

# Diabetes and Cardiovascular Risk Factors in Native Hawaiians

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## Abstract

**Objective:** Diabetes is an increasing health problem among Native Hawaiians. Diabetes is a risk factor for cardiovascular disease (CVD), the leading cause of death among Native Hawaiians. In this article, the prevalence of diabetes is reported and associations with CVD risk factors are examined.

**Design and Methods:** Cross-section of 862 Native Hawaiians, ages 19-88. Physical exam included anthropometric measures, blood pressure, glucose and lipid measures, and personal interview.

**Results:** Age-adjusted prevalences of diabetes (25.1% in men vs. 22.6% in women) and impaired fasting glucose (IFG) (47.8% vs. 39.3%) increased with age and were higher in men. Fasting glucose was higher in diabetic men than women (209 mg/dL vs. 179,  $p = .0117$ ). BMI, waist circumference, systolic blood pressure, triglycerides, and low-density lipoprotein cholesterol were higher in diabetic participants (all  $p < .01$ ), and high-density lipoprotein cholesterol was lower ( $p < .005$ ).

**Conclusions:** Diabetes prevalence in Native Hawaiians is high. The high proportion with IFG and the increase in CVD risk factors with diabetes suggest that community-based programs are needed to focus on diabetes and diabetes-related CVD.

## Introduction

Polynesian Peoples have experienced a rapid rise in diabetes prevalence over the last 40 years.<sup>1-8</sup> The National Center for Health Statistics reports no data on diabetes in Native Hawaiians, the indigenous people of the Hawaiian Islands. Data from the Hawai'i Behavioral Risk Factor Surveillance System (BRFSS)<sup>9</sup> and US state mortality data, however, suggest that diabetes occurs at high rates in Native Hawaiians.<sup>10,11</sup> Diabetes is a major determinant of cardiovascular disease (CVD), the leading cause of death in Native Hawaiians.<sup>12,13</sup> The overall age- and gender-specific mortality rates due to heart disease are 66% greater among Native Hawaiians than among Caucasians in Hawai'i.<sup>14</sup> The Hawai'i Department of Health reported in 2005 that 71% of all deaths were attributable to heart disease. The CVD death rate per 100,000 was 205.3 statewide and 313.9 among Native Hawaiians/part Native Hawaiians.<sup>15</sup> Individual populations may differ in their CVD risk factor profiles because of individual genetic and socioeconomic characteristics.<sup>16</sup> Thus, systematic data on diabetes prevalence and CVD risk factors in Native Hawaiians with diabetes are needed to tailor community and institutional prevention and treatment programs.

The Cardiovascular Risk Clinics (CRCs) were initiated by the Native Hawaiian community to screen for CVD risk factors, including diabetes, among Native Hawaiians on the island of Moloka'i. A large proportion of the adult population participated in these clinics, thus providing systematic cross-sectional data on the cardiovascular risk status of Native Hawaiians. In this article, data are presented on standardized and age-specific prevalence rates of diabetes and impaired fasting glucose (IFG) in Native Hawaiians, and CVD risk factors in Native Hawaiian men and women with and without diabetes are compared.

## Methods

### Study Population

The CRC is a screening program initiated in 1992 and implemented by Na Pu'uwai, the Native Hawaiian Health Care System serving the island of Moloka'i, to identify adults at risk for CVD and refer them to health care services. Native Hawaiian men and non-pregnant women  $\geq$  age 18 were recruited for participation in the CRCs. Recruitment strategies included mailings and direct contact by community health workers. CRCs were conducted in the town and also in remote communities on the island. Although recruitment was not systematically population-based, efforts were made to identify and contact all Native Hawaiian residents and accommodations made to ensure participation regardless of socio-economic status or health condition.

The cohort consisted of 1,064 men and women,  $\geq$  age 18, examined as participants of the CRC program between 1992 and 1998.<sup>17</sup> This group represented approximately half the adult Native Hawaiian population of the island in that age range at the time. The only data available to allow comparisons between our study population and the population of Moloka'i as a whole are from the US census. However, the population covered by the US census differs from our population in age, proportion of self-identified Native Hawaiians, and average household income. Therefore, we cannot make direct comparisons between participants and non-participants.<sup>18,19</sup> Of our cohort, 74 who identified themselves as non-Native Hawaiian and 126 for whom diabetes status could not be determined were excluded, leaving 862 participants (345 men and 517 women, ages 19-88) for the analysis.

### Examination Methods

The examination consisted of a questionnaire evaluating behavioral risk factors, including smoking, alcohol use, physical activity, and diet; measurements of height, weight, waist and hip circumference, and blood pressure (BP); a urine test for protein and glucose; and a fasting blood sample for cholesterol, triglycerides (TGs), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), A1c, and glucose. Systolic and diastolic BPs were averaged from the second and third of consecutive resting measures taken with a standard arm cuff and aneroid sphygmomanometer. Participants were considered hypertensive if they reported a previous diagnosis of hypertension, took antihypertensive medication, or had a systolic BP (SBP)  $\geq$  140 mmHg or a diastolic BP of  $\geq$  90 mmHg. BMI was calculated by the equation (weight (lb)/[height (in)]<sup>2</sup> x 703). Total cholesterol (TC), HDL-C, TG, and glucose concentrations were determined by enzymatic methods using a Roche Hitachi 747 chemistry analyzer and consistent, standardized reagents (Boehringer Mannheim, Indianapolis, IN). LDL-C was calculated in those with TG  $<$  400 using the equation TC-HDL-(TG/5). Diabetes duration was determined by questionnaire.

Diabetes was identified by self-report or fasting glucose (FG)  $\geq 126$  mg/dL; IFG was defined as FG 100-125 mg/dL in participants without diabetes. Use of hypoglycemic agents was not ascertained.

### Statistical Methodology

Prevalence rates for diabetes and IFG were analyzed by age and gender. The direct method was used to adjust diabetes and IFG prevalence rates to age data from the 1995 US Census.<sup>20</sup> Means for continuously distributed variables were compared in men and women and by diabetic status using t tests. A chi-square test was used to compare categorical variables. Variables that were not normally distributed were log-transformed for comparisons.

### Results

Average age was 46, and 57.4% were obese with central fat distribution as indicated by waist circumferences averaging 40 inches in men and 38 inches in women (Table 1). BP and lipid values varied widely. Average age and BMI in men and women were similar, but men had slightly higher BP, lower HDL-C, and were more apt to be smokers.

Diabetes prevalence rates were slightly but not significantly higher in men than in women (Table 2; Figure 1). Age-adjusted rates were 25.1 (men) vs. 22.6% (women). IFG prevalence (Table 2; Figure 1)

was higher in men than in women ( $p = .0053$ ) and was higher than diabetes prevalence in both genders. Rates of diabetes and IFG (Table 2) increased with age in both genders, so that in men and women over age 50, 39.6% and 36.1% had diabetes, respectively, and an additional 58.6% and 54.5% had IFG. Of those with diabetes, many had not been diagnosed (Table 3); rates of undiagnosed diabetes were highest in the younger men. Diabetes control as indicated by fasting glucose levels was significantly higher in men (mean = 209, SD = 91) than in women (mean = 179, SD = 75) ( $p = .0117$ ) but appeared not to differ by age.

Diabetes was associated with greater prevalence of CVD risk factors in men and women, except for smoking (Table 4). In both genders, those with diabetes were more obese and had greater waist circumferences. In men and women with diabetes, the average SBPs were 16 and 12 mmHg higher than in those without, respectively. Diabetes was associated with significant dyslipidemia. Higher levels of LDL-C (difference of 24 mg/dL [men] and 28 mg/dL [women]) and TGs (difference of 102 mg/dL [men] and 95 mg/dL [women]) and lower levels of HDL-C (4 mg/dL [men and women]) were seen in those with diabetes. Smoking rates were higher in men than in women but did not differ significantly between those with and without diabetes in either gender.

Table 1.— Cardiovascular risk factors by gender, Native Hawaiians participating in Cardiovascular Risk Clinics, 1992-1998

Characteristic	Men % or Mean (range)	Women % or Mean (range)	Total % or Mean (range)
N	345	517	862
Age (years)	45 (19-85)	46 (19-88)	46 (19-88)
Body mass index (BMI) (kg/m <sup>2</sup> )	32.7 (18.7-69.0)	32.6 (18.3-88.1)	32.6 (18.3-88.1)
Waist circumference (inches)	40.3 (17-77)	38 (20-80)	39 (17-80)
Current smoker (%)	28.6	25.1	26.5
Hypertensive (%) <sup>1</sup>	45.8	38.1	41.2
Systolic blood pressure (mmHg)	131 (57-214)	127 (73-220)	129 (57-220)
Diastolic blood pressure (mmHg)	85 (45-129)	81 (33-131)	83 (33-131)
LDL cholesterol (mg/dL)	132 (39-400)*	133 (48-400)*	133 (39-400)*
HDL cholesterol (mg/dL)	40 (19-81)	45 (23-100)	43 (19-100)
Triglycerides (mg/dL)	205 (38-999)**	148 (30-997)	171 (30-999)**

<sup>1</sup> Defined as systolic/diastolic  $\geq 140/90$  mm Hg or self-report of previous diagnosis of hypertension or self-report of taking antihypertensive medication;

\* Upper lab limit = 400 mg/dL; \*\* Upper lab limit = 999 mg/dL.

Table 2.— Age-specific prevalence of diabetes<sup>1</sup> and impaired fasting glucose<sup>2</sup> in Native Hawaiian men and women

Age	Men			IFG			Women			P for gender difference (Diabetes) <sup>3</sup>	P for gender difference (IFG) <sup>4</sup>		
	Diabetes	IFG	Mean Duration*	Diabetes	IFG	Mean Duration**	Diabetes	IFG	Mean Duration**				
	N	%		N	%		N	%	N	%			
< 35	139	17.3	1.5	115	47.0		204	12.8	3.3	178	27.5	0.2441	0.0007
35-50	110	18.2	3.3	90	37.8		155	15.5	5.6	131	32.1	0.5609	0.3794
> 50	96	39.6	11.0	58	58.6		158	36.1	8.9	101	54.5	0.5754	0.6105
Total	345	23.8	8.1	263	46.4		517	20.7	7.4	410	35.6	0.2855	0.0053

<sup>1</sup> Defined as self-reported or fasting blood glucose  $\geq 126$  mg/dL; <sup>2</sup> Defined as fasting glucose level 100-125 mg/dL exclusive of diabetes (self-reported and newly diagnosed); <sup>3</sup> Chi-square tests of difference in proportion of men and women with diabetes in each age group; <sup>4</sup> Chi-square tests of difference in proportion of men and women with IFG in each age group; \* By age-group missing duration data; < 35, n = 20 (83%); 35-50, n = 8 (40%); > 50, n = 9 (24%); \*\* By age-group missing duration data; < 35, n = 20 (80%); 35-50, n = 8 (33%); > 50, n = 22 (39%).

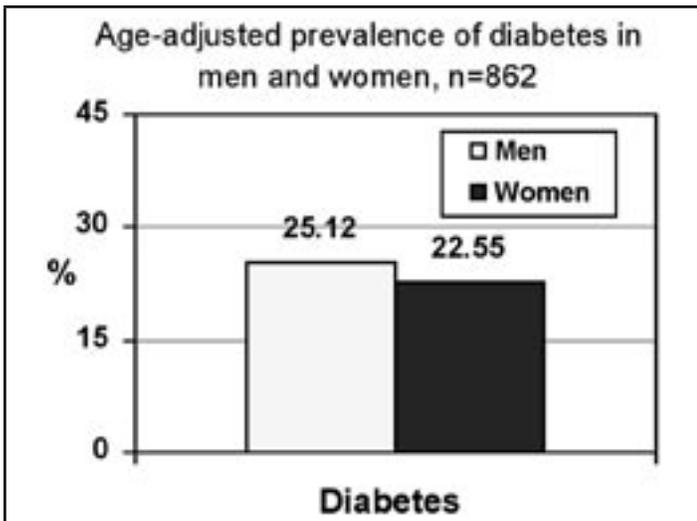


Figure 1A.— Diabetes prevalence in Native Hawaiians, age-adjusted to the 1995 US Census population data

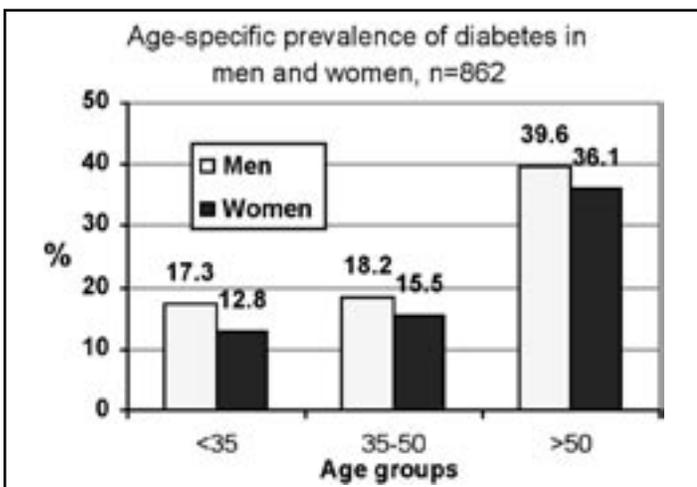


Figure 1B.— Age-specific diabetes prevalence in Native Hawaiians

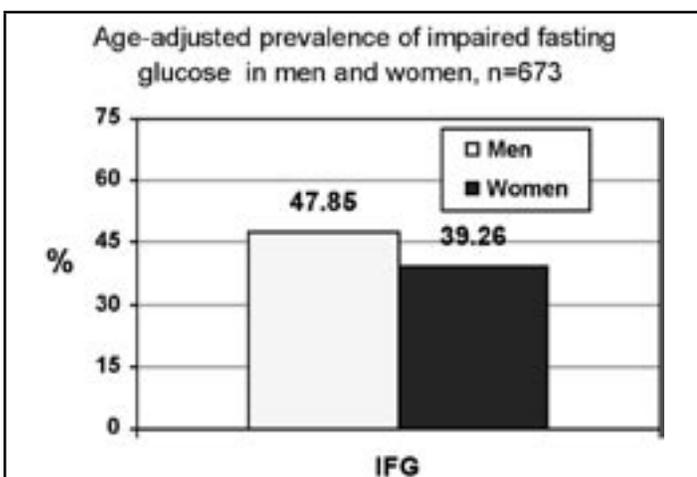


Figure 1C.— Impaired fasting glucose (IFG) prevalence in Native Hawaiians, age-adjusted to the 1995 US Census population data

## Discussion

The results of this systematic analysis of Native Hawaiians showed that 24% of adult men and 21% of adult women had diabetes (Table 2). An additional 46% (men) and 36% (women) had IFG, and a high proportion of the diabetes was undiagnosed, especially in younger men. Both diabetes and IFG increased with age so that in the group over age 50, approximately 37% had diabetes and more than 56% had IFG. Except for smoking, diabetes was associated with higher prevalence of CVD risk factors, including increased rates of dyslipidemia and hypertension. Obesity and central obesity also were higher in those with diabetes.

Previous reports of diabetes rates among Native Hawaiians have been published, most of which are from comparisons of several ethnic groups in Hawai'i.<sup>21,22</sup> In 1958, age-adjusted diabetes prevalence rates in Native Hawaiians and part Native Hawaiians on the island of O'ahu were reported to be 4.9% and 2.7%, respectively, and 1974-1975<sup>23</sup> state health data reported diabetes rates of 2% and 2.2%, respectively, in Native Hawaiian men and women. These numbers were based on self-report. From 1980-1986, age-adjusted diabetes prevalence rates in Native Hawaiian men and women were reported to be 3.0% and 3.1%.<sup>2</sup> In 1985 a report from the Moloka'i Heart Study, a cross-sectional survey of CVD risk factors in a group of 257 residents of the island, reported diabetes prevalences of 15% (ages 40-49) and 20% (ages 50-59).<sup>3</sup> Finally, a 1998 study<sup>21</sup> that included 574 Native Hawaiian adults from the islands of Hawai'i (North Kohala) and Kaua'i reported 20.4% age-adjusted diabetes prevalence rates in both genders.

Although methods varied, the overall pattern shows increasing prevalence of diabetes over the past 50 years in Native Hawaiians. The current report suggests slightly higher rates than those in the North Kohala and Kaua'i studies, although laboratory methods may not be comparable and it is not clear what proportion of the population was sampled in the North Kohala and Kaua'i studies. A pattern of increasing diabetes has been observed during the past 50 years in all US populations and around the world.<sup>24-27</sup> It is likely that in Native Hawaiians, as in all populations, the increases are attributable to increasing rates of obesity and increasingly sedentary lifestyles.<sup>28-31</sup> Only one previous study<sup>21</sup> addressed the issue of unrecognized diabetes (44% using WHO criteria), showing a prevalence similar to that observed in the present study.

Population-based data available on other Polynesian groups who are ethnically related to Native Hawaiians show similar rates of diabetes. In 2001, Simmons et al.<sup>7</sup> found rates of 21.1% and 25.0% in Maoris and other Polynesians, respectively. Earlier work from 1995 showed increasing rates of diabetes in several Polynesian groups.<sup>32</sup> Diabetes rates were higher in those living in urban areas compared with traditional settings, supporting the premise that changing lifestyles play a major role in diabetes prevalence.

In our data set, diabetes rates were somewhat higher in men than in women. Higher rates in men often are found in studies of diabetes in Asian and Polynesian populations.<sup>5-7</sup> This finding differs from most systematic studies of whites, blacks, Hispanics, and American Indians, in which women have a higher prevalence than men.<sup>33,34</sup> However, the greatest increases in prevalence from 1980-2005 occurred among white and black men (116% and 81%, respectively) compared to white and black women (110% and 69%, respectively). The reasons for this gender difference are not clear and warrant further investigation.

Age-group	Men			Women			P-value <sup>1</sup>
	N	% Self-reported	% New diagnosis	N	% Self-reported	% New diagnosis	
<35	10*	40.0	60.0	8**	87.5	12.5	0.0528
35-50	20	65.0	35.0	23	73.9	26.1	0.5256
>50	38	81.6	18.4	56	62.5	37.5	0.0471
Total	68	70.6	29.4	87	67.8	37.2	0.7111

<sup>1</sup>Fisher's exact test of difference in proportion of men and women with undiagnosed diabetes in the age group < 35; chi-square tests of difference in proportion of men and women with undiagnosed diabetes in remaining categories; \*N = 14 men in this age group with FG  $\geq$ 126 mg/dL were missing data for self-report and excluded from analysis for this table; \*\* N = 18 women in this age group with FG  $\geq$ 126 mg/dL were missing data for self-report and excluded from analysis for this table. In each of the other age groups, one woman with diagnosed diabetes was missing self-report data for diabetes.

Characteristic	Men			Women		
	No Diabetes <sup>1</sup> % or Mean (SD)	Diabetes <sup>1</sup> % or Mean (SD)	P-value <sup>3</sup>	No Diabetes <sup>1</sup> % or Mean (SD)	Diabetes <sup>1</sup> % or Mean (SD)	P-value <sup>3</sup>
N	263	82		410	107	
Age (years)	43 (15)	50 (14)	0.0001	44.4 (15.8)	53.1 (13.2)	<0.001
Body mass index (BMI) (kg/m <sup>2</sup> )	31.8 (7.0)	35.4 (9.0)	0.0036	31.2 (8.6)	35.7 (8.7)	0.0002
Waist circumference (inches)	39.4 (7.8)	42.8 (7.7)	0.0012	37.0 (7.4)	40.8 (6.3)	<0.0001
Current smoker (%)	28.1	30.4	0.7034	26.0	23.0	0.4112
Hypertensive <sup>2</sup> (%)	41.4	59.8	0.0037	32.4	59.8	<0.0001
Systolic blood pressure (mmHg)	128 (19)	144 (60)	0.0400	125 (21)	137 (20)	<0.0001
Diastolic blood pressure (mmHg)	85 (13)	86 (10)	0.2611	80 (12)	83 (12)	0.0517
LDL cholesterol (mg/dL)	127 (33)	151 (72)	0.0086	127 (38)	155 (68)	0.0002
HDL cholesterol (mg/dL)	41 (11)	37 (10)	0.0049	46 (11)	42 (9)	<0.0001
Triglycerides (mg/dL)	181 (152)	283 (219)	0.0002	128 (72)	223 (164)	<0.0001

<sup>1</sup>Defined as self-reported or fasting blood glucose  $\geq$ 126 mg/dL; <sup>2</sup>Defined as systolic/diastolic blood pressure  $\geq$ 140/90 mm Hg or self-report of previous diagnosis of hypertension or self-report of taking antihypertensive medication; <sup>3</sup>Chi-square tests of difference in proportion or t-tests of difference in means.

We found high rates of IFG in Native Hawaiians. IFG increased with age in both genders, although rates were higher in men. It is difficult to compare these data to previous studies because the more current American Diabetes Association criterion of FG  $\geq$ 100mg/dL was used in the current analysis, a cut-off level that was not used in previous studies and may not be appropriate in this population. Nevertheless, the only other data reported on glucose intolerance in Native Hawaiians are from the North Kohala/Kaua'i population, which showed that 10.9% of men and 18.7% of women had IGT as determined by glucose tolerance test. This rate did not increase with age and was higher in women than in men. Despite the differing diagnostic criteria, the high rates of deteriorating glucose tolerance observed in both studies are of concern, because individuals with either IFG or IGT have a high probability of developing diabetes.<sup>35,36</sup> The ability to identify these individuals and target them for intervention strategies aimed at controlling weight and increasing physical activity could slow and possibly reverse the increasing trend of diabetes seen in Native Hawaiians.

This article focuses on the prevalence of CVD risk factors in Native Hawaiians with diabetes, because individuals with diabetes are known to have higher rates of CVD. CVD is the leading cause of death in Native Hawaiians,<sup>11</sup> and state BRFSS data report high prevalence rates for CVD risk factors in this group.<sup>37</sup> Comparisons to population-based data in whites and blacks<sup>38</sup> and American Indi-

ans<sup>39,40</sup> show population-specific differences. For almost all of the risk factors, diabetes in Native Hawaiians seems to be associated with greater worsening than in other populations. For example, SBP in Native Hawaiian men and women with diabetes is 12-16 mmHg higher than in those without diabetes. Differences in white, black, and American Indian men with diabetes compared to men without diabetes average 3 mmHg, 11 mmHg, and 7 mmHg, respectively,<sup>35</sup> although in these populations overall rates of hypertension in those without diabetes are higher than among Native Hawaiians. The biggest effect of diabetes in Native Hawaiians appears to be on dyslipidemia. Diabetes is associated with much larger differences in LDL-C in Native Hawaiians than in other groups; in whites and blacks LDL-C increases only slightly and in American Indians LDL-C decreases slightly in those with diabetes. This influence of diabetes on LDL-C in Native Hawaiians may reflect metabolic differences because receptor clearance capacity is the main determinant of LDL-C levels.<sup>41</sup> This observation of increasing LDL-C with diabetes points to the need for attention to and control of LDL-C in Native Hawaiians with diabetes, because of the strong impact of LDL-C on atherosclerotic disease.

As in other populations, diabetes is also associated with higher TGs and lower HDL-C in Native Hawaiians. In this population, the decrease in HDL-C does not differ from other populations, but the effect on TGs appears to be greater, with Native Hawaiians with

diabetes having TG concentrations almost 100 mg/dL higher than those without diabetes. Because TG-bearing lipoproteins in people with diabetes appear to be particularly atherogenic, attention to control of TG levels is needed. Smoking rates did not differ significantly in those with and without diabetes, and almost 30% of the men in this population smoked. Smoking is a strong determinant of vascular disease, especially in individuals with diabetes; thus smoking cessation campaigns also are warranted.

The present report has a number of strengths. The data were from a community-initiated program and CVD risk factor screening was conducted by a community-based organization, thus promoting wide participation. Data were collected systematically on a wide range of physiologic and behavioral risk factors. This was the largest cohort of adult Native Hawaiians studied to date, and the only database of CVD risk factors in Native Hawaiians with or without diabetes.

This report is limited by several factors. This was not a systematic population-based sample and, therefore, the data may be skewed. However, the recruitment by community outreach staff increased the likelihood that a wide range of individuals participated. Although the laboratory measures were not made by a CVD core lab, all measures were made by the same laboratory, using similar methods across the exam period and longitudinal standardization procedures. Although the sampling occurred over six years, standardized questionnaires and methods were used for the interview and physical exam and all personnel were centrally trained.

In summary, this is one of the largest cohorts of Native Hawaiians assessed to understand CVD risk factors in this group. We found high rates of diabetes and IFG that increased with age and were higher in men than in women. In addition, we found that diabetes in this population appears to be associated with adverse changes in cardiovascular risk factors, with diabetic individuals having increased prevalence of hypertension and elevated LDL-C and TGs. The community in Moloka'i is implementing programs for diabetes prevention focused on weight control and physical activity, and health care providers on the island are targeting risk factor management in all patients with diabetes. These strategies should be implemented throughout Hawai'i and in all areas where Native Hawaiians are served.

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