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ABSTRACT:

The objective of this study was to quantify the cost and availability barriers to obtaining healthy foodstuffs in the Republic of the Marshall Islands (RMI). A validated food environment survey procedure was adopted to assess the cost and availability of healthy foods in the larger, but more difficult to access grocery stores, compared to smaller, but more easily accessible, convenience stores in the RMI. Stores were scored based on food availability, price, and quality. Availability score of healthy foods in grocery stores was much higher than in convenience stores (15.6 vs 2.9). Grocery stores also tended to have fresher produce (quality score = 6.7 vs 1.2), but they generally had a higher cost score (price score = -1.1 vs -0.2). Furthermore, healthy alternatives to commonly purchased staples of the RMI diet were limited and trended towards being more costly in all stores surveyed. Grocery stores in the RMI scored substantially lower than stores in economically disadvantaged areas of the United States. In the RMI, there are significant barriers of access and cost to healthy diets. This makes it difficult for average Marshallese families to make alterations to their eating habits, even with educational and community outreach efforts.

KEYWORDS: Diabetes Mellitus Type 2, Marshall Islands, Environment and Public Health

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INTRODUCTION:

The Republic of the Marshall Islands (RMI) is a series of atolls located in the western Pacific Ocean. Though spread out over an area larger than the state of Alaska, the actual land mass of the RMI is approximately the size of Washington DC [1]. Since its formal independence from the United States in 1986, rates of obesity and diabetes in the RMI have been on the rise. In 1998, adult obesity rates (BMI \geq 30) were over 25% [2]. By 2002, rates of obesity had risen to 45%, with total overweight incidence (BMI \geq 25) of more than 80% [3]. These increases in BMI have driven up the rates of many chronic illnesses, including type 2 diabetes mellitus. Though a widely distributed population with poor medical access makes the exact rates hard to quantify, a 2010 study estimates that 41% of the adult population (age 25-64) has diabetes [4]. Because of the chronic nature of the disease, this represents a significant and ongoing cost to the government. Additionally, it is the leading cause of death in this population, and the death rate due to diabetes is the highest in the entire Pacific region [4].

From 1958 to 1999, the RMI population has grown from 14,163 to 50,848 [5, 6]. Fish has historically been the staple of the Marshallese diet, supplemented by fruits and vegetables like coconut and pandanus. However, rapid population growth in the face of limited land, a desire for Western lifestyles, and readily

available imports has resulted in a shift away from this diet. Today, most of the food consumed by the Marshallese people is imported [7]. At the same time, the RMI's remote location means that fresh fruits and vegetables must be air-freighted in, driving up their cost [8]. This is further compounded by high rates of poverty and unemployment [9]; the average wage in the RMI is \$2.57 in the private sector (92% of the workforce), and on average 1.8 wage earners support 9.5 members per household [10]. As a result, household foods are limited and canned or dried goods are the staples of today's high fat, low fiber Pacific Islander diet [11]. One 2002 study determined that 91% of the RMI population did not meet the suggested five fruits and vegetables per day [4], compared to 53% in the US [12]. In the more urban areas of Majuro and Ebeye, where most Marshallese people live, this lifestyle is especially prevalent [9]. To date, there has been little effort to quantify the nutritional environment in the RMI capitol of Majuro. This study aims to examine intrinsic barriers to eating a more nutritious diet by systematically surveying the availability and cost of the most commonly purchased Marshallese foods, as well as some available healthy alternatives.

MATERIALS AND METHODS:

Availability, price and quality of food choices were assessed using The University of

Pennsylvania's Nutrition Environment Measures Survey (NEMS), a validated standardized observational study originally based in Atlanta, GA. It rates convenience and grocery stores on availability, price, and quality, which can then give a general score. The original compiled score had a possible range of -8 to 50, with surveyed Atlanta grocery stores scoring a mean of 22.58 (52.3% of total possible points) and convenience stores scoring a mean of 5.85 (23.8%). For this study, the NEMS survey was adapted to the RMI using guidelines provided in NEMS training modules [13].

Fruits and vegetables used in the original NEMS which were unlikely to be available in the RMI, such as grapes, pears, and cucumbers, were substituted for locally available produce, such as papaya, coconut, and breadfruit, as suggested by the NEMS module. Unavailable packaged foods were removed from the survey and replaced with local items.

All data was gathered from downtown Majuro, the capital city of the RMI, which has the most access to food options in the country with 136 convenience stores and 7 grocery stores. All grocery stores, defined as large walk-in stores with a hired staff selling primarily foodstuffs organized into aisles, were surveyed by a trained rater. The convenience stores were divided into two types: walk-up and walk-in. The walk-in stores were typically larger than

the walk-up stores and sold a wider variety of foods but were still much smaller than grocery stores. The walk-up stores had no place for customers to enter, with only a window through which to order. This distinction between walk-up and walk-in stores was made to avoid sampling bias when randomly selecting convenience stores to analyze. These convenience stores were counted, mapped, and numbered. Two walk-up convenience stores and two walk-in convenience stores from each neighborhood were randomly selected and surveyed.

Three raters underwent a 20-hour online training course for NEMS provided by the University of Pennsylvania. Inter-rater reliability was tested using a randomly selected grocery store, a walk-in convenience store, and a walk-up convenience store, each evaluated by all three raters. Inter-rater reliability was calculated by dividing the points assigned to a store by each rater by the total possible points and comparing the results of each rater. These are reported as the range of inter-rater reliability across the three stores analyzed.

Analysis was performed using the NEMS scoring system, which scores stores based on availability and quality of fresh produce as well as cost of healthy versus unhealthy items. A separate price analysis was also done on the healthy versus unhealthy options found at grocery stores. The comparisons made were:

chicken legs versus boneless skinless chicken breast; regular canned luncheon meat versus light canned luncheon meat; tuna canned in oil versus tuna canned in water; white versus wheat bakery bread and sliced bread; white rice versus brown rice; white flour versus wheat flour; full-fat mayonnaise versus light or fat-free mayonnaise; regular soy sauce versus low sodium soy sauce; solid shortening versus vegetable oil; regular soda versus diet soda; artificial juice drink versus 100% juice; regular chips versus lower fat chips; and donuts compared to oatmeal. The average price differences between these foods were calculated, and discrepancies in healthy food availability were identified. Because the original NEMS-S scoring scale had been changed to reflect Marshallese diets, scores of stores in Atlanta were converted to the RMI scale for comparison; the percentage scored by each store in Atlanta was multiplied by the maximum of 89 points possible in the Marshallese scoring system. This converted score was then used to compare the overall food environment of Atlanta stores to the RMI scores. To analyze the compiled mean scores of grocery stores versus convenience stores, IBM's Statistical Package for the Social Sciences (SPSS) was used to calculate independent sample T-tests for the scores.

RESULTS:

Inter-rater reliability was 95-98% when analyzing the NEMS scores for each store,

indicating low overall variability. Our inter-rater reliability scores were within the 92-100% range that the original published NEMS research stated [13]. Grocery stores had a mean score of 27.3 ± 6.5 while convenience stores scored a mean of 5.15 ± 1.4 . The grocery stores had a mean difference of 22.1 ± 3.40 more points than convenience stores, scoring significantly higher than convenience stores ($p < 0.001$). In general, all grocery stores scored higher than convenience stores (Figure 1).

The stores were scored based on availability and quality of produce and healthy items like beans and fresh fish, and the availability and cost of healthy alternatives, such as wheat flour and brown rice. When scores were broken down by price, availability and quality, convenience stores underperformed in both availability and quality (Table 1); though they were nearly equivalent with grocery stores in price. Availability of fresh fruits and vegetables in grocery and convenience stores was low. Only 40.7% of stores sold oranges, the most commonly available fruit, and only 29.6% of stores had cabbage, the most commonly available vegetable; 22.2% of stores had dried beans and 25.9% of stores had fresh fish available. For healthy alternatives, 11.1% of stores had a healthier version of canned luncheon meat, such as Turkey canned luncheon meat, while 96.3% had regular canned luncheon meat; 18.5% of stores had

tuna canned in water, while 92.6% had tuna canned in oil; 14.8% of stores had brown rice compared to 77.8% with white rice; and 29.6%

of stores had a low-fat version of mayonnaise compared to 85.2% with regular mayonnaise (Table 2).

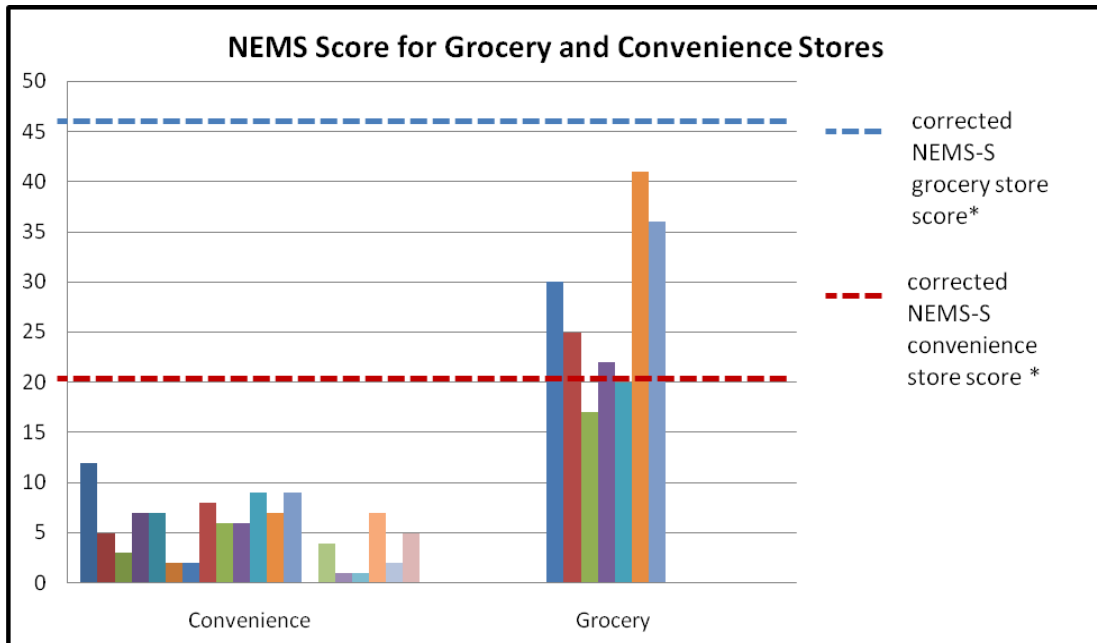


Fig 1: NEMS Score for Grocery and Convenience Stores. Scores are out of a total 89 possible points. The scoring system awards points based on availability and quality of produce and healthy packaged options, as well as whether healthy alternatives are less expensive than unhealthy alternatives. An ideal store would score close to 89 points, signifying the availability and affordability of high quality healthy foods. Stores that earn few points have little healthy food available and the foods that are present are either more expensive than an unhealthy alternative or of poor quality, as defined by >50% of the foods spoiled. All of the grocery stores scored higher than the convenience stores. *NEMS-S scores were converted to reflect a change in total points available by multiplying the percentage scored with the maximum of 89 points possible

Table 1: Scores of grocery versus convenience stores by category

Average points earned by grocery stores and convenience stores			
	Point Range	Grocery Stores (n = 7)	Convenience stores (n = 20)
Availability	0 to 30	15.6 (52.0%)	2.9 (9.7%)
Price	-16 to 32	-1.1 (31.0%)	-0.2 (32.9%)
Quality	0 to 9	6.7 (74.4%)	1.2 (13.3%)

Scores of grocery versus convenience stores by category; Price scores can be negative because stores lose a point when healthy alternatives are more expensive. To calculate a percentage scored on price, we added 16 to the score and divided it by a total of 48 so as to assess the price out of total theoretical points possible. However, because stores gain a point for stocking a healthy option, total number of points can never be negative.

Table 2: Percentage of the 27 stores analyzed

Type of Foodstuffs	Stores with Healthy Choice (n = 27)	Stores with Unhealthy Choice (n = 27)
1) Milk	5 (18.5%)	8 (39.6%)
2) Fruit		
• Apples	10 (37.0%)	
• Oranges	11 (40.7%)	
• Banana	6 (22.2%)	
• Papaya	2 (7.4%)	
• Marshallese Apple	0 (0.0%)	
• Ni	3 (11.1%)	
• Watermelon	1 (3.7%)	
3) Vegetables		
• Sweet Potatoes	1 (3.7%)	
• Cabbage	8 (29.6%)	
• Squash	0 (0.0%)	
• Breadfruit	1 (3.7%)	
• Eggplant	0 (0.0%)	
• Taro	1 (3.7%)	
• Corn	3 (11.1%)	
• Tomatoes	5 (18.5%)	
• Carrots	6 (22.2%)	
• Fresh Beans	0 (0.0%)	
4) Dried Beans	6 (22.2%)	
5) Fresh Fish	7 (25.9%)	
6) Chicken	3 (11.1%)	13 (48.1%)
7) Spam	3 (11.1%)	26 (96.3%)
8) Tuna	5 (18.5%)	25 (92.6%)
9) Baked Bread	2 (7.4%)	11 (40.7%)
10) Starches		
• Rice	4 (14.8%)	21 (77.8%)
• Flour	2 (7.4%)	16 (59.3%)
11) Condiments		
• Ketchup	0 (0.0%)	27 (100.0%)
• Mayo	8 (29.6%)	23 (85.2%)
• Soy Sauce	5 (18.5%)	26 (96.3%)
• Oil/Shortening	26 (96.3%)	21 (77.8%)
12) Beverages		
• Soda	21 (77.8%)	27 (100.0%)
• Juice	8 (29.6%)	20 (74.1%)
13) Bread	1 (3.7%)	4 (14.8%)
14) Chips	3 (11.1%)	22 (81.5%)
15) Donuts/Oatmeal	6 (22.2%)	8 (29.6%)
16) Take Out Meal	1 (3.7%)	8 (29.6%)

Percentage represents the number of stores that carried the food item out of the 27 stores analyzed. For example, 5 out of 27 stores (19%) had a low fat milk option, while 8 out 27 stores (30%) carried full-fat milk.

Table 3: Price difference between healthy and unhealthy alternatives at each grocery store

Food types:	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Mean Difference	Confidence Interval
Chicken	n/a	0.95	n/a	n/a	n/a	2.44	2.8	2.06*	0.95 to 3.17
Spam	n/a	-0.2	n/a	n/a	n/a	0.06	0.04	-0.03	-0.20 to 0.13
Tuna	0.1	0.02	0.17	n/a	n/a	0.12	0.03	0.09	0.03 to 0.14
Rice	n/a	n/a	1.89	n/a	n/a	0.14	-0.12	0.64	-0.60 to 1.87
Flour	n/a	n/a	n/a	n/a	n/a	0.4	0.5	0.45*	0.35 to 0.55
Mayo	-0.09	n/a	-0.1	n/a	-0.1	0.02	0.02	-0.05	-0.11 to 0.01
Soy Sauce	0.02	0	n/a	0.06	n/a	0.26	0.28	0.12*	0.01 to 0.24
Shortening/ Oil	0	0.01	0.02	-0.01	0	0.04	-0.04	0.00	-0.02 to 0.02
Juice	-0.01	-0.1	0.08	-0.04	-0.03	-0.11	0.03	-0.03	-0.08 to 0.02
Chips	n/a	n/a	n/a	n/a	n/a	-0.01	-0.31	-0.16	-0.45 to 0.13
Oatmeal / donuts	n/a	n/a	n/a	n/a	n/a	0.12	-0.53	-0.21	-0.84 to 0.43

N/A indicates that a healthy alternative to the item was not available. Chicken is priced per pound. Bread is priced per loaf. Oatmeal, donuts are priced per serving. The other measures are priced per ounce. *Healthy item significantly more expensive than less healthy alternative

Because convenience stores had such limited availability of healthy alternatives, only grocery stores were subjected to additional price analysis of healthy vs. unhealthy products. Four healthy food items showed statistically significant higher prices when compared to their unhealthy counterparts: boneless/skinless chicken breast (\$2.06 more expensive per ounce; 95% CI: \$0.95-3.17), tuna in water (\$0.09 more expensive per ounce; 95% CI: \$0.03-0.14), whole wheat flour (\$0.45 more expensive per ounce; 95% CI: \$0.35-0.55), and low sodium soy sauce (\$0.12 more expensive per ounce; 95% CI: \$0.01 to 0.24). No healthy options were significantly less expensive than their unhealthy counterparts (Table 3).

DISCUSSION:

Despite recognition that type 2 diabetes is the leading cause of death in the RMI, no objective studies measuring food availability and price in the capital island of Majuro were found on literature search. By clarifying which healthy foods are available and comparable in price to traditional foods, this information could prove valuable in guiding educational programs and lifestyle intervention efforts. Furthermore, an understanding of the state and limitations of the current food environment could help elucidate the factors impacting high obesity and diabetes rates in the RMI.

Diets high in saturated and trans-fats, sugars, and refined grains but low in fiber have been linked to the development of obesity, which is a

major risk factor in type 2 diabetes [14, 15]. Unfortunately, much of the current Marshallese diet is made up of these foods. White rice, white flour, canned luncheon meat, and ramen noodles are now among the most commonly purchased foods [10], largely replacing fresh fish, coconuts, breadfruit, and bananas. There are several reasons for this shift, including the convenience of packaged food, population growth causing decreased land area for agriculture, and a taste preference for salt and sugar without knowledge of the dangers of overconsumption. In recent years there has been an effort to increase awareness of food choices and obesity as causes of type 2 diabetes [16]. However, there are still many barriers to accessing healthier foods in the food environment.

This study shows these barriers include availability, quality, and price of healthy foods at both grocery stores and convenience stores. Convenience stores, the most numerous type of store available, performed significantly worse than their more expensive, less accessible counterparts. While grocery stores had significantly higher NEMS scores than convenience stores, even these venues compared poorly to American cities. Their overall NEMS score of 27.3 points or 31%, as well as the percentages of healthy foods available shown in Table 2, reflects an overall nutritionally poor food environment. In comparison, urban Atlanta stores selected

because of "evidence of socioeconomic disparities in nutrition environments" scored at an average of 53% [13]. Also, a NEMS survey of grocery stores in Little Rock, Arkansas and Burlington, Vermont, had average availability score of 93% (27.9/30), average quality score of 100% (6/6), and average price score of 13% (2.4/18) [17]. In comparison, grocery stores in the RMI scored 52% (15.6/30), 74% (6.7/9) and 31% (14.9/48) for availability, quality and price respectively, scoring lower in both availability and quality. Though the price score was higher in the RMI, this is likely an artifact of how stores are scored. Stores which have more expensive healthy alternatives lose a point for price, but stores which lack the healthy alternative simply do not gain a point. As a result, stores that have limited healthy alternatives, as in the RMI, can have comparatively better price scores. The lower availability of healthy food alternatives in convenience stores compared to grocery stores is a major barrier to healthy food choices. Grocery stores are also farther away than neighborhood convenience stores and usually necessitate a taxi ride. In addition, many outer islands only have convenience stores available.

Even at grocery stores, where availability of food tends to be better, price can be a limiting factor. Chicken legs, tuna canned in oil, white flour, and soy sauce, were shown to be cheaper than their healthy alternative. Two of these, chicken legs and white flour, are known to be in the top five most commonly purchased

foods in the modern Marshallese diet [10]. These staples are high in fat and sugar, respectively, and low in nutritional value. Many other commonly eaten Marshallese foods, such as white rice and canned luncheon meat, were not shown to have a significant difference when compared to healthy alternatives, potentially because low availability of healthy alternatives creates a small sample size.

One possible limitation to this study is that the compiled data came from a randomly selected cross section of small stores on one island in the RMI. Due to the large number of convenience-type stores, and only three trained raters, it was not feasible to rate them all. The sample stores were selected randomly to avoid sampling bias but some bias could still exist given the small sample size. There was also no objective data collected on the alternative food suppliers on island, such as community gardens. However, it has been documented that the majority of foods bought by the average Marshallese citizen are imported packaged foods [10] therefore the contribution to food purchases from a garden is likely minimal at the time of this study.

It is well established that changes in community-wide behavior follow changes to the environment that support this new behavior [18]. The need for these efforts is beginning to be recognized in the RMI as well, and there are several initiatives taking steps to achieve this. The Diabetes Wellness Center, funded through a grant by the US Department of Defense,

enrolls groups of Marshallese adults for three-month long intensive educational, exercise, and nutritional workshops with impressive results. The center also serves a high fiber vegetarian breakfast and lunch daily, has a gym open for membership, and offers free clippings from their garden to members of the community to start their own plots; however, most of the Center's services are too expensive for the average Marshallese citizen, which limits its use. The government-run Ministry of Health has started programs targeting churches as venues for raising awareness about diabetes risk factors and encouraging healthy choices. A moderate-scale Taiwan-sponsored garden in a more remote part of the island has had success growing crops once thought to be unsustainable in the salty climate. Gardening efforts have also begun on less settled outer islands. Unfortunately, these efforts are often limited by grant funding, or are in developmental stages. Gardening is especially difficult because fertile land is scarce and there are few trained gardeners.

Some independent business owners have recognized the need for healthier foods in the RMI and have begun importing inexpensive dried goods such as beans and lentils. However, the purchase of these foods is low, especially among the native Marshallese. This could be attributed to the fact that the Marshallese people are unfamiliar with the foods and are unsure how to prepare them, indicating the need for food education. To this

end, school-based initiatives are underway to improve the nutrition of school lunches and make diabetes education a component of the curriculum for all grades, a method proven to be effective in other high-risk communities, but not yet in effect in the RMI [19, 20]. With education about diabetes, nutrition, and exercise starting at younger ages, there is hope that the development of diabetes as a lifelong illness can be prevented in future generations. However, education and access to healthy, affordable foods must increase in tandem in order for the population to be able to put these lessons into action.

While these initiatives are each having an impact on the sub-populations that they serve, there is still a lack of government supported, nation-wide efforts to make healthy foods more accessible to the Marshallese people. Prevention efforts are challenging for any government, especially one with scarce resources and a high active disease burden to address. The identification of specific barriers to access in this survey could help support the design and implementation of targeted interventions by the government, such as subsidizing costs of healthy food alternatives, encouraging importation and sale of these alternatives in all stores, and expanding gardening efforts. This will take an initial investment, but focused interventions directed at these major barriers to health would result in dramatic savings in healthcare costs.

The impact of preventing, or even delaying, the onset of diabetes in the next generation would be momentous in decreasing morbidity and mortality and decreasing the economic cost to the RMI. Since the rapid shift in lifestyle post-WWII, the RMI has been struggling to improve education, develop industry, and become a self-sustaining country capable of participating in the global economy [16]. These goals have yet to be met, and economic prospects remain bleak as long as so much of their budget must be spent on the increasing numbers of Marshallese people chronically ill with diabetes, while the workforce is depleted by the same disease. Until this epidemic is controlled, the RMI's economy, which is primarily supported by the US, will continue to be dramatically impacted by the disease burden of diabetes. In the meantime, many Marshallese exercise their right to free immigration to the US, with as much as 10% of the Marshallese population living in the US [10] and many having come specifically for healthcare [21]. In addition, Marshallese people living in the US are four to seven times more likely to develop diabetes [21]. Both of these factors increase the burden of care that must be assumed by the US, as a fulfillment of their obligations outlined in the nuclear claims treaty. The US is currently intimately involved both financially and politically in the development of the Marshall Islands and must take an interest in the health status of the population. It is becoming increasingly clear that the Marshallese and US

governments need to act now to address the draining but ultimately preventable disease epidemic of type 2 diabetes in the RMI. Not doing so will result in the slow devastation of an entire nation, and an economic burden on the US with no end in sight.

The results of our study show a food environment that has low availability of healthy alternatives and significant barriers to healthy food in terms of accessibility, price, and quality. Healthy foods were generally more expensive than less healthy alternatives and were not as accessible through the numerous convenience stores throughout the RMI. While the five grocery stores did have a larger selection of healthy foods than convenience stores, these grocery stores had a worse food environment, as defined by selection, quality, and price, than grocery stores located in impoverished urban Atlanta neighborhoods.

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