hispanic White women [24]. Likewise, a Michigan study based on a telephone listing found that the rate of smoking among ArAs in the community was significantly higher than statewide numbers (39% vs 29 %). Additionally, the rate of quitting was significantly lower in ArA (22% vs 47 %) [73]. On the contrary, Jamil et al. found that the rate of smoking was highest among White adults, while water-pipe smoking was highest among ArAs [70]. Lack of education about the dangers of water-pipe smoking and widespread belief that it is safer than cigarette use is thought to be a major contributor to such trends [74]. In fact, a study on Yemeni American youth discovered that lower levels of education were associated with an odds ratio of 9.37 for water-pipe use compared to peers of the same ethnicity that had higher levels of education [75].

A study found that the strongest predictors of smoking cessation in ArAs were being female, having a higher perception of risk and benefit of quitting, and lower level of nicotine dependance [76]. A cross-sectional study on Arab American youth in Virginia found that males were twice as likely as females to be smokers [77]. Female ArA appear to have lower rates of smoking, and similar trends are also seen in Arab countries. According to the WHO estimates, Jordan leads all Arab countries in smoking rate, at 58 % for men but only 13 % for women [78]. Cultural factors may be at play and should influence the design of tailored prevention efforts, as discussed below.

A second habit with significance towards cardiovascular health is exercise. El-Masri et al. found a negative relationship between employment and perceived importance of exercise in a sample of ArAs [44]. Additionally, the Brooklyn study reported that almost 50 % of ArA participants have never exercised. This was especially true in women and individuals who had migrated at older ages. A 2023 systematic review also found a positive association between physical activity and acculturation [79], which has been shown by various studies to negatively correlate with age at immigration [33,43]. Thus, ArAs who migrated to the United States at later stages in their lives should be particularly counseled about the importance of exercise.

7. Prevention and culturally tailored interventions

As highlighted in this review, many studies have reported poor cardiovascular health outcomes in ArAs compared to other ethnicities. Several risk factors have been explored above and are represented in a schematic in Fig. 1. As demonstrated in the figure, social risk factors highlighted in section V may be the most pertinent, as they also contribute to metabolic risk factors. The most effective prevention strategy should thus incorporate cultural factors, with culturally tailored interventions. As highlighted in this review, Arab Americans are a heterogenous group and health characteristics may vary among them. Still, there are some general approaches health practitioners could take to improve cardiovascular outcomes in this minority group.

One important approach among ArAs is education about tobacco use, particular water-pipe smoking. In one study on ArA youth, the prevalence of water-pipe smoking was 38 %, compared to only 21 % in their peers. Also, use of water-pipe in the family was associated with a 6.3-fold increase in the risk of the youth using water-pipes. This form of smoking is prominent in Arab culture, and it is a common misconception that it is not as harmful as cigarette smoking [80]. Physicians should routinely inquire about smoking habits, with particular reference to water-pipe smoking and educate about their health effects. Even in non-smokers, education should be given about the dangers of water-pipe smoking, as family and social circle influence can be strong [81].

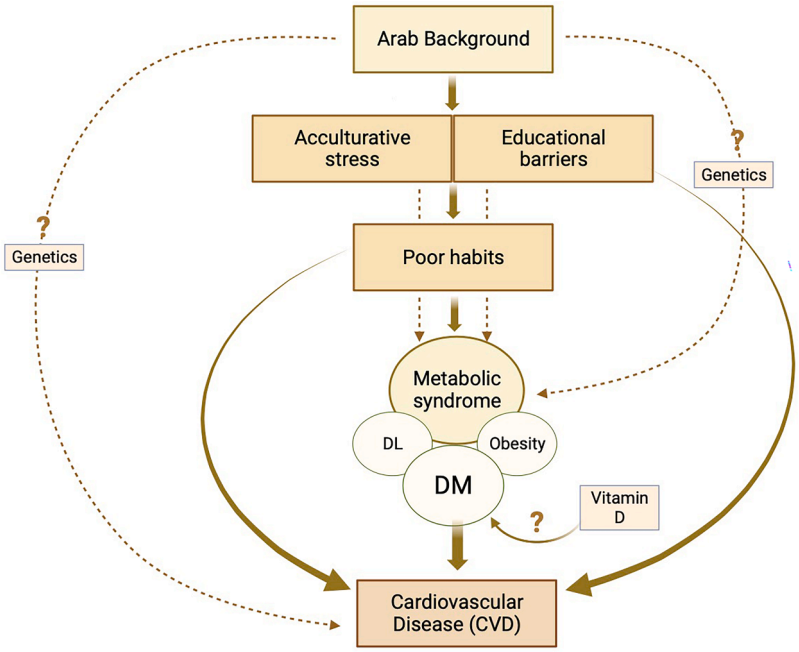

Fig. 1. Mechanisms of potentially elevated cardiovascular risk among Arab Americans.
Abbreviations: DL = Dyslipidemia, DM = Diabetes Mellitus.

Physicians should also address common questions and misconceptions among ArA patients.

In various Arab cultures, smoking is seen as sign of maturity and masculinity, with most traditional smoking cessation programs failing to target these core beliefs [82]. Recently, however, a smoking cessation program tailored for ArA men has been developed. The *Sehatak* program incorporates aspects of traditional smoking cessation programs, including nicotine replacement therapy and motivational interviewing, but tailors them culturally and linguistically for ArA men. At the end, the program demonstrated a significant increase in the number of participants willing to quit [83].

Diabetes prevention and management is also of paramount importance. As highlighted above, many misconceptions about DM exist among ArAs. In particular, an important consideration in ArA patients with DM is the Holy month of Ramadan. Many ArAs identify as Muslim and thus observe a sunrise-to-sunset fast during this month. It is important that individuals with diabetes be educated about risks of fasting, indications to break fasts, symptoms of hypoglycemia, and meal plans. However, a survey determined that such education is not commonly available. In addition, many patients ceased or decreased the frequency of home blood glucose monitoring [84]. This highlights the need for physicians to increase their cultural awareness, as patients will not always volunteer information regarding their day-to-day lives without being specifically asked. Possibly, educational material surrounding diabetes and fasting during Ramadan could be distributed in ArA communities, with cultural and linguistic factors in mind.

Lastly, Arab culture revolves around social connections and hospitality, and interventions that use this to their advantage may be more likely to succeed. In fact, a study testing the effectiveness of a group lifestyle intervention on diabetes prevention in ArAs found a significant increase in participants' physical activity and a decrease in their caloric intake, with most being able to achieve significant weight loss. Importantly, 86 % of participants completed the intervention, likely because they found it engaging. An increased sense of cohesion and ability to socialize with ethnic peers with similar health problems likely contributed to the positive health outcomes seen. Indeed, in another study that tested a weight-loss program in ArAs, those that succeeded in meeting a standardized goal of a 7 % reduction in weight were more likely to have family support (70% vs 30 %, $p = .0023$). Interestingly, within this ArA subgroup, demographic and psychosocial factors were not contributory to outcomes in any significant way [85], meaning that cohesion and social support, on their own, play a key role in the wellbeing of this community. Keeping these considerations in mind is especially important when dealing with older ArAs and those that have immigrated at later stages in life, for whom social support may be lacking. Physicians should inquire about feelings of loneliness and contact social workers when necessary.

8. Limitations, gaps in knowledge and future directions

There are some limitations to the studies included in this review. Firstly, it may not have been possible to accurately assess Arab American status in many of the included studies, as some participants may have been visitors or non-immigrant aliens. Also, in many cases, ArA status was determined using last name, or a combination of first and last name, which may result in some inaccuracies. Many studies have also relied on convenience sampling from local communities rather than true random sampling, due to difficulty in identifying eligible study participants otherwise. Most of the studies were conducted in ArA dense states such as Michigan and California, with nationally representative data lacking.

In general, focus on the cardiovascular health of Arab Americans is sparse in the literature. More large-scale longitudinal studies should be conducted with a focus on social and metabolic risk factors and their impact on CVD risk. It is also important to evaluate the difference in CVD and comorbidities between Arab immigrants and Arab Americans. Assessing for place of birth is important as prior studies have shown. For example, O'Connor et al. compared cardiometabolic health factors between Black Immigrants and Black American men and showed higher glucose levels, worse hypertension, and more visceral adiposity in the Black Immigrant population, though Black immigrants had lower obesity rates than Black Americans [86].

Another study found that Black immigrants who arrived in the United States before 20 years of age had lower CVD risk factors, favoring the immigrant hypothesis [87], which states that immigrants that arrive at later ages tend to have worse outcomes. Heterogenous results indicate that the healthy immigrant effect may not always be valid and should be

considered in a case-by-case basis with adjustment for age of arrival to the United States [88]. Similar studies should also be conducted in Arab Americans.

Finally, as highlighted in this review, type 2 DM is a major contributor to morbidity and mortality in ArAs, even more so than in other communities. Still, this difference cannot be explained by increased obesity rates. One theory is that fat tends to distribute more centrally in people of Arab ancestry, and visceral fat has been shown to have a much higher rate of metabolic complications such as DM [89]. Studies need to be conducted to compare rates of visceral adiposity in ArA and other demographics in America. It is also important to study liver fat, which has also been linked to DM [90]. A second theory is that certain gene polymorphisms frequently present in ArAs predispose them to insulin resistance. A Detroit study found that the heterozygous haptoglobin 2–1 genotype was associated with insulin resistance in ArAs [91]. Current studies demonstrate that haptoglobin is related to insulinemia and insulin resistance [92], but more studies are needed to confirm the effect of genotypes and their prevalence in various populations.

The production of future studies on ArA health is hampered by their lack of recognition as a separate ethnic category. When studies are conducted, they must rely on convenience sampling or imperfect methods of determining ArA status such as last name. The necessary use of non-random sampling methods may limit the internal validity of research on ArA, which leads to a lack of reliable data that could otherwise influence guidelines and standards of care in this population. A further consequence of lumping several ethnic categories, including ArAs into the "non-Hispanic White" category is that statistical conclusions reached are mere generalizations due to the population's vast heterogeneity, which impacts the external validity of studies as discussed by Awad et al. Additionally, a crucial opportunity to advance research on health disparities is lost since individuals within this category are treated as one. ArAs are particularly disadvantaged in this setup, as they are a group within the "non-Hispanic White" population that is more prone to discrimination and "othering" [93]. Thus, to streamline the production of high quality, sound research that accounts for nuances in populations and furthers the efforts to highlight and address health disparities, ArA should be distinguished from "non-Hispanic White" Americans in government health databases. As demonstrated in this paper, from a cardiovascular perspective, these nuances are not trivial and can influence treatment and prevention practices. The issue is not logistical, concerning the small number of ArAs, since there are recognized categories like "Pacific Islander," which represent a much smaller subset of the American population [93].

9. Conclusion

Arab Americans are a minority population in the United States that are understudied. Existing evidence suggests that they are at significantly increased risk of various CVDs and risk factors including stroke, myocardial infarction, hypertension and diabetes mellitus. Psychosocial and demographic factors such as acculturative stress, exposure to discrimination, cultural barriers to disease education and various obstacles to adequate health care access are also important to study and address. More deep phenotyping of ArA including assessment of subclinical atherosclerosis and visceral adiposity is needed. Lastly, longitudinal studies of ArA and incident CVD outcomes are required. Further advancement of research on population risk factors as well as health disparities may be hampered by the lack of a separate racial/ethnic category for Arab Americans in government health databases.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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