Received: 16 July 2022 | Revised: 5 October 2022 | Accepted: 19 October 2022

DOI: 10.1002/wmh3.556

ORIGINAL ARTICLE

WMHP WORLD MEDICAL & HEALTH POLICY WILEY

Social determinants of incidence, outcomes, and interventions of cardiovascular disease risk factors in American Indians and Alaska Natives

Eric Leung[1] | **Tassy Parker**[2] | **Allyson Kelley**[3] | **James C. Blankenship**[4]

[1]University of New Mexico School of Medicine, Albuquerque, New Mexico, USA

[2]Department of Family and Community Medicine, Center for Native American Health, University of New Mexico, Albuquerque, New Mexico, USA

[3]University of North Carolina School of Medicine Center for Health Equity Research, Chapel Hill, North Carolina, USA

[4]Division of Cardiology, University of New Mexico, Albuquerque, New Mexico, USA

Correspondence

James C. Blankenship, Division of Cardiology, University of New Mexico; MC 10 5550, Albuquerque, NM 87131, USA.
Email: jblankenship@salud.unm.edu

Abstract

Cardiovascular disease (CVD) is the leading cause of death among American Indians and Alaska Natives (AIANs). Despite copious research on CVD incidence and outcome discrepancies, a social determinants of health (SDOH) focused framework on CVD risk factors and health outcomes in AIAN populations has not been undertaken. This paper presents the following: (1) a review of the literature on SDOH and CVD in AIAN populations, (2) a summary on intersectionality as it relates to SDOH and CVD, (3) a framework for conceptualizing CVD risks, interventions, structural determinants, and health equity, (4) a summary of potential interventions to address CVD in AIANs, and (5) a discussion about future work. Common SDOH themes across the CVD risk factors in AIANs are income-related obstacles, healthcare access, structural racism, discrimination, and failed colonial policies. Colonization of AIAN populations has resulted in social, political, and economic disadvantages, manifesting as systemic socioeconomic disadvantage and unequal access through elevated poverty rates, lower educational attainment, mental health challenges, and decreased healthcare access. These extensive social factors have a multifactorial effect across several CVD risk factors; all ultimately result in elevated CVD morbidity and mortality. Addressing SDOH and

diminishing disparities is essential to facilitating improved CVD outcomes for AIANs.

KEYWORDS

American Indians and Alaska Natives, cardiovascular disease, health disparities, ischemic heart disease, risk factors, socioeconomic determinants

Highlights

- Cardiovascular disease is the leading cause of death among American Indians and Alaska Natives (AIANs).
- Social determinants of health (SDOH) are a major contributor to cardiovascular disease in this population.
- Addressing SDOH and diminishing disparities is key to improving cardiovascular health for AIANs.

INTRODUCTION AND BACKGROUND

Cardiovascular disease (CVD) is the leading cause of death among American Indians and Alaska Natives (AIANs) (Breathett et al., 2020). In the United States minority populations have both higher rates of CVD and worse health outcomes (Karnati et al., 2020; Virani et al., 2021). Historically, due to the very low incidence of CVD and slower epidemiological transition from infectious disease to chronic disease, it was incorrectly presumed that AIAN populations had inherent protection from CVD. However, recent rates of CVD among AIAN populations have been increasing in contrast to a decrease in rates among the general population, resulting in AIANs becoming disproportionally affected by CVD (Hutchinson & Shin, 2014; Virani et al., 2021). In addition to a higher incidence, AIAN populations have higher mortality rates from these same conditions than other groups (Veazie et al., 2014). The combination of increased morbidity and mortality makes CVD a serious threat to the health of AIAN populations.

Social determinants of health (SDOH) and structural racism have increasingly been recognized as essential factors in health disparities among racial/ethnic groups (Russo et al., 2021). Common SDOH including education, employment, income, family and social support, and community safety, account for up to 50% of health outcomes based on the length and quality of life (Robert Wood Johnson Foundation, 2022). Unlike other racial/ethnic groups AIAN contemporary health disparities stem from colonization, and are associated with cultural losses, historical trauma, discrimination, and lateral oppression (Elm et al., 2019). Colonization created conditions of exclusion, racism, marginalization, oppression, discrimination, and loss of control among AIAN populations. Beginning in the early 1800s, the U.S. government forcibly removed AIs from their homes and land, punished AIs for speaking their language and practicing ceremonies, and forced them to abandon their traditional health food systems.

Multiple well-established risk factors of CVD include diet, physical activity (PA), obesity, diabetes mellitus, kidney disease, hyperlipidemia, hypertension, tobacco use, family history/genetic predispositions, mental health, and pollutants (Table 1). Higher rates of these CVD risk factors compared to other racial/ethnic groups place disproportional burden of CVD on AIANs (Galloway, 2005). In addition to the elevated isolated incidence of these risk factors, AIAN populations are more likely to have multiple risk factors (Struthers et al., 2006). Impacts of SDOH on CVD are notable, for example, deaths attributable to low education are comparable to deaths attributed to acute myocardial infarction (Galea et al., 2011). Many

hypotheses attempt to explain why risk factors differ among populations, often pointing to SDOH. One recent study explored SDOH and found greater social adversity was linked to increased CVD risk factors (Jilani et al., 2021). However, despite copious research on incidence and outcome discrepancies of CVD among minorities and the role of SDOH, a SDOH focused framework on CVD risk factors and health outcomes in AIAN populations has not been undertaken. A new SDOH framework that advocates for examining modifiable CVD risk factors in AIANs is presented here, along with how these risk factors affect health, and potential interventions to mitigate them. This paper is organized in sections: (1) a review of the literature on SDOH and CVD in AIAN populations, (2) a summary on intersectionality as it relates to SDOH and CVD, (3) a framework for conceptualizing CVD risks, interventions, structural determinants, and health equity, (4) a summary of potential interventions to address CVD in AIANs, and (5) a discussion about future work.

A REVIEW OF CVD RISK FACTORS IN AIAN POPULATIONS AND THE SDOH

Diet

Diet is a complex risk factor of CVD with dietary components affecting CVD outcomes differently. Although much of the dietary focus in CVD research is on saturated and unsaturated fats, other dietary components affecting CV health include omega 3 fatty acids, glycemic index, whole grains, fiber, antioxidants, vitamins, phytochemicals, overnutrition, and alcohol (Compher, 2006; Hu, 2009). This variety highlights the complexity of analyzing diet as a CVD risk factor.

Research on AIAN diet is sparse. The Strong Heart Dietary Study showed most AIANs did not meet dietary guidelines for reduction of chronic disease, including total fat intake, saturated fat intake, total energy intake, cholesterol intake, sodium intake, and fiber intake (Zephier et al., 1997). One large U.S. southwest AI-based study revealed fruits and vegetables were consumed less than once per day per person while high fat and sugary beverages like fry bread, sausage, and soft drinks provided 41% of energy and 46% of macronutrients (Ballew et al., 1997). This population also had inadequate intake of key nutrients (Ballew et al., 1997). Although limited, the existing literature points to a poor-quality diet consisting of high-calorie processed food with a lack of traditional foods, fruits, and vegetables (Berg et al., 2012; Compher, 2006). However, the diets of AIANs living on reservations may not differ greatly from the general U.S. population (Stang et al., 2005). Thus, diet may play a role in elevated CVD risk within this population, but further research is necessary.

Physical activity

Increased PA can prevent CVD and decrease risk, even without weight loss (Martinez-Gomez et al., 2019). This benefit has also been demonstrated in populations with concurrent CVD risk factors such as diabetes and kidney disease (Kang et al., 2019; Kodama et al., 2013). Minority populations have suboptimal PA and inactivity is a problem. AIAN adults do not meet the daily or weekly recommended amount of PA (Berg et al., 2012; Storti et al., 2009). Consistent with national trends, age and PA also have an inverse relationship in AIANs (Storti et al., 2009). The number of AIANs aged 65 or older is projected to grow faster than in the overall U.S. population (Administration for Community Living, 2020). This increase in size of the elderly population in combination with the inverse PA-age relationship

TABLE 1 Cardiovascular disease (CVD) risk factors, prevalence, social determinants of health (SDOH) influence, and interventions

CVD risk factor	American Indians and Alaska Natives (AIANs) prevalence	SDOH influence	AIAN interventions
Diet	AIANs do not meet dietary guidelines for reduction of CVD (Hayslett, 2001)	Poverty, food insecurity rural location, food deserts, lack of transportation, distance to food sources, limited refrigeration, higher food costs (Rao et al., 2013)	Navajo Nation local farming to improve fruit and vegetable intake, food sovereignty, access to traditional foods, economic incentives (Setala et al., 2011; Warne, 2007)
Physical activity	14.7% of AIANs meet recommended PA guidelines (Benjamin et al., 2019)	Education, urbanization, geographic isolation (Virani et al., 2021), walkability (Saelens et al., 2003), income (Kari et al., 2015), and occupation	Pathways Curriculum for youth and families, multilevel/component interventions increase PA in AIAN children (Davis et al., 2003; Grant et al., 2015)
Obesity	>82% of AIANs with overweight or obesity (Centers for Disease Control, 2022)	Multigenerational, chemical exposures (Schell & Gallo, 2012), food access, rural environments, education (Adams et al., 2019)	Pathways Study decreased body fat through PA, reduced fat content in school meals, and healthier diet practices at home and school (Davis et al., 2003)
Diabetes mellitus	23.5% of AIANs adults diagnosed with diabetes (Centers for Disease Control, 2022)	Internalized oppression, stigma, (West et al., 2012) limited healthcare (Walker et al., 2014), high uninsured rates, poverty, neighborhoods, limited access to quality food (Gary-Webb et al., 2011)	Discussion-based culturally influenced lifestyle intervention with diabetic women increased fruit and vegetable intake (Thompson et al., 2008), reduced diabetic risk factors
Kidney disease	33% of AIANs with chronic kidney disease (CKD) (Jolly et al., 2009)	Health care access, neighborhood (Jolly et al., 2009), lower socioeconomic status, (Hall, 2018) dietary restrictions, environmental exposures (Ozieh et al., 2021)	Home-based health interventions by community health representatives in Zuni Indians (Nelson et al., 2018)
Hyperlipidaemia	34.0% AIANs with high cholesterol (Centers for Disease Control, 2012) however AIANs have lower low-density lipoprotein (LDL) LDL cholesterol levels than Whites, (Breathett et al., 2020) and high-density lipoprotein	Social and genetic factors, limited opportunities for PA	National Heart, Lung, and Blood Institute Family Heart Study reports that increased alcohol consumption and PA were associated with increased HDL levels while increased smoking was associated with

TABLE 1 (Continued)

CVD risk factor	American Indians and Alaska Natives (AIANs) prevalence	SDOH influence	AIAN interventions
	(HDL) is dependent on obesity and diabetes		decreased HDL (Ellison et al., 2004)
Hypertension (HTN)	27.2% of AIANs diagnosed with HTN (Centers for Disease Control, 2022) versus 24.0% of NHW	Depression is linked to HTN in elderly (Fuchs & Whelton, 2020), age, gender, BMI, financial instability, mental health, and diet	REACH (Racial and Ethnic Approaches to Community Health) increased adherence to hypertension medications in AIANs (Ferdinand et al., 2012) through culture, history (Breathett et al., 2020)
Cigarette smoking	22.5% of AIANs current cigarette smokers (Centers for Disease Control, 2022) versus 15.5% of NHW Highest prevalence of adult and adolescent smoking in the U.S (Centers for Disease Control and Prevention, 2018).	Linked to HTN, diabetes, hyperlipidaemia, cardiovascular morbid and morality, (Benowitz, 2003) income, education, gender SES, culture, legislation, and marketing (Azagba et al., 2020; Mowery et al., 2015; Stehr, 2005)	Good Health and Wellness in Indian Country projects decreases commercial smoking through multifactorial, holistic, culturally appropriate health marketing strategies (Bauer & Espey, 2019), nicotine replacement therapy and home smoking bans effective in AIANs (Comiford et al., 2018)
Pollution	Increased exposure to household air pollution (HAP), (Lowe et al., 2018) tobacco smoke, coal-fired power plants, diesel exhaust, and mining (Ward et al., 2011)	Low-income, rural	Wood stove interventions in AIAN communities lower HAP (Noonan et al., 2020)
Genetic factors	Single set of genes regulates LDL size and obesity, may explain increased risk of diabetes and CVD in AIANs (Voruganti et al., 2006)	Linked to CVD RF phenotypes of obesity, dyslipidaemia, hypertension, and diabetes (North, 2003), low income, rural location	The GOCADAN study (Genetics of Coronary Artery Disease in Alaska Natives) showed that sex, hypertension, diabetes mellitus, albuminuria, high LDL cholesterol, high apolipoprotein B, and low HDL were strong correlates of CVD (Howard et al., 2010)

is likely to exacerbate inadequate PA in the AIAN population. Geographic isolation and rural nature of communities may also play a role in decreased PA. PA is lower in rural versus urban communities (Virani et al., 2021). The proportion of AIANs living in rural areas is twice as high as the general population making them disproportionally affected (American Indians

Remain Disproportionally Rural, 2014). Reservation communities are also often geographically isolated, decreasing outlets for PA which is a barrier in AIAN children (Thompson et al.). Dog attacks in some reservation communities are common, making outdoor PA nearly impossible (Jahns et al., 2014). Income correlates with PA directly in women but inversely in men (Kari et al., 2015). Low-income housing residents have higher rates of physical inactivity due to decreased feeling of safety or walkability (Saelens et al., 2003).

Obesity

Overwhelming evidence supports the impact of obesity on the prevalence, pathogenesis, and progression of CVD (Lavie et al., 2009). Obesity not only has a direct influence on CVD but also indirectly by exacerbating other CVD risk factors including dyslipidemia, type 2 diabetes, hypertension, physical inactivity, and sleep disorders (Powell-Wiley et al., 2021). While overall rates of unhealthy weight in the US population are alarming, rates of overweight or obesity among AIANs are even higher at 82% (Adams et al., 2019). Most concerning is that AIAN children have the highest prevalence of obesity and until recently were the only group with increasing rates (Sharma, 2009). These trends not only highlight the severity of the current obesity problem but also foreshadow a grim future unless effective interventions are implemented. Specific to children, growing up in a rural area confers increased risk for obesity, potentially due to a variety of aforementioned factors such as diet, exercise, and education (Adams et al., 2019).

Multigenerational transmission of obesity is well described. Maternal overweight or obesity, birth weight, household, body mass index, and primary caregiver identification as AIAN have been associated with increased childhood obesity (Adams et al., 2019; Lindberg et al., 2012). However, the specific reasons for intergenerational transmission are unknown with some research pointing to epigenetic factors, social inheritance, perceived and chronic stress, or AIANs' acceptance of obesity as normal (Marley & Metzger, 2015; Schell & Gallo, 2012; White et al., 1997). Population correlative and laboratory causal research have implicated chemical exposure with increased obesity (Schell & Gallo, 2012). AIANs have increased exposure to both environmental and household agents (solid fuel by-products, petroleum products, and pesticides), primarily due to location of reservations, income, and education (Redwood et al., 2012; Schell & Gallo, 2012). High-fat and high-sugar diets cause increased rates of obesity (Kavey, 2010).

Diabetes mellitus

Diabetes mellitus is a well-established CVD risk factor. Epidemiological data demonstrate diabetes doubles CVD risk and further exacerbates that risk in the presence of other risk factors such as lipids, smoking, and hypertension (Kannel & McGee, 1979; Stamler et al., 1993). Diabetes is a worsening epidemic in AIAN populations with the rates of type 2 diabetes higher than all other racial/ethnic groups (Cobb et al., 2014). Additionally, AIANs have significantly lower HbA1c control and diabetes medication adherence rates than non-Hispanic Whites, highlighting a discrepancy in diabetes management (Schmittdiel et al., 2014). Many AIAN adults either have diabetes or multiple risk factors for development of diabetes; therefore, preventing diabetes is important to reduce CVD (Harwell et al., 2003). Increased diabetes prevalence is associated with lower socioeconomic status, obesity, mental health conditions, and diet (Jiang et al., 2007; Subica et al., 2017); increased HbA1c is associated with low health literacy, acculturation, race, mental health conditions, social isolation, health care access, and neighborhood characteristics (Kivimäki et al., 2018; Walker et al., 2014).

Obesity is the greatest risk factor for diabetes, and the two are highly correlated in AIANs (Subica et al., 2017). They have multiple overlapping risk factors with higher rates of both obesity and diabetes making these relationships key to addressing CVD in this population. Neighborhood poverty is associated with poorer health status of diabetics; however, this could be due to limiting PA opportunity, proximity to quality food, safety, education, and mental health (Gary-Webb et al., 2011). Neighborhood influence on diabetic health is not limited to acute factors but follows children and adolescents into adulthood increasing their risk of diabetes (Kivimäki et al., 2018).

Diabetes incidence is also significantly associated with mental health conditions in AIANs (Jiang et al., 2007). This population has a larger adult mental health burden than non-Hispanic Whites compounded by most youth exhibiting "various behavior and emotional problems" and one-fourth meeting criteria for at least one mental health diagnosis (Brave Heart et al., 2016; Dickerson & Johnson, 2012). This is a complex issue with many factors at play, including collective historical trauma experienced by AIANs, internalized oppression, stigma, and strained interactions with colonized systems (West et al., 2012).

Health care

Difficulty obtaining healthcare and having no established source of care were associated with higher HbA1c in AIANs (Walker et al., 2014). Although members of federally recognized AIAN nations are eligible for Indian Health Service (IHS) care, AIANs have the highest uninsured rates among all racial/ethnic groups, two to three times that of non-Hispanic Whites (Johnson et al., 2010). IHS is not health insurance, does not meet Affordable Care Act requirements for healthcare coverage, and often provides inferior care due to underfunding, inaccessibility, limited services, and staffing shortages (Marley, 2019). Furthermore, more than 70% of AIANs live in urban and rural nonreservation areas and may be eligible for basic IHS services but not contract or specialty care (Breathett et al., 2020; Galloway, 2005). Many AIANs residing on reservations do not live near IHS facilities, further limiting their access. While the Patient Protection and Affordable Care Act has expanded access to care through Medicaid for low-income AIANs, the barrier of access may remain as AIANs can view the use of Medicaid as an abrogation of treaty rights to health care through the IHS. Thus, quality healthcare access, both real and perceived, is a significant barrier for diabetes management for AIANs.

Kidney disease

Kidney disease, regardless of the classification as chronic kidney disease (CKD), diabetic kidney disease, or end-stage renal disease, is associated with an increased risk of CVD and its complications (Fox et al., 2012; Go et al., 2004). Kidney disease as a risk factor is so important that individuals with CKD should be viewed as one of the most at-risk groups for CVD independent of other risk factors (Gansevoort et al., 2013). AIANs have triple the rate of CKD compared to Whites, with nearly one-third of AIAN having CKD (Jolly et al., 2009).

Lower socioeconomic status is associated with higher prevalence and incidence of CKD (Hall, 2018). In addition to prevalence, patients with low income have a 58% higher adjusted risk of death from CKD (Fedewa et al., 2014). The relationship between income and CKD may be bidirectional as poverty may lead to CKD through lack of healthcare access, dietary restrictions, environmental exposures, and poor CKD risk factor control, whereas CKD may lead to poverty via disability, unemployment, and health expenditures (Ozieh et al., 2021).

Given the high poverty rates of AIANs, income may be a significant factor in elevated CKD prevalence, incidence, and complications for this population.

Hyperlipidemia

Both decreased high-density lipoprotein (HDL) and increased low-density lipoprotein (LDL) are associated with elevated CVD risk (Emerging Risk Factors et al., 2009). The risk of elevated LDL and the benefit of decreasing LDL on CVD risk is well established. CVD risk due to LDL increases with concentration and duration of exposure with childhood LDL and total cholesterol levels correlating with adult CVD risk burden (Duncan, Freiberg, et al., 2019). The risk of decreased HDL and increased CVD risk is also well established; however, the benefit of increasing HDL to decrease CVD risk remains unclear. Data on cholesterol in AIANs is sparse. AIANs have lower average LDL cholesterol levels than Whites thus this is not a significant risk factor for the general AIAN population (Breathett et al., 2020). However, for the diabetic AIAN population, LDL cholesterol is a strong independent predictor of coronary heart disease, whereas low HDL risk may depend on obesity and diabetes (Breathett et al., 2020; Howard et al., 2000). One study of SDs of cholesterol levels in AIANs found that total PA was significantly related to increased HDL levels (Yurgalevitch et al., 1998). Given that AIANs have lower rates of PA than other groups, this may be a significant SDOH. Increased alcohol consumption is associated with increased HDL levels and reduced incidence of CVD (Toma et al., 2017), although episodic heavy alcohol consumption is associated with an increased risk of acute myocardial infarction despite its HDL effect (Toma et al., 2017). Smoking was associated with decreased HDL (Ellison et al., 2004).

One issue with identifying SDs of cholesterol in AIANs is the role of genetic factors. Lower concentration of lipoprotein(a) has been correlated with AIAN heritage but when used as a predictor of CVD disease, requires input of other factors (Wang et al.). This demonstrates the interrelationship of social factors and genetic factors when analyzing cholesterol as a CVD risk factor.

Hypertension

Hypertension (HTN) is among the best-documented risk factors for CVD, with the strongest evidence for causation and high prevalence of exposure (Fuchs & Whelton, 2020; Kjeldsen, 2018). AIANs have an increased prevalence of HTN compared to all other ethnic/racial groups (Galloway, 2005; Hutchinson & Shin, 2014). However, HTN in AIANs is relatively well controlled as they have higher proportions treated and lower degrees of HTN severity than the general population (Howard et al., 1996). Age is an important CVD risk factor due to the rapidly rising rate of elderly AIANs. This population increase combined with the elevated rate of elderly AIAN HTN suggests disproportionate burden of disease. A risk factor specific to AIAN elderly is the association between depression and HTN. Addressing the elderly AIAN population is important as the prevention of age-related blood pressure increases would reduce cardiovascular consequences and eliminate a large proportion of blood-pressure-related CVD (Fuchs & Whelton, 2020).

Smoking

Smoking has a causal role in the development of CVD through increased risk of thrombosis and atherosclerosis, leading to 21% of U.S. CVD deaths being attributable to smoking (Burns, 2003; World Health Organization, 2012). Smoking has a direct effect on CVD risk

and acts synergistically and multiplicatively with other risk factors—HTN, diabetes, hyperlipidemia—to increase cardiovascular morbidity and mortality (Benowitz, 2003). Therefore, in this population with high rates of several CVD risk factors, smoking exponentially increases CVD risk. AIANs have the highest prevalence of adult cigarette smoking and adolescent smoking across all racial/ethnic groups (Centers for Disease Control and Prevention, 2018). However, there is geographical variation across AIAN groups with the highest rates in the Northern Plains and Alaska and lower prevalence in the Southwest. Despite recent national public health efforts and legislation to decrease rates of smoking, AIANs have not had the same decline as other groups (Mowery et al., 2015). In addition to higher rates, AIANs disproportionally feel the burden of smoking's adverse effects as the proportion of excess mortality for all diseases—greatest in CVDs—caused by smoking is greater in AIANs than in Whites (Mowery et al., 2015).

Tobacco use is part of many AIAN cultures. It is used in ceremonies, prayer, and traditional medicine, and viewed as a sign of respect of elders (Unger et al., 2006). Researchers have attempted to differentiate "traditional" versus "commercial" tobacco. However, commercial cigarettes are often substituted for homegrown tobacco at ceremonies making this distinction impossible (Unger et al., 2006). Despite this cultural use of tobacco, from a health perspective, the use of tobacco in traditional ways is irrelevant to commercial/recreational tobacco use because use of tobacco for traditional purposes is the same in light versus heavy smokers (Nazir et al., 2014). Traditional use of tobacco may be advantageous as this use is correlated to greater cessation in AIAN smokers (Daley et al., 2011). Despite the literature focusing on traditional tobacco use as a factor in increased rates of AIAN smoking, other determinants may have greater effect. Perhaps the greatest influence on smoking rates is a combination of marketing and legislation. Tobacco companies target AIAN communities through promotions, sponsorships, advertising, and exploitation of traditional use (Lempert & Glantz, 2019). Legislation limiting deceptive advertising resulted in nation-wide decrease in cigarette use but tobacco companies are still targeting AIANs. In addition, because tribal lands are considered sovereign nations by the U.S. government, they are exempt from cigarette taxes. This "sin tax" is considered one of the strongest deterrents of cigarette use with estimates showing a doubling of cigarette consumption due to lack of this tax (Stehr, 2005). Therefore, the combination of tobacco company exploitation and lack of federal tax disincentive play a large role in high rates of smoking in AIANs.

Smoking cessation is associated with significantly lower CVD risk within 5 years relative to current smokers and ceases to be associated with elevated CVD risk after 10–15 years (Duncan, Vasan, et al., 2019). This means that smoking cessation in this population could have extreme cardiovascular health benefits.

Pollution

The association between air pollution and CVDs has been of increasing interest. Several environmental air pollutants, especially "fine particulate matter" ($PM_{2.5}$), have been associated with increased CVD morbidity, severity, and mortality (Lee et al., 2014). Household air pollution (HAP) is one of the leading causes of health burden worldwide (Newell et al., 2019). Most research is focused on low/middle-income countries where income is the strongest determinant of high HAP exposure (Newell et al., 2019). AIAN reservations are similar to these low-income countries in that their population is rural with low income. Biomass (usually wood) combustion in deteriorating indoor stoves is the primary source of heat for 89% of families in one southwestern AIAN nation (Lowe et al., 2018). Because wood contains the same toxic agents as more general air pollution, burning wood for heat results in excess CVD risk (Huang et al., 2021). AIANs also have increased exposure to other air pollutants such as tobacco smoke, coal-fired power plants,

diesel exhaust, and mining dust (Ward et al., 2011). The increased air pollution exposure, both indoors and outdoors, may play a role in the elevated cardiovascular and respiratory disease rates in this population.

THE ROLE OF INTERSECTIONALITY

When analyzing risk factors for CVD, it is impossible to neglect the role of intersectionality. As demonstrated with smoking, HTN, diabetes, and hyperlipidemia, these risk factors are multiplicative in their effect on CVD risk. For many risk factors, there is intersectionality among determinants of the risk factors, the risk factors themselves, and diseases caused by risk factors. For example, given the strong associations between CKD and CVD, CKD and diabetes, and diabetes and CVD, these conditions' modifiable risk factors and social determinants are all interconnected. SDs of CKD include psychosocial factors, healthcare access, and neighborhood (Jolly et al., 2009). Diabetes is the main reason for the excessive CKD burden in AIANs (Narva, 2018). Given that AIANs have higher rates of diabetes than any other ethnic/racial group, all the aforementioned diabetic social determinants in AIANs are also applicable to CKD (Table 1). As another example, refined carbohydrates are associated with increased prevalence of CVD, obesity, and diabetes, which themselves are CVD risk factors. The intersectionality of both CVD and diabetic SDs include income, employment, education, food access, loss of culture, and historical trauma. The structural determinants of diabetic social determinants include public policies, social policies, governance systems, colonization, historical forces, social forces, culture and societal values, economy, the educational system, and capitalism. These examples show the interconnectedness of multiple social determinants and disease states for one aspect of a CVD risk factor (diabetes). This interconnectedness may be an asset: if one intervention can successfully address one social determinant or one CVD risk factor, it may have exponential benefit toward the health of AIANs. Based on this review, the authors propose a new framework for conceptualizing the SDOH and CVD risk factors (CVDRFs) in AIAN populations (Figure 1). Here, colonization is the structural determinant that drives unequal and inequitable access to conditions that would promote health and wellbeing. Intersections between SDOH, genetic, behavioral, and social factors, and CVDRFs must be considered within the context of colonization and inequities when developing interventions that address CVD in AIANs.

POTENTIAL INTERVENTIONS TO ADDRESS DISPARITIES IN AIAN POPULATIONS

Interventions that address CVD risk factors and SDOH simultaneously have the most potential for impacting health and wellbeing. Specific interventions targeted towards the individual may not have the greatest effect on the population or addressing structural and institutional inequities but can have a profound effect on individuals or households. Individualized interventions are also more likely succeed because of their specificity, decreased cost, and simplicity.

Air pollution

The most successful personalized intervention found in this review was the stove exchange. In this project, the identified issue was households using stoves not designed for indoor use that were old and inefficient. By simply exchanging old stoves for modern, well-designed stoves, investigators decreased CVD risk due to HAP (Narva, 2018). Although this

intervention did not address the overarching determinants of income constraints that forced the use of inadequate stoves, it could address a specific problem and reduce exposure to HAP.

Physical inactivity

A common theme across many CVD risk factors is their relationship to physical inactivity. Specifically for exercise, lack of places for safe exercise both in adults and children was identified as a problem. Although the rural nature and poverty of reservations present challenges, existing community centers and chapter houses may offer a safe place to exercise. Focusing on exercises that can be done at home and with minimal equipment may further promote activity without the need to commute to a central location. Local solutions do not need to be limited to exercise; they could include educational topics such as healthier eating or increasing health literacy.

Diabetes and kidney disease

Because much of the CKD burden is due to diabetes and the incidence of diabetes is elevated in AIANs, the IHS has aggressively implemented and monitored optimal care practices for people with diabetes at risk for progressive kidney disease (Narva, 2018). In 1989, the IHS established a dedicated kidney disease program to promote prevention and optimal care of CKD. Treatment strategies that slow or halt the progressive loss of kidney function may attenuate CVD risk (Gansevoort et al., 2013). These interventions may have been successful: despite a prevalence 2–3 times higher than Whites, ESRD due to diabetes among AIANs has declined by 53% since 2000, more than any other group (Burrows et al., 2020; Narva, 2018).

Increasing access to quality health care

The most direct intervention to address CVD in AIANs is to increase the access to and quality of health care. IHS has long been underfunded and unable to provide quality primary care to AIAN populations (Marley, 2019). These are some potential solutions to elevate AIAN health care. First, it would be appropriate to include AIAN leaders and healthcare consumers in formal dialog about what solutions are acceptable and sustainable in their respective communities. Second, equitable distribution of health care spending to provide proper funding in support of AIAN health care has already shown great effectiveness in addressing chronic diseases and CVD risk factors like HTN in this population (Parker, 2019). Increasing funding to urban Indian health centers may dramatically increase healthcare access as these facilities often serve AIANs who use both tribal and urban health services. Third, greater support for AIANs who choose self-governance of their community health care systems from IHS may allow locally relevant and culture-specific care. Fourth, increasing the number and quality of healthcare facilities and infrastructure facilitating access to these facilities may alleviate problems in healthcare access in poor and rural communities. Fifth, universal or nationalized health insurance may help fill gaps remaining in IHS health services. Finally, increased training, recruitment, and retention of AIAN healthcare workforce will improve quality of care. AIAN providers are more likely to serve this population and patients often prefer care from providers of similar ethnic/racial backgrounds, both of which can improve health outcomes (Reshaping the Journey: American Indians and Alaska

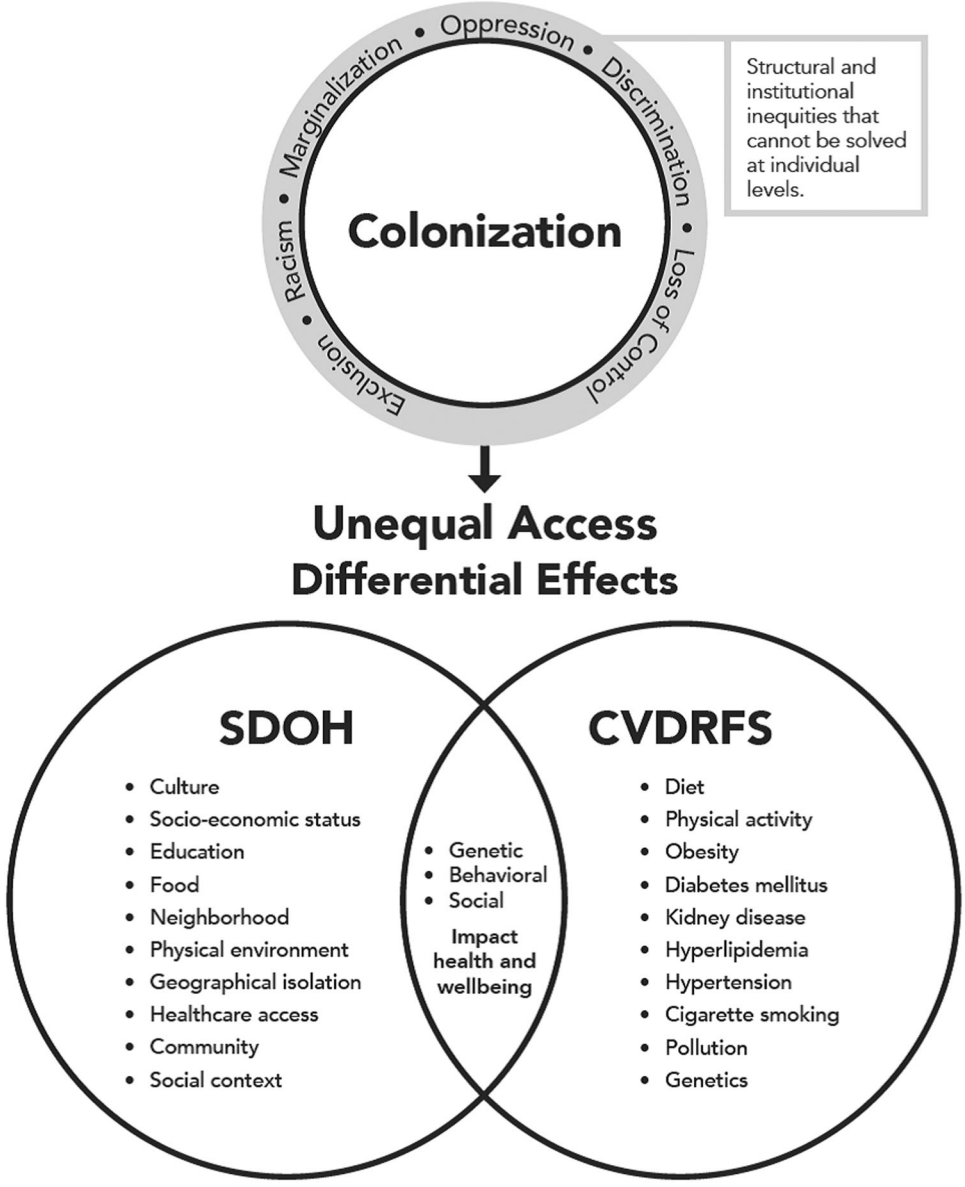

FIGURE 1 Structural determinants of cardiovascular disease (CVD) risk factors and social determinants of health (SDOH) in American Indians and Alaska Natives populations

Natives in Medicine, 2019). Universities must utilize a systematic approach to increasing the number of AIAN healthcare workers. Lessons from the University of New Mexico Indians Into Medicine program (IN-MED) from 2010 to 2014 identified two determinants of academic success: (1) early, diverse, and sustained exposure to role models, academic processes, math, and science, and (2) multilevel support where culture and language are reinforced, and environments are inclusive and supportive (Parker, 2019). Overall, with adequate resources, AIANs could have access to higher quality care to decrease CVD morbidity and improve the overall health of this population.

Addressing the structural determinants of health

Structural and institutional inequities influence every dimension of health (Russo et al., 2021). CVD risk factors like obesity, diabetes, HTN, and physical inactivity are not the cause. These risk factors are a symptom of colonization and subsequent structural and institutional inequities in AIAN populations. Policies and systems change are needed to promote equity in all places, where people live, work, grow, learn, age, and die. The current social and community contexts are set up so that Whites have advantage and privilege. White populations can more easily access employment, affordable food and housing, education, and healthcare (Russo et al., 2021). One of the most glaring disparities influenced by structural determinants is lower educational attainment. AIAN students report the lowest graduation rate in the nation, across any racial or ethnic demographic, with only 74% graduating from high school (National Center for Education Statistics, 2022). Increasing resources to support wellbeing throughout the life course, from conception to early childhood through tertiary education is critical. Federal assistance to AIAN populations seeking college degrees should be revamped with greater attention to SDOH. Most CVD interventions do not focus on educational attainment, income job skills, or social context--this is an injustice. In sum, CVD interventions must consider the interaction of structural determinants, genetics, behaviors, and social conditions that contribute to persistent disadvantage and unequal access in AIANs.

CONCLUSION

Common SDOH themes across the CVD risk factors in AIANs are income-related obstacles, cultural determinants, mental health, healthcare access, structural racism, discrimination, and failed policies. Taken together these factors resulted in political and economic disadvantages, manifesting as systemic socioeconomic disadvantage through elevated poverty rates, lower educational attainment, mental health challenges, and decreased healthcare access. These extensive social factors have a multifactorial effect across several CVD risk factors, ultimately leading to in elevated CVD morbidity and mortality.

Diminishing disparities is essential to facilitating a change in CVD for AIANs. However, attempts to do so face numerous obstacles such as rural isolation, colonial systems, discrimination, marginalization, diminishing returns and differential effects, lack of resources, and population heterogeneity making long-term benefits challenging (Assari, 2020). A new SDOH approach must consider the diversity of AIAN populations and their unique histories and culture, making an individualized assessment of challenges and resources essential to successful intervention. As exemplified by diet, CKD, and tobacco behaviors, interventions must take into consideration cultural and traditional influences and authentic community engagement when designing potential interventions. The multidisciplinary approach should include addressing social barriers such as lack of resources, inadequate education, and inferior healthcare while utilizing established programs, outreach activities, and communities to directly address both CVD risk and upstream determinants.

AUTHOR CONTRIBUTIONS

Eric Leung: Data curation; investigation; methodology; roles/writing - original draft; writing - review and editing. **Tassy Parker**: Methodology; formal analysis; validation; visualization; writing - review and editing. **Allyson Kelley**: Formal analysis; writing - review and editing. **James Blankenship**: Conceptualization; methodology; supervision; writing - review and editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

This manuscript has not been published elsewhere in part or whole. The authors have no conflicts of interest relevant to this topic. This work was not supported by funds from any organization. All authors have reviewed and approved the final manuscript. It was not approved by an investigational review board since it did not involve individual patients or protected health information. It meets all criteria for an ethical manuscript set forth in Wiley's Publication Ethics Guidelines (https://authorservices.wiley.com/ethics-guidelines/index.html).

ORCID

James C. Blankenship http://orcid.org/0000-0003-4966-533X

REFERENCES

Adams, A. K., Tomayko, E. J., A. Cronin, K., J. Prince, R., Kim, K., Carmichael, L., & Parker, T. (2019). Predictors of overweight and obesity in American Indian families with young children. *Journal of Nutrition Education and Behavior*, *51*(2), 190–198. https://doi.org/10.1016/j.jneb.2018.07.011

Administration for Community Living. (2020). Profile of American Indians and ALaska Natives age 65 and older. Accessed May 11, 2022. https://acl.gov/sites/default/files/Profile%20of%20OA/AIANProfileReport2021.pdf

American Indians Remain Disproportionally Rural. (2014). *USDA Econ Res Serv*. American Indians Remain Disproportionally Rural.

Assari, S. (2020). American Indian, Alaska Native, Native Hawaiian, and pacific islander children's body mass index: Diminished returns of parental education and family income. *Research in Health Science*, *5*(1), p64. https://doi.org/10.22158/rhs.v5n1p64

Azagba, S., Shan, L., Latham, K., & Qeadan, F. (2020). Trends in cigarette Smoking among American Indians and Alaska Natives in the USA: 1992–2015. *Cancer Causes & Control*, *31*(1), 73–82. https://doi.org/10.1007/s10552-019-01250-7

Ballew, C., White, L. L., Strauss, K. F., Benson, L. J., Mendlein, J. M., & Mokdad, A. H. (1997). Intake of nutrients and food sources of nutrients among the navajo: Findings from the Navajo Health and Nutrition Survey. *The Journal of Nutrition*, *127*(10), 2085S–2093S. https://doi.org/10.1093/jn/127.10.2085S

Bauer, U. E., & Espey, D. K. (2019). Good health and wellness in Indian country: A new partnership and approach. *Preventing Chronic Disease*, *16*, 190214. https://doi.org/10.5888/pcd16.190214

Benjamin, E. J., Muntner, P., Alonso, A., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Das, S. R., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Jordan, L. C., Khan, S. S., Kissela, B. M., Knutson, K. L., … Virani, S. S. (2019). Heart disease and stroke Statistics—2019 update: A report from the American Heart Association. *Circulation*, *139*(10), e56-28. https://doi.org/10.1161/CIR.0000000000000659

Benowitz, N. L. (2003). Cigarette smoking and cardiovascular disease: Pathophysiology and implications for treatment. *Progress in Cardiovascular Diseases*, *46*(1), 91–111. https://doi.org/10.1016/S0033-0620(03)00087-2

Berg, C. J., Daley, C. M., Nazir, N., Kinlacheeny, J. B., Ashley, A., Ahluwalia, J. S., Greiner, K. A., & Choi, W. S. (2012). Physical activity and fruit and vegetable intake among American Indians. *Journal of Community Health*, *37*(1), 65–71. https://doi.org/10.1007/s10900-011-9417-z

Brave Heart, M. Y. H., Lewis-Fernández, R., Beals, J., Hasin, D. S., Sugaya, L., Wang, S., Grant, B. F., & Blanco, C. (2016). Psychiatric disorders and mental health treatment in American Indians and Alaska natives: Results of The National Epidemiologic Survey on alcohol and related conditions. *Social Psychiatry and Psychiatric Epidemiology*, *51*(7), 1033–1046. https://doi.org/10.1007/s00127-016-1225-4

Breathett, K., Sims, M., Gross, M., Jackson, E. A., Jones, E. J., Navas-Acien, A., Taylor, H., Thomas, K. L., & Howard, B. V. (2020). Cardiovascular health in American Indians and Alaska Natives: A scientific statement from the American Heart Association. *Circulation*, *141*(25), e948-59. https://doi.org/10.1161/CIR.0000000000000773

Burns, D. M. (2003). Epidemiology of smoking-induced cardiovascular disease. *Progress in Cardiovascular Diseases*, *46*(1), 11–29. https://doi.org/10.1016/S0033-0620(03)00079-3

Burrows, N. R., Zhang, Y., Hora, I., Pavkov, M. E., Sheff, K., Imperatore, G., Bullock, A. K., & Albright, A. L. (2020). Sustained lower incidence of diabetes-related end-stage kidney disease among American Indians and Alaska Natives, Blacks, and Hispanics in the U.S., 2000–2016. *Diabetes Care*, *43*(9), 2090–2097. https://doi.org/10.2337/dc20-0495

Centers for Disease Control. (2012). Prevalence of cholesterol screening and high blood cholesterol among adults —United States, 2005, 2007, and 2009. *MMWR Morbidity and Mortality Weekly Report*, *61*(35), 697–702. https://www.cdc.gov/mmwr/pdf/wk/mm6135.pdf

Centers for Disease Control. (2022). *Summary Health Statistics: National Health Interview Survey: 2018*. http://www.cdc.gov/nchs/nhis/shs/tables.htm

Centers for Disease Control and Prevention. (2018). *American Indians/Alaska Natives and tobacco use*. U.S. Department of Health Human Services.

Cobb, N., Espey, D., & King, J. (2014). Health behaviors and risk factors among American Indians and Alaska Natives, 2000–2010. *American Journal of Public Health*, *104*(S3), S481–S489. https://doi.org/10.2105/AJPH.2014.301879

Comiford, A., Garroutte, E., Barbosa-Leiker, C., Chen, S., & McDonell, M. (2018). Prevalence and indicators of household smoking bans among American Indians. *Journal of Community Health*, *43*(4), 746–755. https://doi.org/10.1007/s10900-018-0479-z

Compher, C. (2006). The nutrition transition in American Indians. *Journal of Transcultural Nursing*, *17*(3), 217–223. https://doi.org/10.1177/1043659606288376

Daley, C. M., Faseru, B., Nazir, N., Solomon, C., Greiner, K. A., Ahluwalia, J. S., & Choi, W. S. (2011). Influence of traditional tobacco use on smoking cessation among American Indians: Traditional tobacco and smoking cessation. *Addiction*, *106*(5), 1003–1009. https://doi.org/10.1111/j.1360-0443.2011.03391.x

Davis, S. M., Clay, T., Smyth, M., Gittelsohn, J., Arviso, V., Flint-Wagner, H., Rock, B. H., Brice, R. A., Metcalfe, L., Stewart, D., Vu, M., & Stone, E. J. (2003). Pathways curriculum and family interventions to promote healthful eating and physical activity in American Indian schoolchildren. *Preventive Medicine*, *37*, S24–S34. https://doi.org/10.1016/j.ypmed.2003.08.011

Di Angelantonio, E., Sarwar, N., Perry, P., Kaptoge, S., Ray, K. K., Thompson, A., Wood, A. M., Lewington, S., Sattar, N., Packard, C. J., Collins, R., Thompson, S. G., & Danesh, J., Emerging Risk Factors. (2009). Major lipids, apolipoproteins, and risk of vascular disease. *Journal of the American Medical Association*, *302*(19), 1993–2000.

Dickerson, D. L., & Johnson, C. L. (2012). Mental health and substance abuse characteristics among a clinical sample of Urban American Indian/Alaska native youths in a Large California metropolitan area: A descriptive study. *Community Mental Health Journal*, *48*(1), 56–62. https://doi.org/10.1007/s10597-010-9368-3

Duncan, M. S., Freiberg, M. S., Greevy, R. A., Kundu, S., Vasan, R. S., & Tindle, H. A. (2019). Association of smoking cessation with subsequent risk of cardiovascular disease. *Journal of the American Medical Association*, *322*(7), 642–650. https://doi.org/10.1001/jama.2019.10298

Duncan, M. S., Vasan, R. S., & Xanthakis, V. (2019). Trajectories of blood lipid concentrations over the adult life course and risk of cardiovascular disease and all-cause mortality: Observations from the framingham study over 35 years. *Journal of the American Heart Association*, *8*(11). https://doi.org/10.1161/JAHA.118.011433

Ellison, R. C., Zhang, Y., Qureshi, M. M., Knox, S., Arnett, D. K., & Province, M. A. (2004). Lifestyle determinants of high-density lipoprotein cholesterol: The National heart, lung, and blood institute family heart study. *American Heart Journal*, *147*(3), 529–535. https://doi.org/10.1016/j.ahj.2003.10.033

Elm, J., Walls, M., & Aronson, B. (2019). Sources of stress among midwest American Indian adults with type 2 diabetes. *American Indian and Alaska Native Mental Health Research*, *26*(1), 33–62. https://doi.org/10.5820/aian.2601.2019.33

Fedewa, S. A., McClellan, W. M., Judd, S., Gutiérrez, O. M., & Crews, D. C. (2014). The association between race and income on risk of mortality in patients with moderate chronic kidney disease. *BMC Nephrology*, *15*(1), 136. https://doi.org/10.1186/1471-2369-15-136

Ferdinand, K. C., Patterson, K. P., Taylor, C., Fergus, I. V., Nasser, S. A., & Ferdinand, D. P. (2012). Community-Based approaches to prevention and management of hypertension and cardiovascular disease. *The Journal of Clinical Hypertension*, *14*(5), 336–343.

Fox, C. S., Matsushita, K., Woodward, M., Bilo, H. J., Chalmers, J., Heerspink, H. J. L., Lee, B. J., Perkins, R. M., Rossing, P., Sairenchi, T., Tonelli, M., Vassalotti, J. A., Yamagishi, K., Coresh, J., de Jong, P. E., Wen, C. P., & Nelson, R. G. (2012). Associations of kidney disease measures with mortality and end-stage renal disease in individuals with and without diabetes: A meta-analysis. *The Lancet*, *380*(9854), 1662–1673. https://doi.org/10.1016/S0140-6736(12)61350-6

Fuchs, F. D., & Whelton, P. K. (2020). High blood pressure and cardiovascular disease. *Hypertension*, *75*(2), 285–292. https://doi.org/10.1161/HYPERTENSIONAHA.119.14240

Galea, S., Tracy, M., Hoggatt, K. J., DiMaggio, C., & Karpati, A. (2011). Estimated deaths attributable to social factors in the United States. *American Journal of Public Health*, *101*(8), 1456–1465. https://doi.org/10.2105/AJPH.2010.300086

Galloway, J. M. (2005). Cardiovascular health among American Indians and Alaska Natives. *American Journal of Preventive Medicine*, *29*(5), 11–17. https://doi.org/10.1016/j.amepre.2005.07.023

Gansevoort, R. T., Correa-Rotter, R., Hemmelgarn, B. R., Jafar, T. H., Heerspink, H. J. L., Mann, J. F., Matsushita, K., & Wen, C. P. (2013). Chronic kidney disease and cardiovascular risk: Epidemiology, mechanisms, and prevention. *The Lancet*, *382*(9889), 339–352. https://doi.org/10.1016/S0140-6736(13)60595-4

Gary-Webb, T. L., Baptiste-Roberts, K., Pham, L., Wesche-Thobaben, J., Patricio, J., Pi-Sunyer, F. X., Brown, A. F., Jones-Corneille, L., & Brancati, F. L. (2011). Neighborhood socioeconomic status, depression, and health status in the look ahead (action for health in diabetes) study. *BMC Public Health*, *11*(1), 349. https://doi.org/10.1186/1471-2458-11-349

Go, A. S., Chertow, G. M., Fan, D., McCulloch, C. E., & Hsu, C. Y. (2004). Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *New England Journal of Medicine*, *351*(13),1296–1305.

Grant, V., Brown, B., Swaney, G., Hollist, D., Harris, K. J., Noonan, C. W., & Gaskill, S. (2015). Community-identified strategies to increase physical activity during elementary school recess on an American Indian reservation: A pilot study. *Preventive Medicine Reports*, *2*, 658–663. https://doi.org/10.1016/j.pmedr.2015.08.012

Hall, Y. N. (2018). Social determinants of health: Addressing unmet needs in nephrology. *American Journal of Kidney Diseases*, *72*(4), 582–591. https://doi.org/10.1053/j.ajkd.2017.12.016

Harwell, T. S., Moore, K., McDowall, J. M., Helgerson, S. D., & Gohdes, D. (2003). Cardiovascular risk factors in Montana American Indians with and without diabetes. *American Journal of Preventive Medicine*, *24*(3), 265–269. https://doi.org/10.1016/S0749-3797(02)00640-2

Hayslett, J. (2001). Hypertension treatment patterns in American Indians: The strong heart study. *American Journal of Hypertension*, *14*(9), 950–956. https://doi.org/10.1016/S0895-7061(01)02146-X

Howard, B. V., Comuzzie, A., Devereux, R. B., Ebbesson, S. O. E., Fabsitz, R. R., Howard, W. J., Laston, S., MacCluer, J. W., Silverman, A., Umans, J. G., Wang, H., Weissman, N. J., & Wenger, C. R. (2010). Cardiovascular disease prevalence and its relation to risk factors in Alaska Eskimos. *Nutrition, Metabolism, and Cardiovascular Diseases*, *20*(5), 350–358. https://doi.org/10.1016/j.numecd.2009.04.010

Howard, B. V., Lee, E. T., Yeh, J. L., Go, O., Fabsitz, R. R., Devereux, R. B., & Welty, T. K. (1996). Hypertension in adult American Indians: The strong heart study. *Hypertension*, *28*(2), 256–264.

Howard, B. V., Robbins, D. C., Sievers, M. L., Lee, E. T., Rhoades, D., Devereux, R. B., Cowan, L. D., Gray, R. S., Welty, T. K., Go, O. T., & Howard, W. J. (2000). LDL cholesterol as a strong predictor of coronary heart disease in diabetic individuals with insulin resistance and low LDL: The strong heart study. *Arteriosclerosis, Thrombosis, and Vascular Biology*, *20*(3), 830–835. https://doi.org/10.1161/01.ATV.20.3.830

Hu, F. B. (2009). Diet and lifestyle influences on risk of coronary heart disease. *Current Atherosclerosis Reports*, *11*(4), 257–263. https://doi.org/10.1007/s11883-009-0040-8

Huang, S., Guo, C., Qie, R., Han, M., Wu, X., Zhang, Y., Yang, X., Feng, Y., Li, Y., Wu, Y., Liu, D., Sun, L., Hu, D., & Zhao, Y. (2021). Solid fuel use and cardiovascular events: A systematic review and meta-analysis of observational studies. *Indoor Air*, *31*, 1722–1732. https://doi.org/10.1111/ina.12867

Hutchinson, R. N., & Shin, S. (2014). Systematic review of health disparities for cardiovascular diseases and associated factors among American Indian and Alaska Native populations. *PLoS ONE*, *9*(1), e80973.

Jahns, L., McDonald, L., Wadsworth, A., Morin, C., & Liu, Y. (2014). Barriers and facilitators to being physically active on a rural U.S. Northern plains American Indian reservation. *International Journal of Environmental Research and Public Health*, *11*(11), 12053–12063. https://doi.org/10.3390/ijerph111112053

Jiang, L., Beals, J., Whitesell, N. R., Roubideaux, Y., & Manson, S. M. (2007). Association between diabetes and mental disorders in two American Indian reservation communities. *Diabetes Care*, *30*(9), 2228–2229. https://doi.org/10.2337/dc07-0097

Jilani, M. H., Javed, Z., Yahya, T., Valero-Elizondo, J., Khan, S. U., Kash, B., Blankstein, R., Virani, S. S., Blaha, M. J., Dubey, P., Hyder, A. A., Vahidy, F. S., Cainzos-Achirica, M., & Nasir, K. (2021). Social determinants of health and cardiovascular disease: Current state and future directions towards healthcare equity. *Current Atherosclerosis Reports*, *23*(9), 55. https://doi.org/10.1007/s11883-021-00949-w

Johnson, P. J., Blewett, L. A., Call, K. T., & Davern, M. (2010). American Indian/Alaska native uninsurance disparities: A comparison of 3 surveys. *American Journal of Public Health*, *100*(10), 1972–1979. https://doi.org/10.2105/AJPH.2009.167247

Jolly, S. E., Li, S., Chen, S. C., Narva, A. S., Jurkovitz, C. T., Norris, K. C., & Shlipak, M. G. (2009). Risk factors for chronic kidney disease among American Indians and Alaska natives—findings from the kidney early evaluation program. *American Journal of Nephrology*, *29*(5), 440–446. https://doi.org/10.1159/000174857

Kang, A. W., Garber, C. E., Eaton, C. B., Risica, P. M., & Bostom, A. G. (2019). Physical activity and cardiovascular risk among kidney transplant patients. *Medicine & Science in Sports & Exercise*, *51*(6), 1154–1161. https://doi.org/10.1249/MSS.0000000000001886

Kannel, W. B., & McGee, D. L. (1979). Diabetes and cardiovascular risk factors: The framingham study. *Circulation*, *59*(1), 8–13. https://doi.org/10.1161/01.CIR.59.1.8

Kari, J. T., Pehkonen, J., Hirvensalo, M., et al. (2015). Income and physical activity among adults: Evidence from self-reported and pedometer-based physical activity measurements. *PLoS ONE*, *10*(8), e0135651.

Karnati, S. A., Wee, A., Shirke, M. M., & Harky, A. (2020). Racial disparities and cardiovascular disease: One size fits all approach. *Journal of Cardiac Surgery*, *35*(12), 3530–3538. https://doi.org/10.1111/jocs.15047

Kavey, R. E. W. (2010). How sweet it is: Sugar-sweetened beverage consumption, obesity, and cardiovascular risk in childhood. *Journal of the American Dietetic Association*, *110*(10), 1456–1460. https://doi.org/10.1016/j.jada.2010.07.028

Kivimäki, M., Vahtera, J., Tabák, A. G., Halonen, J. I., Vineis, P., Pentti, J., Pahkala, K., Rovio, S., Viikari, J., Kähönen, M., Juonala, M., Ferrie, J. E., Stringhini, S., & Raitakari, O. T. (2018). Neighbourhood socioeconomic disadvantage, risk factors, and diabetes from childhood to middle age in the young Finns study: A cohort study. *The Lancet Public Health*, *3*(8), e365–e373. https://doi.org/10.1016/S2468-2667(18)30111-7

Kjeldsen, S. E. (2018). Hypertension and cardiovascular risk: General aspects. *Pharmacological Research*, *129*, 95–99. https://doi.org/10.1016/j.phrs.2017.11.003

Kodama, S., Tanaka, S., Heianza, Y., Fujihara, K., Horikawa, C., Shimano, H., Saito, K., Yamada, N., Ohashi, Y., & Sone, H. (2013). Association between physical activity and risk of All-Cause mortality and cardiovascular disease in patients with diabetes. *Diabetes Care*, *36*(2), 471–479. https://doi.org/10.2337/dc12-0783

Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease. *Journal of the American College of Cardiology*, *53*(21), 1925–1932. https://doi.org/10.1016/j.jacc.2008.12.068

Lee, B. J., Kim, B., & Lee, K. (2014). Air pollution exposure and cardiovascular disease. *Toxicological Research*, *30*(2), 71–75.

Lempert, L. K., & Glantz, S. A. (2019). Tobacco industry promotional strategies targeting American Indians/Alaska natives and exploiting tribal sovereignty. *Nicotine & Tobacco Research*, *21*(7), 940–948. https://doi.org/10.1093/ntr/nty048

Lindberg, S. M., Adams, A. K., & Prince, R. J. (2012). Early predictors of obesity and cardiovascular risk among American Indian children. *Maternal and Child Health Journal*, *16*(9), 1879–1886. https://doi.org/10.1007/s10995-012-1024-9

Lowe, A. A., Bender, B., Liu, A. H., Solomon, T., Kobernick, A., Morgan, W., & Gerald, L. B. (2018). Environmental concerns for children with asthma on the Navajo Nation. *Annals of the American Thoracic Society*, *15*(6), 745–753. https://doi.org/10.1513/AnnalsATS.201708-674PS

Marley, T. L. (2019). Ambiguous jurisdiction: Governmental relationships that affect American Indian health care access. *Journal of Health Care for the Poor and Underserved*, *30*(2), 431–441. https://doi.org/10.1353/hpu.2019.0039

Marley, T. L., & Metzger, M. W. (2015). A longitudinal study of structural risk factors for obesity and diabetes among American Indian young adults, 1994–2008. *Preventing Chronic Disease*, *12*, 140469. https://doi.org/10.5888/pcd12.140469

Martinez-Gomez, D., Lavie, C. J., Hamer, M., Cabanas-Sanchez, V., Garcia-Esquinas, E., Pareja-Galeano, H., Struijk, E., Sadarangani, K. P., Ortega, F. B., & Rodríguez-Artalejo, F. (2019). Physical activity without weight loss reduces the development of cardiovascular disease risk factors—A prospective cohort study of more than one hundred thousand adults. *Progress in Cardiovascular Diseases*, *62*(6), 522–530. https://doi.org/10.1016/j.pcad.2019.11.010

Mowery, P. D., Dube, S. R., Thorne, S. L., Garrett, B. E., Homa, D. M., & Nez Henderson, P. (2015). Disparities in smoking-related mortality among American Indians/Alaska natives. *American Journal of Preventive Medicine*, *49*(5), 738–744. https://doi.org/10.1016/j.amepre.2015.05.002

Narva, A. (2018). Population health for CKD and diabetes: Lessons from the Indian health service. *American Journal of Kidney Diseases*, *71*(3), 407–411. https://doi.org/10.1053/j.ajkd.2017.09.017

National Center for Education Statistics. *Public High School Graduation Rates. 2021:1-5*. https://nces.ed.gov/programs/coe/indicator/coi

Nazir, N., Bevil, B., Pacheco, C. M., Faseru, B., McCloskey, C., Greiner, K. A., Choi, W. S., & Daley, C. M. (2014). Characteristics of American Indian light smokers. *Addictive Behaviors*, *39*(1), 358–361. https://doi.org/10.1016/j.addbeh.2013.10.012

Nelson, R. G., Pankratz, V. S., Ghahate, D. M., Bobelu, J., Faber, T., & Shah, V. O. (2018). Home-based kidney care, patient activation, and risk factors for CKD progression in Zuni Indians: A randomized, controlled clinical trial. *Clinical Journal of the American Society of Nephrology*, *13*(12), 1801–1809. https://doi.org/10.2215/CJN.06910618

Newell, K., Cusack, R. P., Kartsonaki, C., Chaudhary, N., & Kurmi, O. P. (2019). *Household air pollution and associated health effects in low and middle-income countries*. Elsevier. https://doi.org/10.1016/B978-0-12-801238-3.11494-1

Noonan, C. W., Semmens, E. O., Ware, D., Smith, P., Boyer, B. B., Erdei, E., Hopkins, S. E., Lewis, J., & Ward, T. J. (2020). Wood stove interventions and child respiratory infections in rural communities: KidsAir rationale and methods. *Contemporary Clinical Trials*, *89*, 105909. https://doi.org/10.1016/j.cct.2019.105909

North, K. E. (2003). Genetic and environmental contributions to cardiovascular disease risk in American Indians: The strong heart family study. *American Journal of Epidemiology*, *157*(4), 303–314. https://doi.org/10.1093/aje/kwf208

Ozieh, M. N., Garacci, E., Walker, R. J., Palatnik, A., & Egede, L. E. (2021). The cumulative impact of social determinants of health factors on mortality in adults with diabetes and chronic kidney disease. *BMC Nephrology*, *22*(1), 76. https://doi.org/10.1186/s12882-021-02277-2

Parker, T. (2019). *Center for native American health IN-MED application*. University of New Mexico.

Powell-Wiley, T. M., Poirier, P., Burke, L. E., Després, J. P., Gordon-Larsen, P., Lavie, C. J., Lear, S. A., Ndumele, C. E., Neeland, I. J., Sanders, P., & St-Onge, M. P. (2021). Obesity and cardiovascular disease: A scientific statement from the American heart association. *Circulation*, *143*(21), e984-1010. https://doi.org/10.1161/CIR.0000000000000973

Rao, M., Afshin, A., Singh, G., & Mozaffarian, D. (2013). Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open*, *3*(12), e004277. https://doi.org/10.1136/bmjopen-2013-004277

Redwood, D., Lanier, A. P., Brubaker, M., Orell, L., Tomorme, L., & George, C. (2012). Occupational and environmental exposures among Alaska native and American Indian people living in Alaska and the southwest United States. *Journal of Environmental Health*, *74*(9), 13.

Reshaping the Journey: American Indians and Alaska Natives in Medicine. *Association of American Medical Colleges*. https://store.aamc.org/reshaping-the-journey-american-indians-and-alaska-natives-in-medicine.html

Robert Wood Johnson Foundation. *County Health Rankings*. https://www.countyhealthrankings.org/explore-health-rankings/measures-data-sources/county-health-rankings-model

Russo, R. G., Li, Y., Đoàn, L. N., Ali, S. H., Siscovick, D., Kwon, S. C., & Yi, S. S. (2021). COVID-19, social determinants of health, and opportunities for preventing cardiovascular disease: A conceptual framework. *Journal of the American Heart Association*, *10*(24), e022721. https://doi.org/10.1161/JAHA.121.022721

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: An environment scale evaluation. *American Journal of Public Health*, *93*(9), 1552–1558. https://doi.org/10.2105/AJPH.93.9.1552

Schell, L. M., & Gallo, M. V. (2012). Overweight and obesity among north American Indian infants, children, and youth. *American Journal of Human Biology*, *24*(3), 302–313. https://doi.org/10.1002/ajhb.22257

Schmittdiel, J. A., Steiner, J. F., Adams, A. S., Dyer, W., Beals, J., Henderson, W. G., Desai, J., Morales, L. S., Nichols, G. A., Lawrence, J. M., Waitzfelder, B., Butler, M. G., Pathak, R. D., Hamman, R. F., & Manson, S. M. (2014). Diabetes care and outcomes for American Indians and Alaska natives in commercial integrated delivery systems: A SUrveillance, PREvention, and ManagEment of diabetes mellitus (SUPREME-DM) study. *BMJ Open Diabetes Research & Care*, *2*(1), e000043. https://doi.org/10.1136/bmjdrc-2014-000043

Setala, A., Bleich, S. N., Speakman, K., Oski, J., Martin, T., Moore, R., Tohannie, M., & Gittelsohn, J. (2011). The potential of local farming on the navajo nation to improve fruit and vegetable intake: Barriers and opportunities. *Ecology of Food and Nutrition*, *50*(5), 393–409. https://doi.org/10.1080/03670244.2011.604585

Sharma, A. (2009). Obesity prevalence among Low-Income, Preschool-Aged children—United States, 1998–2008. *MMWR*, *58*(28), 769–773.

Stamler, J., Vaccaro, O., Neaton, J. D., & Wentworth, D. (1993). Diabetes, other risk factors, and 12-Yr cardiovascular mortality for men screened in the multiple risk factor intervention trial. *Diabetes Care*, *16*(2), 434–444. https://doi.org/10.2337/diacare.16.2.434

Stang, J., Zephier, E. M., Story, M., Himes, J. H., Yeh, J. L., Welty, T., & Howard, B. V. (2005). Dietary intakes of nutrients thought to modify cardiovascular risk from three groups of American Indians: The strong heart dietary study, phase II. *Journal of the American Dietetic Association*, *105*(12), 1895–1903. https://doi.org/10.1016/j.jada.2005.09.003

Stehr, M. (2005). Cigarette tax avoidance and evasion. *Journal of Health Economics*, *24*(2), 277–297. https://doi.org/10.1016/j.jhealeco.2004.08.005

Storti, K. L., Arena, V. C., Barmada, M. M., Bunker, C. H., Hanson, R. L., Laston, S. L., Yeh, J. L., Zmuda, J. M., Howard, B. V., & Kriska, A. M. (2009). Physical activity levels in American-Indian adults. *American Journal of Preventive Medicine*, *37*(6), 481–487.

Struthers, R., Baker, M., & Savik, K. (2006). Cardiovascular risk factors among Native American women Inter-Tribal heart project participants. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, *35*(4), 482–490. https://doi.org/10.1111/j.1552-6909.2006.00069.x

Subica, A. M., Agarwal, N., Sullivan, J. G., & Link, B. G. (2017). Obesity and associated health disparities among understudied multiracial, pacific islander, and American Indian adults: Understudied racial disparities in obesity. *Obesity*, *25*(12), 2128–2136. https://doi.org/10.1002/oby.21954

Thompson, J. L., Allen, P., Helitzer, D. L., Qualls, C., Whyte, A. N., Wolfe, V. K., & Herman, C. J. (2008). Reducing diabetes risk in American Indian women. *American Journal of Preventive Medicine*, *34*(3), 192–201. https://doi.org/10.1016/j.amepre.2007.11.014

Thompson, J. L., Davis, S. M., Gittelsohn, J., Going, S., Becenti, A., Metcalfe, L., Stone, E., Harnack, L., & Ring, K. (2001). Patterns of physical activity among American Indian children: An assessment of barriers and support. *Journal of Community Health*, *26*(6), 423–445.

Toma, A., Paré, G., & Leong, D. P. (2017). Alcohol and cardiovascular disease: How much is too much. *Current Atherosclerosis Reports*, *19*(3), 13. https://doi.org/10.1007/s11883-017-0647-0

Unger, J. B., Soto, C., & Baezconde-Garbanati, L. (2006). Perceptions of ceremonial and nonceremonial uses of tobacco by American-Indian adolescents in California. *Journal of Adolescent Health*, *38*(4), 443.e9–443.e16. https://doi.org/10.1016/j.jadohealth.2005.02.002

Veazie, M., Ayala, C., Schieb, L., Dai, S., Henderson, J. A., & Cho, P. (2014). Trends and disparities in heart disease mortality among American Indians/Alaska Natives, 1990–2009. *American Journal of Public Health*, *104*(S3), S359–S367. https://doi.org/10.2105/AJPH.2013.301715

Virani, S. S., Alonso, A., Aparicio, H. J., Benjamin, E. J., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Cheng, S., Delling, F. N., Elkind, M. S. V., Evenson, K. R., Ferguson, J. F., Gupta, D. K., Khan, S. S., Kissela, B. M., Knutson, K. L., Lee, C. D., Lewis, T. T., … Tsao, C. W. (2021). Heart disease and stroke Statistics—2021 update: A report from the American Heart Association. *Circulation*, *143*(8). https://doi.org/10.1161/CIR.0000000000000950

Voruganti, V. S., Cai, G., Cole, S. A., Freeland-Graves, J. H., Laston, S., Wenger, C. R., MacCluer, J. W., Dyke, B., Devereux, R., Ebbesson, S. O. E., Fabsitz, R. R., Howard, B. V., & Comuzzie, A. G. (2006). Common set of genes regulates low-density lipoprotein size and obesity-related factors in Alaskan Eskimos: Results from the GOCADAN study. *American Journal of Human Biology*, *18*(4), 525–531. https://doi.org/10.1002/ajhb.20527

Walker, R. J., Smalls, B. L., Campbell, J. A., Strom Williams, J. L., & Egede, L. E. (2014). Impact of social determinants of health on outcomes for type 2 diabetes: A systematic review. *Endocrine*, *47*(1), 29–48. https://doi.org/10.1007/s12020-014-0195-0

Wang, W., Hu, D., Lee, E. T., Fabsitz, R. R., Welty, T. K., Robbins, D. C., Yeh, J. L., & Howard, B. V. (2002). Lipoprotein(a) in American Indians is low and not independently associated with cardiovascular disease: The strong heart study. *Annals of epidemiology*, *12*(2), 107–114.

Ward, T., Boulafentis, J., Simpson, J., Hester, C., Moliga, T., Warden, K., & Noonan, C. (2011). Lessons learned from a woodstove changeout on the Nez Perce reservation. *Science of the Total Environment*, *409*(4), 664–670. https://doi.org/10.1016/j.scitotenv.2010.11.006

Warne, D. (2007). Policy challenges in American Indian/Alaska Native health professions education. *Journal of Interprofessional Care*, *21*(Suppl 2), 11–19. https://doi.org/10.1080/13561820701520426

West, A. E., Williams, E., Suzukovich, E., Strangeman, K., & Novins, D. (2012). A mental health needs assessment of urban American Indian youth and families. *American Journal of Community Psychology*, *49*(3–4), 441–453. https://doi.org/10.1007/s10464-011-9474-6

White, L. L., Ballew, C., Gilbert, T. J., Mendlein, J. M., Mokdad, A. H., & Strauss, K. F. (1997). Weight, body image, and weight control practices of Navajo Indians: Findings from the navajo health and nutrition survey. *The Journal of Nutrition*, *127*(10), 2094S–2098S. https://doi.org/10.1093/jn/127.10.2094S

World Health Organization. (2012). *WHO global report on mortality attributable to tobacco*. World Health Organization.

Yurgalevitch, S. M., Kriska, A. M., Welty, T. K., Go, O., Robbins, D. C., & Howard, B. V. (1998). Physical activity and lipids and lipoproteins in American Indians ages 45-74. *Medicine Science in Sports and Exercise*, *30*(4), 543–549.

Zephier, E. M., Ballew, C., Mokdad, A., Mendlein, J., Smith, C., Yeh, J. L., Lee, E., Welty, T. K., & Howard, B. (1997). Intake of nutrients related to cardiovascular disease risk among three groups of American Indians: The strong heart dietary study. *Preventive Medicine*, *26*(4), 508–515. https://doi.org/10.1006/pmed.1997.0164

AUTHOR BIOGRAPHIES

Eric Leung was born in Yakima Washington and graduated from the University of New Mexico in 2020. He is currently a 3rd year medical student at the University of New Mexico. His previous work includes a presentation at the American Medical Student National Convention in 2020 on “Social Determinants of Obesity in New Mexico”. His is currently studying outcomes of percutaneous coronary intervention in Hispanics. He plans to enter a residency program in internal medicine and focus his career on

diminishing disparities and advancing health care for all racial and ethnic minorities with a focus on social determinants of health and health economics.

Tassy Parker, PhD, RN, is a citizen of the Seneca Nation, director of the University of New Mexico Health Sciences Center for Native American Health (CNAH), and founding director of CNAH's Public Health Institute for Indigenous Knowledge and Development. Dr. Parker is a professor with tenure in the Department of Family and Community Medicine, Professor in the Colleges of Nursing and Population Health, and UNM Health Sciences Associate Vice President for American Indian Health Research and Education. A community based participatory research practitioner, Dr. Parker is MPI on two NIH grants, including an R01, and co-I/site PI on seven additional NIH grants. Her current studies include examination of American Indian cognitive assessment tools, dementia screening in urban/rural American Indians and Alaska Natives, youth suicide prevention, hypertension and related conditions, diabetes, COVID vaccine uptake and vaccine equity, and social network analysis related to young adult opiate and other drug use. A significant body of Dr. Parker's previous research addressed American Indian pediatric obesity prevention, historical trauma, and depression (first to examine the use of Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic tools in an Indian Health Service clinic) and other mental health conditions. Dr. Parker is President of the Board of Directors, First Nations Community Health Source, an urban Indian Health Service clinic/FQHC serving American Indians and Alaska Natives and others in Albuquerque's most economically depressed quadrant, and serves on the Seneca Nation Health Board that oversees operations of a tribally operated health system. She currently serves on the NIH All of Us Research Program Advisory Panel, External Advisory Committee of the Wisconsin Alzheimer's Disease Research Center, Internal Advisory Committee of the UNM Alzheimer's Disease Research Center, and Scientific Advisory Board of the Alzheimer's Disease Neuroimaging Initiative, UC San Francisco.

Allyson Kelley supports research, evaluation, training and technical assistance efforts for several community health initiatives in the United States. She leads a multidisciplinary team of associates and together they work to build evaluation capacity, understanding, and infrastructure that results in opportunities for community healing and transformation. Her research interests include building community capacity to address the cultural, social, and environmental factors that contribute to differences in health outcomes among underserved populations in the United States. Allyson is committed to building the next generation of public health professionals. She has mentored more than 300 undergraduate and graduate students. Allyson graduated from the University of North Carolina Greensboro earning a Doctor of Public Health in Community Health and the University of Alaska Anchorage with a Masters of Public Health in Public Health Practice. She is the author of three books published by Routledge, Evaluation in Rural Communities and Public Health Evaluation and the Social Determinants of Health, and Treatment Program Evaluation. Allyson has one book scheduled for publication with Routledge in 2023, Spiritual Healing for Trauma and Substance Abuse Recovery: Clinical and Real-life Applications.

James Blankenship is currently director of the University of New Mexico Division of Cardiology and cardiac catheterization laboratories. He received an AB magna cum laude in biochemistry from Cornell University School of Arts and Sciences in 1976, an MD from Cornell University Medical College in 1980, and a masters of health care management from Harvard University School of Public Health in 2014. He completed

residency in internal medicine and a fellowship in cardiology at the University of Michigan 1980–1987. He worked as an interventional cardiologist for Geisinger Health System until 2020 where he served as catheterization laboratory director for 20 years, as director of cardiology at Geisinger Medical Center for 10 years, and as chair of cardiology for Geisinger Health System for 3 years. He served as president of the Society for Cardiovascular Angiography and Interventions (2015–2016) and has represented the American College of Cardiology on the AMA's Relative Value Update Committee for 20 years. After submitting Rainier, Kilimanjaro, and Aconcagua (but failing on Denali) he moved to New Mexico to be close to his grandchildren.

How to cite this article: Leung, E., Parker, T., Kelley, A., & Blankenship, J. C. (2022). Social determinants of incidence, outcomes, and interventions of cardiovascular disease risk factors in American Indians and Alaska Natives. *World Medical & Health Policy*, 1–21. https://doi.org/10.1002/wmh3.556