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# Cardiometabolic Health Disparities in Native Hawaiians and Other Pacific Islanders

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## Abstract

Elimination of health disparities in the United States is a national health priority. Cardiovascular disease, diabetes, and obesity are key features of what is now referred to as the "cardiometabolic syndrome," which disproportionately affects racial/ethnic minority populations, including Native Hawaiians and other Pacific Islanders (NHOPI). Few studies have adequately characterized the cardiometabolic syndrome in high-risk populations such as NHOPI. The authors systematically assessed the existing literature on cardiometabolic disorders among NHOPI to understand the best approaches to eliminating cardiometabolic health disparities in this population. Articles were identified from database searches performed in PubMed and MEDLINE from January 1998 to December 2008; 43 studies were included in the review. There is growing confirmatory evidence that NHOPI are one of the highest-risk populations for cardiometabolic diseases in the United States. Most studies found increased prevalences of diabetes, obesity, and cardiovascular risk factors among NHOPI. The few experimental intervention studies found positive results. Methodological issues included small sample sizes, sample bias, inappropriate racial/ethnic aggregation of NHOPI with Asians, and a limited number of intervention studies. Significant gaps remain in the understanding of cardiometabolic health disparities among NHOPI in the United States. More experimental intervention studies are needed to examine promising approaches to reversing the rising tide of cardiometabolic health disparities in NHOPI.

### Keywords

cardiovascular diseases; diabetes mellitus; healthcare disparities; health status disparities; metabolic syndrome X; minority groups; minority health; obesity

## INTRODUCTION

The prevalence of cardiometabolic disorders, including cardiovascular disease, diabetes, and obesity, has reached epidemic proportions worldwide. Prevalences of diabetes and cardiovascular disease among ethnic minorities in the United States exceed those seen in the general population (1–7). Because of the excess health burden of cardiovascular disease and diabetes in ethnic minorities, cardiometabolic risk, as the precursor of these diseases, provides a specific target for conducting investigations that aim to reverse and/or eliminate these



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disparities. Moreover, obesity, as one of the central pathophysiologic mechanisms underlying the syndrome of cardiometabolic risk, might constitute an earlier "upstream" target for treatment and prevention that could be effective in reducing excess morbidity.

In this review, we focused on cardiometabolic health disparities among Native Hawaiians and other Pacific Islanders (NHOPI). As a federal designation, "Native Hawaiian or Other Pacific Islander" refers to persons with origins in any of the original peoples of the islands of Polynesia, Micronesia, and Melanesia (8). The first Polynesian settlers of the Hawaiian Islands are thought to have migrated from the Marquesas Islands as early as 100 B.C.E., some 2,000 years ago (9). Hawaiians lived in isolation until 1778, when European explorers brought with them deadly foreign infectious diseases that decimated the Native population. Colonization and the eventual overthrow of the Hawaiian monarchy resulted in a loss of land and political power, as well as traditional practices and customs, including the near extinction of the Hawaiian language (9).

Events such as the cultural revival referred to as the "Hawaiian Renaissance," the return of the island of Kahoolawe to the Hawaiian people, the formation of political bodies such as the Office of Hawaiian Affairs, the public recognition of the illegal overthrow of the Hawaiian monarchy, and the ongoing voyages of the Hokule'a using historical navigation techniques of Native Hawaiians serve to highlight the resiliency and strength of this population. However, despite these positive social and political developments, NHOPI are overrepresented in lower socioeconomic groups, report greater difficulties in obtaining health care, and may be affected by internalized racism as a consequence of their historical experience of disenfranchisement and loss of power within their traditional homeland (10–12). In addition, NHOPI continue to bear a disproportionate burden of disease, including cardiovascular disease and diabetes.

Today, the state of Hawai'i has the largest population of Native Hawaiians in the United States, followed by California. Among ethnic subgroups in Hawai'i, Native Hawaiians have the highest prevalence of diagnosed diabetes (11.5%), with reported prevalences ranging from 19% to 22% for type 2 diabetes and from 16% to 35% for impaired glucose tolerance (5,13, 14). Cardiovascular disease mortality among Native Hawaiians in 2004 was more than twice that in Japanese, who had the lowest rates (372 per 100,000 population vs. 167 per 100,000 population), and diabetes-related mortality was 3 times higher in Native Hawaiians than in Caucasians (39 per 100,000 population vs. 13 per 100,000 population) (6). The Native Hawaiian Health Research (NHHR) Project examined the relation between a clustering of cardiovascular risk factors and biochemical markers of insulin resistance (fasting insulin and C-peptide levels) (7). The investigators found that fasting insulin concentrations were correlated with body mass index, waist-to-hip ratio, blood pressure, and levels of triglyceride, high density lipoprotein cholesterol, and glucose. A significant correlation was also found between increasing insulin resistance and increased clustering of cardiovascular disease risk factors. The NHHR study, in addition to a limited number of other studies on NHOPI, suggests that significant disparities occur between and among these populations. The purpose of this review was to systematically assess the state of the science related to cardiovascular disease, diabetes, and adiposity among NHOPI.

## METHODS

Database searches were performed in PubMed and MED-LINE for the time period of January 1998 to December 2008, with keyword combinations of the following racial/ethnic groups in an "OR" search term: *Native Hawaiian, Hawaiian, Pacific Islander, Samoan, Tongan, Micronesian, New Zealand, Maori, Melanesia, Chamorro, Guamanian, Fijian*, and *Polynesian* (Figure 1). The racial/ethnic groups were then included in combination with the following terms defined as an "OR" function: *minority, minorities, groups, ethnicity*, and *ethnicities*. The above racial/ethnic AND minorities search term was identified as a "Set A"

keyword search. Results from the Set A keyword search were then combined with Set B keywords as an "OR" search term which included the following: *inequity, inequality, health disparities, health differences, cardiovascular, hypertension, heart, heart failure, heart disease, heart disease risk factors, cardiac, cardiomyopathy, diabetes, syndrome X, metabolic syndrome, insulin resistance, glucose intolerance, prediabetes, cardiometabolic, obesity, adiposity, overweight, physical inactivity, physical activity, nutrition, diet,* and *smoking* in combination with *United States*.

Additional studies ($n = 21$) were also extracted from the reference lists of the articles identified in the initial search using Set A AND Set B keywords; these studies were reviewed for inclusion/exclusion. The searches were restricted to English-language articles on humans aged ≥19 years that had been published in peer-reviewed scientific journals. Articles were excluded from the review if they were letters, editorials, or literature reviews without new data; if they had been published in a foreign language; or if they were nonempirical.

Using this search strategy, we identified 311 citations, of which 98 were deemed relevant through review of the article title (performed by a single reviewer). All 98 articles underwent abstract review by 2 independent reviewers, using a standard checklist adapted from other reviews of the health-disparities literature (15). Of the 98 abstracts reviewed, 71 articles were selected for a full text review, which was performed by 2 independent reviewers to ensure compliance with all inclusion criteria, as well as ranking on the following study design criteria: 1) use of appropriate indicators for patient characteristics (e.g., race, ethnicity, or ancestry, sex, age, education, income); 2) inclusion of objective measures of the outcomes of interest (i.e., measured height, weight, and systolic and diastolic blood pressure; self-report of or medical chart review to determine obesity, cardiovascular disease, and/or diabetes status, etc.); 3) inclusion of well-defined measures of disease status; and 4) appropriate adjustment for patient comorbid conditions (i.e., age, sex, body mass index for diabetes outcomes, blood pressure for cardiovascular outcomes, etc.).

After full text review, a joint review meeting was convened to determine the final selection of articles to be included in this study. A total of 28 articles were excluded for 1 or more of the following reasons: 1) NHOPI were aggregated with other racial/ethnic groups (i.e., "Asians and Pacific Islanders" was a single category) (18% of articles); 2) the article was a review or editorial (36%); 3) the study included NHOPI but there was no specified outcome related to cardiometabolic diseases (21%); 4) the NHOPI study population lived outside of the United States (14%); 5) the study population was under age 19 years (i.e., children or youths) (7%); and 6) there was another miscellaneous reason for study exclusion (the article had been published in a non-peer-reviewed journal, no NHOPI population was included, etc.) (4%). Thus, the final number of articles included in this literature review of cardiometabolic health and health-care disparities among NHOPI was 43.

## RESULTS

### Cardiovascular disease

**Study characteristics—**A total of 12 papers pertaining to cardiovascular disease or its risk factors were reviewed (Table 1). The majority of studies ($n = 10$) were cross-sectional. In 4 of the 10 cross-sectional studies, investigators had prospectively collected new data, and in 2 they had used retrospective data collected from administrative databases. A single prospective study included a cohort that had been followed for over 4 years. One study included qualitative data collected through focus groups of NHOPI. The only study in which researchers had proposed testing an intervention had had a quasi-experimental, pre-post study design without controls for testing of a Native Hawaiian cultural intervention designed to improve hypertension

profiles. Fifty percent of the papers included a study sample of at least 300 participants of NHOPI ancestry.

**Study findings—**NHOPI women were found to have a high frequency of hypertension and high cholesterol in comparison with whites and other ethnic groups (16,17). Studies that examined hypertension along with other covariates in NHOPI found that hypertension was significantly related to degree of Hawaiian ancestry and especially diastolic blood pressure after controlling for other covariates (18). The sole genetic study found that increased corrected Q–T interval (Q-Tc), which has been associated with heart disease and sudden death, was associated with the angiotensin-converting enzyme insertion/insertion (*ACE II*) genotype, which is found with greater frequency among Native Hawaiians than in other ethnic groups (19). Verderber et al. (20) compared post-coronary artery bypass graft (CABG) complications across ethnic groups and found that NHOPI had similar early post-CABG complications (first 20 hours after CABG) but experienced significantly more ventricular arrhythmias requiring medical treatment on postoperative day 2 than Japanese. In another study, NHOPI men with acute coronary syndrome were significantly more likely to receive CABG (odds ratio = 1.8, 95% confidence interval: 1.2, 2.7) and less likely to receive percutaneous coronary intervention following their first hospitalization than were whites (21). No ethnic differences in endovascular treatment for acute coronary syndrome were found in women (21).

In the only longitudinal prospective cohort study, investigators were interested in examining measures of socioeconomic status and cardiovascular disease risk factors in American Samoans versus Western Samoans. Ezeamama et al. (22) found that high socioeconomic status was associated with increased odds of cardiovascular disease risk factors in Western Samoa but decreased odds in more developed American Samoa. The authors attributed this differential effect of socioeconomic status on cardiovascular disease risk factors to the heterogeneity across the Samoan Islands in specific exposures to economic development and the natural history of individual cardiovascular disease risk profiles.

**Study limitations—**The cardiovascular disease literature reviewed had a number of limitations. First, nearly all of the studies were observational studies with cross-sectional data, which does not permit a clear understanding of cause and effect for significant associations between outcomes and exposures. Half of the studies reviewed had relatively small sample sizes or had serious sample biases that confounded the study's findings. Finally, several of the studies of sufficient quality were drawn from 2 research groups that have established cohorts in rural communities in Hawai'i (Grandinetti et al. (19,23)) and in Western and American Samoa (Ezeamama et al. (22)); those findings may not be generalizable to other NHOPI populations in the United States.

### Type 2 diabetes mellitus

**Study characteristics—**A total of 16 diabetes-related studies were reviewed. Most were cross-sectional investigations (10 studies), although 1 study was descriptive and 2 were retrospective (Table 2). Nine of the cross-sectional studies examined the population-based data of the NHHR Project, including a quasi-experimental study that was a nonrandomized concurrent intervention which included Native Hawaiians with diabetes or at risk for diabetes. Another quasi-experimental study compared "before" and "after" hemoglobin A1c levels in a small sample of Native Hawaiian, Samoan, and Tongan participants undergoing an intervention delivered by community health workers. Sample sizes ranged from 78 participants to more than 3,000. The 2 retrospective studies examined the incidence of macrosomia and gestational hypertension among NHOPI women.

**Study findings—**Among studies using the NHHR data, Grandinetti et al. (5) found prevalences of type 2 diabetes and impaired glucose tolerance to be higher among NHOPI than among Caucasian participants. The overall prevalence of diabetes was 4 times higher in the NHHR participants than in the Second National Health and Nutrition Examination Survey population, and the prevalence of diabetes was also significantly higher among full Hawaiians than among part-Hawaiians. In comparison with global estimates of standardized prevalence rates (24), 1 study revealed that the prevalences of diabetes and impaired glucose tolerance among Hawaiians in the NHHR study were among the highest reported, except for Pima and Nauruan populations (5). Grandinetti et al. (5) also found that the age-adjusted prevalence of impaired glucose tolerance was higher in Hawaiian women than in men and was significantly associated with measures of adiposity (i.e., body mass index, waist circumference, and waist-to-hip ratio). Similarly, Kaholokula et al. (18) reported that increased Hawaiian blood quantum was significantly associated with higher fasting glucose concentration, body mass index, and waist-to-hip ratio.

Three studies examined the relation between ethnicity, depressive symptoms, and diabetes among NHHR participants. Among Native Hawaiians with diabetes, depressive symptoms were associated with poorer physical functioning, poorer perception of general health, more severe and limiting bodily pains, less energy, and more emotional problems (25). NHHR participants with elevated hemoglobin A1c levels reported more depressive symptoms and a lower quality of life than participants with normal hemoglobin A1c levels (26,27). Another cross-sectional study of NHHR participants examined dietary patterns, ethnicity, and the prevalence of diabetes and found that consumption of local ethnic foods was positively correlated with body mass index, smoking, waist-to-hip ratio, fasting glucose, and 2-hour glucose (28). Native Hawaiians were found to have significantly higher consumption of these foods and the highest total energy intake in comparison with all other ethnic groups. These results suggest that total energy intake may be a more significant risk factor for diabetes than a specific dietary pattern among Native Hawaiians (28). In the nonrandomized concurrent intervention study that enrolled Native Hawaiians with diabetes or at risk for diabetes, participants in a family support intervention were more likely than a standard intervention group to advance from the pre-action stage of change to the action/maintenance stage with regard to fat intake and physical activity (29).

Three additional studies examined diabetes-related conditions. Mau et al. (30) found that the prevalence of chronic kidney disease was higher among Native Hawaiians than among Asian and Pacific Islander participants in the National Kidney Foundation's Kidney Early Evaluation Program community screening. In a retrospective study of perinatal outcomes in NHOPI women by Silva et al. (31), a higher percentage of NHOPI women required insulin during pregnancy and before 20 weeks' gestation, suggesting that there may be a larger subset of NHOPI women with preexisting undiagnosed diabetes.

**Study limitations—**A major limitation of the diabetes-related research with NHOPI populations is the lack of studies that have tested the efficacy of interventions. A large number of studies were observational, cross-sectional studies that precluded causal inferences. Several of the studies also had small sample sizes, resulting in limited generalizability.

## Obesity

**Study characteristics—**There were 15 obesity-related studies reviewed (Table 3). Four studies examined data from the Multiethnic Cohort Study, a population-based cohort study designed to examine risk factors for cancer (i.e., obesity) that included Asian, black, Hawaiian, Latino, and white adults from Hawai'i and California. One additional study was a population-based prospective cohort study of ethnic groups residing in Hawai'i. Another study pooled data

from 18 population-based epidemiologic studies conducted in Hawai‘i over a period of 25 years to examine trends in body mass index among different ethnic groups in Hawai‘i and to explore associations between food intake and excess weight. Seven studies were cross-sectional. Two studies, 1 cross-sectional and 1 longitudinal, examined genetic associations with body mass index among Samoans residing in American Samoa. One study was qualitative; the researchers conducted focus groups with 32 Native Hawaiian community college students to explore facilitators and barriers to living a healthy lifestyle.

**Study findings—**Prevalences of overweight and obesity were consistently higher among Native Hawaiians than in other ethnic groups (whites, blacks, Latinos, Asians, and Filipinos) across studies. Grandinetti et al. (32) reported a combined prevalence of 82% for overweight and obesity in NHHR study participants, as compared with a national prevalence of 53%; 49% were obese as compared with 21% nationally. Body mass index was also higher in persons with an ethnic admixture that included Native Hawaiian ancestry, as compared with most other ethnic combinations (32,33). In pooled data from 18 population-based studies carried out over 25 years, Native Hawaiians had the highest prevalence of excess weight at all times (34).

Energy intake was consistently higher among NHOPI than in other ethnic groups in Hawai‘i. Both the NHHR and Multiethnic Cohort studies found that total dietary energy intake was significantly associated with Native Hawaiian ancestry and increased body mass index (32, 34). In 2 large population-based prospective studies, Native Hawaiians had the highest chronic disease risk scores in comparison with other ethnic groups, primarily because of high prevalences of overweight and obesity, higher rates of smoking, and chronic alcohol use (35). In the NHHR study, increased body weight was strongly associated with glucose intolerance (5). Despite the high prevalence of overweight and obesity, NHOPI reported a higher prevalence of physical activity in the 2001 Hawai‘i Behavioral Risk Factor Surveillance System survey than did other ethnic groups (36).

**Study limitations—**The obesity-related studies reviewed had several limitations. First, the cross-sectional design of many of the studies did not allow for determination of causal relations. Second, many of the studies were questionnaire-based and may have been vulnerable to recall bias or a propensity towards giving socially desirable answers. Finally, investigators in several studies were unable to measure confounding variables, which limited the potential for understanding the true association between exposure and disease.

## DISCUSSION

Studies of cardiometabolic disparities among NHOPI are sparse. The 43 studies in this review were published in the last 10 years and provide growing evidence that NHOPI are one of the highest-risk US populations affected by cardio-metabolic diseases. Some progress has been made in addressing these disparities, as evidenced by the handful of studies that have shifted from observational research towards program development and then to experimental and clinical trial-type studies that include NHOPI. However, there were a number of methodological issues apparent during the course of this literature review. For example, there were several studies that were limited by sample bias (convenience samples, etc.) and relatively small sample sizes (i.e., <50 subjects). NHOPI comprise less than 1% of the US population, and thus recruitment of NHOPI into research studies remains a challenge. Despite these challenges, a number of research teams have been successful in enrolling sufficient-sized samples or have taken advantage of existing data or administrative databases to better understand cardiometabolic diseases in this population. Moreover, recent developments in the use of community engagement approaches have served to increase the participation of this population in research activities and ensure that studies are relevant and translatable to NHOPI communities.

Aggregation of NHOPI with Asian Americans in several publications limited the number of available studies for this review. There was also a paucity of experimental studies that were adequately designed to reduce treatment bias (i.e., randomization) and longitudinal prospective cohort studies that would allow elucidation of cause-and-effect relations in cardiometabolic diseases. However, a few focus groups and quasi-experimental studies provided preliminary data that offer potential for designing intervention studies in the future.

Several studies (29,37–40) provided initial insights on promising approaches in NHOPI populations, such as social and/or family support and the inclusion of cultural and/or traditional healing methods as alternatives or supplements to conventional medical regimens. Other studies provided empirical evidence with which to develop scientifically informed and culturally specific diet-based interventions for prevention and treatment of cardiometabolic disparities. Health care differences in cardiovascular disease treatment suggest that more study is needed in order to determine the best medical treatments for high-risk ethnic groups such as NHOPI (20,21). Further investigation is needed to examine both provider factors and patient factors that may underlie the treatment differentials between patients who may receive different treatments and hence have different outcomes.

There remain significant gaps in our understanding as to why cardiometabolic diseases occur more frequently in the NHOPI population in the United States (Figure 2). Any number of factors, alone or in combination, may contribute to the creation of disparities in health within this population. Compared with most other US ethnic groups, NHOPI are overrepresented in the lower socioeconomic strata, under-represented in higher education, and more likely to be marginalized from the larger society (41). Behavioral risk factors for diabetes and cardiovascular disease, such as tobacco use and psychological distress, are highly prevalent in NHOPI (42). In the case of Native Hawaiians, many health professionals have suggested that the health disparities experienced by Native Hawaiians are associated with their lower social status and adverse historical relations with Western governments (43,44). Thus, it would seem appropriate in future studies to explore psychosocial stressors that may contribute to health disparities in NHOPI.

Future research aimed at eliminating cardiometabolic disparities in health and health care among NHOPI needs to move beyond observational studies into intervention studies that will engage NHOPI communities in the process while maintaining scientific rigor. Researchers should consider the whole spectrum of types of scientific studies—ranging from genetic, bench studies to clinical studies to effectiveness studies that test interventions in real-world settings. NHOPI can participate in this research not only as study subjects but also as investigators. In this way, they can both obtain health equity and, more importantly, help to promote health and wellness for all.

## Abbreviations

| | |
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| CABG | coronary artery bypass graft |
| NHHR | Native Hawaiian Health Research |
| NHOPI | Native Hawaiians and other Pacific Islanders |

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## REFERENCES


1. Acton KJ, Burrows NR, Moore K, et al. Trends in diabetes prevalence among American Indian and Alaska Native children, adolescents, and young adults. Am J Public Health 2002;92(9):1485–1490. [PubMed: 12197981]
2. Allison MA, Budoff MJ, Wong ND, et al. Prevalence of and risk factors for subclinical cardiovascular disease in selected US Hispanic ethnic groups: the Multi-Ethnic Study of Atherosclerosis. Am J Epidemiol 2008;167(8):962–969. [PubMed: 18283034]
3. Burrows NR, Geiss LS, Engelgau MM, et al. Prevalence of diabetes among Native Americans and Alaska Natives, 1990–1997: an increasing burden. Diabetes Care 2000;23(12):1786–1790. [PubMed: 11128353]
4. Egede LE, Dagogo-Jack S. Epidemiology of type 2 diabetes: focus on ethnic minorities. Med Clin North Am 2005;89(5):949–975. viii. [PubMed: 16129107]
5. Grandinetti A, Chang HK, Mau MK, et al. Prevalence of glucose intolerance among Native Hawaiians in two rural communities. Native Hawaiian Health Research (NHHR) Project. Diabetes Care 1998;21 (4):549–554. [PubMed: 9571341]
6. Johnson DB, Oyama N, LeMarchand L, et al. Native Hawaiians mortality, morbidity, and lifestyle: comparing data from 1982, 1990, and 2000. Pac Health Dialog 2004;11(2):120–130. [PubMed: 16281689]
7. Mau MK, Grandinetti A, Arakaki RF, et al. The insulin resistance syndrome in native Hawaiians. Native Hawaiian Health Research (NHHR) Project. Diabetes Care 1997;20(9):1376–1380. [PubMed: 9283783]
8. Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity. Washington, DC: OMB Publications Office; 1997 [Accessed April 6, 2009]. Executive Office of the President, Office of Management and Budget, Office of Information and Regulatory Affairs. http://www.whitehouse.gov/omb/fedreg_1997standards/
9. Bushnell, OA. The Gifts of Civilization: Germs and Genocide in Hawaii. Honolulu, HI: University of Hawaii Press; 1993.
10. Fong M, Braun KL, Tsark JU. Improving Native Hawaiian health through community-based participatory research. Cal J Health Promot 2003;1:136–148. special issue: Hawaii.
11. Kana'iaupuni, SM.; Malone, NJ.; Ishibashi, K. Income and Poverty Among Native Hawaiians: Summary of Ka Huaka'i Findings. (PASE report). Honolulu, HI: Policy Analysis and System Evaluation; 2005 [Accessed April 6, 2009]. (http://www.ksbe.edu/spi/PDFS/Reports/Demography_Well-being/05_06_5.pdf
12. Salvail, FR.; Nguyen, D.; Liang, SL. 2008 State of Hawaii—By Demographic Characteristics. Behavioral Risk Factor Surveillance System. Honolulu, HI: Hawaii State Department of Health; 2008 [Accessed April 6, 2009]. http://hawaii.gov/health/statistics/brfss/brfss/brfss2008/demo08.html
13. Grandinetti A, Kaholokula JK, Theriault AG, et al. Prevalence of diabetes and glucose intolerance in an ethnically diverse rural community of Hawaii. Ethn Dis 2007;17(2):250–255. [PubMed: 17682354]
14. Salvail, FR.; Nguyen, D. 2006 State of Hawaii—By Demographic Characteristics. Behavioral Risk Factor Surveillance System. Honolulu, HI: Hawaii State Department of Health; 2006 [Accessed April 6, 2009]. Have you ever been told by doctor that you have diabetes? State of Hawaii BRFSS 2006 [table]. http://hawaii.gov/health/statistics/brfss/brfss/brfss2006/demo06.html
15. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Washington, DC: National Academies Press; 2003. Institute of Medicine, Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care, Board on Health Sciences Policy.
16. Novotny R, Davis J, Ross P, et al. Adiposity and blood pressure in a multiethnic population of women in Hawaii. Ethn Health 1998;3(3):167–173. [PubMed: 9798115]
17. Sundaram AA, Ayala C, Greenlund KJ, et al. Differences in the prevalence of self-reported risk factors for coronary heart disease among American women by race/ethnicity and age: Behavioral Risk Factor Surveillance System. Am J Prev Med 2005;29(5 suppl 1):25–30. 2001. [PubMed: 16389122]
18. Grandinetti A, Chen R, Kaholokula JK, et al. Relationship of blood pressure with degree of Hawaiian ancestry. Ethn Dis 2002;12(2):221–228. [PubMed: 12019931]

19. Grandinetti A, Seifried SE, Chow DC, et al. Association between angiotensin-converting enzyme gene polymorphisms and QT duration in a multiethnic population in Hawaii. Auton Neurosci 2006;130(1–2):51–56. [PubMed: 16769256]
20. Verderber A, Castelfranco AM, Nishioka D, et al. Cardiovascular risk factors and cardiac surgery outcomes in a multiethnic sample of men and women. Am J Crit Care 1999;8(3):140–148. [PubMed: 10228654]
21. Taira DA, Seto TB, Marciel C. Ethnic disparities in care following acute coronary syndromes among Asian Americans and Pacific Islanders during the initial hospitalization. Cell Mol Biol (Noisy-le-Grand) 2001;47(7):1209–1215. [PubMed: 11838969]
22. Ezeamama AE, Viali S, Tuitele J, et al. The influence of socioeconomic factors on cardiovascular disease risk factors in the context of economic development in the Samoan archipelago. Soc Sci Med 2006;63(10):2533–2545. [PubMed: 16876925]
23. Grandinetti A, Keawe'aimoku Kaholokula J, Chang HK, et al. Relationship between plasma glucose concentrations and Native Hawaiian ancestry: the Native Hawaiian Health Research Project. Int J Obes Relat Metab Disord 2002;26(6):778–782. [PubMed: 12037647]
24. King H, Rewers M. Global estimates for prevalence of diabetes mellitus and impaired glucose tolerance in adults. WHO Ad Hoc Diabetes Reporting Group. Diabetes Care 1993;16(1):157–177. [PubMed: 8123057]
25. Kaholokula JK, Haynes SN, Grandinetti A, et al. Ethnic differences in the relationship between depressive symptoms and health-related quality of life in people with type 2 diabetes. Ethn Health 2006;11(1):59–80. [PubMed: 16338755]
26. Grandinetti A, Kaholokula JK, Crabbe KM, et al. Relationship between depressive symptoms and diabetes among native Hawaiians. Psychoneuroendocrinology 2000;25(3):239–246. [PubMed: 10737695]
27. Kaholokula JK, Haynes SN, Grandinetti A, et al. Biological, psychosocial, and sociodemographic variables associated with depressive symptoms in persons with type 2 diabetes. J Behav Med 2003;26 (5):435–458. [PubMed: 14593852]
28. Kim H, Park S, Grandinetti A, et al. Major dietary patterns, ethnicity, and prevalence of type 2 diabetes in rural Hawaii. Nutrition 2008;24(11–12):1065–1072. [PubMed: 18586461]
29. Mau MK, Glanz K, Severino R, et al. Mediators of lifestyle behavior change in Native Hawaiians: initial findings from the Native Hawaiian Diabetes Intervention Program. Diabetes Care 2001;24 (10):1770–1775. [PubMed: 11574440]
30. Mau MK, West MR, Shara NM, et al. Epidemiologic and clinical factors associated with chronic kidney disease among Asian Americans and Native Hawaiians. Ethn Health 2007;12(2):111–127. [PubMed: 17364897]
31. Silva JK, Kaholokula JK, Ratner R, et al. Ethnic differences in perinatal outcome of gestational diabetes mellitus. Diabetes Care 2006;29(9):2058–2063. [PubMed: 16936153]
32. Grandinetti A, Chang HK, Chen R, et al. Prevalence of overweight and central adiposity is associated with percentage of indigenous ancestry among native Hawaiians. Int J Obes Relat Metab Disord 1999;23(7):733–737. [PubMed: 10454107]
33. Albright CL, Steffen A, Wilkens LR, et al. Body mass index in monoracial and multiracial adults: results from the Multiethnic Cohort Study. Ethn Dis 2007;17(2):268–273. [PubMed: 17682357]
34. Maskarinec G, Takata Y, Pagano I, et al. Trends and dietary determinants of overweight and obesity in a multiethnic population. Obesity (Silver Spring) 2006;14(4):717–726. [PubMed: 16741275]
35. Maskarinec G, Carlin L, Pagano I, et al. Lifestyle risk factors for chronic disease in a multiethnic population: an analysis of two prospective studies over a 20-year period. Ethn Dis 2007;17(4):597–603. [PubMed: 18072366]
36. Mampilly CM, Yore MM, Maddock JE, et al. Prevalence of physical activity levels by ethnicity among adults in Hawaii, BRFSS 2001. Hawaii Med J 2005;64(10):270–273. [PubMed: 16294701]
37. Boyd JK, Braun KL. Supports for and barriers to healthy living for Native Hawaiian young adults enrolled in community colleges [electronic article]. Prev Chronic Dis 2007;4(4):A88. [PubMed: 17875263]

38. Elstad E, Tusiofo C, Rosen RK, et al. Living with *ma'i suka:* individual, familial, cultural, and environmental stress among patients with type 2 diabetes mellitus and their caregivers in American Samoa [electronic article]. Prev Chronic Dis 2008;5(3):A79. [PubMed: 18558029]
39. Kaholokula JK, Saito E, Mau MK, et al. Pacific Islanders' perspectives on heart failure management. Patient Educ Couns 2008;70(2):281–291. [PubMed: 18068939]
40. Kretzer K, Davis J, Easa D, et al. Self identity through ho'oponopono as adjunctive therapy for hypertension management. Ethn Dis 2007;17(4):624–628. [PubMed: 18072370]
41. Marsella, AJ.; Oliveira, J.; Plummer, CM., et al. Native Hawaiian (kanaka maoli) culture, mind, and well-being. In: McCubbin, HI.; Thompson, EA.; Fromer, JE., editors. Resiliency in Ethnic Minority Families: Native Immigrant American Families. Madison, WI: University of Wisconsin, Center for Excellence in Family Studies; 1995. p. 93-113.
42. Wong MM, Klingle RS, Price RK. Alcohol, tobacco, and other drug use among Asian American and Pacific Islander adolescents in California and Hawaii. Addict Behav 2004;29(1):127–141. [PubMed: 14667425]
43. Crabbe KM. Conceptions of depression: a Hawaiian perspective. Pac Health Dialog 1999;6(1):122–126.
44. Rezentes, WCIII. Ka Lama Kukui—Hawaiian Psychology: An Introduction. Honolulu, HI: 'A'ali'i Books; 1996.
45. Yeo KK, Beauvallet S, Mau MK, et al. Procedural success and complications following percutaneous coronary interventions among Asians and Pacific Islanders. Clin Cardiol 2005;28(9):429–432. [PubMed: 16250266]
46. Chiem B, Nguyen V, Wu PL, et al. Cardiovascular risk factors among Chamorros [electronic article]. BMC Public Health 2006;6:298. [PubMed: 17156462]
47. Taira DA, Gelber RP, Davis J, et al. Antihypertensive adherence and drug class among Asian Pacific Americans. Ethn Health 2007;12(3):265–281. [PubMed: 17454100]
48. Grandinetti A, Chang HK, Theriault A, et al. Metabolic syndrome in a multiethnic population in rural Hawaii. Ethn Dis 2005;15(2):233–237. [PubMed: 15825969]
49. Wu PL, Sadler GR, Nguyen V, et al. Diabetes management in San Diego's Chamorro community. Diabetes Educ 2005;31(3):379–390. [PubMed: 15919638]
50. Beckham S, Bradley S, Washburn A, et al. Diabetes management: utilizing community health workers in a Hawaiian/Samoan population. J Health Care Poor Underserved 2008;19(2):416–427. [PubMed: 18469413]
51. Kaholokula JK, Nacapoy AH, Grandinetti A, et al. Association between acculturation modes and type 2 diabetes among Native Hawaiians. Diabetes Care 2008;31(4):698–700. [PubMed: 18202248]
52. Maskarinec G, Meng L, Kolonel L. Alcohol intake, body weight, and mortality in a multiethnic prospective cohort. Epidemiology 1998;9(6):654–661. [PubMed: 9799177]
53. Galanis DJ, McGarvey ST, Quested C, et al. Dietary intake of modernizing Samoans: implications for risk of cardiovascular disease. J Am Diet Assoc 1999;99(2):184–190. [PubMed: 9972185]
54. McGarvey ST, Forrest W, Weeks DE, et al. Human leptin locus (LEP) alleles and BMI in Samoans. Int J Obes Relat Metab Disord 2002;26(6):783–788. [PubMed: 12037648]
55. Henderson KD, Goran MI, Kolonel LN, et al. Ethnic disparity in the relationship between obesity and plasma insulin-like growth factors: the Multiethnic Cohort. Cancer Epidemiol Biomarkers Prev 2006;15(11):2298–2302. [PubMed: 17119061]
56. Howarth NC, Murphy SP, Wilkens LR, et al. Dietary energy density is associated with overweight status among 5 ethnic groups in the Multiethnic Cohort Study. J Nutr 2006;136(8):2243–2248. [PubMed: 16857848]
57. Dai F, Keighley ED, Sun G, et al. Genome-wide scan for adiposity-related phenotypes in adults from American Samoa. Int J Obes (Lond) 2007;31(12):1832–1842. [PubMed: 17621312]
58. Novotny R, Nabokov V, Derauf C, et al. BMI and waist circumference as indicators of health among Samoan women. Obesity (Silver Spring) 2007;15(8):1913–1917. [PubMed: 17712106]
59. Maskarinec G, Aylward AG, Erber E, et al. Soy intake is related to a lower body mass index in adult women. Eur J Nutr 2008;47(3):138–144. [PubMed: 18427855]

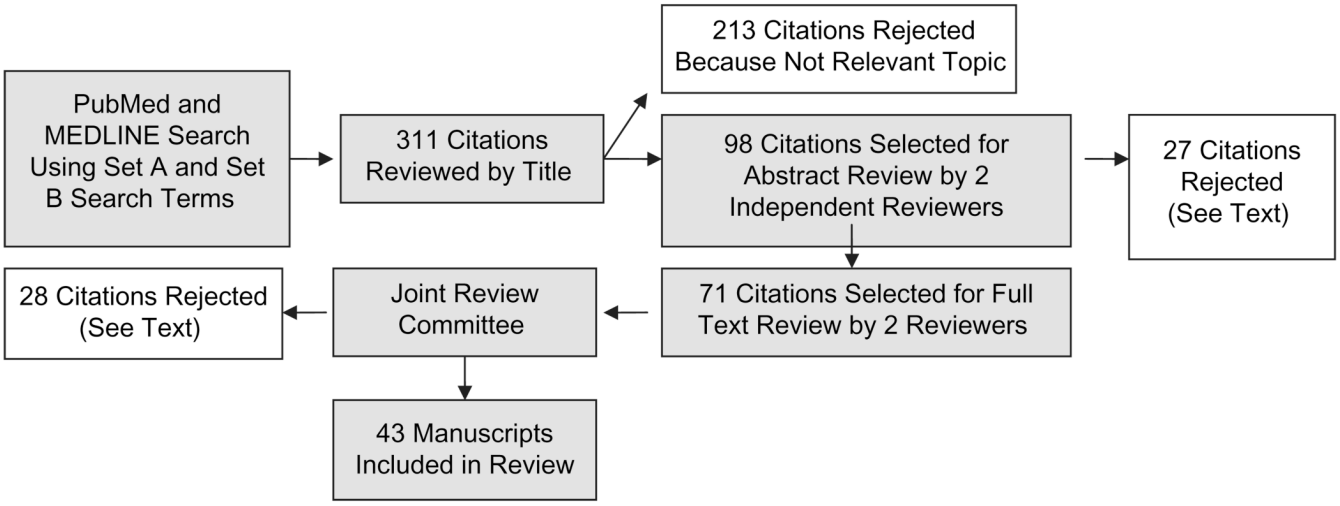


**Figure 1.**

Procedures used to review the literature on cardiometabolic health disparities among Native Hawaiians and other Pacific Islanders, January 1998–December 2008. Set A: inclusion of *Native Hawaiian*, *Hawaiian*, *Pacific Islander*, *Samoan*, *Tongan*, *Micronesian*, *New Zealand*, *Maori*, *Melanesia*, *Chamorro*, *Guamanian*, *Fijian*, and *Polynesian* in an "OR" search term along with the following racial/ethnic terms: *minority*, *minorities*, *groups*, *ethnicity*, and *ethnicities*, defined as an "OR" search term. Set B: *inequity*, *inequality*, *health disparities*, *health differences*, *cardiovascular*, *hypertension*, *heart*, *heart failure*, *heart disease*, *heart disease risk factors*, *cardiac*, *cardiomyopathy*, *diabetes*, *syndrome X*, *metabolic syndrome*, *insulin resistance*, *glucose intolerance*, *prediabetes*, *cardiometabolic*, *obesity*, *adiposity*, *overweight*, *physical inactivity*, *physical activity*, *nutrition*, *diet*, and *smoking* in combination with *United States*.

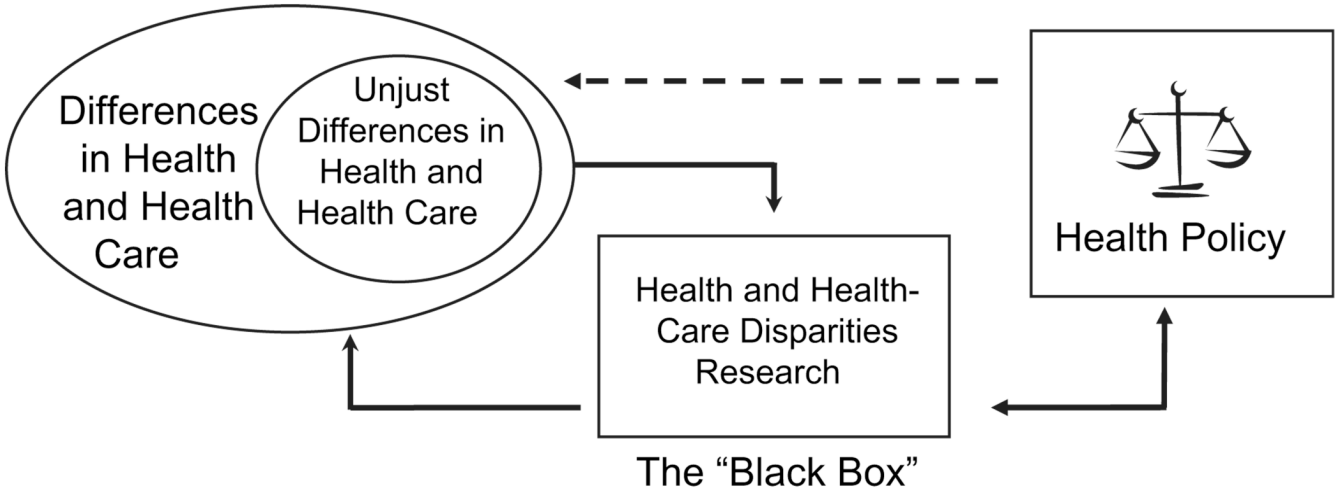


**Figure 2.**
Conceptual model of health and health-care disparities.

## Table 1

Literature on Cardiovascular Health Disparities Among Native Hawaiians and Other Pacific Islanders, January 1998–December 2008

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| Novotny et al., 1998 (16) | 66 Native Hawaiian women out of a total multiethnic sample of 421 | 16 | 25–35 | Observational, cross-sectional, clinical research sample | Examine anthropometric variations between multiethnic women and their relation to blood pressure and cholesterol.<br>Native Hawaiian women had the highest measures of adiposity. Cholesterol was not associated with adiposity. Blood pressure was associated with adiposity but did not vary by ethnicity. | Sample bias; relatively small study. |
| Verderber et al., 1999 (20) | 23 Pacific Islanders out of a total multiethnic sample of 60 | 38 | 40–85 | Observational, cross-sectional, hospital surgery sample | Describe risk factors for cardiac disease and post-CABG outcomes and complications in multiethnic patients.<br>No ethnic differences in postoperative complications in first 20 hours. At 48 hours post-CABG, Pacific Islanders required significantly more care than Japanese ($P < 0.01$). | Sample bias (single hospital, relatively small sample). No adjustment for physician as covariate. |
| Taira et al., 2001 (21) | 361 Native Hawaiians out of a total multiethnic sample of 2,962 | 11 | ≥18 | Observational, cross-sectional, administrative database sample | Examine differences in revascularization and mortality rates following acute coronary syndrome in a multiethnic patient population.<br>Ethnic differences in types of procedures received were significant only for men. Native Hawaiian men were less likely to receive percutaneous coronary intervention (adjusted OR = 0.51, 95% CI: 0.34, 0.75) and more likely to receive CABG (adjusted OR = 1.8, 95% CI: 1.2, 2.7) than whites. No significant ethnic differences in women. | Cross-sectional; claims data from single health insurer. |
| Grandinetti et al., 2002 (18) | 572 Native Hawaiians; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based sample | Examine degree of Hawaiian ancestry and blood pressure and relation to other covariates.<br>Adjusted prevalence of hypertension increased with degree of Hawaiian ancestry, except for 100% Hawaiian ancestry. Hawaiian ancestry was significantly associated with systolic and diastolic blood pressure ($P < 0.0001$). After adjustment for all significant | Percentage of Hawaiian ancestry was self-reported; cross-sectional design; sample population only from rural location. Assessment of adequate blood pressure control with medications not described. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | covariates, only diastolic blood pressure was associated with Hawaiian ancestry ($P$ = 0.008). | |
| Sundaram et al., 2005 (17) | 510 NHOPI women out of a total multiethnic sample of 120,035 | <1 | ≥18 | Observational, cross-sectional telephone survey, 2001 BRFSS | Determine prevalence of cardiovascular disease risk factors among multiethnic women in 2001 BRFSS.<br>NHOPI women had second highest prevalence of hypertension at 33.7% (age-adjusted) and highest prevalence of high cholesterol (23.9%). | All data were self-reported. Cross-sectional; relatively small sample compared with other ethnic groups. |
| Yeo et al., 2005 (45) | 377 Pacific Islanders out of a total multiethnic sample of 2,598 | 14 | ≥18 | Observational, case-control, hospital administrative database sample | Examine ethnic differences in percutaneous coronary intervention success and/or complications in hospitalized patients.<br>Despite higher rates of diabetes, hypertension, obesity, and renal failure in NHOPI, there was no difference in percutaneous coronary intervention complications compared with whites or Japanese. | Sample bias (recruited from a single hospital). Cross-sectional data; no long-term outcomes available. |
| Chiem et al., 2006 (46) | 228 Chamorros | 100 | ≥18 | Observational, cross-sectional telephone survey, community administrative database sample | Describe cardiovascular disease risk factors in Chamorro community to aid in developing programs.<br>Crude frequencies of hypertension, diabetes, hyperlipidemia, and physical inactivity were higher in Chamorros than in US whites. Chamorro women were more likely to have hypertension and diabetes. Men were more likely to have elevated body mass index and cholesterol. | Sample bias (recruited from community database). No adjustment for covariates. Cross-sectional data. Self-reported health risk factors. |
| Ezeamama et al., 2006 (22) | 1,289 Samoans (American and Western Samoan) | 100 | 25–58 | Observational, prospective cohort, population-based sample | Investigate cross-sectional and prospective associations between SES and cardiovascular disease risk factors and predict the probability of risk factors by SES level between American Samoa and Samoa.<br>High SES was associated with increased odds of risk factors in less developed Western Samoa and decreased odds of risk factors in more developed American Samoa. Inverse association between SES and risk factors in Western Samoa vs. American Samoa is attributable to heterogeneity across the Samoan | Relatively large sample of Samoan participants; subjects were younger and thus there were fewer cases of cardiovascular disease risk factors. Men lost to follow-up in both locations were more likely to be employed in the wage-labor market and may have introduced attrition bias. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | Islands in specific exposures to economic development and natural history of individual risk factors. | |
| Grandinetti et al., 2006 (19) | 185 Native Hawaiians out of a total multiethnic sample of 588; nonpregnant | 31 | ≥30 | Observational, retrospective cohort; randomly selected nested study of population-based sample | Examine angiotensin-converting enzyme gene polymorphisms and increased Q-Tc (associated with heart disease) between ethnic groups.<br>Increased Q-Tc was highest among persons with the *ACE II* genotype. *ACE II* genotype was higher in Native Hawaiians (50.3%) than in whites (21%). After adjustment, prevalence of increased Q-Tc was significantly associated with *ACE II* genotype independently of ethnicity ($P < 0.01$). | Cross-sectional prevalence Cases may lead to bias. |
| Kretzer et al., 2007 (40) | 15 Native Hawaiians out of a total multiethnic sample of 23 | 65 | ≥30 | Quasi-experimental (no control group), pre-post intervention, community sample | Evaluate whether a class on self-identity via ho‘oponopono would improve high blood pressure.<br>Ho‘oponopono intervention (4-hour group class) reduced mean systolic and diastolic blood pressure, which was sustained for 2 months after intervention. Results for the 15 Native Hawaiians were aggregated with those for the remaining 8 other non-Hawaiian participants. | No control group, small sample size, and potentially biased sample. No adjustment for medication changes. |
| Taira et al., 2007 (47) | 3,746 Native Hawaiians out of a total multiethnic sample of 28,395 | 13 | ≥18 | Observational, cross-sectional; health insurance administrative database sample | Examine factors associated with antihypertensive medication adherence within a multiethnic patient population using administrative claims data.<br>Overall adherence in all ethnic groups was less than 65%. After adjustment, Native Hawaiians were less likely to adhere than whites (OR = 0.84, 95% CI: 0.78, 0.91), and this was consistent across therapeutic classes. Other patient factors associated with lower adherence: younger age, higher morbidity, and history of heart disease. Seeing a physician of the same ethnicity did not improve adherence. | Cross-sectional claims data from a single health insurance plan. Patient adherence was measured by filling of prescriptions, not at patient level. Lack of information on impact of comorbid conditions on medication adherence. |
| Kaholokula et al., 2008 (39) | 36 NHOPI and family caregivers | 100 | ≥18 | Focus group, community sample | Identify health beliefs, attitudes, practices, and social and family relations important in heart failure treatment among NHOPI. | Small sample size, and only 30% were heart failure patients. Qualitative study design with potentially subjective responses. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | Native Hawaiians with heart failure reported coping experiences of denial of illness, hopelessness, and despair and relied on spiritual/religious beliefs for support. Samoans preferred being treated by physicians, while Native Hawaiians preferred traditional healers. Barriers to heart failure care include poor knowledge, lack of trust of the physician, a poor patient-physician relationship, finances, dietary changes, and increased demands on time. | |

Abbreviations: ACE II, angiotensin-converting enzyme insertion/insertion; BRFSS, Behavioral Risk Factor Surveillance System; CABG, coronary artery bypass graft; CI, confidence interval; NHOPI, Native Hawaiians and other Pacific Islanders; OR, odds ratio; Q-Tc, corrected Q–T interval; SES, socioeconomic status.

**Table 2**

Literature on Diabetes Health Disparities Among Native Hawaiians and Other Pacific Islanders, January 1998–December 2008

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| Grandinetti et al., 1998 (5) | 574 Native Hawaiians from 2 rural communities in Hawai‘i; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based sample | To estimate prevalences of type 2 diabetes and impaired glucose tolerance.<br>Prevalence of impaired glucose tolerance was 16%; diabetes, 20%. Prevalence of impaired glucose tolerance was significantly higher in women and significantly associated with body mass index, waist circumference, and waist-to-hip ratio. Age-adjusted prevalence of diabetes was 4 times higher than in the Second National Health and Nutrition Examination Survey population. | Cross-sectional; self-reported ancestry, contributing to possible misclassification. |
| Grandinetti et al., 2000 (26) | 581 Native Hawaiians from 2 rural communities in Hawai‘i; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based ample | To examine the association between diabetes and CES-D depressive symptoms.<br>Among participants reporting a prior history of diabetes, both mean CES-D score and depressive symptom prevalence were significantly higher than in participants with no prior history of chronic illness, after adjustment for age and social support. High hemoglobin A1c level (≥7%) was also associated with higher prevalence of CES-D-assessed depressive symptoms. Results suggest that hyperglycemia may explain the high prevalence of depressive symptoms among participants with known and newly identified diabetes. | Cross-sectional design; thus, the temporal relation between glycemic control and CES-D depressive symptoms could not be determined. |
| Mau et al., 2001 (29) | 147 Native Hawaiians with diabetes or metabolic syndrome and their ‘ohana (family) support person | 100 | ≥30 | Quasi-experimental, nonrandomized, controlled trial; subjects recruited from population-based sample | To examine association of stage of change with diet and exercise in response to lifestyle intervention.<br>Stage of change was significantly associated with positive dietary and exercise behaviors. Participants in the family support intervention group were more likely to advance from pre-action to action/maintenance regarding fat intake and physical activity than the standard intervention | Nonrandomized intervention; lack of true control group. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | group. | |
| Grandinetti et al., 2002 (18) | 578 Native Hawaiians from 2 rural communities in Hawai‘i; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based sample | To investigate the relation between glucose and percentage of Hawaiian blood quantum.<br>Increased Hawaiian blood quantum was significantly associated with increased fasting glucose level, body mass index, waist-to-hip ratio, and age. Full Hawaiians had higher glucose concentrations than part-Hawaiians after adjustment for age, sex, body mass index, and waist-to-hip ratio. | Cross-sectional survey; self-reported ancestry, contributing to possible misclassification; self-reported lifestyle behaviours |
| Kaholokula et al., 2003 (27) | 59 Native Hawaiians out of a total multiethnic sample of 141; nonpregnant | 41 | ≥30 | Observational, nested case study from a population-based sample | To examine correlations between glycemic status and health-related quality of life and depressive symptoms.<br>No correlation between depressive symptoms and glycemic status was observed. Health-related quality of life had the greatest magnitude of effect on depressive symptoms in people with diabetes compared with glycemic status and knowledge of diabetes diagnosis. Relation between depressive symptoms and health-related quality of life was influenced by glycemic status, sex, education, marital status, and social support. | Limited generalizability; little variability in body mass index and waist-to-hip ratio. |
| Grandinetti et al., 2005 (48) | 510 Native Hawaiians out of a total multiethnic sample of 1,447; nonpregnant | 35 | ≥30 | Observational, retrospective cohort, population-based sample | To estimate the prevalence of metabolic syndrome.<br>Prevalence of metabolic syndrome was significantly higher among Native Hawaiians and all other minority ethnic groups than among Caucasians. Prevalences were similar in all non-Caucasian groups. Prevalence of abdominal obesity and low high density lipoprotein cholesterol was highest in Native Hawaiians. | Cross-sectional |
| Wu et al., 2005 (49) | 228 Chamorros in San Diego, California | 100 | ≥18 | Observational, cross-sectional telephone survey, administrative database | To assess diabetes risk status, incidence, and morbidity.<br>Diabetes prevalence was 16.2%; 60% of respondents with diabetes were obese as compared with 21% of those without diabetes. Respondents without diabetes reported more days of moderate physical activity than those with diabetes. More than half of | Data were population- and geography-specific and may not be generalizable. Self-reported data. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | all men and women reported consuming less than the recommended 5 or more fruits and vegetables per day. Prevalence of high blood pressure was 42.5%, higher than the nationwide 2003 Behavioral Risk Factor Surveillance System prevalence of 24.8%. | |
| Kaholokula et al., 2006 (25) | 80 Native Hawaiians out of a multiethnic total sample of 190; nonpregnant, with diabetes | 50 | ≥30 | Observational, nested case study from population-based sample | To examine relation between depressive symptoms and aspects of health-related quality of life in type 2 diabetes.<br>Ethnicity moderated the relation between depressive symptoms and quality-of-life aspects of physical and role-emotional functioning, bodily pain, vitality, and general health. | Cross-sectional survey, small sample sizes. |
| Silva et al., 2006 (31) | 614 NHOPI women out of a multiethnic total sample of 2,155 women | 28 | ≥18 | Observational, retrospective cohort, medical-right-based sample | To examine ethnic differences in perinatal outcomes among women with gestational diabetes.<br>Being NHOPI was a significant predictor of fetal macrosomia. Higher percentage of NHOPI women required insulin during pregnancy and before 20 weeks' gestation, suggesting that there may be a larger subset of NHOPI women with preexisting undiagnosed diabetes. | Retrospective study; ethnicity was self-reported. |
| Grandinetti et al., 2007 (13) | 510 Native Hawaiians out of a total multiethnic sample of 1,452; nonpregnant | 35 | ≥30 | Observational, retrospective cohort, population-based sample | To assess prevalences of diabetes and glucose intolerance.<br>Threefold higher prevalence of diabetes among Asian and Native Hawaiian groups than among Caucasians; diabetes prevalences were similar across non-Caucasian ethnic groups despite differences in body mass index. | Cross-sectional; self-reported lifestyle behaviors. |
| Mau et al., 2007 (32) | 196 Native Hawaiians out of a total multiethnic sample of 793 | 25 | ≥18 | Observational, cross-sectional, community clustered sample | To examine associations between factors associated with chronic kidney disease.<br>Chronic kidney disease was highest among Native Hawaiians. Diabetes, hypertension, and lower education were significantly associated with increased chronic kidney disease in Native Hawaiians. | Cross-sectional; community sample may have been biased. |

| Study Authors and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| Beckham et al., 2008 (50) | 78 Native Hawaiians, Samoans, and Tongans out of a total sample of 116 diabetes clinic patients | 67 | ≥18 | Quasi-experimental, refusal control group, pre-post intervention with lack of control for number of visits, clinic sample | To examine the effectiveness of a culturally tailored diabetes management program delivered by community health workers, using intervention refusers as the comparison group.<br>72 of 80 participants in the community-health-worker-delivered intervention had a postintervention decrease in hemoglobin A1c level of 2.2% (SD, 1.8), as compared with 21 of 36 participants who declined community health worker intervention, who had a 0.2% (SD, 1.5) decrease in hemoglobin A1c. | Small sample size, pre-post study design, biased sample without true control group. 42% of the control group vs. 10% of the intervention group was lost to follow-up. Intervention group received more visits than controls. |
| Elstad et al., 2008 (38) | 64 Samoans (35 with diabetes and 29 caregivers) | 100 | ≥18 | Focus groups, community sample | To study perceptions of diabetes to design a culturally appropriate program.<br>American Samoans with type 2 diabetes experienced multiple types of stress. Environmental and familial stress worsened their glucose levels. Despite the effects of family stress on diabetes, family members were often the primary caregivers. | Small sample size; focus groups were mixed with persons with diabetes and caregivers, which may have biased responses. |
| Kaholokula et al., 2008 (51) | 495 Native Hawaiians from 2 rural communities in Hawai‘i; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based sample | To examine associations between modes of acculturation and diabetes prevalence.<br>Native Hawaiians with a traditional mode of acculturation were more likely to have diabetes (27.9%) than persons with integrated (15.4%), assimilated (12.5%), or marginalized (10.5%) modes. | Cross-sectional survey. Modes of acculturation included only Native Hawaiian vs. American; other ethnic cultures were not included. |
| Kim et al., 2008 (28) | 434 Native Hawaiians out of a multiethnic total sample of 1,257; nonpregnant | 35 | ≥30 | Observational, retrospective cohort, population-based sample | To examine associations of diabetes with dietary pattern and ethnicity.<br>Consumption of local ethnic foods was correlated with body mass index, smoking, waist-to-hip ratio, and glucose. Consumption of these foods was higher for Native Hawaiians than for other ethnic groups. Native Hawaiians had the highest total energy intake. | Cross-sectional; possible recall bias on food frequency questionnaire; measurement error in estimation of food portions. |

Abbreviations: CES-D, Right for Epidemiologic Studies Depression Scale; NHOPI, Native Hawaiians and other Pacific Islanders; SD, standard deviation.

**Table 3**

Literature on Obesity Health Disparities Among Native Hawaiians and Other Pacific Islanders, January 1998–December 2008

| Study Author(s) and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| Maskarinec et al., 1998 (52) | 4,321 Native Hawaiians out of a total multiethnic sample of 27,678 | 16 | >30 | Observational, prospective cohort, population-based sample of 2% of the Hawai‘i State population | To investigate effects of alcohol intake and body weight on mortality from all causes, cancer, cerebrovascular disease, and coronary heart disease.<br>Native Hawaiians had the highest mortality rate and a higher prevalence of obesity.<br>BMI[a] >29.3 was associated with 50% higher risk of death. Coronary heart disease mortality was higher in Native Hawaiians with BMIs >29.3. | No information on preexisting cardiovascular disease, serum cholesterol level, hypertension, diabetes, or family history. |
| Galanis et al., 1999 (53) | 946 Samoans in Western Samoa and American Samoa | 100 | 25–55 | Observational, cross-sectional, retrospective cohort, community and workplace sample | To describe dietary intake as measured by 24-hour recall of American Samoans and Western Samoans.<br>American Samoans consumed a greater proportion of carbohydrates and protein but less fat or saturated fat than Western Samoans. The mean BMI of American Samoans was 35.2 as compared with 30.3 for Western Samoans. | No biochemical measurement of cardiovascular disease risk or correlations with anthropometric measurements; potential sample bias; recall bias on dietary assessment. |
| Grandinetti et al., 1999 (32) | 567 Native Hawaiians in 2 rural communities in Hawai‘i; nonpregnant | 100 | ≥30 | Observational, retrospective cohort, population-based sample | To assess the relation of degree of Native Hawaiian ancestry with BMI and waist-to-hip ratio.<br>Combined prevalence of overweight and/or obesity was 81.5% in Native Hawaiians as compared with the US prevalence of 52.6%. 49% of Native Hawaiians were obese as compared with the US prevalence of 21% Increased waist circumference was found in 51% of Native Hawaiians. More women (59%) than men (39%) had increased waist circumference. Age, percentage of Native Hawaiian ancestry, and total dietary energy intake were significantly associated with increased BMI and waist-to-hip ratio. Adiposity increased with percentage of Native Hawaiian ancestry. | Cross-sectional; self-reported ancestry and dietary recall. |
| McGarvey et al., 2002 (54) | 181 Samoans and American Samoans | 100 | 25–55 | Observational, nested study in a prospective cohort; | To test the association of 6 genetic microsatellite markers related to the | Functional significance of present finding remains unclear. |

| Study Author(s) and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | population-based sample | human leptin (*LEP*) locus and the pro-opiomelanocortin gene region in adult Samoans and American Samoans.<br>Significantly greater frequency of allele 226 at the *LEP* locus in the nonobese Samoans than in the obese subjects. | |
| Mampilly et al., 2005 (36) | 585 Native Hawaiians out of a total multiethnic sample of 3,732 | 16 | ≥18 | Observational, cross-sectional telephone survey; Behavioral Risk Factor Surveillance System population sample | To assess the physical activity levels of multiethnic groups in Hawai‘i.<br>Native Hawaiians were more active (39% moderate, 24% vigorous) than other Asians and Pacific Islanders but less active than whites. 48% of Native Hawaiians reported being overweight as compared with 58% of whites, 42% of Filipinos, and 41% of Japanese. | Telephone survey; self-report of physical activity. Self-reported weight and height. |
| Henderson et al., 2006 (55) | 159 Native Hawaiians out of a random subsample of 811 persons from Hawai‘i and California | 20 | 45–74 | Observational, nested study in a prospective cohort; randomly selected sample | To examine the relation between circulating levels of 2 primary proteins (IGF-1 and IGFBP-3) in the insulin-like growth factor pathway and obesity in 5 racial/ethnic groups using BMI as an indicator of adiposity.<br>No significant interaction was found between IGF-1 and BMI in Native Hawaiians as compared with Japanese and Latinos, in whom decreased IGF-1 was associated with increasing BMI. | Unmeasured confounding factors; racial/ethnic differences in BMI cutpoints may have confounded study. Plasma IGF-I and IGFBP-3 were measured at a single time point. |
| Howarth et al., 2006 (56) | 433 Native Hawaiians out of a total multiethnic sample of 2,326 persons from Hawai‘i and California | 19 | 45–74 | Observational, prospective cohort; population-based sample | To determine whether dietary energy density was related to current BMI and risk of overweight/obesity in a multiethnic population.<br>Native Hawaiian men had the highest BMI; weight and dietary energy density were significantly related to BMI. Native Hawaiian women were second-heaviest after African Americans. Higher energy density was significantly associated with greater likelihood of being overweight in all ethnic and sex groups. Native Hawaiians were unusual in that low energy density was associated with high BMI. | Food frequency assessment of dietary energy density based on recall. Dietary recall may vary by body weight. |
| Maskarinec et al., 2006 (34) | 9,994 Native Hawaiians out of a total multiethnic sample of 76,163 | 13 | ≥18 | Observational, prospective cohort; pooled data from 18 population-based studies | To describe trends in BMI and the relations of nutrient and food intake with excess | Limited in comparability of nutritional measures across studies over time, mainly because dietary assessment |

| Study Author(s) and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | carried out over 25 years in Hawai‘i | weight.<br>Native Hawaiians had the highest prevalence of excess weight at all times. Carbohydrates were positively associated with excess weight among Native Hawaiians. Nutritional determinants of excess weight were similar among whites, Japanese, and Native Hawaiians, despite marked differences in BMI. | methods have improved over the years; recall bias. |
| Albright et al., 2007 (33) | 12,306 Native Hawaiians out of a multiethnic total sample of 200,003 | 6 | 45–74 | Observational, prospective cohort; population-based sample | To examine BMI in persons with ethnic admixture as compared with persons who were monoracial but shared a common ethnicity/race.<br>Native Hawaiians had the highest BMI compared with other ethnic groups. Ethnic admixtures that included Native Hawaiian heritage had higher BMIs than most other ethnic combinations. | Self-reported height, weight, and ethnicity; unable to quantify the genetic contribution of each ethnicity reported. |
| Boyd, 2007 (37) | 32 Native Hawaiian community college students | 100 | 18–25 | Focus group, university convenience sample | To assess perceptions of healthy lifestyles and supports for and barriers to healthy living.<br>Demanding lifestyle and laziness were cited as barriers to being physically active. Preferences for group-oriented and college-course-based opportunities to learn about healthy living and how to become more physically active. | Small sample size; biased sample. |
| Dai et al., 2007 (57) | 583 American Samoans | 100 | ≥18 | Observational, nested study in a prospective cohort; random selection sample | To detect trait loci influencing adiposity-related phenotypes using a whole genome linkage scan approach in families from American Samoa.<br>Strong evidence for a major locus on chromosome 6q23.2 influencing serum leptin levels. Another genetic region, 16q21, appears to be a susceptibility locus that affects phenotypes for BMI, percentage of body fat, leptin levels, and waist circumference. | No adjustment for other important genetic and environmental factors that contribute to adiposity, such as diet and physical activity. |
| Maskarinec et al., 2007 (35) | 16,079 Native Hawaiians out of a multiethnic total sample of 117,065 | 14 | ≥40 | Observational, prospective cohort; population-based sample | To investigate changes in risk factors in Hawai‘i over 20 years and compare health behaviors among ethnic groups.<br>Native Hawaiians had the highest chronic disease risk scores in comparison with | Differences in data collection across 2 studies; improvements in nutritional assessment over time; validity of ethnicity assignment (self-reported); little information on socioeconomic status. |

| Study Author(s) and Year (Ref. No.) | Sample and No. of Subjects | % of Total Sample Who Were NHOPI | Age, years | Study Design | Main Goal and Outcomes/Findings | Limitations |
|---|---|---|---|---|---|---|
| | | | | | other groups. BMI was highest for Native Hawaiians. | |
| Novotny et al., 2007 (58) | 55 Samoan women | 100 | 18–28 | Observational, cross-sectional, convenience sample | To examine anthropometric cutoff points as indicators of chronic disease risk.<br>80% of sample was overweight or obese. BMI and dual-energy X-ray absorptiometry lean mass were significantly and positively associated with glucose levels. | Cross-sectional, small sample of Samoan women; biased sample. |
| Maskarinec et al., 2008 (59) | 254 Native Hawaiian women out of a multiethnic total sample of 1,418 | 18 | ≥21 | Observational, cross-sectional, breast-cancer-related participant sample | To examine relation of soy intake with body weight over the life span of women.<br>Meat and vegetable intake and total energy intake (kcal/day) were higher for Native Hawaiians. Eating more soy foods in adulthood did not predict lower BMI or lower annual weight gain for Native Hawaiians. | Self-reported height, weight, and diet data; lifetime recall of soy intake was difficult. |

Abbreviations: BMI, body mass index; IGF-1, insulin-like growth factor 1; IGFBP-3, insulin-like growth factor binding protein 3; NHOPI, Native Hawaiians and other Pacific Islanders.

[a] Weight (kg)/height (m)$^2$.