YALE JOURNAL OF BIOLOGY AND MEDICINE 94 (2021), pp.5-12.

ORIGINAL CONTRIBUTION

YALE JOURNAL OF BIOLOGY AND MEDICINE
YJBM
CELEBRATING 90 YEARS 1928–2018

Undiagnosed Hypertension and Undiagnosed Type 2 Diabetes among Overweight and Obese Marshallese Participants in a Diabetes Prevention Program

Pearl A. McElfish[a,*], Aaron J. Scott[b], Harish E. Chatrathi[b], Brett Rowland[b], Christopher R. Long[a], Nirav Nagarsheth[a], Mikaila Calcagni[a], Jay Patolia[a], Lauren K. Haggard-Duff[c], and James P. Selig[d]

[a]College of Medicine, University of Arkansas for Medical Sciences Northwest, Fayetteville, AR, USA; [b]Office of Community Health and Research, University of Arkansas for Medical Sciences Northwest, Fayetteville, AR, USA; [c]College of Nursing, University of Arkansas for Medical Sciences Northwest, Fayetteville, AR, USA; [d]Department of Biostatistics, University of Arkansas for Medical Sciences, Little Rock, AR, USA

Hypertension and type 2 diabetes (T2D) are major public health issues that disproportionately affect minority communities, including Native Hawaiians and Pacific Islanders (NHPI). Minority communities are also more likely to have undiagnosed hypertension and T2D. Marshallese Pacific Islanders have been shown to have high proportions of diagnosed and undiagnosed hypertension and T2D. Using survey and biometric data collected from 378 overweight/obese Marshallese Pacific Islander adults, this study documents the prevalence of hypertension and T2D, as well as the prevalence of undiagnosed hypertension and T2D. The study also examines associations between undiagnosed hypertension and undiagnosed T2D and age group, sex, health care access (defined by foregone care due to cost and health insurance status), and body mass index (BMI). Among participants with blood pressure readings indicative of hypertension, 68.4% were undiagnosed, and among participants with HbA1c indicative of T2D, 31.6% were undiagnosed. A quarter of participants (24.5%) had blood pressure and HbA1c measures indicative of both undiagnosed hypertension and undiagnosed T2D. Undiagnosed hypertension was significantly associated with age group (p's<0.0001) and sex (p=0.028). Undiagnosed T2D was significantly associated with age group (p's<0.05), forgone care due to cost (p=0.018), health insurance status (p=0.035), and BMI (p=0.001). Participants in this study had high proportions of undiagnosed hypertension and undiagnosed T2D. These findings will be immediately useful for those working to address hypertension and T2D disparities among Marshallese and other NHPI populations.

*To whom all correspondence should be addressed: Dr. Pearl A. McElfish, University of Arkansas for Medical Sciences Northwest, 1125 N. College Ave., Fayetteville, AR, 72703; Tel: 479-713-8680; Fax: 479-713-8670; Email: pamcelfish@uams.edu; ORCID iD: 0000-0002-4033-6241.

Abbreviations: T2D, Type 2 Diabetes; NHPI, Native Hawaiians and Pacific Islanders; NHANES, National Health and Nutrition Examination Survey; RCT, randomized controlled trial; DPP, Diabetes Prevention Programs; BMI, body mass index; HbA1c, Hemoglobin A1c; SBP, Systolic blood pressure; DBP, diastolic blood pressure; OR, Odds Ratio; CI, Confidence Interval; SD, Standard Deviation; BRFSS, Behavioral Risk Factor Surveillance System.

Keywords: hypertension, type 2 diabetes, overweight/obesity, Marshallese, undiagnosed disease, healthcare access

INTRODUCTION

Over 100 million (46.0%) US adults aged 20 and older have hypertension, which is a leading risk factor for cardiovascular disease, heart attack, stroke, and aneurysm [1]. Minority populations, including Native Hawaiians and Pacific Islanders (NHPI), have been shown to have higher rates of hypertension relative to Caucasians [1-3]. Approximately 30 million (9.4%) US adults have type 2 diabetes (T2D), and an additional 84 million (33.9%) have prediabetes [4]. T2D increases patient risk for cardiovascular disease, kidney disease, and eye disease [4]. Minority populations, including NHPI, have higher rates of T2D relative to Caucasians [3,5,6]. It is well established that being overweight or obese is a leading risk factor for both hypertension and T2D [7,8], and NHPI have been shown to have higher rates of obesity relative to Caucasians [3].

Undiagnosed hypertension and T2D are significant public health issues in the US and globally [9,10]. Undiagnosed hypertension and undiagnosed T2D refer to persons with blood pressure or blood sugar readings indicative of hypertension or T2D, but without previous diagnosis of hypertension or T2D by a health care professional. According to 2011-2014 National Health and Nutrition Examination Survey (NHANES) data, 15.9% of US adults with hypertension were undiagnosed. Among those with hypertension, a higher percentage of non-Hispanic Asians (24.7%) and Hispanics (20.2%) were undiagnosed than non-Hispanic Whites (14.9%) [11]. Younger age, being male, limited education, health insurance status, income status, and ethnicity are some of the factors associated with a greater likelihood of undiagnosed hypertension [12-14]. Between 2011 and 2016, 4.97% of US adults were estimated to have undiagnosed T2D [5], and 23.8% of all individuals with T2D were undiagnosed [4]. Similar to NHANES statistics on undiagnosed hypertension, the prevalence of undiagnosed T2D was greater among non-Hispanic Asians (7.5%), Hispanics (7.5%), and non-Hispanic Blacks (5.2%) than non-Hispanic Whites (3.9%) [5].

The NHPI population in the US increased by 40% between 2000 and 2010 [15]. Marshallese are a Pacific Islander population from the Republic of the Marshall Islands. Arkansas has the largest population of Marshallese in the continental US [15], with approximately 10,000 Marshallese residents [16]. The Marshallese community in Arkansas has been shown to have particularly high prevalence of obesity, hypertension, and T2D. According to community-based health screenings of Marshallese adults in Arkansas, 61.7% were obese, 41.2% had blood pressure readings indicative of hypertension, and 38.4% had HbA1c readings indicative of T2D [17].

Purpose of the Study

This study has four objectives. First, summarize the proportions of a sample of overweight/obese Marshallese adults with hypertension and undiagnosed hypertension. Second, summarize the proportions of a sample of overweight/obese Marshallese adults with T2D and undiagnosed T2D. Third, summarize mean blood pressure and HbA1c for participants with diagnosed versus undiagnosed hypertension and T2D, respectively. Fourth, determine if the prevalence of undiagnosed hypertension and undiagnosed T2D differ by age group, sex, health care access, and/or body mass index (BMI).

MATERIALS AND METHODS

Study Population

This study used baseline (ie, pre-intervention) data from a randomized controlled trial (RCT) testing Diabetes Prevention Programs (DPP). Marshallese adults (aged 18 and older) with a BMI $\geq$25 kg/m^2 were eligible to enroll in the study. All participants were recruited in community settings and were consented by bilingual Marshallese study staff. Baseline data were collected in 2018 and 2019. Additional details regarding recruitment and study design have been published elsewhere [18]. A total of 378 participants were recruited from 30 churches in Arkansas and Oklahoma.

Measures

Survey and biometric data were captured prior to initiation of the DPP interventions. All data were collected by study staff who completed extensive data collection and research ethics trainings. Survey items were translated from English to Marshallese by a certified translator and were approved by the trial's Marshallese Community Advisory Board prior to study implementation. Survey data were collected in participants' language of choice (English or Marshallese) by bilingual Marshallese study staff.

Sociodemographic Data. Age was calculated using participants' self-reported date of birth and date of baseline data collection and rounded down to the nearest integer (eg, a calculated age of 35.7 years would be rounded to 35 years). Three age groups were then created: young adults (18-34 years), middle-aged adults (35-54 years), and older adults (55+ years). Sex (male/female) was recorded by participant response.

Health Care Access. Two items from the Behavioral Risk Factor Surveillance System's (BRFSS) Healthcare Access Core Section were used to determine healthcare access [19]. One item assessed participants' current insurance status: "Do you have any kind of health care coverage, including health insurance, prepaid plans such

as HMOs, or government plans such as Medicare?" One item assessed whether participants had foregone medical care in the past year due to cost: "Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?"

Biometric Data. BMI was calculated using participants' measured height and weight ((weight in pounds/[height in inches]^2)*703). Height (without shoes) was measured to the nearest 0.25 inch using a stadiometer. Weight (in light clothing without shoes) was measured to the nearest 0.5 pound using a calibrated digital scale.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a sphygmomanometer and stethoscope or digital blood pressure device with participants seated and their arm supported and elevated to place the cuff at approximately heart height. Blood pressure was taken after allowing participants to rest (ie, seated for at least 5 minutes). If the participant's initial blood pressure reading was indicative of hypertension, the study team took an additional blood pressure reading after waiting 5 minutes. If the second reading was also indicative of hypertension, a third reading was taken after waiting an additional 5 minutes. Participants were determined to have hypertension if, at the third reading, their SBP was ≥130 or their DBP was ≥80 [20].

T2D was assessed by analysis of blood collected through finger stick using a Rapid A1c test kit and Siemens DCA Vantage Analyzer [21]. HbA1c was recorded as percent of glycated hemoglobin (NGSP %). Participants were determined to have T2D if their HbA1c was ≥6.5%. Participants were referred to a primary care physician if they had blood pressure or HbA1c readings indicative of hypertension or T2D, respectively.

Prior Diagnoses and Disease Statuses. Prior hypertension and T2D diagnoses were determined using items from the BRFSS's Chronic Health Conditions module. Each participant was asked, "Has a doctor, nurse, or other health professional EVER told you that you had any of the following? For each, tell me Yes, No, or Not Sure. […] High blood pressure? […] Diabetes?"

Hypertension status was determined by comparing participant's blood pressure results with their survey responses regarding prior diagnosis of hypertension. Undiagnosed hypertension refers to participants who reported never being previously diagnosed with hypertension but based upon biometric data collection had SBP ≥130 or DBP ≥80. Diagnosed hypertension refers to participants who reported having been previously diagnosed with hypertension and based upon biometric data collection, had SBP ≥130 or DBP ≥80.

T2D status was determined by comparing participant's HbA1c results with their survey responses regarding prior diagnosis of T2D. Undiagnosed T2D refers to participants who reported never being previously diagnosed with T2D, but based upon biometric data collection had HbA1c ≥6.5%. Diagnosed T2D refers to participants who reported having been previously diagnosed with T2D and based upon biometric data collection had HbA1c ≥6.5%.

Analysis

Study objectives one, two, and three were examined using descriptive statistics. Study objective four was examined using logistic regression models. Each of the two models contained age group, sex, foregone health care, insurance, and BMI as predictors. The alpha level was set at 0.05 two-tailed. All analyses were carried out in SAS/STAT®v14.2. (SAS Institute Inc., Cary, NC, USA) [22].

Human Subjects/Ethical Standards Statement

All study procedures and protocols were approved by the University of Arkansas for Medical Sciences Institutional Review Board (IRB#201034). The study is registered in clinicaltrials.gov (#NCT03270436).

RESULTS

Detailed baseline characteristics of the study sample (N=378) are provided in Table 1. The mean age of participants was 42.3 (±11.6) years. The majority of participants (56.6%) were female. Among participants who responded to the survey question regarding foregone health care (N=377), 40.3% reported that there was a time in the past 12 months when they needed care but were unable to see a doctor due to cost. Among participants who responded to the survey question regarding current health insurance status (N=372), 42.5% reported they had no health insurance.

Among participants with complete blood pressure data (N=377), 62.3% had blood pressure readings indicative of hypertension. Of those with blood pressures indicative of hypertension, 68.4% were previously undiagnosed. Mean SBP and DBP was 152.4 (±23.7) mm Hg and 87.1 (±12.0) mm Hg, respectively, among participants with diagnosed hypertension. Mean SBP and DBP was 133.1 (±11.6) mm Hg and 83.7 (±7.2) mm Hg, respectively, among participants with undiagnosed hypertension. Among participants with complete HbA1c data (N=378), 48.2% had HbA1c readings indicative of T2D. Of those with HbA1c readings indicative of T2D, 31.6% were previously undiagnosed. Mean HbA1c was 10.6% (±2.4) among participants with diagnosed T2D and 8.3% (±2.3) among participants with undiagnosed T2D. Among those with both blood pressure readings indicative of hypertension and HbA1c readings indicative of T2D, a quarter (24.5%) had both undiagnosed hypertension and undiagnosed T2D. Among the entire sample,

Table 1. Baseline demographics, select biometrics, health insurance coverage, and forgone health care due to cost among participants enrolled in a Diabetes Prevention Program trial, *N*=378.

Participant Characteristics	*n* (%) or Mean ± SD
Age (years)	42.3 ± 11.6
Age Group	
18 – 34 years	97 (25.7)
35 – 54 years	223 (59.0)
55+ years	58 (15.3)
Sex	
Female	214 (56.6)
Male	164 (43.4)
HbA1c (%)	7.7 ± 2.8
Systolic Blood Pressure	130.2 ± 19.7
Diastolic Blood Pressure	79.5 ± 10.6
Body Mass Index	33.7 ± 5.4
Health Insurance Coverage (n=372)	
Yes	214 (57.5)
No	158 (42.5)
Forgone Health Care (n=377)	
Yes	152 (40.3)
No	225 (59.7)

Note: numbers of participants are noted where data are missing; Percentages may not total 100 due to rounding; SD=standard deviation; HbA1c=glycated hemoglobin; "Health Insurance Coverage" includes any type of health insurance; "Forgone health care" was assessed with the survey item: "Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?"

42.4% had undiagnosed hypertension and 14.6% had undiagnosed T2D (Table 2).

Hypertension diagnosis status was associated with age group and sex, but not with foregone health care due to cost, health insurance coverage, or BMI. Among those with blood pressure readings indicative of hypertension, young adults (age 18-34 years) were over three times as likely to be undiagnosed as middle-aged adults (age 35-54) [*OR:* 3.70 (1.33, 10.30)] and 18 times as likely to be undiagnosed as older adults (age 55+ years) [*OR:* 18.32 (5.79, 58.04)]. Middle-aged adults were five times as likely to be undiagnosed as older adults [*OR:* 4.943 (2.30, 10.63)]. Males were twice as likely to be undiagnosed as females [*OR*: 2.10 (1.08, 4.07)].

T2D diagnosis status was associated with age group, foregone health care due to cost, health insurance coverage, and BMI, but not with sex. Among those with HbA1c readings indicative of T2D, young adults had statistically equal odds of being undiagnosed as middle-aged adults [*OR*: 1.67 (0.61, 4.95)], but were over five times as likely to be undiagnosed as older adults [*OR*: 5.50 (1.54, 19.58)]. Middle-aged adults were over three times as likely to be undiagnosed as older adults [*OR*: 3.29 (1.20, 9.01)]. Participants who were unable to receive health care due to cost were less than half as likely to be undiagnosed as those who had no cost barrier to care [*OR*: 0.39 (0.18, 0.85)]. Uninsured participants were more than twice as likely to be undiagnosed as those who were insured [*OR*: 2.31 (1.06, 5.04)]. Participants who were obese were over five times as likely to be undiagnosed as those who were overweight [*OR*: 5.51 (2.05, 14.79)] (Table 3).

DISCUSSION

This study documented the proportion of individuals with potentially undiagnosed hypertension and undiagnosed T2D among a sample of overweight/obese Marshallese adults. The results show a high proportion of undiagnosed hypertension and undiagnosed T2D among participants in this study. Among all participants, 42.4% had undiagnosed hypertension, and 14.6% had undiagnosed T2D. Of those with blood pressures indicative of hypertension, 68.4% were previously undiagnosed. Of those with HbA1c readings indicative of T2D, 31.6% were previously undiagnosed. Relative to national averages of undiagnosed hypertension and undiagnosed T2D in other minority groups, prevalence of undiagnosed hypertension and undiagnosed T2D are strikingly high-

Table 2. Hypertension and type 2 diabetes status of participants enrolled in a Diabetes Prevention Program trial, *N*=378.

Participant Characteristics	*n* (%)
Hypertension (baseline biometric) (n=377)	235 (62.3)
Previous Hypertension Diagnosis (n=375)	
Yes*	85 (22.7)
No	290 (77.3)
Hypertension Status (n=234)	
Undiagnosed	160 (68.4)
Diagnosed*	74 (31.6)
Type 2 Diabetes (baseline biometric) (n=378)	182 (48.2)
Previous Type 2 Diabetes Diagnosis (n=369)	
Yes†	127 (34.4)
No	242 (65.6)
Type 2 Diabetes Status (n=174)	
Undiagnosed	55 (31.6)
Diagnosed†	119 (68.4)

Note: numbers of participants are noted where data are missing; Percentages may not total 100 due to rounding; *Eleven participants indicated a previous diagnosis of hypertension; however, they did not have blood pressure readings indicative of hypertension at the time of data collection; †Eight 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.

er among the Marshallese [17]. Moreover, among those with both blood pressure readings indicative of hypertension and HbA1c readings indicative of T2D, 24.5% of the participants had undiagnosed hypertension and undiagnosed T2D simultaneously.

Younger age was associated with a higher prevalence of undiagnosed hypertension and undiagnosed T2D among the Marshallese participants. Prior studies of minority populations in the US and other global populations show similar correlations between younger age and undiagnosed hypertension and T2D [11,12,23]. These findings could be due to bias among younger participants, who may believe they are less susceptible to chronic diseases like hypertension and T2D. Men also showed greater prevalence of undiagnosed hypertension relative to women in this study. This finding is consistent with published data demonstrating men have higher rates of undiagnosed hypertension [11,24-27]. This finding suggests that increased outreach to encourage regular health screenings among Marshallese men is needed, particularly among those who are overweight or obese.

The mean blood pressure, both SBP and DBP, for those with undiagnosed hypertension was lower than those with diagnosed hypertension. Similarly, HbA1c among those with undiagnosed T2D was lower than those with diagnosed T2D (8.3% compared to 10.6%). This finding suggests that these issues have developed more recently and demonstrates an important opportunity to intervene before participants' chronic condition worsens. Early detection of these diseases has the potential to significantly improve individual and population health and decrease overall morbidity and mortality rates [28,29].

Individuals with undiagnosed T2D reported a lower prevalence of forgone healthcare than those who had received a previous diagnosis of T2D. While this finding was surprising, those with a previous diagnosis may be more likely to be aware of the need to go to the doctor and to report a time in the past 12 months when they needed to see a doctor, but could not because of cost. Insurance status was associated with T2D, with uninsured participants more than twice as likely to be undiagnosed as those who were insured. This finding is consistent with prior literature, which has shown a lack of health insurance to be associated with undiagnosed T2D in other populations [30,31]. Insurance status was not associated with hypertension diagnosis status. This finding contradicts prior studies which have shown that insurance status was associated with a lower prevalence of undiagnosed hypertension [11].

Finally, the current study found participants who were obese were significantly more likely to have undiagnosed T2D than those who were overweight. Obesity is one of the leading risk factors for T2D; therefore, it would be expected that obese individuals would be screened for T2D and be more likely to have a diagnosis. A longitudinal population-based study conducted in

Table 3. Logistic regression of hypertension and type 2 diabetes status and age group, sex, forgone health care, and health insurance.

	Undiagnosed Hypertension		Undiagnosed Type 2 Diabetes	
Measure	*OR (95%CI)*	*p*	*OR (95%CI)*	*p*
Age Group†				
18-34	18.32 (5.79,58.04)	**<0.0001**	5.50 (1.54,19.58)	**0.009**
35-54	4.943 (2.30,10.63)	**<0.0001**	3.29 (1.20,9.01)	**0.021**
55+ (ref)	—		—	
Sex				
Male	2.10 (1.08,4.07)	**0.028**	1.37 (0.64,2.91)	0.416
Female (ref)	—		—	
Forgone Health Care				
Yes	0.58 (0.29,1.13)	0.106	0.39 (0.18,0.85)	**0.018**
No (ref)	—		—	
Health Insurance				
No	1.05 (0.52,2.13)	0.901	2.31 (1.06,5.04)	**0.035**
Yes (ref)	—		—	
Body Mass Index				
Obese	1.04 (0.48,2.25)	0.919	5.51 (2.05,14.79)	**0.001**
Overweight (ref)	—		—	

Note: OR=odds ratio; CI=confidence interval; ref=reference group. "Health Insurance Coverage" includes any type of health insurance; "Forgone health care" was assessed with the survey item: "Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?"; Bold *p*-values indicate statistical significance; †A follow up comparison was made between young and middle-aged adults (18-34 vs. 35-54) on undiagnosed hypertension and undiagnosed type 2 diabetes; Young adults were found to have over three times the odds of having undiagnosed hypertension [*OR*: 3.70 (1.33,10.30), *p*=0.012], but had statistically equal odds of having undiagnosed type 2 diabetes [*OR*: 1.67 (0.61,4.95), *p*=0.319].

the US found large increases in diagnosed T2D and large decreases in undiagnosed T2D, specifically among those with BMI ≥35 [32]. Another study of obesity and undiagnosed T2D in the US found no differences in diagnosis status by BMI, with similar odds of having undiagnosed T2D across all BMI categories [33].

The mixed findings regarding health care access, obesity, and undiagnosed hypertension and T2D points to multiple factors influencing diagnosis among the Marshallese participants. Prior studies with the Marshallese community suggest that language barriers, lack of understanding of how to navigate the US healthcare system, and perceptions of stigma may serve as the primary barriers to proper diagnosis and treatment of health conditions [34-37]. The decades-long exclusion of Marshallese migrants from federal health care programs such as Medicaid has also been a significant barrier to care for this at-risk population [38], as further evidenced by the extremely high number of uninsured individuals in this study. However, Medicaid coverage was reinstated as part of the COVID-19 relief and omnibus spending bill passed and signed into law in December 2020 [39]. Future research will be needed to examine to what extent the reinstatement of Medicaid eligibility improves insurance coverage, as well as healthcare seeking behaviors, among Marshallese in Arkansas and other parts of the US.

Limitations

These study results should be examined in light of some limitations. First, many of the measures assessed in this study were collected via self-report, which can result in biased answers. Second, the data and associations presented are cross-sectional in nature. Third, the study sample is a purposive sample consisting solely of overweight and obese Marshallese adults residing in Arkansas or Oklahoma with no control or comparator group. Fourth, the study used the definition of hypertension established by the American College of Cardiology and American Heart Association in 2018 (SBP≥130 or DBP≥80) [20], which complicates comparisons to past studies which used SBP≥140 or DBP≥90 as criteria for defining hypertension. Finally, it is not recommended to make a diagnosis of hypertension during a single visit even when using multiple readings; rather, multiple readings should be taken on two or three separate occasions [40]. Therefore, the results and conclusions presented here may not

be generalizable to other NHPI or other racial/ethnic minority populations and other geographic locations.

CONCLUSION

This study documents the high prevalence of undiagnosed hypertension and undiagnosed T2D among an underserved population with health disparities. These results are useful for researchers and health care providers working to address hypertension and T2D among Marshallese and other NHPI populations. The results of this study make clear that preventive interventions for both hypertension and T2D should be prioritized by those working with these communities. The findings also illustrate the importance of raising general awareness and improving the early detection of chronic diseases among this at-risk population. Research and programmatic efforts to improve knowledge and prevention of chronic diseases in NHPI communities should take into account the distinct features of each community [41].

Author Contributions: PM: Conceptualization, Writing – Original draft preparation, Funding acquisition. AS: Conceptualization, Writing – Original draft preparation, Methodology, Formal analysis, Data curation. HC: Writing – Original draft preparation. BR: Writing – Original draft preparation, methodology. CL: Conceptualization, Writing – Reviewing and Editing, Methodology. NN: Writing – Reviewing and Editing. MC: Writing – Reviewing and Editing. JP: Writing – Reviewing and Editing. LKH-D: Writing – Reviewing and Editing. JS: Writing – Reviewing and Editing, Validation.

Acknowledgments: Community engagement efforts were supported by the UAMS Translational Research Institute funding through the United States National Institutes of Health (NIH) National Center for Research Resources and National Center for Advancing Translational Sciences (1U54TR001629-01A1). Funding for the Diabetes Prevention Program trial was provided through a Patient-Centered Outcomes Research Institute (PCORI) award (AD-1603-34602). The content presented in this publication is solely the responsibility of the authors and does not necessarily represent the official views of NIH or PCORI. The project was made possible because of the existing community-based participatory research partnership with local Marshallese faith-based leaders, the Arkansas Coalition of Marshallese, the Marshallese Education Initiative, and the Marshallese Consulate General in Springdale, Arkansas.

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