

Undiagnosed hypertension and type 2 diabetes mellitus among Marshallese adults in the Republic of the Marshall Islands

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Abstract

Background: Given the lack of healthcare access in the Republic of the Marshall Island (RMI) and the potential for complications related to type 2 diabetes mellitus (T2DM) and hypertension, it is crucial to examine these conditions among Marshallese in the RMI.

Objectives: This study aims to identify the proportion of Marshallese adults in the RMI with undiagnosed T2DM and hypertension.

Design: Using a community-based participatory research approach, screening events were conducted at 20 churches in Majuro Atoll.

Methods: Participants completed a questionnaire and biometric data measures, including hemoglobin A1c and blood pressure.

Results: Among participants with blood pressure data ($N=528$), 11.9% had readings indicative of hypertension, and 38.1% were undiagnosed. Among participants with hemoglobin A1c (HbA1c) data ($N=450$), 45.3% had readings indicative of T2DM, and 39.2% were undiagnosed.

Conclusion: This study utilized a community-based participatory research approach that promotes equitable and ethical research. Results reaffirm the need to identify strategies for increasing healthcare access and for research to address health disparities in the RMI.

Plain language summary

Study using data collected during health screenings in the Republic of the Marshall Islands (RMI) to identify the number of Marshallese people with undiagnosed diabetes and/or high blood pressure

The Republic of the Marshall Island (RMI) is a nation located in the Pacific Ocean between Hawai'i and New Zealand. The RMI was the location of nuclear testing by the United States (US) in the 1940s and 1950s, changing the diet of Marshallese people, and leading to a high rate of type 2 diabetes and high blood pressure. However, healthcare in the RMI is less available than in the US, meaning Marshallese people may not be aware if they have these chronic conditions. The goal of our study was to determine the prevalence of undiagnosed type 2 diabetes and high blood pressure among

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participants in church-based health screenings in the RMI. The study team found that 38.1% of people with readings indicating type 2 diabetes and 39.2% of people with readings indicating high blood pressure were undiagnosed. These results show there is additional work needed in the RMI to increase access to healthcare services.

Keywords

Hypertension, type 2 diabetes mellitus, Republic of the Marshall Islands, Pacific Islanders, undiagnosed cardiometabolic disease

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Introduction

The Republic of the Marshall Islands (RMI) is a grouping of 28 small islands (atolls) located between Hawai'i and New Zealand, with a total estimated population of 59,000 residents.¹ In the 1940s and 1950s, the United States (US) military conducted nuclear weapons testing on the atolls of the RMI, dramatically altering the Marshallese lifestyle.^{1,2} Nuclear radiation contaminated the local food ecosystems and forced Marshallese people to shift from a diet of fresh fruits, vegetables, and fish to a diet of high-carbohydrate, processed commodity foods, and the nuclear fallout also reduced physical activity related to food acquisition.²⁻⁶ In addition to the environmental destruction, the US military subjected the Marshallese people to medical research on the effects of the nuclear fallout without obtaining informed consent, leading to a communal distrust of outside medical researchers.³

Due to the medical and historical traumas resulting from the nuclear testing and subsequent changes in lifestyle, the Marshallese population now experiences high rates of overweight and obesity-related illness, particularly type 2 diabetes mellitus (T2DM) and hypertension. The RMI has the highest age-adjusted T2DM rate in the world (23.0%), compared to lower US (13.3%) and global (9.3%) rates,⁷⁻¹¹ and a 2017 report estimated that 19.6% of the adult population in the RMI had hypertension.¹² In the state of Arkansas, home to the largest concentration of Marshallese in the continental US, community-based health screening of Marshallese adults found that 61.7% of the participants were obese, 41.2% had blood pressure readings indicative of hypertension, and 38.4% had hemoglobin A1c (HbA1c) readings indicative of T2DM.¹³

Individuals with undiagnosed hypertension and T2DM had blood pressure and HbA1c levels indicating the potential presence of these conditions, but they had not been diagnosed with either health condition by a healthcare professional. Hypertension and T2DM are risk factors for cardiovascular diseases and other serious conditions and can be life-threatening if left untreated.¹⁴ According to the 2017 report, of the 19.6% of adults in the RMI with hypertension, 40.6% were aware (diagnosed) of their hypertension, 23% were treating their hypertension, and 13.5% had

their hypertension under control.¹² Another study conducted among Marshallese adults in Arkansas found that among participants with blood pressure readings indicative of hypertension, 68.4% were undiagnosed, and among participants with HbA1c indicative of T2DM, 31.6% were undiagnosed.¹⁵

Available data from studies in both the US and the RMI indicate that T2DM and hypertension are significant health disparities affecting the Marshallese community. However, no studies have collected primary data to examine diagnosed and undiagnosed rates of both T2DM and hypertension among Marshallese populations living in the RMI, where healthcare resources are less available than in the US.¹⁶ This study seeks to fill this gap by identifying the proportion of a sample of Marshallese adults in the RMI with diagnosed and undiagnosed T2DM and diagnosed and undiagnosed hypertension. Considering the constraints on healthcare access in the RMI and the severe consequences of untreated T2DM and hypertension, it is crucial to examine the rates of diagnosed and undiagnosed T2DM and hypertension in the RMI to identify strategies for overcoming diagnosis barriers and expanding healthcare approaches.

Materials and methods

Health screenings

The research team, in partnership with our community partners and the RMI Ministry of Health and Human Services, conducted the health screenings as part of a needs assessment to understand the current prevalence and severity of T2DM in faith-based organizations in the RMI.¹⁷

Community-based participatory research

This study utilized a community-based participatory research (CBPR) approach which promotes equitable and ethical research.¹⁸⁻²¹ The use of a CBPR approach is important given the historical trauma experienced by the Marshallese people, including the nuclear weapons testing conducted in the RMI by the US military and the resulting unethical research on Marshallese exposed to nuclear fallout.³ CBPR engages community partners and honors their unique contributions at all stages of research, as well as

ensures Marshallese cultural knowledge informs the process.^{22–26} More details on the CBPR approach and community partners who participated in the needs assessment are available in a prior publication.¹⁷

Recruitment

Churches were recruited through our CBPR collaboration. Health screenings were held at the church, and both church members and nonmembers in the area were invited to participate. Inclusion criteria were broad, and all adults 18 or older were allowed to participate.

Consent

The study was reviewed and approved by the University of Arkansas for Medical Sciences Institutional Review Board (IRB #262557) and approved by the RMI Ministry of Health. Previous work with the Marshallese community has highlighted participants' desire for a simplified consent process and verbal discussion of study requirements.²⁷ A study information sheet was provided in Marshallese. Participants were allowed time to read and review the information sheet with a community health worker and were encouraged to ask any questions they may have had. Participants verbally acknowledged consent prior to proceeding in the data collection, and all participants received a copy of the study information sheet in Marshallese for their records. Verbal consent was preferred by community members as it accommodated those with lower literacy levels and decreased the time to completion for each screening. Acknowledgment of verbal consent was documented in REDCap.²⁸ Participants who consented to the study were given \$10 as compensation for their participation. All participants received health counseling at the screenings, and those with results indicating a risk of T2DM or hypertension were referred to the RMI Ministry of Health's non-communicable disease clinic with appointments for follow-up. Those who did not consent to have their data recorded were still offered the health screening but did not complete the survey.

Measures

Survey and biometric data were captured as part of the health screenings. All staff had previous experience with the collection of biometric and survey data in the RMI and had completed Collaborative Institutional Training Initiative (CITI), Health Insurance Portability and Accountability Act (HIPAA), blood-borne pathogen, biometric data collection, and study-specific trainings. Study instruments were chosen collaboratively with Marshallese stakeholders, were translated into Marshallese, and were validated with Marshallese participants. The data collection methods and survey items have been utilized in prior studies with more than 1000 Marshallese participants.^{25,26,13,29–32}

Age and sex of the participant were collected via self-report. Prior diagnoses of hypertension and T2DM were captured using an item from the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System survey. Participants were asked, "Has a doctor, nurse, or other health professional EVER told you that you had (diabetes; hypertension)?" (Yes/No). Biometric measures collected included glycated hemoglobin (HbA1c), weight, height, and blood pressure. Participants' weight (without shoes) was measured to the nearest 0.5 pound using a calibrated digital scale. Height (without shoes) was measured to the nearest 0.25 inch using a stadiometer. Body mass index (BMI) was calculated using collected height and weight ((weight in pounds \times 703)/(height in inches²)).

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured using a digital blood pressure device with the participant seated, arm elevated, and cuff placed at approximately heart height. Blood pressure was taken after the participant was seated and rested for at least 5 min. If the participant's initial blood pressure reading was indicative of hypertension, an additional blood pressure reading was recorded after waiting 5 min. If the second reading was further indicative of hypertension, a third reading was taken after an additional 5 min. Participants were determined to have results indicative of hypertension if, at the third reading, their SBP was ≥ 130 and/or their DBP was ≥ 80 .³³

HbA1c was collected via finger prick using aseptic techniques and analyzed using pts Diagnostic's A1C NOW + point-of-care tests. HbA1c was recorded as percent of glycated hemoglobin National Glycohemoglobin Standardization Program (NGSP %). Participants were determined to have results indicative of T2DM if their HbA1c was $\geq 6.5\%$.³⁴

Analysis

Study objectives were examined using descriptive statistics to describe the participants and the number of potentially undiagnosed cases of T2DM and hypertension in the sample. Analysis was performed using STATA SE v17 (StataCorp LLC, College Station, Texas, USA).³⁵

Results

A cross-sectional, convenience sample of 528 Marshallese adults from 20 churches located on Majuro Atoll participated in the health screenings. Only 450 participated in the HbA1c screening with 78 not receiving an HbA1c test due to supply chain issues limiting the number of tests available.

The descriptive results are provided in Table 1. The mean age of the participants in the health screening was 43.4 years (± 15.1 years), with a range of 18–83 years old. Just over half of the participants (54.7%) were between the ages of 18 and 44 years, and 45.3% were 45 years of age or

Table 1. Participant demographics and biometric results.

	Observations	N (mean \pm SD)	% of sample	Range
Age (years)	528	43.4 \pm 15.1		18–83
Age groups	528			
18–44		289	54.7	–
45+		239	45.3	–
Sex	527			
Female		326	61.9	–
Male		201	38.1	–
HbA1c (%)	450	7.2 \pm 2.5		4.1–14.1
Weight (in pounds)	525	168.3 \pm 38.3		85.8–311.2
BMI	525	31.4 \pm 6.8		17.2–58.8
Systolic blood pressure (mmHg)	528	118 \pm 19		82–211
Diastolic blood pressure (mmHg)	528	73 \pm 11		44–119

BMI: body mass index; HbA1c: hemoglobin A1; SD: standard deviation.

Only valid percentages are shown. Percentages may not total 100 due to rounding. HbA1c only completed for 450 participants due to supply chain issues in obtaining A1CNOW+ kits.

older. Nearly two-thirds of the participants were female (61.9%). The mean weight of the participants was 168.3 lbs. (\pm 38.3 lbs.) with a mean BMI of 31.4 (\pm 6.8). Mean SBP of the participants was 118 mmHg (\pm 19 mmHg), and the mean DBP was 73 mmHg (\pm 11 mmHg). The mean HbA1c of the participants was 7.2% (\pm 2.5%).

Table 2 presents the results of the analysis of undiagnosed cases of hypertension and T2DM. Among participants with complete blood pressure data ($N=528$), 11.9% had blood pressure readings indicative of hypertension. Of those with blood pressures indicative of hypertension, 38.1% were previously undiagnosed. Mean SBP and DBP was 156.6 (\pm 23.8) mmHg and 88.0 (\pm 13.0) mmHg, respectively, among participants with previously diagnosed hypertension. Mean SBP and DBP was 148.5 (\pm 23.8) mmHg and 92.2 (\pm 9.2) mmHg, respectively, among participants with previously undiagnosed hypertension (Table 3).

Among participants with complete HbA1c data ($N=450$), 45.3% had HbA1c readings indicative of T2DM. Of those with HbA1c readings indicative of T2DM, 39.2% were previously undiagnosed (Table 2). Mean HbA1c was 10.3% (\pm 2.3%) among participants with previously diagnosed T2D and 7.9% (\pm 1.7%) among participants with previously undiagnosed T2DM (Table 3).

Discussion

This study sought to fill a gap in the literature by identifying the proportion of Marshallese adults in the RMI with diagnosed and undiagnosed T2DM and diagnosed and undiagnosed hypertension. The proportion of blood pressure measurements indicative of hypertension among the participants in the RMI health screenings (11.9%) were lower than a previous 2017 report on hypertension in the RMI (19.6%)¹² and lower than a similar study of

Table 2. Hypertension and T2DM status of health screening participants.

Hypertension (baseline biometric) ($n=528$)	63 (11.9)
Previous hypertension diagnosis	
Yes ^a	92 (17.4)
No	436 (82.6)
Hypertension status	
Undiagnosed	24 (38.1)
Diagnosed ^a	39 (61.9)
Diabetes (baseline biometric) ($n=450$)	204 (45.3)
Previous diabetes diagnosis	
Yes ^b	140 (31.1)
No	310 (68.9)
Diabetes status	
Undiagnosed	80 (39.2)
Diagnosed ^b	124 (60.8)

T2DM: type 2 diabetes mellitus

Percentages may not total 100 due to rounding.

^aFifty-three participants indicated a previous diagnosis of hypertension; however, they did not have blood pressure readings indicative of hypertension at the time of data collection.

^bSixteen participants indicated a previous diagnosis of type 2 diabetes; however, they did not have HbA1c readings indicative of type 2 diabetes at the time of data collection. HbA1c only completed for 450 participants due to supply chain issues in obtaining HbA1c testing kits.

Marshallese living in Arkansas (41.2%).¹³ However, the proportion of HbA1c results indicative of T2DM (45.3%) were higher among the participants in the RMI study compared to the Arkansas study (38.4%).¹³ Of the participants with results indicative of hypertension or T2DM, 38.1% did not have a previous diagnosis of hypertension, and 39.2% did not have a previous diagnosis of T2DM. The percentage of undiagnosed hypertension in this sample (38.1%) is lower than a previous 2017 report on hypertension in the RMI (59.4%)¹² and also lower than the Arkansas study (68.4%),¹⁵ but higher than a similar study in Samoa

Table 3. Mean blood pressure and HbA1c by diagnosis status.

	Mean \pm SD
Systolic blood pressure	
Undiagnosed	148.5 (\pm 23.8) mm Hg
Diagnosed	156.6 (\pm 23.8) mm Hg
Diastolic blood pressure	
Undiagnosed	92.2 (\pm 9.2) mm Hg
Diagnosed	88.0 (\pm 13.0) mm Hg
HbA1c	
Undiagnosed	7.9% (\pm 1.7%)
Diagnosed	10.3% (\pm 2.3%)

HbA1c: hemoglobin A1c; SD: standard deviation.

(11.8%).³⁶ Results for undiagnosed T2DM were higher among the RMI participants (39.2%) when compared to the Arkansas study results (31.6%)¹⁵ and the study in Samoa (20.5%).³⁶ Socioecological barriers make diagnosing and managing T2DM, hypertension, and other comorbidities difficult. The unemployment rate in the RMI is high (40%), and there is a low national minimum wage; these factors make fresh, healthy foods cost prohibitive for many Marshallese.³⁷ Our previous work with Marshallese living in the RMI has illustrated how many individuals rely heavily on less expensive options such as rice and processed foods supplied by the US.^{25,26} Prior work has shown many Marshallese living in the RMI do not have a regular source of healthcare, and when they are diagnosed with T2DM, it is difficult to obtain or afford diabetes testing supplies and medication.²⁵ These socioecological factors may help to explain the rates of undiagnosed T2DM and hypertension among Marshallese adults.

The relatively low HbA1c for the previously undiagnosed participants (7.9%) compared to those with a T2DM diagnosis (10.3%) highlights the need for health screening programs and research related to prevention and early detection of T2DM in the RMI. Future research in this area should consider conducting longitudinal cohort studies with members of younger populations to identify specific factors leading to the development of insulin resistance, prediabetes, and T2DM. Studies and programs involving younger populations will help researchers understand how and when insulin resistance and prediabetes develop in the Marshallese populations and allow interventions to take place earlier in the disease course. Furthermore, the evidence of uncontrolled T2DM among those with a previous T2DM diagnosis is concerning, because uncontrolled T2DM increases the risk of diabetes-related complications such as retinopathy and skin infections, and the barriers to healthcare access further exacerbate the prevention and treatment of complications related to T2DM. Future health screening programs should consider including screenings for T2DM-related complications.

Limitations

There are limitations to consider when interpreting the findings. The convenience sample limits the ability to generalize the results to broader Marshallese and Pacific Islander communities. The sampling method also limits comparisons to other studies. Furthermore, the proportions of hypertension and T2DM reported have not been age-adjusted; however, we attempted to mitigate sampling concerns by recruiting participants from across the adult lifespan. The exact number of churches on Majuro is not known; however, we included as many different congregations and denominations of churches as possible to ensure a diverse sample of residents. Finally, some participants in the screenings may have been aware of potential health conditions and, therefore, more likely to agree to participate in the study.

Conclusion

Despite these limitations, this is the first study to have examined diagnosed and undiagnosed T2DM and hypertension among Marshallese populations living in the RMI, where healthcare resources are constrained. Overall, the results of the screenings show a high proportion of participants with results indicative of T2DM and hypertension, with the percent of screened adults with an HbA1c indicative of T2DM in this study higher than previously observed.¹¹ The results of this study reaffirm the need to identify strategies for overcoming diagnosis barriers and expanding healthcare approaches and will inform future research addressing health disparities in the RMI, especially those related to cardiometabolic diseases.

Declarations

Ethics approval and consent to participate

The study was reviewed and approved by the University of Arkansas for Medical Sciences Institutional Review Board (IRB #262557) and approved by the RMI Ministry of Health. Participants verbally acknowledged consent prior to proceeding in the data collection, and all participants received a copy of the study information sheet in Marshallese for their records.

Consent for publication

Not applicable.

Author contributions

Jennifer A Andersen: Conceptualization; Data curation; Formal analysis; Methodology; Supervision; Writing – original draft; Writing – review & editing.

Brett Rowland: Data curation; Investigation; Project administration; Supervision; Writing – original draft; Writing – review & editing.

Erin Gloster: Writing – original draft; Writing – review & editing.

Gail O’Connor: Investigation; Project administration; Supervision; Writing – review & editing.

Williamina Ioanna Bing: Project administration; Supervision; Writing – review & editing.

Jack Niedenthal: Investigation; Writing – review & editing.

Sheldon Riklon: Investigation; Writing – review & editing.

Pearl A McElfish: Funding acquisition; Investigation; Supervision; Writing – review & editing.

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Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials

The deidentified data underlying the results presented in this study may be made available upon request from the corresponding author, Dr Pearl A McElfish, at pamcelfish@uams.edu. The data are not publicly available in accordance with funding requirements and participant privacy.

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