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Health Disparities of Cardiometabolic Disorders Among Filipino Americans: Implications for Health Equity and Community-Based Genetic Research

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Abstract

Health disparities are well-documented among different racial and ethnic minority groups in the United States. Filipino Americans (FAs) are the third-largest Asian-American group in the USA and are commonly grouped under the Asian categorization. FAs have a higher prevalence of cardiometabolic disorders than non-Hispanic Whites and other Asian subgroups with rates comparable to African Americans. Although no major epidemiological studies have ascertained the prevalence of cardiometabolic diseases in FAs, limited reports suggest that FAs have a higher prevalence of dyslipidemia, hypertension, diabetes, metabolic syndrome, hyperuricemia, and gout than non-FAs. A recent genetic study has shown that FAs could have the highest prevalence of a genetic polymorphism strongly associated with the development of gout and gout-related comorbidities. While developing cardiometabolic disorders is a heterogeneous and multifaceted process, the overall prevalence of certain cardiometabolic disorders parallel the prevalence of population-level risk factors, including genetics, dietary lifestyles, health beliefs, and social determinants of health. Therefore, assessment of the Filipino cuisine, health behaviors among Filipinos, socio-cultural factors, and acculturation to living in the USA are equally critical. Ascertaining the contribution of the biological causes to disease onset and the different psychosocial factors that could modulate disease risk or disease management are needed. Ultimately, a multilevel research approach is critical to assess the role of biological and non-biological risk factors of cardiometabolic disorders in FAs to inform culturally appropriate health promotion, disease prevention strategies, and a personalized approach to health.

Keywords

Filipinos; Minorities; Health disparities; Gout; Genetics; Diet; Community health; Cardiovascular diseases; Immigration; Acculturation; Precision medicine

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Declarations

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Background

Health disparities exist among racial and ethnic minority groups in the United States (US), with differences in disease prevalence, mortality rates, and responses to medications [1]. These differences are multifactorial in nature, with genetic variation explaining a portion of this variability. Additionally, social and lifestyle factors are significant contributors to these disparities. The rapidly growing Asian subpopulations are generally aggregated under the "Asian and Pacific Islanders" category. The aggregation of heterogeneous groups with different prevalence of social determinants of health and genomic architectures may be masking the differences in the etiology of the health conditions and the exact frequency of the same health conditions across the different subgroups [2–4]. Moreover, the representation of minority subgroups in research has been limited. Indeed, most of the research has focused on large racial and ethnic minority categories, which are defined as "White, Black, or African American, American Indian, or Alaskan Native, and Asian." The underrepresentation of minority subgroups in research is increasing the burden of health disparities and creating knowledge gaps. These current research methodologies are hampering our potential to advance the biomedical field to improve public health [5, 6]. The Filipino American (FAs) population is a prime example of an Asian subgroup that has been commonly ascribed as Asian, despite having a different prevalence of social determinants of health and a higher prevalence of chronic health conditions than other Asian subgroups [2, 3]. Aggregating FAs and other Asian subgroups under the broader categorization of "Asians" may be leading to more health disparities [3]. Thus, the purpose of this article is to provide a focused examination of the behavioral, cultural, and psychosocial analyses that may contribute to the disproportionate prevalence of cardiometabolic risk factors in FAs. This analysis could inform the design of future community-based clinical research in FAs. To this end, the engagement of FA in clinical research will add to our growing body of knowledge about the sources of variability of disease risk and progression, as well as the predicted response to drug therapy across different minority groups. The overall arching goal of minority-specific research is that the inclusion of minority populations in biomedical research will enable us to understand the genetic heterogeneity in complex traits, reduce health disparities, promote health equity, and improve overall public health.

Health Disparities Among Filipino Americans

Filipino Americans (FAs) are the third-largest Asian subgroup in the US, with a significantly disproportionate prevalence of cardiometabolic disorders compared with non-Hispanic Whites and other Asian subgroups [2, 7, 8]. Despite their relatively large population size and being well represented in the US workforce, the representation of FAs in biomedical research has been limited, possibly due to concerns over their immigration status, specific health beliefs, and the aggregation of Asian subgroups under the Asian category [9–11]. The underrepresentation is widening the knowledge gap about disease prevalence in the FA community and their relative disease risks. Nonetheless, limited reports, including medical records data and small cohort studies, have suggested that FAs are at a greater risk for developing cardiometabolic disorders at much higher rates than their non-FAs counterparts [4, 12]. Hyperuricemia and gout are well-documented cardiometabolic risk factors and occur at higher rates in FAs [13–16]. Although the development of these conditions is a

multifactorial process, dietary patterns, lifestyle factors, and genetics could significantly contribute to the development of hyperuricemia or goutrelated cardiometabolic disorders [17]. A genetic analysis of a Filipino cohort, using biorepository samples, showed that Filipinos have the highest prevalence (46%) of hyperuricemia and gout risk allele rs2231142 G > T in *ABCG2* [18]. This markedly high-risk allele prevalence could partly explain the reported high incidence of gout and hyperuricemia in FAs, especially when accustomed to a high purine diet [13, 19, 20].

Elucidating the role of genetics, lifestyle factors, and socioeconomic status concerning cardiometabolic disorders, including hyperuricemia and gout in a FA cohort study, is warranted. In a population that is genetically predisposed to developing cardiometabolic diseases, including diabetes, hypertension, and dyslipidemia, the impact of acculturation and customization to a Western lifestyle could increase their risk for developing major cardiovascular diseases [7, 18, 21, 22]. Similar to populations of Asian ancestry, being genetically predisposed to a higher risk for developing hyperuricemia and gout than Europeans, FAs confer a much higher risk for the same conditions due to their high disease risk alleles frequencies [18, 23–25]. Moreover, hyperuricemia and gout could clinically predispose patients to common cardiometabolic and renal diseases. Therefore, both hyperuricemia and gout could serve as disease risk predictors at the population level [26–29]. Generally, chronic kidney disease (CKD) occurs at a significantly higher rate in patients with hyperuricemia and gout than those without either conditions [30]. Increasingly important, CKD is significantly associated with morbidity and mortality and disproportionately affects individuals of racial and ethnic minorities [31]. FAs are more likely to develop CKD and diabetic kidney disease compared with other Asian subgroups and Caucasians. An epidemiologic study among Asian Americans in Hawaii between 2001 and 2003 showed that FAs were at an increased risk for developing CKD if they were 65 or older or had hypertension or diabetes mellitus [32]. These findings are consistent with the high prevalence of proteinuric diabetic kidney disease among Filipinos compared with non-Hispanic Whites (37.9 vs. 24.8, $p < 0.0001$) [31].

The epidemiological association between CKD, hypertension, gout, and hyperuricemia is well established. The observed trends of these health conditions in FAs suggest population-specific risk factors and a pleiotropic predisposition, leading to this constellation of chronic diseases, which may partly explain the reported health disparities. Nonetheless, information on immigration status, years lived in the US, access to medical care, sociodemographic data, and other social determinants of health may also help delineate the etiology and the entanglement of these chronic diseases among FAs. Ultimately, investigating the underpinning mechanisms of health disparity, as indicated by the high prevalence of cardiometabolic disorders among FAs, warrants a multidimensional analysis of the contributing factors leading to disproportionate disease prevalence among FAs [33, 34]. Below, we provide an overview of the dietary, behavioral, and psychosocial factors that could be contributing to the health disparities of cardiometabolic disorders in FAs. Additionally, we discuss the challenges and opportunities to reduce the ongoing health disparities within the FA community.

History of Filipino Cuisine and Cardiometabolic Disease Risk

Pre-colonial food (900–1521) in the archipelago, now known as the Philippines, bore similarities to its Southeast Asian neighbors with marked influences from the cuisine of its Indian, Arab, Chinese, and other Asian trading partners and early Austronesian settlers [35]. A Filipino food cultural historian characterized the cuisine of that period as "showing an originality of taste," which the chronicler of the Magellan Spice Expedition described as "very salted." Salt, vinegar, sugar, and, to some extent, fat met the need to prolong the shelf-life of food in the hot climates of the islands and the acquired tastes for which they had been ingrained in the Filipino palate. To tame bold flavors resulting from using these natural preservatives, rice, a primary crop of the Philippines, eaten at almost every meal together with intensely flavored *ulam* (dishes), became the favored staple. Cooking techniques at that period mainly involved grilling, boiling, baking in a pit, steaming, and cooking without heat, such as using vinegar as fire.

The era under Spanish rule (1565–1898) expanded the cuisine. New techniques such as braising, roasting, and relleno (filling a food cavity with stuffing); foreign ingredients, such as tomato and beef; rice-meat dishes, such as paella; and a predilection for richer fare and elaborate dishes, especially during the celebrations of religious festivals, were introduced. The period that followed (1898–1946) under the Americans introduced institutionalized health and sanitation codes that ushered canned meat and fruits, among others, into the Filipino diet [36]. It was also during this period until after the WWII that mass migration of Filipinos to America surged. In the immigration process, adherence to the "Filipino taste" using ingredients available in the new home country is common. Hence, it is permissible to suggest that colonization brought about the Filipinization of Western food, and migration brought about the Westernization of Filipino food. The admixing of the Filipino cuisine with the Western diet, which is high in protein, salt, and fats and low in fruits and vegetables, allows for high dietary salt intake and an increased risk for developing dyslipidemia and hypertension among FAs. The high dietary sodium intake, hypertension, and dyslipidemia were reported as significant risk factors for developing cardiovascular diseases (CVD) in FAs [12, 37]. The bicultural eating patterns among FAs show a preference for both typical Western diet and traditional Filipino food. The main change observed in the eating pattern of Filipinos who immigrate to the US is the higher fat intake [20]. In the Philippines, the average Filipino diet consists of rice, vegetable, and fish. In their new home country, the consumption of meat, dairy, baked products, and fast foods increases due to the accessibility and affordability of these types of food [38]. Indeed, living in the US for over five years has been determined as one of the significant predictors of CVD risk in FAs [39].

Role of Immigration and Acculturation in Cardiometabolic Diseases

Acculturation has been defined as "the dual process of cultural and psychological change that occurs as a result of contact between two or more cultural groups and their members" [40]. Concerning immigrant groups, this may be estimated based on length of residency, food customs, language adaptation, media consumption, and values and attitudes, among other factors. However, individual characteristics upon arrival into the host nation, for example, age, income, and social support, can alter the degree and rate of acculturation.

Similarly, the risk of developing new disease onset among immigrants tends to follow the length of stay in the new environment. A minimum residency of 15 years indicates an increased likelihood for chronic cardiometabolic conditions and health behaviors promoting their development [41]. According to 2015 statistics, 49% of foreign-born FAs have resided within the US for at least 21 years, with up to 72% having lived in the US for greater than ten years. This statistic brings a high proportion of the FA population into the increased CVD risk category [8]. Additionally, when examining this subgroup cross-generationally, first-generation Filipino immigrants have distinct health disparities from second-generation immigrants. For example, the unadjusted odds ratio for non-US born long-term (≥ 15 years in the US) immigrants was 2.8 ($p < 0.005$) for hypertension and 4.0 ($p < 0.005$) for diabetes compared with second-generation Filipinos [42]. However, there was no significant difference in hypertension and diabetes between recent immigrants (≤ 14 years in the US) and second-generation Filipino immigrants [42]. These results are consistent with acculturation theories that health practices of immigrants tend to converge with those of their US counterparts over time.

Examining Filipino acculturation, previous studies addressed the socio-cultural aspects that Filipino immigrants bring with them from their motherland as determinants of health, for instance, colonial mentality, a form of internalized oppression through ethnic inferiority with a preference for Western culture. They demonstrate how colonial mentality interplays with the cultural attitude of *pakikisama* (or getting along with others to avoid conflict) [43]/ "Pre-acculturation," or priming for Western culture due to globalization of Western media and products, promotes early lifestyle assimilation by Filipino immigrants with an emphasis on diet. The adaptation of an American diet is correlated with an increased intake of sugar, fat, and calories. In the Philippines, Filipinos consumed more fruits, vegetables, pork, chicken, and fish but less beef [20, 42]. However, those immigrating to America had increased consumption of beef, pork, dairy, soda, and fast foods, due to increasing availability, with reduced intake of fruits and vegetables and unchanged patterns in rice consumption [20, 42]. At the same time, bicultural Filipino immigrants continue to include in their diet native Filipino foods, many of which are high in salt and fat, such as soy sauce, *bagoong* (shrimp paste), *patis* (fish sauce), *lechon* (roasted pig), and *lumpia* (fried rolls). A culture of *pakikisama* with their community encourages these habits, leading to the availability of Filipino and Western foods together in social settings and celebrations with expectations of eating both [44].

The effect of the colonial mentality and Westernization on Filipinos is quantified using assimilation measures. Assimilation measures include increased rates of inter-ethnic marriage, residential and ethnic identity integration, and the use of the English language when compared with other Asian subgroups [45]. However, this mentality is also tempered by microaggressions or even blatantly racist experiences after Filipino immigrants arrive in America and develop into a level of mistrust of Western culture. Unsurprisingly, this cultural mistrust shares similar origins with the colonial mentality, arising from a history of oppression, such as Western schooling systems in the Philippines during the colonial era. The extension of oppression towards FAs was far-reaching outside the Philippines, explaining the discriminatory practices upon their arrival to America and maltreatment and disempowerment in California in the 1900s [42]. More recently, FAs report facing

microaggressions in the form of assumed second-class citizenship, deviance, and inferiority, while simultaneously being held to the Asian American standard as the "model minority." From a psychosocial perspective, the conflict of these opposing experiences develops into frustration with fear of alienation from the majority culture and its institutions [46].

The study of internalized oppression, racism, and microaggressions in Black and indigenous Americans demonstrated increased school dropout, substance abuse, incarceration, and other high-risk behaviors [47]. Literature on the effect of racism on Filipinos shows similar disparities measured by high rates of high school and college dropout, incarceration, substance abuse, psychological distress, and cardiometabolic disorders compared with Caucasians [46, 48]. Additionally, racist experiences are correlated to a 2 to 3 odds ratio of reduced trust and satisfaction in healthcare, ultimately leading to unmet health needs [49]. The effects of a culture of mistrust and racism compound the social determinants of health that many immigrants and minorities already face, including access to resources, affordable and quality care, and employment [50]. Along with those elements is systemic racism—and, with it, cultural barriers to health, such as work and time constraints, health deprioritization, and linguistic barriers—thereby limiting FAs' capacity to counteract the adverse effects of acculturative lifestyle changes [49]. With the accumulation of multiple negative psychosocial experiences (e.g., immigration, acculturation, microaggression, racism), the resulting stress substantially contributes to the individual's load and manifests in the health disparities noted above [51].

Health Beliefs and Disease Management

Health beliefs among population groups play a significant role in prioritizing health, receiving care, and choosing the treatment modalities. Specifically, select minority, immigrant, or underserved groups may hold distinct health beliefs that could interfere with their decision to seek medical care, but rather a spiritual leader or a non-traditional medical care provider [52, 53]. Unlike other Asian subgroups, English is widely used among Filipinos, which reduces some health barriers to receive care in the US and navigate a complex system. Specifically, FAs have adapted to the US healthcare system and have become acculturated at various levels while working and living in the US. Integration of their Filipino cultural values, beliefs, and behaviors influences their practices and attitudes towards health care and decisions to seek medical treatment and services. However, FAs remain to hold on to some health beliefs that somewhat resemble other Asian subgroups [54].

Like other Asian ethnicities, the concept of "*timbang*" or balance is central to Filipino self-care practices and views on health [54]. It is believed that health and happiness are due to balance, whereas illness is consequent to imbalance. An example of the interaction between hot and cold elements is the concept of *pasma* or "exposure illness." When a condition considered to be "cold" is attacked by a "hot" element and vice versa. There is a belief that women who give birth are considered "hot" in nature, and therefore, should not be exposed to hot environments such as eating "hot" foods as it would aggravate their condition. On the other hand, the woman should not be in "cold" environments, as it would result in palpable "knots" in muscle or subcutaneous tissues on the woman's body

[10]. Homeostasis is attained by a balance between "hot" and "cold" elements, and the dominance of either element will lead to illness. With this principle, FAs seek to prevent or correct these imbalances. This homeostasis may occur using home remedies, traditional practices, or other alternative forms of medicine. Massage therapy or "*hilot*" is a frequently encountered health practice associated with folk medicine practitioners to prevent the entry of cold elements [10]. Other health practices among Filipinos include herbalism, plant medicine, acupuncture, and faith or spiritual healing, which can be used, in conjunction, with conventional medicine. For example, guava leaves are used by Filipino elders to clean the intestines and to treat constipation, hemorrhoids, indigestion, and for washing minor cuts [55]. However, there is concern that practices of primarily self-treatment, especially among the older adults, may prevent or delay getting early formal medical access and interventions.

In response to illness, FAs have developed coping mechanisms that include the following: *tiyaga*, *lakas ng loob*, *tatawanan ang problema*, *bahala na*, and *pakikisama* [29]. Patience and endurance or *"tiyaga"* enables Filipinos to tolerate uncertainty. Flexibility or "*lakas ng loob*" is having inner strength and courage within oneself. Humor or "*tatawanan ang problema*" is the ability to laugh at oneself in difficult situations or times of crisis. Fatalism or "*bahala na*" is the view that illness or suffering is an inherent part of life and is the will of God; therefore, we should not interfere with Gods' will. It is an attitude of "we'll cross that bridge when we get there," conceding to the collective wishes of the family or community or "*pakikisama*" to maintain group harmony [56].

Family is at the core of the Filipino culture and involves not only a network of biological connection, but it also transfers those qualities to those outside of the family. More than often, because many Filipinos in the US work in health-related fields, FAs are most likely to seek medical help or advice from family members or friends who are healthcare professionals. Two main concepts determine how much trust FAs give when seeing their physicians: *Hindi ibang tao* (one of us) and *Ibang Tao* (not one of us) [57]. In Filipino social interactions, the medical provider is perceived in one of these two categories. Depending on the category the medical provider is in, it determines the level of interaction and the amount of trust given. If a medical provider is regarded as "*hindi ibang tao*" (one of us), one can expect FAs to be more transparent about the details of their health, feeling more at ease with their provider. If the provider is categorized as "*ibang tao*" (not one of us), FAs are more hesitant in expressing their emotions and needs, and instead, they will respond politely but at a superficial level [57]. While many FAs have integrated into the American healthcare system, their cultural differences and values still need to be acknowledged to provide optimal healthcare, improve health assessment and intervention, and promote understanding between provider and patient.

Health beliefs and practices could substantially differ among FA. Indeed, we recognize that considerable intracultural diversity among FAs regarding health beliefs and health practices exists. For example, FAs who have been in the US for a long time are more acculturated to the American health care system than those who recently migrated. The less acculturated immigrants may adhere more to traditional medicine and prefer indigenous healing practices, including complementary and alternative medicine. Overall, these health beliefs and behavioral practices among FAs could substantially influence the decision and

the timing to seek medical care, which could have significant consequences on disease diagnosis, treatment, and medication adherence.

Social Determinants of Health and Cardiometabolic Disorders

Although genomics could predispose specific population subgroups to cardiometabolic disorders and subsequent major cardiovascular events, trends in disease prevalence suggest important sociodemographic factors in disease incidence [1]. Increasingly important, data suggest a causal role of social determinants of health in disease onset and progression, including immigration [58–61]. The burden of cardiometabolic disorders in disadvantaged populations is a partial consequence of lower socioeconomic status and other social stressors, both of which are recognized as significant risk factors for morbidity and mortality [58, 60]. Structural barriers to optimal health have been conceptualized to contribute to health inequity among disadvantaged populations, including racial and ethnic minorities [1]. These barriers include limited health literacy, poor lifestyle choices, limited access to healthcare, and guarded views on Western medicine [1, 54, 62]. These barriers will likely preclude the individuals from seeking medical care, recognizing the symptoms of ongoing cardiovascular risk factors, and adhering to ongoing treatments for cardiometabolic disorders.

Psychosocial distress also plays a significant role in predisposing minority populations to develop cardiometabolic risk factors [63]. For example, post-traumatic stress due to violence, trauma, and racial discrimination could increase the risk of developing major cardiovascular events [64, 65]. Most recently, violence targeted towards the Asian American community is another example of psychosocial distress in minority populations, which compounds their health disparities further. Nevertheless, positive stress-buffering effects of strong racial or ethnic identity have been reported. A study conducted in a FA cohort with a higher degree of ethnic identity reported fewer depressive symptoms and better coping ability when faced with racial discrimination [66]. This example of resilience highlights two critical aspects in studying minority populations, such as FAs. First, maintaining a strong cultural identity and social connectedness could have a positive impact on overall health. Second, the adoption and sustainability of culturally tailored interventions are needed for community-based research among minority groups.

Challenges and Opportunities for Health Equity

The FA population is a growing immigrant minority in the US but remains minimally represented in biomedical and genomics research [9]. The engagement of minority and immigrant populations, e.g., FAs, in genomics and pharmacogenomics research will expand the global benefits of personalized medicine and move us beyond the “the one genotype fits all” paradigm. With most of the genetic research on Filipinos taking place in the Philippines, engaging FAs in biomedical research in the US will expand our knowledge of the effect of immigration, different lifestyles, dietary changes, and acculturation on disease risk and gene-environment interactions. Therefore, engaging FAs in biomedical research will enable the community to garner the benefits of genomics research and provide new insights that may explain the high prevalence of cardiometabolic conditions throughout the community.

Furthermore, an equitable community-academic partnership approach could help establish a new framework for conducting research that may improve the participation of disadvantaged communities in future studies and propel the field of precision health moving forward. Collectively, the information derived from such collaboration will inform culturally appropriate disease prevention strategies, increase community engagement, promote health equity, and reduce the burden of health disparities on the Filipino community and the overall healthcare system at large.

The optimal management of patients at risk for CVD has become increasingly challenging, given the global rise in obesity, diabetes, metabolic syndrome, and hypertension [67, 68]. Thus, conducting research focused on identifying and addressing the risk factors associated with CVD in FAs is a significant step towards health promotion and health equity. Moreover, the prevalence of hyperuricemia and gout, major independent cardiometabolic risk factors, are globally rising and disproportionately affect FAs. With such rapid population growth and a high disease burden on the Filipino community, elucidating disease risk factors will help develop targeted interventions and unfold granular differences in disease etiology between population subgroups. As demonstrated in prior ethnic groups, community-based research in FAs is a promising approach to provide culturally tailored interventions and address community-specific health disparity [73]. This research approach requires community engagement at all levels of the research process in an equitable manner. Ultimately, providing health information and dietary recommendations to increase health literacy about cardiometabolic diseases among FAs need to be personalized and culturally acceptable [9].

Precision Medicine and Pharmacogenomics

The precision medicine initiative aims to provide a personalized approach to treat the patient, using their demographic and genetic information to limit the trial-and-error strategy and minimize the risk of adverse drug events [6, 69, 70]. And with the growing racial and population diversity in the US, the need for implementing a precision medicine-based approach is increasingly important to move us beyond the racial and ethnic categorization to deliver patient-centered care [74]. The selection of drug therapy to manage FAs with cardiometabolic disorders is a challenge given the FAs' guarded perspectives on receiving medical care and using Western medicine drugs, primarily driven by the pluralism of medical care and socially influenced medical decisions [62]. When such a belief system exists, medication adherence becomes a significant challenge leading to poor patient treatment outcomes. Thus, conservative strategies towards drug selection represent an optimal approach for managing any condition within this ancestrally unique population rather than a one-dose-fits-all approach. Indeed, a pharmacogenomic-based approach to drug selection, which recognizes an individual's genetic predisposition to cardiometabolic disorders and specific responsiveness to drug therapy, has been shown to improve adherence rates, clinical outcomes (safety and efficacy), and decrease the associated healthcare costs to these conditions [71, 72]. With an end goal of state-wide implementation of pharmacogenomics in clinical practice to guide patient care, pharmacogenomics studies focused on population subgroups are needed [6]. History of mistrust in Western medicine among minorities, including FAs, imposes unique challenges for conducting clinical and genetic research among underserved populations [11]. To ameliorate these challenges,

a culturally appropriate research study design rooted in Filipino cultural values with community input is critical to guide community engagement and a meaningful research endeavor. Ultimately, including FAs in genetic-based studies will enable the community to harness the benefits of precision medicine and improve treatment outcomes of common chronic diseases in the FA community.

Conclusions

Filipinos are a distinct racial group with a unique cultural background and health belief system. Cardiovascular diseases among FAs are high compared with other racial groups. While genetics may significantly explain some of the health disparities observed in FAs, dietary habits, acculturation, and social lifestyles, coupled with specific health belief systems, could be significant predictors in the disparate cardiometabolic disorders reported in FAs. Community engagement-based research is a promising approach to reduce the barriers associated with engaging minorities in clinical research. This approach substantially empowers the community to address pertinent health issues to achieve health equity. Finally, including minorities, such as FAs, in genetic research will enhance disease prediction models and expand the precision medicine treatment algorithms to provide personalized medicine and avoid unwanted adverse drug events.

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