Social Determinants

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Social Determinants of Health and Cardiovascular Care: A Historical Perspective

Dr. Martin Luther King Jr. once said, "Of all the forms of inequality, injustice in healthcare is the most shocking and inhumane." These words are as relevant today as nearly 60 years ago, when they were first spoken by Dr. King at a convention of the Medical Committee for Human Rights in Chicago in March of 1966 [1]. As elusive as the concept of health equity sounds, inequities in health and healthcare

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are explained—to a large extent—by the conditions in which individuals live and work, procreate and grow old, form social networks, and seek and provide help [2]. These conditions—collectively known as the social determinants of health (SDOH)—determine our physical, emotional and financial wellbeing, susceptibility to illness, and overall health and quality of life [3] (Fig. 1).

Traditional models of health and medical care in the US have historically ignored the role of SDOH in predicting wellness and illness [4]. However, radical changes in healthcare financing in the past decade, including performance-based reimbursement mechanisms such as value-based care models, coupled with the documented benefits of primary and secondary prevention on healthcare expenditures and overall value of services, have highlighted the importance of acknowledging and incorporating SDOH in chronic disease prevention and management [5, 6]; these changes in healthcare financing and overall service delivery have helped bring SDOH to 'mainstream' clinical practice models, including care for cardiovascular disease (CVD) [5–7].

SDOH provide unique opportunities for tailoring medical care to the individual patient, thereby improving health outcomes and reducing observed disparities by informing equitable resource utilization and health services delivery [8–10]. Despite the proven link between SDOH and health outcomes, and the demonstrated urgency to incorporate SDOH into existing and any future policy and practice models, social determinants are grossly under-utilized—to the detriment of the individual patient, and the population at large [4, 11]. In particular, current frameworks of 'precision care' rarely incorporate SDOH into clinical decision management tools, severely limiting the documented benefits of SDOH application in clinical settings [9, 12, 13].

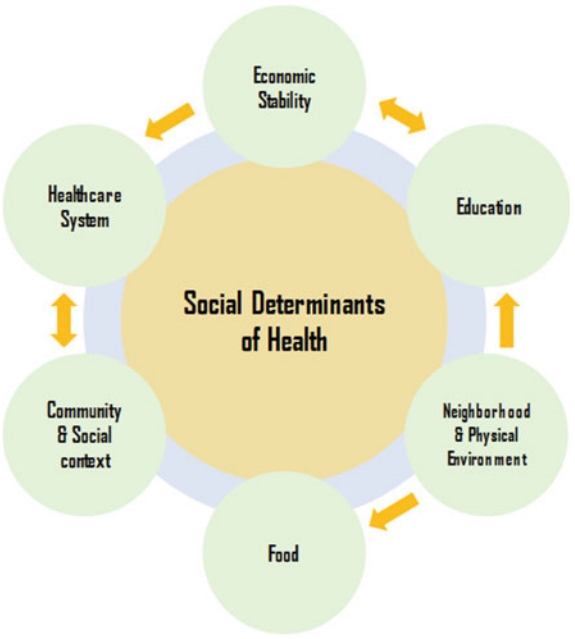

Fig. 1 Social determinants of health

President Barack Obama launched the Precision Medicine Initiative in 2015, and outlined its goals as, '…delivering the right treatments, at the right time, every time to the right person' [14]. However, recent evidence points to the challenges and shortcomings of contemporary precision medicine—from both an economic and health outcomes perspective—owing to inattention to SDOH [13, 15, 16]. Indeed, real-world evidence clearly suggests that SDOH integration into clinical care is associated with improved outcomes in vulnerable populations [17, 18]. Consequently, novel health services delivery approaches advocate for the use of individuals' unique social and environmental *risk factor* profile to guide disease prevention and management efforts and maximize the utility of *precision health*, with major implications for health equity [12, 15].

This chapter discusses SDOH in the context of disparities in CVD care and outcomes. We highlight the link between different SDOH domains and CVD; potential role of SDOH in identifying high-risk, marginalized population subgroups; and the use of SDOH knowledge to inform care delivery to underserved populations, given their unique SDOH burden. In addition, we provide a brief overview of the major efforts in highlighting disparities in health and healthcare in the US over the past four decades.

Landmark Reports on Health Disparities: Relevance to CVD

Much awareness, attention and work in the field of health disparities and minority health is pioneered by the landmark report on minority health, "Black and Minority Health", issued in 1985 by then Secretary of US Health and Human Services, Margaret M. Heckler [19]. The critical report presented objective evidence of wide disparities in health outcomes, experienced disproportionately by the minority populations in the US, particularly the Black population. The Heckler report was the first detailed account of health disparities on a national level in the US, and the first major acknowledgement of such disparities by the US government. The report highlighted that heart disease and stroke were the leading cause of excess mortality in Black people compared to White people—with an average annual excess mortality burden of 31% [19].

It was not until nearly two decades later that the findings from the Hecker report were used as a framework to build on work in the field, and determine future directions on a path to health equity. The groundbreaking Institute of Medicine (IOM) report titled "Unequal Treatment: Confronting Racial and Ethnic Disparities in Healthcare," [20] analyzed evidence from nearly 600 published studies and revealed glaring racial/ethnic disparities in outcomes for major medical conditions, including CVD. The IOM report provided the first comprehensive framework to address disparities in health and healthcare, with a particular focus on race, racism, and discrimination, and the interplay of various SDOH to produce health outcomes in minority populations. The report concluded with a set of recommendations, and provided a basis for design of interventions to address such disparities—a

framework that many academicians, clinicians, population health scientists and policy makers have used in the past two decades.

Subsequently, the American College of Cardiology (ACC) and the Henry J. Kaiser Family Foundation (KFF) published a joint review of disparities in cardiovascular services in the US, and reported that Black people were less likely than White people to receive diagnostic and revascularization procedures, even after adjusting for patient characteristics [21].

These accounts were followed by major work from the Centers for Disease Control and Prevention (CDC): "State of Health Disparities and Inequalities in the US," [22] and two landmark scientific statements on SDOH from the American Heart Association [23, 24]. These reports further acted as stark reminders of the fact that healthcare in the US in general, and cardiovascular care specifically, are not equitable, and that much needed attention must be accorded to SDOH if the goals of health equity were to be achieved nationally. These reports are summarized in Table 1.

Prior work presents important opportunities to further knowledge on health disparities in the US, including frameworks that can—and must—be used to design evidence-based, scientifically robust interventions in order to address various SDOH and improve CVD risk and outcomes in vulnerable populations. The goal is to inform future actions to incorporate SDOH into policy-making and clinical practice, and reduce disparities in CVD and associated outcomes locally, nationally and globally.

Role of SDOH in Cardiovascular Care: Ignored for Far Too Long

Current State of CVD Disparities in the US

CVD is the leading cause of death in the US, [25] with significant financial implications for both patients and the healthcare system. The cost of CVD in the US is estimated at nearly $550 billion annually, including $237 billion in lost productivity due to premature CVD and stroke [26]. By 2035, the direct costs associated with CVD are expected to double in the US, with nearly 45% of the population expected to develop some form of CVD [26]. Marginalized populations, such as racial/ethnic minorities are affected disproportionately by CVD, and its risk factors [27–29].

Recent data from Centers for Disease Control and Prevention (CDC) [27] show that non-Hispanic Black people experience nearly 1.5 times increased prevalence of hypertension and diabetes, and 20% higher rates of CVD related mortality, relative to non-Hispanic White people. Non-Hispanic Black people are more than twice as likely to die from heart disease, compared to other minority groups, including non-Hispanic Asian people or Pacific Islanders. While a decreasing trend in CVD

Table 1 Landmark reports on health disparities in the US

Agency	Published	Title	Major CVD related findings	Link
U.S Department of Health and Human Services. *Contributor: Heckler, M*	1985	Report of the Secretary's Task Force on Black & Minority Health. The 'Heckler' Report	Heart disease and stroke were the leading cause of excess mortality in the Black population, compared to their White counterparts	https://collections.nlm.nih.gov/catalog/nlm:nlmuid-8602912-mvset
Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care *Smedley, BD.* et al	2002	Unequal Treatment: Confronting Racial and Ethnic Disparities in Healthcare	Black people were less likely to undergo cardiac catheterization, revascularization procedures or CABS after MI, compared to White people	https://www.nap.edu/catalog/12875/unequal-treatment-confronting-racial-and-ethnic-disparities-in-health-care
Henry J. Kaiser Family Foundation. *Lillie-Blanton, M.* et al	2002	Racial/Ethnic Differences in Cardiac Care: The Weight of the Evidence	Black people were less likely than White people to receive diagnostic and revascularization procedures, even after adjusting for patient characteristics	https://www.kff.org/wp-content/uploads/2002/09/6040r-racial-and-ethnic-differences-in-cardiac-care-report.pdf
Centers for Disease Control and Prevention: State of Health Disparities and Inequalities in the US	2013	CDC Health Disparities and Inequalities Report	Age-adjusted coronary heart disease (CHD) death rate was higher among non-Hispanic Black people than any other racial/ethnic group. Rate of premature death (aged < 75 yrs) was higher among non-Hispanic Black people than their White counterparts	https://www.cdc.gov/minorityhealth/CHDIReport.html

prevalence is observed in non-Hispanic White people over the past two decades, rates of heart disease have remained relatively unchanged in racial/ethnic minority populations [27].

Such disparities are linked to multiple SDOH in underserved populations—including barriers to care and socioeconomic disadvantage—which exert both independent and cumulative effects on CVD outcomes. For example, rates of most CVD preventive services are higher in non-Hispanic White people, relative to other racial/ethnic groups [27, 30]. Compared to non-Hispanic White people, Asian people are reported to have 60–64% lower likelihood of routine weight and blood pressure screening, whereas Hispanic people are over 50% less likely to report routine blood pressure measurement, and 66% less likely to be asked by their healthcare provider about smoking habits [30].

A recent study of nearly 45,000 non-institutionalized US adults reported substantial and persistent disparities in CVD prevalence by socioeconomic status (SES), from 1999–2016 [31]. Abdalla et al. found that overall prevalence of congestive heart failure (CHF) and stroke was less than one-third, and less than one-half in the 'highest resource' group, respectively, relative to the remainder of the population. In addition, disparities in CVD prevalence between the highest and lowest resource groups have widened over the past twenty years [31].

SDOH are important predictors of disparities in CVD risk and outcomes, and are particularly relevant to CVD prevention and management [23]. Current models of CVD care are mostly designed to address *traditional* risk factors for CVD; much effort, energy and resources have been allocated to the *medical determinants of health* [32]. However, past and present models of CVD care seldom acknowledge the critical role of SDOH, or the failure of leaders in the field to build a comprehensive yet personalized care model, informed by SDOH. Meaningful reductions in cardiovascular health disparities cannot be achieved without incorporating SDOH into existing models of care, and informing CVD prevention and management approaches. Indeed, SDOH are critical to achieving true equity in cardiovascular care, and outcomes.

SDOH, 'Traditional' Risk Factors and Current Models of CVD Care

Most existing practice models of CVD prevention target traditional *downstream* CVD risk factors such as cigarette smoking, diabetes mellitus, obesity, hypertension and physical activity; [33] very few recognize SDOH as major *upstream* determinants of CVD outcomes, and fewer yet, identify potential mechanisms to incorporate SDOH into prevention efforts—both on a policy and practice level [32, 33]. Contrary to current norms of CVD care, years of research have shown that a 'prescription' for healthy behaviors seldom achieves the intended goal of lower CVD risk, or improved clinical outcomes in most patients [34–36]. Instead,

improvements in individual risk factor profile require a multi-faceted approach that targets different SDOH domains, as well as pathways that link each domain to CVD outcomes [32, 33].

Addressing *upstream* determinants of health is a top Healthy People 2030 goal: "creating social, physical, and economic environments that promote attaining the full potential for health and well-being for all" [37]. It is known that medical care for traditional disease risk factors accounts for only 10–20% of the variation in health outcomes; the rest is explained by our behaviors, environment, and the conditions in which we live and work, i.e. SDOH [38]. Indeed, findings from a unique population-based study using data from over 3000 US counties across 45 states demonstrate that socioeconomic factors, health behaviors, medical care and physical environment contribute 47, 34, 16 and 3%, respectively to a composite health outcomes score on a national level in the US [36].

Equitable healthcare resource distribution, such as uniform access to best practice interventions for CVD prevention can significantly reduce disparities risk in CVD mortality, overall and by SES [39]. However, current best practices rarely incorporate SDOH as the "causes of causes," i.e. upstream determinants of classic CVD risk factors—a missed opportunity for population health management. Unfortunately, improvements in CVD care have not been shared equally among different population subgroups over the past century. Indeed disparities in CVD risk and outcomes persist across a wide spectrum of SDOH [29, 31, 40, 41]. As discussed in the following sections, SDOH affect CVD not only directly but also indirectly via effects on health behaviors and other traditional risk factors. These pathways are discussed in greater detail in the following sections.

SDOH and CVD: A Review of Current Literature

The link between individual socioeconomic factors and health outcomes has been extensively studied. However, relatively few studies have investigated the association between different SDOH domains and risk factors, overall burden and long-term outcomes for CVD.

The landmark American Heart Association (AHA) "Scientific Statement on Social Determinants of Risk and Outcomes for Cardiovascular Disease" highlighted major shortcomings of the US healthcare system in failing to address, and incorporate SDOH into policies and practices for cardiovascular care [24]. The report also highlighted critical knowledge gaps that must be filled in order to move the needle from health disparity to health equity; particularly if we are to stem the rising burden of CVD in the US, which continues to impact marginalized populations disproportionately, and is projected to rise to over 45% by 2035—a 30% increase since 2015 [26].

The following subsections review existing knowledge of the link between different SDOH—organized into distinct domains and subdomains—and CVD. Each section discusses current evidence and major pathways of the SDOH-CVD link.

SDOH: A Domain-Based Analysis

SDOH influence CVD via multiple pathways and mechanisms. The association between SDOH within each domain and CVD, and possible pathways of the observed association are discussed briefly in this section. As depicted in Fig. 1, SDOH do not act in isolation; rather different SDOH interact to influence CVD. The discussion of SDOH herein is based on the frameworks proposed by Healthy People 2020 and the Kaiser Family Foundation, [2, 42] which organize SDOH into six distinct domains: economic stability, education, food, neighborhood and physical environment, health care system and community and social context.

Economic Stability

Economic stability is defined by income, wealth, employment status and occupational category. While other definitions of economic stability also include physical living conditions, education and food insecurity, [2, 42] those are discussed separately, given their independent association with CVD. This section focuses on income and employment as the major measures of economic stability.

Current Evidence and Pathways

The association between low income and increased risk of myocardial infarction (MI), heart failure and stroke is seen across study designs and target populations [43, 44]. In a unique computer simulation study of over 31 million US adults aged 35–64 years, Hamad et al. [45] analyzed the association between low SES (defined as <150% of federal poverty level [FPL] or education less than high school) and premature (i.e. occurring before age 65 years) CHD and myocardial infarction (MI) deaths, and found that rates of premature MI and CHD mortality were twice as high in the low SES group, relative to high SES group. The authors further demonstrated that SES-associated 'upstream' risk factors explained a greater proportion of the observed mortality disparities, compared to traditional risk factors (60% vs. 40%, respectively).

A meta-analysis of 70 studies reported an overall increased risk of acute myocardial infarction (AMI) for all three measures of SES, i.e. income, education and occupation [46]. The study found 71% increased AMI risk for low income (pooled relative risk [RR] 1.71; 95% CI 1.43–2.05); 34% for low education (pooled RR 1.34; 95% CI 1.22–1.47); and 35% for low occupational socioeconomic position (pooled RR 1.35; 95% CI 1.19–1.53). Another meta-analysis of over 50 studies reported an increased risk of hypertension associated with socioeconomic adversity [47]. Leng et al. found 19% (pooled odds ratio [OR] 1.19; 95%

CI = 0.96–1.48), 31% (pooled OR 1.31; 95%CI 1.04–1.64) and over 100% (pooled OR 2.02; 95%CI 1.55–2.63) increased risk of hypertension for income, occupation and education, respectively.

These findings are further corroborated by results from the landmark Whitehall study of nearly 18,000 British civil servants, which showed that civil servants in the lowest SES category had nearly 3 times increased risk of CHD mortality over a 10-year period, compared to those in the highest SES category; smoking and other traditional CVD risk factors only explained part of the observed mortality difference [48].

The association between economic stability and population level CVD outcomes has been analyzed on a global scale. For example, in a comprehensive review of published literature on SES and stroke outcomes, Addo et al. [49] reported that both stroke mortality and disability-adjusted life years (DALY) lost are over threefold higher in low income countries, compared to high and middle income countries. A national prospective cohort study of over 45,000 patients in Netherlands, followed for three years, reported a 37–39% increased relative risk of AMI and 55–74% increased relative risk of chronic ischemic heart disease (CIHD), with the variation attributed to gender [50]. Similarly, the Atherosclerosis Risk in Communities (ARIC) study—a large-scale, prospective cohort of nearly 10,000 community-dwelling, predominantly black and white men and women—found that participants who experienced decline in income levels over a mean follow-up of 17 years had higher risk of MI and stroke, compared to those whose income remained relatively unchanged [51]. Conversely, participants whose income increased during the study period experienced lower incidence of CVD compared to those individuals whose income was unchanged [51].

Employment status and occupational category are important markers of economic stability, and independent determinants of CVD. Unemployment, change in employment status, blue collar/service occupational categories and job stress are all linked to poor CVD outcomes in a variety of target populations. For example, a unique prospective study of over 40,000 Japanese men and women followed for an average of 15 years reported a 1.5–threefold increased risk of stroke incidence and stroke mortality in individuals who experienced job loss (Hazard Ratio [HR] for stroke incidence, men 1.58 [95%CI 1.18–2.13]; HR for stroke mortality, women 2.48 [95%CI 1.26–4.77]) or reemployment (HR for stroke incidence, men 2.96 [95%CI = 1.89–4.62]; HR for stroke mortality, women = 2.48 [95%CI = 1.26–4.77]) [52].

In addition to the direct effects on CVD, economic stability plays a major role in determining a variety of CVD outcomes via indirect effects on other SDOH domains. Multiple proposed mechanisms link SES and CVD; most of which are based on the interplay of different SDOH domains potentiating the risk of adverse CVD outcomes. For example, loss of income has been associated with consumption of unhealthy foods, unhealthy behaviors such as smoking, and greater degree of psychological stress and depression, which are in turn linked to elevated risk of CVD [53, 54]. Income level and loss of employment can affect health insurance coverage, access to medical care and neighborhood of residence; all of which

impact cardiovascular health [55]. Higher SES facilitates access to resources such as knowledge, social networks, safe/stable housing and access to health care that can mitigate the negative effects of economic instability on CVD and overall health [56].

Summary

- *Economic stability affects CVD through a multitude of direct and indirect pathways, with great implications for both individual and population cardiovascular health*
- *CVD treatment and prevention efforts must carefully consider the role of economic stability, both on a clinical and policy level*
- *Future research must focus on development and validation of an exhaustive measure of economic stability, inclusive of income and wealth, education, and occupational status and employment, to be applied to diverse population subgroups*

Education

The association between education and health, wellbeing and quality of life is well documented in the literature [57]. Education impacts health broadly, and CVD in particular, via numerous pathways. The discussion of education herein includes both formal educational attainment, and health literacy.

Current Evidence and Pathways

Low educational attainment is associated with adverse CVD risk factor profile and increased risk of CVD incidence and mortality [41]. Results from the recent Prospective Urban Rural Epidemiologic (PURE) study of over 150,000 participants from 20 countries globally—followed for an average of 7.5 years—document a 1.23 to 2.23 times increased risk of major cardiovascular events for low educational attainment, relative to high level of education, with the highest risk observed in low-income countries (HR [low vs high level of education] 2.23; 95% CI 1.79–2.77). These results are supported by a meta-analysis of 72 cohort studies from Asia, Europe and the US, which reported an up to 40% higher risk of stroke, CAD

and cardiovascular mortality in individuals with low educational attainment, relative to their counterparts [58].

INTERHEART—a case–control study of over 26,000 participants from 52 countries reported an over 30% increased risk of non-fatal AMI associated with less than 8 years of education; the observed association persisted even after adjusting for a variety of sociodemographic and clinical covariates [59, 60]. Similarly, findings from the ARIC study—a prospective study of 13,948 White and African American adults aged 45–64 years—demonstrated an inverse relationship between educational attainment and lifetime CVD risk; [61] Kubota et al. found that over 1 in 2 participants with less than high school education experienced a lifetime event of CVD.

Education can affect CVD outcomes both directly and indirectly via effects on other SDOH. In general, academic success is linked to higher earnings, which in turn provide resources for access to healthcare, better housing and healthier food options [62–64]. Further, education is an important determinant of occupational status; low educational attainment is linked to unemployment, which predisposes to poverty, food insecurity, unstable/unsafe housing and various other intermediary behavioral and environmental factors that predict adverse CVD outcomes [65].

Nearly 80 million U.S adults are reported to have limited health literacy, which is associated with poor health outcomes [66]. Higher education levels increase access to, and understanding of, important resources such as recommendations/guidelines for a balanced diet, physical activity, as well as available evidence on risk factors, prevention and management of major chronic illnesses, including CVD [67].

It has been previously reported that individuals with limited health literacy are more likely to adopt unhealthy behaviors such as smoking, and less likely to achieve cessation [68, 69]. The negative effects of education on adverse CVD outcomes such as coronary artery disease (CAD) persist, regardless of other sociodemographic factors and clinical predictors [70]. Conversely, higher health literacy is associated with healthy behaviors, positive lifestyle changes, and increased medication adherence [71, 72].

Traditional risk factors such as diabetes, hypertension and body mass index (BMI) have been shown to mediate the relationship between education and CVD [122], which further reinforces the intersectional nature of SDOH, i.e. effects on cardiovascular health via multiple direct and indirect pathways, including interlinkages among different SDOH domains, as well as between each domain and traditional/clinical risk factors.

Summary

- *Education exerts important influences on cardiovascular health, both directly and indirectly* via *'facilitatory' effects on other SDOH such as income and occupation*
- *Education—both formal educational attainment and health literacy—play an important role in shaping our behaviors, and determining the risk of CVD*
- *Future efforts must focus on elucidating possible pathways between education and various upstream and downstream CVD risk factors*
- *Effects of education and other SDOH, including income, occupation and race/racism must be analyzed from an intersectionality lens*

Neighborhood and Physical Environment

This diverse domain encompasses various aspects of housing (e.g. safety, quality), physical environmental conditions such as air/water quality, availability of playgrounds, greenness, walkability, availability of hospitals, schools and grocery stores, and public transport [2]. Our built environment determines access to a wide range of other SDOH, and factors that can directly or indirectly affect risk of CVD. For example, neighborhood safety and sidewalk availability to facilitate physical activity and availability of nearby hospital to receive immediate medical care. These relationships and pathways linking neighborhood/physical environment to both CVD, and other SDOH, are discussed below.

Current Evidence and Pathways

Disadvantaged neighborhoods are known to predict adverse CVD outcomes [73]. Unger et al. [74] studied the association between neighborhood characteristics and cardiovascular health using baseline (2000–2002) data from the Multi-Ethnic Study of Atherosclerosis (MESA)—a national prospective cohort study nearly 7000 of middle aged and older adults in the US. The authors reported that resources for physical activity (OR 1.19; 95%CI 1.08–1.31), neighborhood walkability (OR 1.20; 95%CI 1.05–1.37) and high neighborhood SES (OR 1.20; 95%CI 1.05–1.37) were all associated with increased odds of ideal cardiovascular health score (cumulative measure of traditional CVD risk factors) [74].

The Jackson Heart Study—a landmark cohort study of over 4000 African American men and women aged 21–93 years—assessed the association between neighborhood disadvantage/poor social conditions and CVD risk, and found that each standard deviation (SD) increase in neighborhood disadvantage increased the risk of CVD by 25% (HR 1.25; 95% CI 1.05–1.49) in women but not in men [75]. The authors also reported an inverse relationship between neighborhood disadvantage, and duration/frequency of physical activity, with implications for overall CVD risk factor profile in disadvantaged communities. Similarly, findings from the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) [76]—a large cross-sectional study of approximately 45,000 adults aged 40–70 years—showed a 19–33% higher 10-year CVD risk for individuals living in neighborhoods with low walkability scores, relative to residents of neighborhoods with high scores [76].

Other aspects of physical environment, such as air quality also have important effects on cardiovascular health. A systematic review of 18 studies (5 cohort and 13 cross-sectional) found that particulate matter air pollution was associated with the presence and progression of subclinical atherosclerosis, as measured by coronary artery calcium score and carotid intima media thickness [77]. Further, neighborhood safety might directly affect physical activity and possibly increase psychological stress—both risk factors for CVD [78, 79]. A cross-sectional study of the young and middle aged population in Stockholm, Sweden found that individuals living in unsafe neighborhoods with high crime rates experienced an up to 75% increased odds of CHD (OR 1.75; 95% CI 1.37–2.22) [78].

A cross-sectional study of 11,404 Australian adults reported a protective effect of neighborhood greenness (37% lower odds) on hospitalization for heart disease or stroke [80]. The Baltimore Memory Study, a cross-sectional study of 1,140 Baltimore residents aged 50–70 years, demonstrated that individuals in the most unsafe neighborhoods, as assessed by the self-reported neighborhood psychosocial hazards scale (NPH)—including indicators of public safety, physical disorder, economic deprivation and social disorganization—experienced over 4 times higher odds of myocardial infarction (MI) and 3 times higher odds of MI, stroke, transient ischemic attack (TIA), or intermittent claudication compared with residents living in safer neighborhoods [79].

Relatively little is known about the cumulative 'life course' effects of neighborhood disadvantage. While long-term effects of SES and neighborhood conditions have been examined overall, relatively few studies have examined such effects on cardiovascular outcomes [81–83]. Findings from a MESA study of nearly 5000 middle aged and older men and women, followed up for 20 years, suggest that worse neighborhood trajectory class (i.e. greater neighborhood poverty) predicted worse CVD outcomes, as measured by common carotid intima media thickness; however, the association was only observed in women. Greater research is needed to increase understanding of neighborhood and physical environment effects across the life course.

Summary

- *Neighborhood and physical environment provide, and facilitate access to, a variety of other SDOH*
- *Neighborhood environment affects CVD risk both directly as well as* **via** *behavioral and psychosocial pathways*
- *Weight of current evidence suggests a positive impact of favorable neighborhood conditions and a negative effect of unfavorable neighborhood conditions on overall cardiovascular health*
- *Further research is needed to better understand how exposure to adverse physical and psychosocial environments in early life predicts adverse CVD outcomes later in life*
- *Future efforts must examine the life-course perspective of disease and health in the context of neighborhoods, with particular attention to potential disparities in long-term outcomes by race/ethnicity*

Food

Dietary behaviors are an important part of traditional risk factor modification recommendations to promote cardiovascular health. Existing guidelines to reduce CVD risk via improvements in dietary habits have been extensively reviewed previously [84]. However, diet has mostly been analyzed in conjunction with other behavioral risk factors such as physical activity; much less attention has been paid to food as a distinct SDOH domain, particularly in the context of food insecurity—as discussed in this section.

Current Evidence and Pathways

Presence of nearby grocery stores and supermarkets is essential to availability of healthy food choices, which may improve overall cardiovascular risk profile. Kaiser et al. [85] used data from the MESA study to evaluate the relationship between neighborhood physical and social environment, and incident hypertension in nearly 3400 adults aged 45–84 years with a mean follow up of over 10 years; the authors reported that a 1 standard deviation (SD) increase in healthy food availability was associated with a 12% lower risk of hypertension (HR 0.88; 95%CI 0.82–0.95). Similarly, results from another MESA study of over 6800 US adults suggested that availability of 'favorable' food stores—defined as chain and non-chain

supermarkets, and fruit and vegetable markets—was associated with 22% increased odds of a favorable cardiovascular profile (cumulative risk score based on traditional CVD risk factors) [74].

Morland et al. [86] studied the association between presence of supermarkets and convenience stores with CVD risk factors using data from over 10,000 adults enrolled in the ARIC study. The authors reported that prevalence of supermarkets was associated with lower prevalence of obesity (prevalence ratio [PR] 0.83; 95% CI 0.75–0.92) and overweight (PR 0.94; 95% CI 0.90–0.98); conversely, presence of convenience stores was associated with higher prevalence of both obesity (PR 1.16; 95% CI 1.05–1.27) and overweight (PR 1.06; 95% CI 1.02–1.10) [86]. Similar findings were documented by Powell and colleagues, who studied the association between access to local convenience stores vs supermarkets, and adolescent body mass index (BMI) in over 73,000 adolescents; [87] and reported that one additional chain supermarket per 10,000 capita was associated with 0.11 units lower BMI, and 0.6 percentage point reduction in overweight prevalence, whereas an additional convenience store per 10,000 capita was associated with 0.03 units higher BMI and 0.2 percentage points increase in prevalence of overweight [87].

Availability of healthy food choices may have important effects on CVD-related health behaviors. For example, Morland et al. [88] studied the contextual effects of local food environment on residents' diet using data from the ARIC study, and reported that presence of each additional supermarket in the census tract increased fruit and vegetable consumption by 32% and 11% in African Americans and Whites, respectively. However, low income neighborhoods are less likely to have healthy food outlets and supermarkets, and more likely to have small grocery and convenience stores [89]. Data from the 2000 Census [89] suggests considerable racial/ethnic and socioeconomic disparities in access to healthy food outlets, with 25% fewer chain supermarkets in low income neighborhoods, compared to middle-income neighborhoods; and 50–70% fewer chain supermarkets in African American and Hispanic neighborhoods, relative to White neighborhoods.

Living in a food desert—defined as area with both poor food access and low area income [90]—might increase risk of adverse CVD outcomes. A recent national cross-sectional study of nearly 9,000 young adults reported an increased cardiovascular health risk associated with residence in a food desert [91]. Similarly, a prospective study of nearly 5,000 middle aged and older individuals reported a 39% increased risk of MI and 18% increased risk of death from MI associated with living in a food desert, in patients with existing coronary artery disease (CAD); however, the association was observed only for low area income and not food access [92]. Greater research is needed to better understand the impact of environmental and contextual factors (e.g. nearby supermarkets) vs individual level barriers to access, such as income and/or other resources for accessing healthy food options (e.g. Supplemental Nutritional Assistance Program [SNAP] benefits, transportation, etc.).

Summary

- *Access to, and availability of healthy food is critical toward cardiovascular health, regardless of other sociodemographic determinants*
- *Both individual and area income, and availability of supermarkets and healthy food options are important from a primary and secondary CVD prevention perspective*
- *Further study is needed to better define—and measure—variables such as 'food access' that are often not well defined or appropriately analyzed in epidemiological studies*
- *Additional research is needed to understand the impact of economic resources (e.g. income, SNAP) on healthy food choices*
- *Public health programs should focus on developing evidence-based behavioral interventions that target enhanced utilization of healthy food options made available* via *supermarkets and grocery stores*
- *Community partnerships are key to improving access to healthy, affordable food*

Community and Social Context

Community and social context is defined as "the context in which societal and cultural factors interact to impact health outcomes" [93]. This domain is generally divided into four distinct sub-domains, including social support, social cohesion/social networks, community engagement and discrimination [3]. Each subdomain is subclassified to represent distinct constructs. For example, social support is often classified into the following four types: emotional, instrumental, informational and appraisal [94]. Similarly, discrimination is subdivided by (a) impact on specific population subgroups, such as racial/ethnic, national origin, gender, sexual orientation, elderly, and disabled; and (b) level of impact, such as individual and structural [3].

Current Evidence and Pathways

Each community and social context subdomain is linked to CVD via multiple, often interconnected pathways. For example, social support—a key subdomain—is linked to psychological wellbeing, increased ability to cope with stress, improved self-care and overall health-related quality of life [94, 95]. In a secondary analysis

of randomized controlled trial (RCT) data from over 300 older adults with a history of heart failure (HF), Gallagher and colleagues found that individuals with high levels of social support were more likely to consult with a health professional for weight gain, adhere to medication, get a flu shot, and exercise regularly, compared to those with medium or low levels of social support [95].

Conversely, lack of social support has been associated with increased risk of CVD. In a secondary analysis of data for over 200 patients from two prospective studies, Wu et al. reported 2.5 times increased risk of adverse cardiac events in patients experiencing both lack of social support and medication non-adherence, relative to those with medication adherence and higher social support (OR) 2.47; 95% CI 1.16 5.23) [96]. In the same study, the authors reported a mediation effect of medication adherence on the social support-cardiac event-free survival relationship, highlighting a possible mechanism through which social support might impact cardiovascular health.

In one of the largest reported prospective cohort studies on the topic, Kawachi and colleagues [97] studied 32,624 male health professionals over a 4-year follow-up period, and reported that participants with the least social support had 1.9 times increased risk for cardiovascular mortality and 2.21 times increased risk of incident stroke, compared to those in the highest social support category (RR 1.90 & 2.21 for cardiovascular mortality and incident stroke, respectively).

While direct pathways from racism to CVD are relatively unclear, discrimination has been documented to have detrimental effects on overall cardiovascular health in marginalized populations [98]. A review of published empirical evidence (24 studies) of the link between racism/ethnic discrimination and hypertension found consistently elevated risk of hypertension in individuals experiencing racism; the observed patterns were more pronounced for institutional racism, compared to individual racism; and ambulatory blood pressure relative to resting blood pressure monitoring [99]. Similarly, results from the Metro Atlanta Heart Disease Study show that high psychological stress associated with racial discrimination is a strong predictor of incident hypertension in African Americans [100].

Social networks and social cohesion are important determinants of self-care and health. In a prospective study of 1,384 participants from the Cardiovascular and Metabolic Disease Etiology Research Center–High Risk Cohort, Joo and colleagues found that individuals with deficient social networks were 72% more likely to have higher CAC scores (>400) [101]. In addition, greater social cohesion has documented beneficial effects on cardiovascular health. For example, a prospective cohort study of over 500 middle aged and older women reported that each single point increase in social network index (SNI) score was associated with nearly 20% reduced risk of CVD mortality (Relative Risk [RR] 0.81; 95% CI 0.66–0.99); the authors reported that high SNI scores predicted lower total adverse cardiovascular events (combined mortality, hospitalization, MI, stroke, CHF; RR 0.85; 95% CI 0.75–0.96) and lower rehospitalization rates (RR 0.87; 95% CI 0.77–0.99) over the 2.3 year follow-up period [102].

The positive impacts of community engagement on cardiovascular health, and negative effects of a lack thereof, have been documented in the literature. In a

unique cohort study of 2.8 million Swedish adults aged 45–74 years, low linking social capital (i.e. low community engagement) was associated with nearly 20% and 30% increased risk of CHD in men and women, respectively [103]. Conversely, in a convenience sample of middle aged and older African American women, Brown and colleagues demonstrated that a community engagement intervention for healthy behaviors was associated with improvements in cardiorespiratory fitness (Time to finish VO2max (min) = −1.87) and both systolic (−12.73 mmHg) and diastolic (−3.31 mmHg) blood pressure [104].

Summary

- *Existing evidence strongly suggests a negative effect of lack of/poor social support and social cohesion, and deficient social networks on cardiovascular health*
- *Evidence for a positive effect of social support—including the long-term impact of social support interventions—on CVD outcomes is less well documented in the literature*
- *Further evidence from large-scale, prospective studies is critical to clearly demonstrating the benefits of social support on cardiovascular health*
- *Greater quantitative and qualitative evidence is needed to develop a standardized social support measurement tool, with provisions for adaptation and use in a variety of sociodemographic settings*
- *Relatively few studies have examined the impact of race, racism and racial/ethnic discrimination on CVD; further study is warranted to elucidate potential mechanisms that explain the discrimination-CVD link in vulnerable populations*

Healthcare

Healthcare is a major SDOH. Given healthcare dynamics in the US, health insurance is a major determinant of access to essential health services; lack of which directly, and severely, limits access to health care and increases risk of adverse health outcomes, particularly among vulnerable and underserved minority population subgroups [105, 106].

Current Evidence and Pathways

It is known that being uninsured or underinsured diminishes the likelihood of receiving preventive care for CVD, increases the risk of missed doctor appointments and medication non-adherence, and is associated with poor overall cardiovascular health [107, 108]. A large-scale prospective study of over 15,000 middle aged and older adults reported that individuals without health insurance had 65% increased risk of stroke, and 26% increased risk of mortality, relative to the insured [109]. Further, the uninsured were less likely to be aware of CVD risk factors such as hypertension and hyperlipidemia, and less likely to report routine physical examination, compared to those with insurance coverage.

Disparities in access to care are a major driver of disparities in health outcomes, with a disproportionate impact on racial/ethnic minorities. Non-Hispanic Blacks and Hispanics make up the bulk of the uninsured population in the US, predisposing these already vulnerable populations to adverse CVD outcomes—as highlighted in multiple prior reports [29, 110–112]. Related, type of insurance is an important determinant of access to care. Findings from a nation-wide survey of 230,258 Medicaid beneficiaries indicated that this population is twice as likely to experience barriers to obtaining primary care, relative to those with private insurance [113]. For example, low re-imbursement for Medicaid patients has been cited as a possible reason for physicians not accepting Medicaid patients [114].

The beneficial effects of insurance coverage for the previously uninsured are well documented, [115] as evidenced by a household survey of 2203 middle aged and older adults, which showed that differences in CVD risk screening such as cholesterol screening between the insured and uninsured were reduced by nearly 20%, after the latter acquired Medicare coverage at the age of 65 [116]. Similarly, in a quasi-experimental study of over 1,000,000 US adults with CVD, Barghi et al. [117] reported positive outcomes with increased access to health services post ACA. The authors reported that, relative to the pre-ACA period (2012–2013), health insurance coverage, ability to pay for a doctor's visit and frequency of having an annual check-up increased by nearly 7, 3.6 and 2.2%, respectively in the post-ACA period (2015–2016).

In addition, transportation barriers, such as lack of access to personal vehicle or safe/reliable public transport may restrict access to, and utilization of health services, potentially resulting in delayed and/or missed care and prescription non-adherence [118].

A relatively under-investigated area is the issue of implicit provider bias in US healthcare, which might be based on race/ethnicity, SES, gender, weight and/or disability status. For example, findings from the Commonwealth Fund Minority Health Survey of US adult population document that low income is the most common reason for perceived discrimination [119]. In the same study, the authors reported that African Americans and Hispanics were more likely to report perceived discrimination, compared to White participants. Such biases affect patient-clinician

interaction, medication adherence, treatment decisions, and overall quality of care and health outcomes [120].

Summary

- *Access, quality and timeliness of care are critical determinants of cardiovascular health*
- *Vulnerable population subgroups, including racial/ethnic minorities and the socioeconomically disadvantaged, face multiple health system barriers*
- *Lack of/limited insurance coverage, implicit bias and perceived discrimination predispose marginalized groups to higher CVD risk, and adverse CVD outcomes*
- *Major policy interventions are needed at local, state and federal levels to improve access to healthcare in minority populations*
- *Existing knowledge of the prevalence, and consequences of implicit bias and discrimination in healthcare is scant*
- *Future efforts must focus on studying, and addressing, both observed and implicit barriers to healthcare in underserved populations*

Conclusions

Disparities in CVD outcomes continue to affect vulnerable populations in the US adversely, and disproportionately. Existing disparities in both cardiovascular risk factors and major CVD outcomes cannot be reduced without effectively incorporating SDOH into CVD prevention and management paradigms. Recent social justice movements in the US have attracted much needed attention toward inequities in healthcare; however, SDOH remain grossly underutilized in contemporary clinical practice models, to the detriment of the individual patient and the healthcare system.

Policy initiatives to improve individual and population level health outcomes, reduce health inequities, and provide evidence-based personalized care, such as the Precision Medicine Initiative (2015) [14] and 21st Century Cures Act (2016), [15] hinge on integrative care models that must effectively incorporate individuals' unique SDOH burden. Recent efforts to achieve these goals, such as The National Association of Community Health Center's (NACHC) Protocol for Responding to and Assessing Patients' Assets, Risks, and Experiences (PRAPARE)

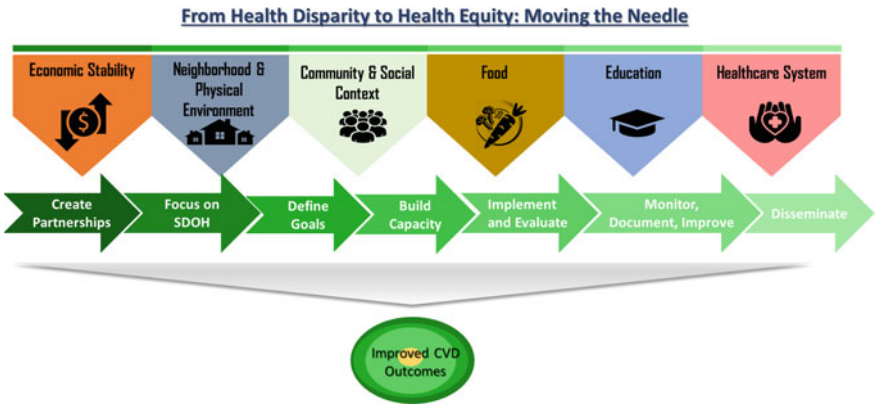

Fig. 2 On the road to health equity

Implementation and Action Toolkit offer great promise, and exciting opportunities for future work in the field [121]. Future efforts must focus on development and validation of these and similar tools in a variety of clinical settings, including CVD.

Meaningful synthesis, use and application of SDOH knowledge to design equitable care models, and narrow CVD disparities will require rigorous and coordinated efforts on the following fronts (Fig. 2):

1. Large-scale efforts to collect data on SDOH in local, regional and national data streams, including surveys, registries and clinical/claims databases.
2. Ensure accuracy of race/ethnicity data to generate reliable estimates of racial/ethnic disparities in cardiovascular outcomes in the US.
3. Greater use of existing population health databases to examine both cross-sectional and longitudinal effects of SDOH on CVD risk factors and outcomes.
4. Use knowledge generated from item 3 to design and implement evidence-based public health interventions, targeting 'upstream' and 'midstream' factors.
5. Train the new generation of healthcare workforce to understand the burden and implications of health disparities in the US; include modules on cultural competence and implicit bias in medical school and residency training curricula.
6. Create multidisciplinary teams of clinicians, data scientists and population health experts in order to harmonize efforts to achieve health equity.

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