# Diabetes Mellitus Prevalence in Out-Patient Marshallese Adults on Ebeye Island, Republic of the Marshall Islands

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## Abstract

*The purpose of this study was to use a low-cost method of estimating prevalence of diabetes mellitus for a small island population receiving medical care from a single facility. A suitable sample of 692 (16.4%) from a total of 4,223 medical records of Ebeye Island Marshallese adult outpatients 30 or more years of age was reviewed in July and August 2000 for evidence of diabetes mellitus. Diagnosed diabetes was defined as having a diagnosis of diabetes noted in the chart. In patients without a diagnosis of diabetes, undiagnosed diabetes was defined as one fasting whole blood glucose ≥ 7.0 mmol/l (126 mg/dl) or one random whole blood glucose ≥ 11.1 mmol/l (200mg/dl). Impaired fasting glucose was defined as one fasting whole blood glucose 6.1-7.0 mmol/l (110-125mg/dl). For this population of adults 30 or more years in age, the crude prevalence of diabetes [diagnosed cases 13% (confidence interval, CI = 10-15%) and undiagnosed cases 6.9%(CI = 5.0-8.8%)] was 20% (CI = 17-23%). As the population of Ebeye is younger than the world population, adjustment to a standard world population gives an age-adjusted prevalence of diabetes in adults 30 or more years of age of 27%, and an age-adjusted prevalence in adults 20 or more years of age of 20%. In comparison, the crude prevalence of diagnosed and undiagnosed diabetes in the U.S. in adults 20 or more years of age is 8.3%, and the worldwide prevalence in adults 20 or more years of age is 4.0%. Limitations of our methodology include lack of randomization, lack of access to proper laboratory equipment, and passive case-finding, necessitating revision of standard diagnostic criteria. Prevalence rates of diabetes in Marshallese outpatients are thus significantly higher than U.S. or worldwide rates. In addition, there are many cases of undiagnosed diabetes in the RMI. Recommended are a cross-sectional serosurvey of a large age- and gender-stratified population, increased resources to care for people with diabetes, and public health interventions to improve nutrition and facilitate physical activity in order to lower the prevalence of diabetes. The large-scale social forces that lead to diabetes need to be addressed accordingly.*

King, et al[1] estimated the worldwide prevalence of diabetes in adults ≥20 years of age to be 4.0% in 1995. The rate is expected to rise to 5.4% by the year 2025. While rates are higher in developed countries, most of the estimated increase will result from increasing numbers of cases in developing countries. The people of the Pacific Islands have high rates of diabetes.[2] High prevalence has been documented in Saipan Chamorros and Carolinians,[3] Nauruans,[4] Native Hawaiians,[5,6] and Samoans.[7] The Samoa study demonstrated an increased prevalence between 1978 and 1991.

Pacific Island peoples are spread over many small and large islands. Few estimates of diabetes among this population are available, and resources for conducting epidemiologic studies are meager. Nonetheless, better documentation of actual rates is needed in order that prevention and intervention programs can be implemented. We conducted this study with the intent of describing a low-cost method of estimating prevalence for small and reasonably stable populations receiving medical attention from a single source of care. We hope that other districts conducting similar inquiries can learn from our experience in order perform better studies. Thus, utilizing existing sources of data, we conducted a chart review study to estimate the prevalence of diabetes in Marshallese adults (≥30 years of age) at the Ebeye Community Health Center (ECHC).

## Background

The RMI is composed of 29 atolls and 5 small, low-lying islands. Although the total landmass (70 sq. mi. or 181 sq. km.) is approximately equal to Washington D.C., the nation spreads across 750,000 square miles of the Central Pacific. The nation is roughly split into 2 island chains, Ratak (Sunrise) in the east, and Ralik (Sunset) in the west. Majuro, the nation's capital, is in the Ratak chain, while Kwajalein Atoll, where Ebeye is located, is in the Ralik chain. According to the 1999 Census, the total population of the RMI is 50,840, 68% of which resides in Majuro and Kwajalein Atolls.[8]

Kwajalein Atoll contains 97 islands with a total landmass of 6.5 square miles. The islands enclose a 1,100 square mile lagoon. According to the census, the total Marshallese population of Kwajalein atoll is 10,902, the vast majority of which, 9,345 live on Ebeye, one island within Kwajalein Atoll. Ebeye, with a landmass of 0.14 square miles, has the highest

population density in the RMI at 66,750 people per square mile.[9] The average household size in Kwajalein atoll is 9.[10]

Although somewhat geographically isolated, the RMI has a long history of occupation and colonization, being claimed first by Spain, then colonized by Germany and subsequently Japan. After World War II, the U.S. administered the Marshall Islands as part of the Trust Territory of the Pacific Islands. During their administration, the U.S. conducted a nuclear testing program in the northern atolls of Bikini and Enewetak from 1946 to 1957.[11] The Marshall Islands separated from the Trust in 1978 and have been independently governed since that time. Currently, the U.S. leases Kwajalein Island and several other islands in the atoll to support a military base formerly called the United States Army Kwajalein Atoll/Kwajalein Missile Range (USAKA/KMR), now known as the Reagan Test Site (RTS), where some two thousand U.S. personnel working for defense contractors and their dependents live. Grocery stores are generally well-stocked, and the amenities on Kwajalein Island are similar to those available to the general public in Hawaii. The contractors at RTS are some of the few large employers in the Marshall Islands, and the employment opportunities draw many families to Kwajalein Atoll from other atolls. A minority of Marshallese workers lives on Kwajalein, while the majority lives on Ebeye and commutes to work by ferry. As noted above, some nine thousand Marshallese live on the 66 acres of Ebeye Island. Large-scale agriculture is not possible on coral rock and paved Ebeye. Historically, water, sewage, and electricity services have been spotty. The variety of available foods is limited, and the Marshallese tend to subsist on chicken, fish, and non-perishable items. Poor quality food and the lack of participation in physical activity may contribute to overweight and obesity in Ebeye.

This study does not examine the epidemiology of overweight and obesity on Ebeye, but the epidemic of overweight has been documented in other areas of the Marshall Islands. In a study of 1100 subjects from Majuro (the capital of the Marshall Islands) and three remote islands, in 18 to 49 year-olds, 30.7% of men were overweight (25<BMI<30) and 19.8% were obese (BMI>30); 28.8% of women were overweight and 32.8% were obese (Gittelsohn J et al. Overnutrition and undernutrition in the Republic of the Marshall Islands. Unpublished report, 1998).

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## Methods

As of July 2000, there were 14,806 outpatient medical records at the ECHC. The ECHC is connected to Ebeye Hospital and is the only source of outpatient health services on the island. The total number of records for patients thirty years or older (born before July 1, 1970) was 4,223. In order to assess the preva-

lence of diabetes on Ebeye, 734 of these records were reviewed. All active charts were considered eligible for inclusion.

A convenience sample of ECHC patients from a list organized alphabetically by family names was utilized. If circumstances had allowed, the intent was to review all available records of patients thirty years or older. Family practice faculty (KB, SY) performed the initial data collection. The bulk of the data collection was then performed by one medical student (AD) working part-time, over a two-month period. We terminated data collection when the time allotted by the student expired. The charts that were reviewed thus consisted of patients with last names starting with the letters A through D, though the possibility of bias introduced by family clustering of cases is introduced.

Information regarding age, gender, ethnicity, medical history of diabetes, and blood glucose levels was collected. Information from 42 medical records was not utilized because of incomplete information, age (born after July 1, 1970 and therefore inappropriately sampled), or non-Marshallese ethnicity. The remaining 692 (16.4%) charts were representative of adult (≥30 years of age), Marshallese clinic users on Ebeye. Table 1 compares the age structure of our study population with that of the age structure of the residents of Ebeye as recorded in the 1999 census.

| Table 1.— Age Structure of the Study Population | | | | |
|---|---|---|---|---|
| Age | Ebeye CHC Study Population | % | Ebeye Census | % |
| 30-39 | 302 | 43% | 1227 | 45.5% |
| 40-49 | 206 | 30% | 843 | 31.2% |
| 50-59 | 110 | 16% | 391 | 14.5% |
| 60-74 | 52 | 7.5% | 193 | 7.2% |
| ≥ 75 | 22 | 3.1% | 40 | 1.5% |
| Total | 692 | | 2694 | |

Comparison of age structure of study population with age structure of residents of Ebeye as recorded in 1999 Census.

Based on the information found in the medical records, patients were classified into three groups: (a) diabetic, (b) impaired fasting glucose, and (c) non-diabetic or no glucose screens done, defined as follows. Patients diagnosed with diabetes by their clinicians were classified as diabetic. Patients without previously diagnosed diabetes were categorized in the following manner:

(a) undiagnosed diabetes: fasting whole blood glucose ≥ 126mg/dl (7.0 mmol/l) or random whole blood glucose ≥ 200 mg/dl (11.1 mmol/l)

(b) impaired fasting glucose (IFG): fasting whole blood glucose 110-125 mg/dl (6.1-7.0 mmol/l)

(c) normal fasting glucose: fasting whole blood glucose, < 110 mg/dl (6.1 mmol/l) or never having had their glucose tested.

Patients who had received glucose testing had had their *whole blood* glucose measured with an Elite personal glucometer from Bayer (the only means of measuring glucoses on Ebeye, as no analyzer was available at the time of the study.) Of note, the above values are the *serum* glucose criteria of the American Diabetes Association (ADA).[13] Whole blood glucose levels are lower than equivalent serum glucose levels. Thus, by utilizing serum glucose cutoffs for whole blood levels, we *underestimate* the prevalence of diabetes. Further, the ADA diagnostic criteria require that these glucose criteria be met on two separate occasions, and that the > 11.1 mmol/l (200 mg/dl) values be accompanied by symptoms. We, however, relied on single measurements if multiple measurements were not available because the proportion of patients who had any glucose measurements done at all was very small. We also did not require that patients exhibit symptoms, as progress notes were sparse. Patients with known diabetes, as diagnosed by their health providers in Ebeye, were included in the diabetic group. Information about levels was obtained from progress notes and laboratory results indicating blood glucose measurements.

Patients who had not had a glucose measurement were categorized as non-diabetics. After the sampling had been performed - in order to ascertain the approximate fraction of clinic patients that had had a glucose measured - a small non-random subsample of 67 alphabetically contiguous charts of patients determined to be non-diabetic were reviewed a second time.

## Statistical Analysis

The direct method of age-adjustment, utilizing the age distribution of the Republic of the Marshall Islands[14] and a standardized world population (utilized by the International Association of Cancer Registries),[15] was used to calculate an age-adjusted prevalence rate. This rate utilized as its denominator the number of charts that we reviewed. Although our sampling was not randomized, assuming that no major bias was introduced via the sampling method, confidence intervals of the prevalence rates were calculated.

## Results

A total of 692 outpatient medical records were analyzed. Of the subsample of 67 patients who were determined not to have diabetes, most (47 of 67 or 70%) had not ever had a glucose measurement. That is, the majority of patients classified as non-diabetic were thus classified on the basis of not ever having had a glucose measurement performed. Table 2 depicts the classification of patients into diagnostic groupings, stratified according to age.

Table 3 shows the prevalence of the various diagnostic categories. The total prevalence of diabetes (diagnosed and undiagnosed) in Marshallese outpatients ≥30 years of age is 20% (CI = 17-23%), with 13% (CI = 10-15%) of patients with diagnosed diabetes and 6.9% (5.0-8.8%) with undiagnosed diabetes. The prevalence of impaired fasting glucose (IFG), 2.5%, is shown in Table 4. Table 5 shows the age-stratified breakdown of hyperglycemia (that is the sum of patients with diagnosed and undiagnosed diabetes and impaired fasting glucose). Overall, the prevalence of all measured parameters increases with age, though the rate drops slightly from the 50-59 to the 60-74 age groups. Figure 1 depicts the breakdown of diagnosed and undiagnosed diabetes and IFG for all age groups greater than 30 years of age.

| Table 2. Outpatient Medical Record Review of Marshallese Patients ≥30 Years of Age at the Ebeye CHC | | | | | | |
|---|---|---|---|---|---|---|
| Age | Date of Birth | Diagnosed Diabetes | Undiagnosed Diabetes | Impaired Fasting Glucose | Normal Glucose/ Not Tested | Total |
| 30-39 | 7/1/61- 6/30/70 | 8 | 8 | 2 | 284 | 302 |
| 40-49 | 7/1/51-6/30/61 | 24 | 10 | 7 | 165 | 206 |
| 50-59 | 7/1/41-6/30/51 | 35 | 17 | 4 | 54 | 110 |
| 60-74 | 7/1/26-6/30/41 | 14 | 10 | 1 | 27 | 52 |
| ≥75 | Before 7/1/26 | 7 | 3 | 3 | 9 | 22 |
| Total | | 88 | 48 | 17 | 539 | 692 |

Results of reviewed outpatient medical records of 692 patients ≥30 years of age at the Ebeye Community Health Center. Patients diagnosed with diabetes by their clinicians were classified as having diagnosed diabetes. Patients without previously diagnosed diabetes were categorized as follows: undiagnosed diabetes (fasting whole blood glucose ≥126mg/dl or random whole blood glucose ≥200 mg/dl); impaired fasting glucose (fasting whole blood glucose 110-125 mg/dl); normal fasting glucose, (fasting whole blood glucose, <110 mg/dl).

| Table 3.— Prevalence of Diabetes in Marshallese Outpatients ≥30 Years of Age at the Ebeye CHC | | | | | | |
|---|---|---|---|---|---|---|
| Age | 30-39 | 40-49 | 50-59 | 60-74 | ≥75 | All Ages |
| Diagnosed Diabetes (CI) | 2.7% (0.8-4.4) | 12% (7.3-16) | 32% (23-41) | 27% (15-39) | 32% (12-51) | 13% (10-15) |
| Undiagnosed Diabetes (CI) | 2.7% (0.8-4.4) | 4.9% (2.0-7.8) | 15% (10-25) | 19% (8.5-30) | 14% (0-29) | 6.9% (5.0-8.8) |
| Total Prevalence of Diabetes (diagnosed + undiagnosed) | 5.3% (2.8-7.8) | 17% (11-22) | 47% (38-57) | 46% (33-90) | 45% (25-66) | 20% (17-23) |

Percentage of the Marshallese population ≥30 years of age with physician-diagnosed diabetes and undiagnosed diabetes, based on medical record review. CI = confidence interval.

| Table 4.— Prevalence of Impaired Fasting Glucose in Marshallese Outpatients ≥30 Years of Age at the Ebeye CHC | | | | | | |
|---|---|---|---|---|---|---|
| Age | 30-39 | 40-49 | 50-59 | 60-74 | ≥75 | All Ages |
| Impaired Fasting Glucose | 1% | 3% | 4% | 2% | 14% | 2.5% |

Prevalence of impaired fasting glucose in Marshallese outpatients of the Ebeye Community Health Center age ≥30 years, based on medical records. Impaired fasting glucose is based on a fasting whole blood glucose 110-125 mg/dl.

| Table 5.— Prevalence of Hyperglycemia (Diabetes & Impaired Fasting Glucose) in Marshallese Outpatients ≥30 Years at the Ebeye CHC | | | | | | |
|---|---|---|---|---|---|---|
| Age | 30-39 | 40-49 | 50-59 | 60-74 | ≥75 | All Ages |
| Total Prevalence of Diabetes and Impaired Fasting Glucose | 6.0% | 20% | 51% | 48% | 59% | 22% |

Prevalence of diabetes and impaired fasting glucose in Marshallese outpatients of the Ebeye Community Health Center age ≥30 years, based on medical records. Diabetes includes previously diagnosed and undiagnosed diabetes defined by the criterion of fasting whole blood glucose ≥126 mg/dl or random whole blood glucose ≥200 mg/dl. Impaired fasting glucose is based on criterion of fasting whole blood glucose 110-125 mg/dl.

| Table 6.— Age-Adjusted* Prevalance Rates for Various Denominators and Comparable Figures from Elsewhere | |
|---|---|
| Age-Adjusted Prevalence of Diabetes in Ebeye Population as a Whole | 12% |
| Age-Adjusted Prevalence of Diabetes in Ebeye Adults ≥ 20 Years of Age | 20% |
| Crude Prevalence of Diabetes in U.S. Adults ≥ 20 Years of Age† | 8.3% |
| Worldwide Prevalence of Diabetes in Adults ≥ 20 Years of Age‡ | 4.0% |
| Age-Adjusted Prevalence of Diabetes in Ebeye Adults > 30 Years of Age | 27% |
| Crude Prevalence of Type 2 Diabetes in Native Hawaiians > 30 Years of Age§ | 20.4% |

*to World Standard population, see note 15; †CDC, see note 16; ‡King, see note 1; §Grandinetti, see note 5
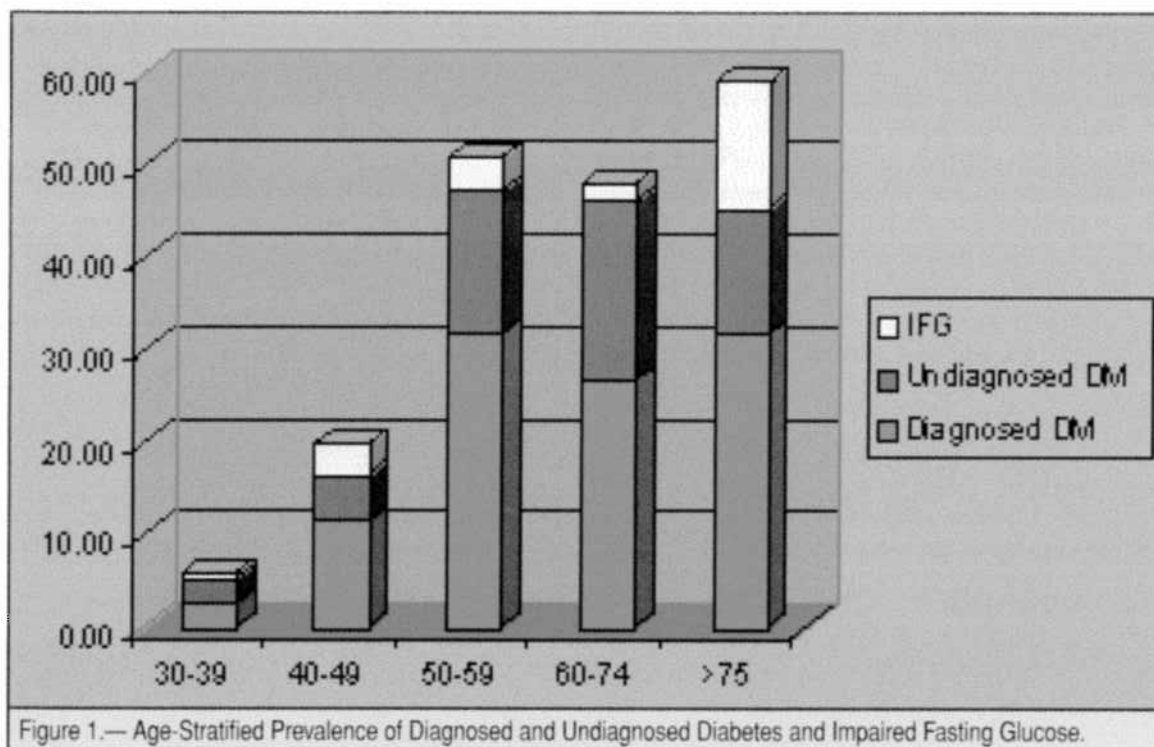
Figure 1.— Age-Stratified Prevalence of Diagnosed and Undiagnosed Diabetes and Impaired Fasting Glucose.

Figure 1 shows an age-stratified prevalence of diagnosed and undiagnosed diabetes and IFG in outpatients of the Ebeye Community Health Center age ≥30 years, based on medical records. Diabetes includes previously diagnosed and undiagnosed diabetes defined as fasting whole blood glucose ≥126 mg/dl or random whole blood glucose ≥200 mg/dl. Impaired fasting glucose is defined as fasting whole blood glucose 110-125 mg/dl.

For purposes of comparison with published data, we calculate the age-adjusted prevalence rates for diabetes in Ebeye in the entire population and in adults≥ 20 years of age as follows. Assuming that there are no cases of diabetes in Marshallese under the age of 30, the age-adjusted (to the world standard population) prevalence rate for diabetes (diagnosed and undiagnosed) in the Ebeye population as a whole is 12%. The age-adjusted prevalence rate for diabetes in Ebeye adults ≥20 years of age is 20%. The age-adjusted prevalence rates for diabetes in adults ≥30 years of age is 27%. It would also be possible to age-adjust to the U.S. population to facilitate comparison to U.S. figures, but this would greatly inflate the figures.

## Discussion

The age-adjusted prevalence of diagnosed diabetes was 20% in Marshallese outpatients > 20 years of age at the ECHC. This is a much higher rate than the crude prevalence of diabetes (diagnosed and undiagnosed) of 8.3% in U.S. adults >20 years of age (in an older population than the world standard)[16] and the worldwide rate of 4.0% in adults >20 years of age. See Table 6.

The crude prevalence of IFG was lower in Marshallese outpatients ≥30 years of age (2.5%) than in U.S. adults ≥20 years of age (6.9%). This difference reflects the low levels of testing for fasting glucose in our population and is an artifact of our passive case-finding methodology.

The age-adjusted prevalence of diabetes (diagnosed and undiagnosed) in Marshallese ≥30 years of age, 27%, is greater than that found in Native Hawaiians of the same age, 20.4%.[18] See Table 6. These rates also exceed those found in Western Samoa, American Samoa, and Samoans living in San Francisco.[19] Of note, the study on Native Hawaiians utilized an active case-finding serosurvey methodology and the 1985 WHO criteria for defining diabetes.

It was not possible to assess patients' body mass indices in this study, as most patients did not have their heights and weights in their records. Although the prevalence of overweight and obesity on Ebeye has not been studied, if it is similar to the prevalence documented on Majuro (Gittelson et al, 1998), it may contribute significantly to the high prevalence of diabetes on Ebeye.

A significant portion of the population is not being tested or treated for diabetes. This may point to a lack of understanding of the disease, an unwillingness to seek western medical attention, a lack of resources to test for the diabetes, cultural barriers to care, or inadequate screening. Despite the dedication of its workers, health services are limited by inadequate funding. As noted above, at the time of this study, all glucose measurements were performed on a personal glucometer, as the health services did not have an analyzer. Medications for diabetes were often in short supply.

As noted above, the prevalence of diabetes in the Marshall Islands must be seen in the context of large-scale social forces, including history and political economy. Living conditions on Ebeye are directly related to the strategic uses to which the U.S. has put the Marshall Islands. Weapons testing in the Marshall Islands by the U.S. has disrupted the traditional Marshall Islands culture and has greatly distorted its economy. Ecological destruction, dependence on the U.S., and overcrowding have led to substantial changes in the lifestyle and diet of the Marshallese[20] which presumably have contributed to epidemics of obesity and diabetes in the Marshall Islands.

Limitations of the study. Because the proportion of patients who had ever had a glucose measured was low, we required that the criterion value be met once only, without subsequent confirmation. This may overestimate the number of patients that we enumerated with undiagnosed diabetes.

The number of outpatient charts, 14,806, actually exceeds the population of Ebeye Island, counted to be 9,449 in the 1999 census.[21] This probably reflects a net out-migration of the population from the Ebeye. The 1999 census notes a dramatic change in the age structure of the RMI between the 1988 and the 1999 censuses, with a narrowing of the base of the age pyramid – reflective of a decline in fertility and an out-migration of families with very young children.[22] A second possibility is that patients who have expired might still be on the clinic rolls. Table 1 shows that the study population was comparable to the census population, except for those ≥75 years of age, who were over-represented. Furthermore, given the special circumstances of Ebeye, as outlined above, these findings with this population cannot be generalized to the population of the Republic of the Marshall Islands as a whole.

Other possible sources of data such as inpatient charts, diabetes clinic logs, and the results of community screening programs were not utilized, as the record-keeping was arranged differently, and avoiding duplicate counting would have been difficult. If additional cases from such sources of data were to be counted, however, they would increase the estimated prevalence.

Case-finding was not randomized. Clusters of family members who share or do not share a predisposition to diabetes may share the same last name, putting them closer together in an alphabetical listing. Randomized sampling would have been preferable but would have required more resources. If resources allowed, it would be preferable to review all available charts; then it would not be necessary to calculate confidence intervals.

Data contained in this paper would benefit from confirmation with repeat fasting plasma glucose measurements and oral glucose tolerance tests. If patients with no record of whole blood glucose were formally tested, some proportion of this group would have diabetes and impaired fasting glucose, leading to higher estimates than reported here.

## Conclusion

The prevalence of diabetes and impaired fasting glucose in Marshallese on Ebeye is higher than the worldwide rate. There is a need for more thorough investigation to confirm the overall prevalence of diabetes in the Marshallese population. The next step in further delineating the prevalence of diabetes in the RMI would be to conduct a cross-sectional serosurvey of a large, age- and gender-stratified population.

Pacific islands have few funds available for health care, let alone epidemiological inquiries. The methodology utilized here is suggested as a low-cost method for other Pacific districts interested in estimating the prevalence of diabetes in their islands.

Further investigations need to be done to assess the prevalence of obesity, waist-hip ratio, and physical activity. Research should also focus on the Marshallese people's ideas about weight, disease, wellness, and diabetes.

While more accurate prevalence measures would be useful, these findings should spur an island-wide effort to ameliorate the epidemic of diabetes. People with diabetes need to be identified through intensive screening efforts. Clinical care for patients with diabetes needs to be improved. A family (ohana) support lifestyle interventions for Native Hawaiians have been shown to be more effective than standard care and may be useful in the treatment of diabetes in Marshallese. Further, public health interventions to improve nutrition, facilitate physical activity, and decrease rates of obesity are needed. Nutritional counseling to improve dietary choices must take cultural preferences into account.[24]

The distortions in the culture and lifestyles of the Marshallese people secondary to the continued use of Kwajalein Atoll for Ballistics Missile Defense have likely contributed to the prevalence of diabetes in Ebeye. Through its historical and current involvement in the Marshall Islands, the U.S. bears considerable responsibility for the health and welfare of the Marshallese people. The U.S. should continue to work in concert with the RMI government to address the needs of the community. As noted by Zimmet, "Type 2 diabetes will not be prevented by traditional medical approaches; what is required are major and dramatic changes in the socio-economic and cultural status of people in developing countries and the disadvantaged, minority groups in developed nations."[25] A social justice perspective[26] on the health problems of the Marshallese people suggests that the response of the health community should be one in solidarity with the people.

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