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An Examination of the Socio-Ecologic Factors Associated with Diabetes Status in Palau

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University of Miami
2016

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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Introduction: Type 2 diabetes accounts for 90% of all diabetes cases worldwide. The epidemic of Type 2 diabetes is particularly severe in Palau, one of the six U.S. Affiliated Pacific Islands (USAPIs). The current study uses data from the 2016 Palau Hybrid Survey to understand the relationship between multiple levels of the Socio-Ecologic Model and two diabetes outcome measures: diabetes status and diabetes diagnosis status. Specifically, the following question was used to guide the current research study: To what extent are socio-ecologic factors associated with diabetes indicators in the Palau Hybrid Survey?

Methods: The Palau Hybrid Survey is a population-based survey conducted from May - December 2016. The survey combined self-reported risk factors with physical and biochemical measurements to determine the risk and prevalence of NCDs. A total of 1671 individuals were included in analyses for the current study. Two multivariate logistic regression models were performed to ascertain the effects of selected variables on the two outcome measures in Palau. Permission to conduct this secondary analysis was sought from the Palau Institutional Review Board in March 2018.

Results: Results of the diabetes regression model suggest that older age, self-rated health fair or poor health, obese BMI, and hypertension are significant predictors of diabetes in Palau. Overall, the model was statistically significant and explained 12.8% (Nagelkerke R^2) of the variance in diabetes ($\chi^2(14)=118.60$, $p <.001$). Results of the diabetes diagnosis regression model suggest that age, gender, ethnicity, sugar sweetened beverage consumption, and annual health exam are significant predictors of diabetes diagnoses in Palau. The model was statistically significant and explained 23.1% of the variance in diabetes diagnosis ($\chi^2(14)=56.65$, $p <.001$).

Discussion: Our data indicate the diabetes prevalence in Palau to be about 20%. Most alarmingly, 65% of diabetics in Palau are undiagnosed. Overall, findings were consistent with previous research, indicating that individuals living in Palau have similar risk factors for diabetes. However, the high percentage of undiagnosed diabetics in Palau is cause for concern. Public health practitioners should encourage the population to visit a primary healthcare provider for diabetes screening and treatment.

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Table of Contents

Chapter 1. Introduction

Background

Non-communicable diseases (NCDs), also referred to as chronic diseases,[1] are slow-progressing and long-lasting illnesses caused by a combination of genetic, physiological, environmental, and behavioral factors.[2] NCDs represent 70% of all deaths globally, killing 40 million people each year.[2] There are four main types of NCDs: cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes. These four categories of NCDs account for over 80% of all premature NCD deaths, constituting a major public health issue worldwide.[2]

Diabetes mellitus (hereby referred to as diabetes) accounts for 1.6 million worldwide NCD deaths annually, with the global prevalence of diabetes steadily rising each year.[2] Diabetes is a chronic, metabolic disease characterized by elevated blood glucose levels, which causes serious damage to the heart, blood vessels, eyes, kidneys, and nerves over time.[2] Type 2 diabetes, the most common form of the illness, occurs primarily in adults when the body becomes resistant to insulin, or cannot produce enough insulin on its own.[2] Type 2 diabetes accounts for 90% of all diabetes cases worldwide, with the greatest burden of type 2 diabetes falling on socially disadvantaged groups and Indigenous peoples.[3,4] Eighty percent of people with diabetes live in low- and middle-income countries and communities, presenting a unique challenge as many of these areas have inadequate resources for diabetes treatment and management.[4] Numerous modifiable behavioral risk factors are associated with a higher risk for type 2 diabetes, including being overweight or obese, not being physically active, and poor dietary habits.[5] Other risk factors for diabetes include having a family history of the illness, having high blood pressure, and being of African American, Alaskan Native, Native American, Asian American, Hispanic/Latino, or Pacific Island descent.[5] Researchers[4,6-8] predict that the global prevalence of diabetes will continue to rise, with an estimated 600 million adults to be affected by the disease by 2035. Decreasing the burden of diabetes remains a global public health priority, with many organizations committed to reducing premature death from NCDs, including diabetes.[4,9]

Regional Context – U.S. Affiliated Pacific Islands

The epidemic of Type 2 diabetes is particularly severe in the six U.S. Affiliated Pacific Islands (USAPIs).[10] The USAPIs consists of three United States territories: American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI); and three independent countries with a Compact of Free Association agreement with the United States: the Republic of Palau, the Federated States of Micronesia (FSM), and the Republic of the Marshall Islands.[11] In 2010, The Pacific Island Health Officers Association (PIHOA) declared[12] a regional emergency due to the growing epidemic of NCDs in the USAPIs. One study[10] attributes the growing prevalence of Type 2 Diabetes to the ongoing transition from traditional ways of life (i.e. communal farming and fishing) to Westernization (i.e. more consumerism with increased reliance on imported convenience foods). Hosey and colleagues[10] also cite the high prevalence of obesity, a common risk factor for type 2 diabetes, as a consequence of the more Westernized Island culture. This transition to Western culture in traditional-living indigenous communities has been referred to as ‘coca-colonization,’ and researchers describe its devastating impact on NCDs.[13] Despite the high burden of diabetes in the region, surveillance data surrounding NCDs are limited.[10] A study[14] of chronic disease surveillance systems in the

USAPIs reported that Guam is the only USAPI jurisdiction with sustained capacity for monitoring and tracking adult health behaviors through the territory's participation in the Behavioral Risk Factor Surveillance System (BRFSS). Researchers also noted concerns with data quality in these jurisdictions, including:

1) Timeliness of data collection, analysis, and reporting,

2) Underreported vital statistics registration data, and

3) Underreported diagnostic or mortality data for USAPI residents who receive medical treatment in the US mainland.[14]

These unique challenges necessitate innovative strategies to strengthen the surveillance infrastructure in USAPI jurisidictions.[14] Hosey and colleagues[14] recommended collaborations among USAPIs governmental organizations, local and regional partnerships, and U.S. and international agencies as an approach to improving chronic disease surveillance in the region. Other studies also recognize the important health problems facing the Pacific Islands region, and urge global researchers and policymakers to prioritize the health of these populations.[15] Chronic disease surveillance provides an important foundation for population health efforts, giving light to important data about health behaviors and risk factors in an area. Improving these systems is a crucial first step to reducing health disparities in the USAPIs.

Community Context – Republic of Palau

The Republic of Palau is a sovereign nation located in the western Pacific Ocean, about 500 miles to the east of the Philippines and to the north of Papua New Guinea.[16] Palau gained sovereignty in 1994, and is in a Compact of Free Association with the United States.[17] The nation consists of over 340 islands, forming the western edge of the

Caroline Islands, an archipelago in the west central Pacific ocean.[16] Only eight islands of Palau are permanently inhabited, with an estimated total population of 21,729.[16,18,19] These islands comprise Palau's 16 states, and contain most of the 189 square miles of land area.[16] About 67% of the population resides in the state of Koror, the most urban area in Palau.[17] Koror State is comprised of three Islands, Koror, Ngerekebegsang, and Malakal.[17] Airai, located on Babeldaob Island, is a "suburb" of Koror and the second most populated state, holding about 15% of the population.[17] Babeldaob Island is the largest island in Palau and encompasses ten states, including Airai and Melekeok, where the capital Ngerulmud is located.[16] Outside of Koror and Airai, the remaining states in Palau are sparsely populated and rural.[17] Figures 1 and 2 provide an overview of Palau in terms of island and state geography.[20]

Palau's healthcare services are supported primarily through the government's Ministry of Health,[17] which provides comprehensive primary and secondary prevention services, as well as limited tertiary services.[17] These services are made available through the 80-bed Belau National Hospital, and Community Health Centers (CHC) of which Palau has six "super" dispensaries and four satellite sites.[17] "Super" dispensaries are visited by a regularly scheduled doctor, while other medical dispensaries are staffed by at least one nurse.[21] The Belau National Hospital and Central CHC is located in Koror State, as well as three private medical clinics, and one private dental clinic.[17] Babeldaob Island has five medical facilities: Eastern CHC (Melekeok State), North CHC (Ngarchelong State), West CHC (Ngaremlengui State), CHC (Airai State), and Camp Katuu Military Medical Clinic (Airai State).[17] The South CHC is located in Peleliu State, and only accessible by boat.[17,21] Lastly, a satellite dispensary is located in each of the following states: Angaur, Kayangel, Sonsorol, and Hatohbei (the Southwest Islands).[17]

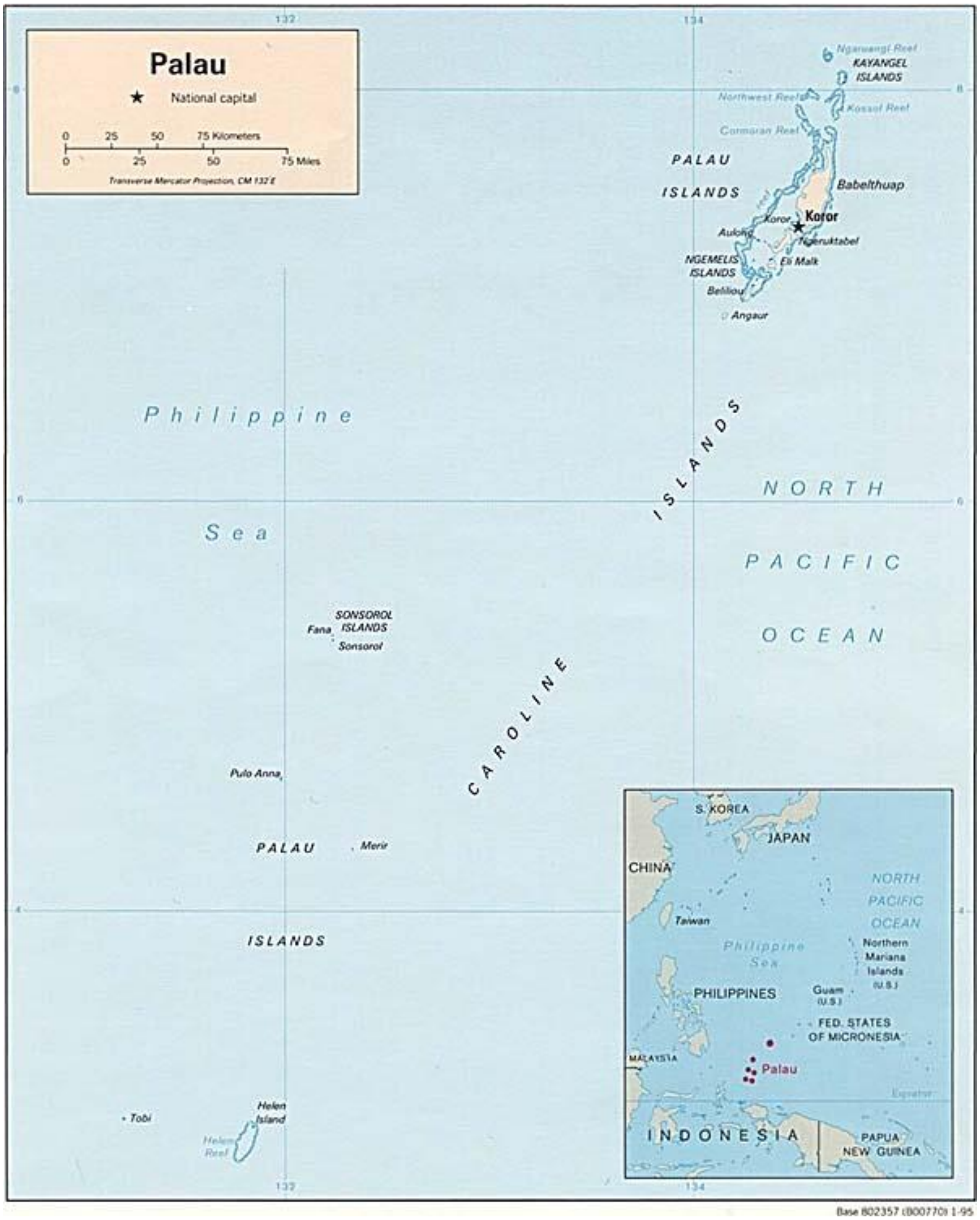

Figure 1. Map of Palau Islands. Retrieved from Perry-Castañeda Library Map Collection, University of Texas at Austin.[20]

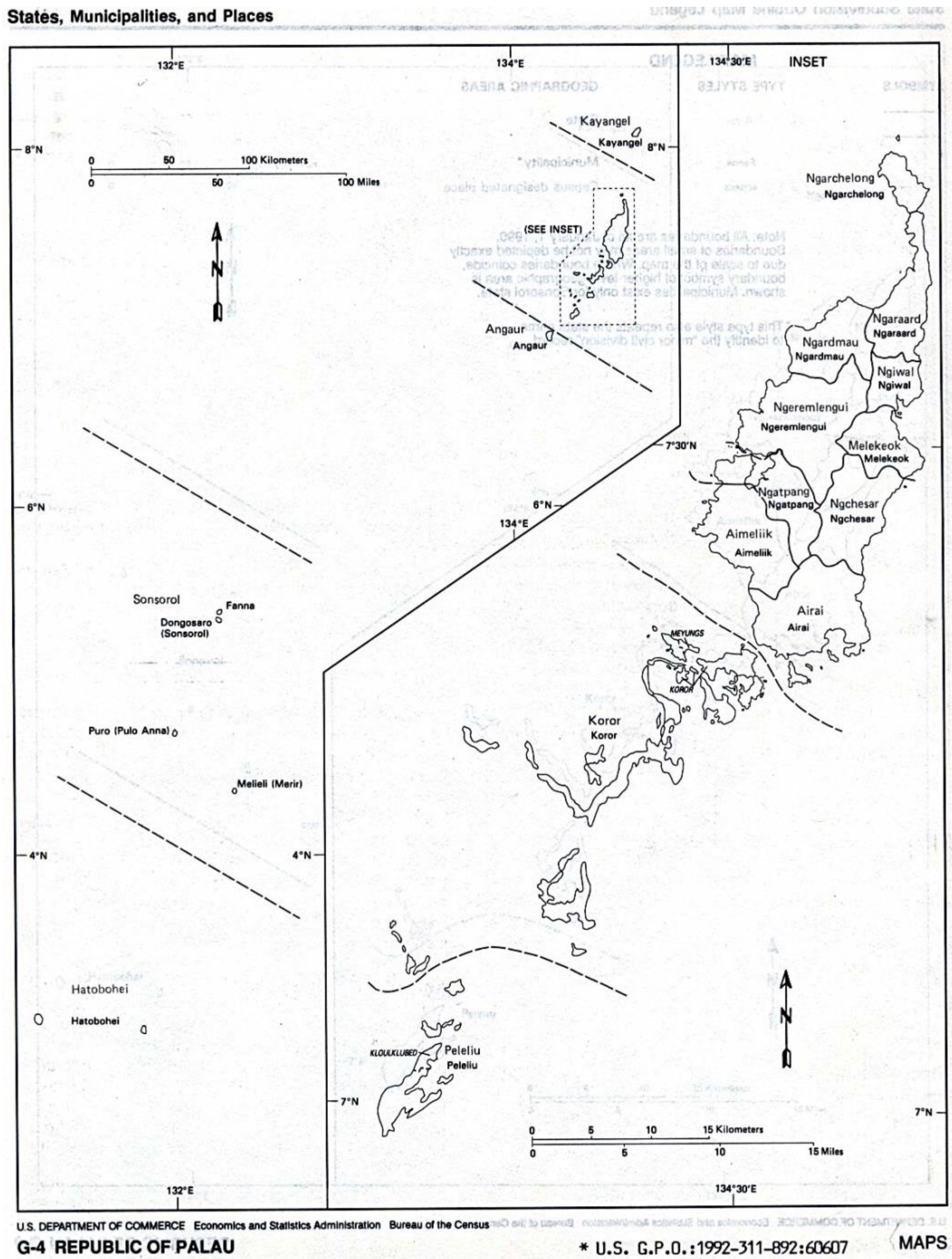

Figure 2. Map of Palau states. Retrieved from Perry-Castañeda Library Map Collection, University of Texas at Austin.[20]

Patients are able to request diabetes screening services during their regular clinic visits.[16] Screening and diagnosis testing available on-island include: fasting and random blood sugar, 2-hour glucose tolerance test, HbA1c, triglyceride, total cholesterol (not HDL or LDL), creatinine, and uric acid.[16] These services are also provided during health fairs and community events.[16] However, details regarding the frequency and location of these events were unavailable. For diabetes treatment and management, Palau has a Diabetes Clinic based on the Health Disparities Collaborative (HDC) model.[16] This model uses a team of health professionals (i.e. physicians, nurses, data staff, and senior administrators) to provide comprehensive care for patients with diabetes.[16,22] Additionally, the HDC model emphasizes the principles of diabetes self-management through community resources in order to fully meet the needs of patients.[16] An evaluation of this collaborative model reports clinically significant reductions in HbA1c, as well as overall improvements to diabetes self-management goal setting and support.[22]

Following PIHOA's 2010 declaration,[23] the President of Palau similarly announced[24] a state of emergency on NCDs in 2011, calling for immediate action to reduce and eliminate the prevalence of NCDs in the country. Palau's most recent mortality data indicates that NCDs account for 64.2% of all deaths in the nation.[17] Cardiovascular disease was the leading cause of death (29.6%), followed by cancer (17.9%), injury (13.0%), and diabetes (11.7%).[17] Data from the 2013 WHO STEPwise Approach to Risk Factor Surveillance Survey (STEPS) indicated that 18% of adults aged 25-64 currently have diabetes.[25] Research also indicated that 40% of the population has prediabetes and is at high risk for developing the disease.[25] These findings suggests that it may only be a matter of time before a significant proportion of those with prediabetes develop overt diabetes.[25] Thus, routine surveillance for risk factors and disease prevalence is necessary to manage the burden of diabetes in Palau. Additionally, the

STEPs Survey did not have data on detailed dietary history including fruit and vegetable consumption, alcohol consumption, and physical activity levels.[25] These behavioral risk factors are extremely important to understanding the predictors of diabetes in Palau. Research suggests that particular genotypes associated with obesity were overrepresented in Palauans compared with Asian populations.[26] Findings from other studies reported that Pacific countries were more tolerant of obesity, and did not have a negative perception of larger bodies. This suggests that traditional values surrounding body image also may be contributing to chronic disease risk factors in Palau.[27,28] Overall, the literature surrounding chronic disease risk factors, prevalence, and management in Palau is limited. Furthermore, diabetes is a chronic disease that is highly preventable and manageable, but sadly represents a significant portion of disability and years of life lost. With the growing epidemic of chronic disease, a more thorough understanding of diabetes and its associated risk factors in this population is warranted.

Justification of Current Project

The current study uses data from the 2016 Palau Hybrid Survey, a novel population-based household survey that combined NCDs and associated risk factors, substance use, and mental health indicators from May – December 2016. The Hybrid Survey was implemented through collaboration between the Palau Ministry of Health, CDC, Substance Abuse and Mental Health Services Administration (SAMHSA), and WHO. Survey methodology was designed to assess the SAMHSA, National Outcome Measures (NOMs), CDC, and WHO risk factor indicators. Detailed descriptions of the study methods are available in Chapter 3. The current study provides important epidemiologic surveillance for Palau by surveying behavioral risk factors (i.e. fruit and vegetable consumption, physical activity levels, substance use) with physical and biochemical measurements (height, weight, fasting blood glucose, cholesterol, blood pressure) to adequately assess the burden of NCDs. Study findings will provide a better understanding of the risk factors influencing diabetes in this Pacific Island nation, allowing researchers to develop future studies and interventions to alleviate the burden of diabetes in this population. With previous findings[25] indicating that a high number of Palauans currently have prediabetes, this project will give further insight into the epidemiologic trends of diabetes in this country. As diabetes remains a growing global public health problem, the Hybrid Survey data will provide important insight on how to move forward with diabetes prevention activities in Palau.

Socio-Ecologic Model

The Socio-Ecologic Model (SEM) is a useful framework for understanding the multilevel influences of a phenomenon. In this model, the outcome of interest is determined by:

1. Intrapersonal factors, including characteristics of the individual such as knowledge, attitudes, and self-concept.
2. Interpersonal processes and primary groups, including formal and informal social networks such as family and friendship networks.
3. Institutional factors including social institutions with organizational characteristics.
4. Community factors including relationships among organizations, institutions, and informal networks.
5. Public policy including local, state, and national laws.[29]

Previous research applies SEM to other chronic disease risk factors in ethnically diverse samples, including some in Pacific Island Nations.[30-32] However, levels of SEM have not been explored within the socio-ecological context of diabetes in Palau. The current study seeks to investigate the factors associated with diabetes in Palau, using SEM as a guiding framework. As shown in Figure 1, the study will focus in detail on the intrapersonal-, institutional-, and community-level influences of diabetes in Palau. Interpersonal- and policy-level influences will not be explored in the current study due to the limited number of these variables available for analysis in the dataset. Intrapersonal factors such as sociodemographic characteristics, body mass index (BMI), and dietary habits may shed light on the individual elements associated with diabetes in this population. Institutional factors, such as the health system structure, may be a powerful source of influence that may impact Palauans risk for diabetes. Community factors such as cultural and behavioral norms surrounding NCDs are likely to impact risk and prevalence of diabetes in this population. Lastly, policy factors such as regional and national declarations to combat the rise of NCDs may alter an individual's diabetes risk, although we are unable to explore these relationships in the present dataset. Given that diabetes is a complex disease shaped by a variety of different social, behavioral, and genetic risk factors from different spheres of influence, SEM is a great fitting model to guide this research. Understanding the multiple levels of risk factors is vital to providing context to the burden of diabetes in Palau.

Formal Statement of the Problem

The current study seeks to understand the following: To what extent are socio-ecologic factors associated with diabetes indicators in the Palau Hybrid Survey? This research will focus primarily on intrapersonal-, institutional-, and community-level factors associated with diabetes based off the available data from the Palau Hybrid Survey. The purpose of the current study is to gain meaningful insight on the burden of diabetes in Palau. Understanding the socio-ecologic factors influencing diabetes will help researchers and practitioners at CDC, PIHOA, and other organizations better serve this community through the development of meaningful interventions and programs that target these risk factors.

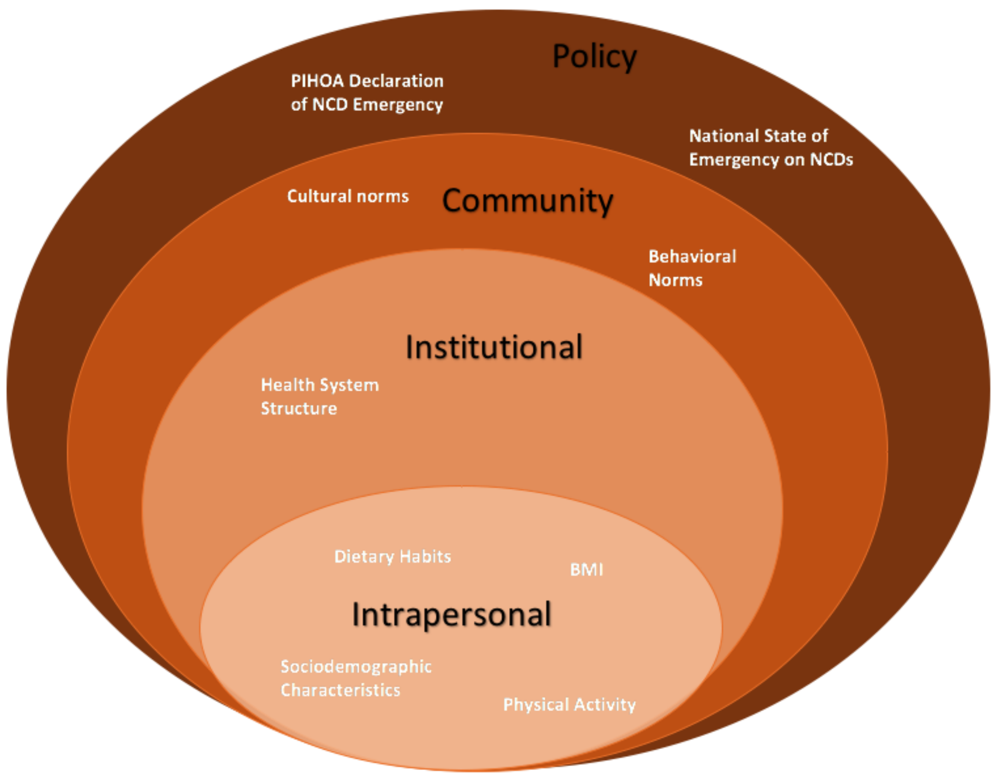

Figure 3. Overview of the Socio-Ecologic Model, including the intrapersonal-, institutional-, and community-level factors under study. Adapted from McLeroy and colleagues.[29]

Chapter 2. Literature Review

The following chapter will explore the current literature surrounding socio-ecologic factors as it relates to diabetes in Palau. Ecological models provide an important context to the multiple levels of influence of social and behavioral factors.[33] Given that diabetes is a complex disease shaped by several different elements, SEM provides a useful perspective to diabetes surveillance, prevention, and control.

<u>Intrapersonal Factors</u>

Several themes exist in the literature that document the intrapersonal risk factors for diabetes. These themes encompass a variety of individual behaviors with serious health implications. Topics in this section include substance use, metabolic syndrome, dietary habits, and other intrapersonal behaviors associated with NCDs.

Smoking is one of the leading causes of preventable death globally.[34] Research suggests that smoking is a serious modifiable risk factor for type 2 diabetes.[34] Several clinical studies report that active smoking could be independently associated with glucose intolerance, impaired fasting blood glucose, and type 2 diabetes.[35-37] Additionally, a systematic review found that among 25 identified studies, all but one reported an association between active smoking and an increased risk of diabetes, although not all were statistically significant.[34] This review also indicated that studies reported a stronger association between smoking and diabetes incidence in older participants, and in those who were overweight or obese.[34] These findings suggest that other individual factors such as age and BMI may also be independently associated with diabetes risk. According to findings from the 2013 WHO STEPS Survey,[38] 26.1% of young adults in Palau self-reported that they were current smokers. In comparison, data from the 2015 National

Health Interview Survey (NHIS) indicated that 13.1% of young adults in the U.S are current cigarette smokers.[39] In addition to tobacco use, the Pacific presents a unique cultural challenge with the use of betel nut in Pacific populations. Betel nut (also known as areca nut) is the seed of the fruit of the oriental palm, *areca catechu.*[40] Slices of the nut, either natural or processed, are mixed with a variety of substances and spices such as tobacco products, cardamom, coconut and saffron, and then chewed for a mild stimulant.[40] An estimated 600 million people chew betel nut worldwide, primarily in Asia and the Pacific. Several studies have explored the relationship between betel nut chewing and diabetes incidence.[40-43] Findings suggest that betel nut is an independent risk factor for diabetes and is associated with poor glycemic control and kidney damage in addition to diabetes risk.[40-43] However, study samples were limited to populations in East Asia and the South Pacific. Data specific to Palau are needed to understand the risk of betel nut and diabetes in this unique population. All in all, the literature suggests that Palauans may be at a higher risk for developing Type 2 diabetes given the high smoking prevalence in the population, and engagement in other substance use behaviors.

Alcohol use is another behavioral risk factor that is a significant predictor of diabetes, with higher alcohol consumption associated with increased diabetes risk.[44] Clinical findings indicate that changes in levels of alcohol metabolites, increases HDL cholesterol concentration, and the anti-inflammatory effect of alcohol may increase insulin sensitivity after moderate alcohol consumption.[45-48] Results of a meta-analysis demonstrate that alcohol is a protective factor from developing type 2 diabetes when a person consumed a moderate amount of alcohol at two drinks per day.[44] However, studies showed that higher drinking levels increased the risk for diabetes.[44] These findings suggest that binge and/or heavy alcohol drinking is a significant risk factor for diabetes.[44] Understanding the relationship between heavy alcohol consumption and diabetes status is important to fully understanding the behavioral context of this disease.

Several additional common individual risk factors for NCDs are documented in the literature including diet, physical activity, and BMI. Findings from the STEPS Survey revealed an alarmingly high prevalence of obesity, with nearly half (48.9%) of the young population classifying as overweight or obese.[38] In the U.S., 17.3%[49] of young adults aged 18-24 self-reported obesity, compared to the 21.6%[38] of young adults in Palau. Caution must be taken when comparing self-reported measures of obesity and physical measurements of BMI. However, this evidence shows that Palauans may have a higher risk for developing Type 2 diabetes given the comorbidity of obesity and other behavioral risk factors.

A cluster of risk factors for type 2 diabetes which occur together more often than by chance alone have become known by researchers as the "metabolic syndrome."[50] These interrelated risk factors include hypertension, dyslipidemia (raised triglycerides and lowered high-density lipoprotein cholesterol), raised fasting glucose, and obesity.[50] The importance of the metabolic syndrome is that it helps identify individuals at high risk of both type 2 diabetes and cardiovascular disease, with several expert groups producing diagnostic criteria based on these standards.[51] Clinical studies report that over-nutrition and obesity may contribute to inflammation, thus increasing insulin resistance and the development of type 2 diabetes.[52] Findings from the National Health and Nutrition Examination Survey (NHANES) found that the association between metabolic syndrome and ethnicity varied by gender.[53] Findings from the STEPS Survey also demonstrate gender differences in hypertension, with males more likely to have high blood pressure than females.[38] In a study examining metabolic NCD risk factors in Palau, findings indicated that Palauan's had a significantly higher mean diastolic blood pressure compared to Filipinos in both sexes.[54] Palauans were also much more likely to be overweight or obese compared to Filipinos, independent of age and various other potential confounding factors.[54] This suggests that although the influence of metabolic risk factors alone is a significant predictor of diabetes, other intrapersonal-level factors such as sex and ethnicity are also related to this risk.

Literature also documents a variety of lifestyle behaviors known to be associated with diabetes. Several studies examining dietary patterns and incidence of Type 2 diabetes consistently show that fruit and vegetable intake are important dietary components associated with a decreased risk of diabetes.[55-57] Findings suggest that this decreased risk may be due to the antioxidant content in fruits and vegetables contributing to a reduction of systemic oxidative stress.[58] Additionally, green leafy vegetables are thought to reduce the risk of type 2 diabetes, with a meta-analysis finding magnesium intake to be inversely associated with the incidence of type 2 diabetes.[57] In a study conducted in three Pacific Island countries (Fiji, Kiribati, and Vanuatu), researchers note the modernization of diet in the Pacific meant a progressive change from root-crops, coconuts, and leafy vegetables to white rice, white bread, canned and processed foods, and greater reliance on added flavorings often high in sugar and salt.[59] Overall, these findings suggest that a traditional lifestyle may be a protective factor from diabetes.[59] However, these findings are over twenty years old and more current research in this area is needed. Few recent studies have explored the association between diet and diabetes in

Pacific Islander populations. Using the Hybrid Survey data to analyze the association between dietary habits and diabetes in Palau is a key step forward in this area of research.

Other elements of diet such as the consumption of sugar-sweetened beverages have been associated with increased risk for diabetes. A multitude of studies suggest that consumption of sugar-sweetened beverages is likely to contribute to an increased risk for the development of Type 2 diabetes.[60-63] Similarly, a systematic review reported an 18% greater incidence of Type 2 diabetes with consumption of sugar sweetened beverages greater than one serving per day.[64] Studies also showed habitual consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice was prospectively associated with type 2 diabetes incidence.[64] However, these findings did not include Pacific Island populations. Future research in this population is necessary to see if similar associations exist in Pacific Island countries.

Behavioral risk factors such as physical activity are also known to be associated with diabetes risk. In a meta-analysis of 10 prospective cohort studies, researchers observed a substantial inverse association between physical activity of moderate intensity and risk of type 2 diabetes.[65] Individuals who regularly participated in moderate intensity physical activity had a 30% lower risk of type 2 diabetes compared with sedentary individuals.[65] This association remained significant even when controlling for BMI, another factor that seriously increases the risk for diabetes.[65] Additional research is needed to gather more evidence on lifestyle behaviors and metabolic risk factors and their association with diabetes in this population.

Other individual risk factors such as socio-economic position are also associated with an increase of type 2 diabetes, particularly lower socio-economic groups whether measured by education level, occupation, or income.[66] However, few studies have explored these factors and their association with diabetes in Palau. More research that investigates the variety of individual-level factors associated with diabetes is extremely important to better understanding the socio-ecologic burden of NCDs in Palau.

Institutional Factors

Several institutional systems exist in Palau that may influence diabetes risk. Chronic disease literature documents the Pacific Chronic Disease Council's (PCDC) implementation of an NCD collaborative pilot, which assessed the feasibility of adopting the Health Resources and Services Administration (HRSA) Health Disparities Collaborative Model (HDC) as a strategy to strengthen the quality of NCD prevention and management in the Pacific region.[22] The pilot's framework is based on the evidence-based Chronic Care Model (CCM) which restructures medical care using a systematic approach to create partnerships between health systems and communities.[67] The CCM targets population-based healthcare through enhanced health system organizational design that incorporates evidence-based disease management, better use of information technology through the use of patient registries, and self-management support strengthened through more effective use of community resources.[22,68] Islands used the Chronic Disease Electronic Management System (CDEMS), an open-source patient registry and data management software application, to track diabetes outcome measures.[17] Maintenance of CDEMS was the responsibility of trained data staff under supervision of their NCD Collaborative team lead.[17] Research findings suggest that CCM is effective in improving the health of patients with diabetes who receive care in primary care settings, with studies noting positive clinical outcomes and improved disease self-management.[67] In Palau, the implementation of the NCD Collaborative allowed for the Ministry of Health to integrate lessons learned from participating in the HRSA HDC.[22] However, published data regarding the diabetes care outcomes measures were limited to the Federated States of Micronesia, and the Republic of the Marshall Islands.[68] Research reports that numerous problems arose in the implementation of CDEMS, including lack of policies and procedures for data collection, lack of variable definitions, and no collaboration between clinicians and data staff. Other concerns were that the staff responsible for managing the data systems did not have the skills, education, or training support to fulfill their duties.[69] Further research on the success of the HDC and CCM in Palau is needed to assess if there are any improvements in diabetes care related to these models.

The presence of organizational funding for NCD prevention in Palau is another institutional mechanism that may influence diabetes prevention programming Palau. The CDC, Division of Diabetes Translation (DDT) has provided financial support to the six USAPI jurisdictions for diabetes prevention and control programs since 1986.[10] Most recent literature states that the average DDT funding award for a USAPI is $106,082, which primarily covers administrative and staffing costs (i.e. a diabetes coordinator) with modest support for community programs and outreach.[10] Additional funding may exist for the USAPIs through other organizational mechanisms, however these are not documented in the scientific literature. These financial relationships are important to providing context to diabetes prevention and control activities in Palau.

Community Factors

Community-level influences such as environmental exposures, and culture and behavioral norms surrounding NCDs are likely to impact risk and prevalence of diabetes in this population. Research findings suggest that environmental factors such as passive smoke exposure and cooking oil used in mealtime preparation may also be associated with individual diabetes risk. A recent meta-analysis found evidence that non-smokers exposed to passive smoke have a 21% increased risk of type 2 diabetes compared with non-smoking individuals without passive smoke exposure.[70] Other studies corroborate these results, suggesting that there may be a causal relationship between passive smoking and diabetes due to the temporality, dose-response effect, and the indirect plausibility of biological effect based on Hill's nine criteria of causation.[71] These findings indicate that secondhand smoke exposure may increase the risk of diabetes, exemplifying how social and community norms surrounding health behaviors can influence risk at the individual level. Findings from the current study will determine if these associations remain significant in Palau.

Literature documents the ongoing cultural shift from tradition Island ways of life to a more Westernized lifestyle as affecting food and dietary habits in Island populations.[10] The replacement of traditional foods with imported, processed food has contributed to the high prevalence of obesity and related NCD risk factors in the Pacific region.[72] Additionally, these "modern" dietary patterns characterized by high consumption of foods such as potato chips, rice, instant noodles and low intake of local foods are known to be associated with an increased prevalence of metabolic syndrome.[73] On the contrary, more traditional Pacific Island dietary patterns high in fresh fish, seafood, and other local foods such as taro, papaya, and coconut have been associated with reduced prevalence of metabolic syndrome, increased high-density lipoprotein (HDL) cholesterol, and reduced waist circumference in a Samoan sample.[73] In the Federated States of Micronesia, researchers found heavy reliance on poor-quality imported foods exacerbating the genetic predisposition of people in FSM to obesity.[74] This research suggests that the Island food environment is an important community-level influence in an individual's risk for diabetes and related NCDs. Other findings report that cultural food practices, such as high levels of saturated fat in food preparation may be associated with the high diabetes prevalence in minority populations.[75] These findings suggest that household meal preparation in areas with rich tradition and culture may have higher risk for diabetes. Mealtime and food preparation have also been described as risk factors for NCDs. Ho and colleagues report that higher prevalence of unhealthy behaviors in an indigenous Canadian population may be associated with higher diabetes risks.[76] Researchers found butter or margarine to be used more often during cooking than lower fat spreads.[76] Additionally, researchers noted pan-frying and using added fat when boiling, baking, or microwaving as common food preparation practices.[76] Although more research in this area is needed, Ho and colleagues suggest that increasing knowledge around healthier food preparation would be an effective strategy to reduce the burden of diabetes in this population.[76] Contrarily, a meta-analysis of nine publications found a small or neutral association with butter and diabetes risk.[77] Further research in this area is necessary to see how cultural food practices impact diabetes risk in Palau.

Policy Factors

Public policy plays a major role in influencing public health by facilitating, or hindering, healthier choices in a population.[78] In type 2 diabetes prevention, policy is important in influencing lifestyle behaviors such as diet, physical activity, and smoking that can help prevent the disease.[78] The declaration of emergency on NCDs as a major health threat in the Pacific Region, and in the nation of Palau is a powerful policy statement that may impact NCD risk. Although direct associations between these policies and diabetes risk is unknown, they provide important context for understanding the significance of the NCD burden in Palau. Given that national and regional institutions recognize NCDs as a serious public health issue, these concerns may filter down to the individual level. In addition to the declaration of emergency, Palau has developed a National NCD Plan for 2008-2011 and 2015-2020 with the support from the WHO, the Secretariat of the Pacific Community (SPC), and CDC.[14] These plans focus on reducing behavioral risk factors for NCDs. The existence of these plans provides theoretical evidence that public policy can influence NCD risk at the individual level. Palau also has smoke-free laws that ban smoking in healthcare, government and educational facilities, indoor offices, and public transportation areas.[79] However, smoking is allowed in lodging establishment guestrooms, and designated areas of restaurants, bars, clubs, hotels, and motels.[80] A WHO report[80] notes that Palau has weak enforcement strategies for these laws as they only fine the smoker for non-compliance, rather than also applying penalties to the owner or manager of the establishment, as recommendations suggest. Scientific research that explores these policy influences on individual diabetes risk in Palau is important to better understanding the context of NCDs in the nation.

In conclusion, this chapter sufficiently explores the multiple levels of influence on diabetes risk according to the SEM. It is evident that these levels often interact together to form a diabetes risk profile for an individual. This context is essential to moving forward in the battle against diabetes in Palau.

Chapter 3. Methods

Overview of Current Study

The current study is a secondary analysis of the Palau Hybrid Survey, a population-based adult survey conducted in the Republic of Palau from May 2016 to December 2016. The Hybrid Survey aimed to assess the burden of non-communicable diseases, substance use, mental health, and other selected risk factors for poor health in the Palauan population according to CDC, PIHOA, WHO, and SAMHSA surveillance frameworks. The survey combined self-reported risk factors with physical and biochemical measurements to determine the current risk and prevalence of NCDs. The current study provides necessary data about the risk and protective factors for diabetes in Palau, and significant socio-ecologic factors associated with diabetes status in this population.

Study Population/Participants

The target population for the Hybrid Survey included all Palau residents aged 18 or older who were able to understand English or Palauan language, and provide consent for participation. Respondents not meeting these criteria were ineligible for participation in the study.

A stratified random sample of all households in Palau was performed based on population size at the village level in order to select the study population for the Hybrid Survey. A total of 2,409 households were included in this sample. One individual was selected at random from each household using the Kish Selection Method.[81] This sampling strategy allowed for data to be representative of the total population in Palau, with demographic distributions of the Hybrid Survey mirroring the distributions of the Palau 2015 Census. A total of 1768 individuals participated in the 2016 Palau Hybrid Survey (response rate = 73.4%). Ninety-seven individuals for which a diabetes status could not be determined were excluded from analyses, leading to a final sample of N = 1671 for this analysis.

Data Collection

Data collection for the Palau Hybrid Survey began on May 7, 2016 and concluded on December 31, 2016. All interviews and measurements were performed by surveyors contracted by the Palau Ministry of Health who underwent an extensive, one-week training. Surveyors collected data using face-to-face questionnaires on a tablet with assistance from showcards for particular questions. Data were uploaded from the tablet on a weekly basis at the Palau Ministry of Health. Personal identifiers and participant information was de-identified prior to obtaining access to the dataset.

Anthropometric and other physical and biochemical measurements were conducted at central locations the morning after survey completion to allow for fasting measurements. Specifically, physical measurements were taken by the trained surveyor who conducted the interview to assess height, weight, and blood pressure. Height was measured in centimeters using a Seca 213 portable stadiometer. Weight was measured in kilograms using a Seca 813 portable digital scale. Three blood pressure measurements were taken from each participant using an Omron HEM-907 blood pressure monitor. The average of these three measurements was used to assess hypertension status. Biochemical measurements were collected to assess cholesterol levels of participants. Fasting blood glucose, total cholesterol, and HDL cholesterol were measured using a portable

Cardiochek whole blood analyzer. A PTS Panels test strip was used that simultaneously measured glucose, total cholesterol, and HDL cholesterol.

Measures

The current study uses SEM as a guiding framework for understanding the factors associated with diabetes in Palau. Exposure variables are primarily at the intrapersonal level, however some institutional and community-level factors associated with diabetes status in Palau are also included in analyses. The two main outcome measures are diabetes, and diabetes diagnosis status.

Outcome Variables

Diabetes was assessed through both self-report and physical measurements. Participants were asked two questions to determine their diabetes diagnosis status. Participants were first asked, have you ever had your blood sugar checked by a doctor, nurse, or other health worker?". If the participant responded "yes," he or she was then asked: "Have you ever been told by a doctor, nurse, or other health worker that you have high blood sugar or diabetes?"[82] Then, two self-report questions were asked to determine participant's diabetes medication status: "Are you currently receiving insulin prescribed by a doctor or other health worker for your high blood sugar or diabetes? and "Are you currently receiving other types of medicine prescribed by a doctor or other health worker for your high blood sugar or diabetes that you have taken in the past two weeks?"[82] Participants who responded that they had been diagnosed with diabetes and were currently taking insulin or medication were considered to have diabetes. In addition, diabetes status was assessed through fasting blood glucose measurements. Fasting blood glucose was measured using a portable Cardiochek whole blood analyzer using previously described methods. Participants with glucose measurements above 126 mg/dL were considered to be diabetic. For analyses, a dichotomous diabetes status variable was created with two categories (1) – no diabetes and (2) – diabetes. Participants in the diabetes category are those who self-reported that they were taking insulin or other medication for their diabetes, and/or had fasting blood glucose measurements at or above 126 mg/dL. For analyses, diabetics (through self-report and/or high fasting blood glucose measurement) were also recoded according to their diagnostic status into a dichotomous variable with the categories (1) – diagnosed and (2) – undiagnosed.

Intrapersonal-Level Variables

Intrapersonal factors included: gender, age, education, ethnicity, fruit and vegetable consumption, processed meat consumption, sugar sweetened beverage consumption, physical activity, self-rated health, betel nut chewing, binge drinking, smoking, BMI, hypertension, total cholesterol, and HDL cholesterol.

Demographics

Surveyors indicated the participant's gender as male or female in the demographic portion of the survey. Age was determined through the question "How old are you?" in which participants indicated their numerical age in years. For regression analyses, age was recoded into a categorical variable with categories: (1) – less than 35 years old, (2) – 35-64 years old, and (3) – 65+ years old. Education level was assessed through the question: "What is the highest level of formal education you have completed?"[82] Answer options included: (1) – Less than high school (2) – High school completed (3) – Associate's degree completed (4) – Bachelor's degree completed and (5) Graduate or professional degree completed. These answer options were coded numerically and inputted as a categorical variable in SPSS. Due to the small sample size, education was recoded into a binary variable with the categories: (1) – Completed high school or less than high school and (2) – Completed greater than high school.[82] Ethnicity was ascertained through the question "What is your ethnic background?" in which participants selected one of the following options: (1) – Palauan (2) – Filipino or (3) – Other. Participants who selected other were prompted to describe their ethnic background in a subsequent question.[82] Ethnicity was recoded into a dichotomous variable with categories of (1) – Palauan and (2) – Other prior to analysis.

Lifestyle Behaviors

Fruit and vegetable consumption was assessed through the questions: "In a regular week, how many days do you eat fruit?," and "In a regular week, how many days do you eat vegetables?"[82] Participants responded by indicating the number of days per week they eat fruit and vegetables. Fruit and vegetable servings was assessed through the questions: "On one of the days that you eat fruit, how many servings of fruit do you eat?" and "On one of the days that you eat vegetables, how many servings of vegetables do you eat?"[82] Participants quantified the number of fruit and vegetable servings they consume each day. The fruit and vegetable consumption variable was then calculated by averaging participant's daily fruit and vegetable servings. Averages were then recoded into a binary categorical variable for analyses. Categories for fruit and vegetable servings were as follows: (1) – Less than 5 average servings per day, and (2) – 5 or more average servings per day. Processed meat consumption was assessed through the question "In a regular day, how many times do you eat processed meats? This does not include canned fish."[82] Participants responded to this question by indicating the number of times per day they consume processed meats. For analyses, responses were recoded into a binary categorical variable with the following categories: (1) – 0 processed meats consumed per day, and (2) – 1 or more processed meats consumed per day. Sugar sweetened beverage consumption was determined through the question "In a regular day, how many sugary drinks do you drink? This does not include diet drinks made with artificial sweeteners."[82] in which participants indicated the number of drinks per day consumed. Responses were recoded into a binary categorical variable with the following categories: (1) – 0 drinks consumed per day and (2) – 1 or more drinks consumed per day. Physical activity was assessed through the Global Physical Activity Questionnaire (GPAQ), a 16-item measure developed by the WHO for physical activity surveillance.[83] The questionnaire encompasses three domains: activity at work, travel to and from places, and recreational activities. Sample items from each domain include "How much time do you spend doing vigorous-intensity activities at work on a regular day?," "How much time do you spend walking or bicycling for travel on a regular day?," and "How much time do you spend doing moderate-intensity sports, fitness, or recreational activities on a regular day?"[82] Participants responded by indicating the number of hours and minutes spent doing these types of physical activities. Total physical activity score was determined using complex calculations per GPAQ guidelines.[83] Physical activity cutoff values were assigned based off GPAQ guidelines to create the categorical level of total physical activity variable with categories of low, moderate, and high. Self-rated health was assessed through the statement "Would you say that your general health is…" and participants responded with either (1) – Excellent, (2) – Very Good, (3) – Good, (4) – Fair or Okay, or (5) – Poor or

Not Good.[82] Prior to analysis, the self-rated health variable was recoded to a dichotomous variable with categories (1) – Good or better health and (2) – Fair or poor health.

Betel nut chewing was evaluated by asking participants: "During the past 30 days, how many days did you chew betel nut?," in which respondents numerically indicated the number of days they have chewed.[82] Tobacco use was similarly assessed through the question: "During the past 30 days, how many days did you smoke cigarettes?" in which respondents indicated the number of days they have smoked. Binge drinking was determined by asking participants "During the past 30 days, how many days did you have: for men – five or more standard alcoholic drinks? For women – four or more standard alcohol drinks?" in which participants gave the numerical number of days they binge drank in the past 30 days.[82] Betel nut chewing, tobacco use, and binge drinking were each recoded into a binary categorical variable in which any "use" in the past 30 days considered that person a (1) – Yes, and no "use" in the past 30 days considered a (2) – No.

Physical Indicators

Using the previously collected height and weight measurements, BMI was calculated by dividing participants weight in kilograms by their height in meters, squared (BMI = kg/m^2). For analyses, individual BMIs were recoded into categories based on standard weight status categories for BMI.[84]

Hypertension was assessed through self-report and physical measurements as previously described. Three self-reported questions were used to assess hypertension diagnosis and medication status: "Have you ever had your blood pressure checked by a doctor, nurse, or other health worker?", "Have you ever been told by a doctor, nurse, or other health worker that you have high blood pressure or diabetes?", and "Are you currently receiving medicine prescribed by a doctor or other health worker for your high blood pressure or hypertension that you have taken in the past two weeks?".[82] Participants that indicated they have been diagnosed with hypertension and are currently receiving medication for their hypertension were considered to be hypertensive. The average of three systolic and three diastolic measurements were also used to assess hypertension status. Systolic measurements greater than 140 and/or diastolic measurements above 90 were considered to be hypertensive. These cutoff values are consistent with National Heart, Lung, and Blood Institute (NHLBI) guidelines.[85] For analyses, a hypertension variable was created with two categories (1) – No hypertension and (2) – Hypertension. Participants in the hypertension category are those who self-reported that they were taking medication for their high blood pressure, and/or had high blood pressure measurements.

For total cholesterol, participant measurements were recoded and assigned into one of two categories: (1) – Total cholesterol less than 190 mg/dL, and (2) – Total cholesterol 190 mg/dL or higher. Those with total cholesterol 190 or higher mg/dL were considered to have elevated cholesterol. Similarly, HDL values were recoded into two categories: (1) – Less than 40 mg/dL (low HDL) and (2) – 40 or more mg/dL (good HDL).

Institutional-Level Variables

Two indicator variables were used in this dataset: annual health exam in the past year, and annual dental exam in the past year. Annual health exam was assessed through the question: "About how long has it been since you last visited a medical provider for an annual check-up? An annual check-up is a general physical exam, not an exam for a specific injury, illness, or condition."[82] Dental exam was assessed by asking participants: "How long has it been since you last visited a dentist or dental clinic for any reason? Include visits to dental specialists, such as orthodontists."[82] Response options for both questions included: (1) – Within the past year (anytime less than 12 months ago), (2) – Within the past 2 years (1 year but less than 2 years ago), (3) – Within the past 5 years (2 years but less than 5 years ago), (4) – 5 or more years ago, and (5) – Never. Prior to analyses, an annual health exam variable was created by recoding participant responses into one of two categories (1) – No annual exam in the past year and (2) – Annual exam in the past year. Similarly, the annual dental exam variable was created by recoding participant responses into one of two categories (1) – No dental exam the past year and (2) – Dental exam in the past year.

Community-Level Variables

One indicator variable, secondhand smoke exposure, was used for analyses.

Environmental Exposures

Secondhand smoke was measured through three questions:

1) "During the past 7 days, on how many days did someone other than you smoke tobacco inside your home while you were at home?"

2) "During the past 7 days, on how many days did you breathe tobacco smoke at your workplace from someone else other than you who was smoking tobacco?" and

3) "During the past 7 days, on how many days did you ride in a vehicle where someone other than you was smoking tobacco?[82]

For each item, participants responded by indicating the numerical number of days in the past 7 days that they had been exposed to secondhand smoke. Prior to analysis, these variables were recoded into a single variable to assess any exposure to secondhand smoke. Variable categories included (1) – has not been exposed to secondhand smoke at home, work, or car in the past seven days and (2) – has been exposed to secondhand smoke at home, work, or car in the past seven days.

Statistical Analysis

Data were analyzed using SPSS 25. The chi-square test for differences in proportions was performed for categorical variables to explore associations with diabetes status and diabetes diagnosis status. A p-value of <.05 was considered to be statistically significant. Bivariate and multivariate logistic regression was performed to determine predictors of the selected diabetes outcomes. Independent variables with a p-value of >.05 in both outcome variables were excluded from the multivariate regression model. Results from statistical analyses are presented in Chapter 4, and the Tables 1-7 in the Appendix.

Ethics Approval

Permission to conduct this secondary analysis was sought from the Palau Institutional Review Board in March 2018.

Chapter 4. Results

Study Sample

A total of 1671 individuals were included in analyses for the current study, with a mean age of 47.22 (sd=14.86). Males and females were nearly equally represented in the dataset as 50.2% (n= 839) of participants identified as male, and 49.8% (n=832) identified as female. The majority of participants reported living in Koror State (65.1%; n=1088), followed by Airai (12.0%; n=200) and Peleliu (3.8%; n=64). In terms of socioeconomic background, 15.5% (n=259) of the sample did not complete high school, 49.3% (n=822) only completed high school, 21.4% (n=357) completed an associate degree, 10.9% (n= 182) completed a bachelor's degree, and 2.9% (n= 48) completed a graduate or professional degree. A total of 71.1% (n=1188) identified as Palauan, 19.6% (n=328) of participants identified as Filipino, and 9.3% (n=155) identified as other. Overall, diabetes prevalence in the sample was 22.2% (n=371). Among participants with diabetes, 65.5% (n=241) were undiagnosed. These sample characteristics are shown in Table 1.

Bivariate Results

Intrapersonal-Level Variables

The majority of participants fell into the age category of 35-64 years old (65.3%; n=1091), followed by less than 35 (21.7%; n= 362), and 65+ (13.0%; n=218). Most participants consumed less than five fruit and vegetable servings per day (89.7%; n=1488). Processed meat consumption varied, with 55.2% (n=920) of participants consuming 0 processed meats per day. The majority of participants 76.8% (n=1284) reported consuming 1 or more sugar sweetened beverages per day. A total of 51.0%

(n=849) participants reported engaging in moderate or high physical activity each week. Additionally, most participants (53.0%; n= 853) self-reported their health as good or better. In terms of substance use, the majority of participants had not smoked cigarettes in the past 30 days (80.2%; n=1338), nor had they binge drank in the past 30 days (72.9%; n=1216). However, a majority of participants (51.6%; n= 861) had chewed betel nut in the past 30 days. Physical measurements indicated that 37.7% (n= 539) of the sample classified as obese, followed by 34.8% (n= 498) as overweight, and 27.5% (n=393) having a healthy BMI. A majority of participants (66.2%; n=1103) did not have hypertension. Similarly, most participants (71.7%; n= 1041) did not have elevated cholesterol. However, most participants (52.9%; n=768) had low HDL cholesterol. These descriptive statistics are presented in Table 2.

A Chi-Square test of independence was performed to examine the associations between each intrapersonal-level variable and two outcomes: diabetes and diabetes diagnosis status. Results suggest that there is a statistically significant association between several intrapersonal-level variables and the two outcomes of interest (Table 2, Table 3). For diabetes, these include: age ($p < .001$), ethnicity ($p = .005$), processed meat consumption ($p<.001$), sugar sweetened beverage consumption ($p=.005$), self-rated health ($p<.001$), BMI ($p<.001$), hypertension ($p<.001$), HDL cholesterol ($p<.001$), and total cholesterol ($p=.042$) (Table 3). Results suggested that participants with diabetes are older (70.1%; n= 260 for ages 35-64; 22.6%; n=84 for ages 65+) compared to participants without diabetes (63.9%; n=831 for ages 35-65; 10.3%; n=134 for ages 65+). A slightly higher prevalence of Palauans had diabetes (76.0%; n= 282) compared to the proportion of Palauans among non-diabetics (69.7%; n= 906). Additionally, more participants with diabetes self-rated their health as fair or poor (58.1%; n=208) compared to participants without diabetes (43.8%; n=549). Participants with diabetes had a much higher prevalence of hypertension (53.4%; n=194) compared to participants without diabetes (28.2%; n=365). Similarly, participants with diabetes had a higher prevalence of low HDL cholesterol (54.7%; n= 203) compared to participants without diabetes (43.5%; n=565). Participants with diabetes had a slightly higher prevalence of elevated cholesterol (32.6%; n= 114) compared to participants without diabetes (27.0%; n=297). On the other hand, participants with diabetes had a slightly lower prevalence of processed meat consumption (35.9%; n=132) compared to those without diabetes (47.3%; n=615).

For diabetes diagnosis status, significant intrapersonal exposures include: age (p <.001), ethnicity (p = .009), processed meat consumption (p=.002), sugar sweetened beverage consumption (p=.001), annual exam (p=.008), binge drinking (p<.001), hypertension (p=.013), and HDL cholesterol (p<.001) (Table 4). Results suggested that participants with a diabetes diagnosis had a higher prevalence of being age 65+ (33.9%; n=43) compared to participants without diabetes diagnosis (16.2%; n=39). Participants with a diabetes diagnosis had a higher prevalence of being Palauan (86.6%; n=110) compared to those without a diagnosis (70.1%; n=169). Participants with a diabetes diagnosis had a lower prevalence of consuming 1+ processed meats (24.8%; n=31) and 1+ sugar sweetened beverages (60.6%; n=77) compared to those without diabetes (42.1%; n=101 and 77.6%; n=187, respectively). Participants with a diagnosis had a lower prevalence of binge drinking (10.2%; n=13) compared to participants without a diagnosis (33.6%; n=11). Additionally, participants with a diagnosis had a higher prevalence of hypertension (63.8%; n=81) compared to those without diabetes (48.1%;

n=116). On the other hand, participants with a diagnosis had a slightly lower prevalence of low HDL cholesterol (53.5%; n=68) compared to participants without a diagnosis (55.2%; n=133). Lastly, participants with a diagnosis had a higher prevalence of having an annual exam in the past year (65.9%; n=83) compared to those without a diagnosis (48.9%; n=116).

Community-Level Variables

A total of 74.7% participants (n=1194) did not have any secondhand smoke exposure in their home, workplace, or vehicle. A Chi-Square test of independence was performed to examine the association between secondhand smoke exposure and diabetes status among the study sample. Results suggested that those with diabetes had a slightly lower prevalence of secondhand smoke exposure (21.8%; n=77) compared to those without diabetes (26.3%; n=328), however these findings were not statistically significant (Table 3). A Chi-Square test of independence was also performed to examine the association between secondhand smoke exposure and diabetes diagnosis status in the sample. Those without a diabetes diagnosis had about the same prevalence of secondhand smoke exposure (20.2%; n=24) compared to those without a diagnosis (22.9%; n=53). These findings were not statistically significant (Table 4).

Institutional-Level Variables

Approximately half (52.9%; n=871) of participants reported having an annual health exam in the past year. A total of 40.5% (n=667) of participants reported that they had a dental exam in the past year. A Chi-Square test of independence was also performed to examine the association between annual exam and the two outcomes: diabetes and diabetes diagnosis status. Participants with diabetes had a slightly higher prevalence of annual exams (54.9%; n=201) compared to participants without diabetes (52.4%; n=670). These findings were not statistically significant (Table 3). However, results suggest that participants with a diabetes diagnosis had a significantly higher prevalence of annual exams (65.9%; n=85) compared to those without a diagnosis (48.9%; n=116; p=.008) (Table 4). Annual dental exam was not significantly associated with either outcome (Table 3, Table 4).

Diabetes Regression Model

Bivariate logistic regression analyses suggested that age, ethnicity, processed meat consumption, sugar sweetened beverage consumption, self-rated health, BMI, hypertension, and HDL cholesterol were independently, significantly associated with diabetes (Table 6). These results are comparable to the Chi-Square results previously described and shown in Table 3. Therefore, all eight variables were included in the final diabetes status regression model. Physical activity was significant at $p<.10$ and was included in the diabetes regression model to explore the relationship with diabetes after adjusting for other variables. Gender and education were also included to control for socio-economic indicators. Additionally, annual exam was included in the diabetes regression model to allow for comparison between variables in the diabetes diagnosis model.

More specifically, bivariate results suggest that participants in older age groups have nearly 8 times the odds of diabetes (OR=7.78; 95%CI 4.82, 12.54; $p<.001$). Additionally, these results suggest that being Palauan (OR= 1.38; 95%CI 1.06, 1.80; p=.018), fair or poor self-rated health (OR= 1.78; 95%CI 1.40, 2.26; $p<.001$), overweight BMI (OR= 1.59; 95%CI 1.12, 2.22; p=.007), obese BMI (OR= 1.96; 95%CI 1.42, 2.72;

p<.001), hypertension (OR=2.92; 95%CI 2.30, 3.70; p<.001), and low HDL cholesterol (OR= 1.30; 95%CI 1.02, 1.66; p=.032) are also significantly associated with higher risk for having diabetes (Table 6). On the other hand, processed meat consumption (OR= 0.62, 95%CI 0.49, 0.79; p<.001) and sugar sweetened beverage consumption (OR= 0.69; 95%CI 0.53, 0.90; p=.005) were significant protective factors for developing diabetes in this sample (Table 6).

A multivariate logistic regression was performed to ascertain the effects of the following 12 variables on diabetes status in Palau: age, gender, ethnicity, processed meat consumption, sugar sweetened beverages, self-rated health, BMI, hypertension, HDL cholesterol, physical activity, education, and annual health exam (Table 5). These variables were included for based on a p-value of <.05, and/or theoretical reasons described in Chapter 3. The logistic regression model was statistically significant ($\chi^2(14)=118.60$, p <.001). The model explained 12.8% (Nagelkerke R^2) of the variance in diabetes. Results of this regression model suggest that older age, self-rated fair or poor health, obese BMI, and hypertension are significant predictors of diabetes in Palau (Table 5). Specifically, participants ages 35-64 had 2.71 times higher odds of diabetes than participants under age 35 when controlling for all other independent variables (OR= 2.71, 95%CI 1.71, 4.28; p<.001). Participants above age 65 had almost 4 times higher odds of diabetes than participants under age 35 (OR= 3.91, 95%CI 2.23, 6.87; p<.001). Participants who self-rated their health as fair or poor had 1.64 times higher odds of diabetes compared to participants who self-rated their health as good or better when controlling for all other independent variables in the model (OR=1.64, 95%CI 1.23, 2.17; p=.001). Obese participants had 1.56 times higher odds of diabetes compared to participants with a healthy BMI (OR=1.56, 95%CI 1.06, 2.29; p=.025). Lastly, participants with hypertension had almost twice the odds of diabetes compared to those without hypertension (OR=1.94, 95%CI 1.47, 2.57; p<.001). These results are shown in Table 6. There was no evidence of multicollinearity between variables (Table 5).

Diabetes Diagnosis Regression Model

For the diabetes diagnosis status regression model, bivariate logistic regression analyses suggest that age, gender, ethnicity, processed meat consumption, sugar sweetened beverages, annual health exam, and hypertension were independently, significantly associated with diabetes diagnosis in the sample (Table 7). These results are comparable to the Chi-Square results previously described and shown in Table 4. Therefore, all seven variables were included in the final regression model. Physical activity, education, BMI, and self-rated health were also included in the final diabetes diagnosis status model to allow for comparison with the diabetes status model. Binge drinking was excluded from analyses due to possible confounding associations with age, and lack of significant association with diabetes status.

Specifically, bivariate results indicated being age 35-64 (OR= 5.79; 95%CI 1.34, 25.03; p=.019), being age 65+ (OR= 13.78; 95%CI 3.06, 26.02; p=.001), being female (OR=1.55; 95%CI 1.01, 2.40; p=.047), and having hypertension (OR= 1.90; 95%CI 1.22, 2.95; p=.004) are significantly associated with higher odds of a diabetes diagnosis (Table 7). Processed meat consumption (OR= 0.45; 95%CI 0.28, 0.73; p=.001), sugar sweetened beverage consumption (OR=0.45, 95%CI 0.28, 0.71; p=.001), and not having an annual health exam (OR=0.50; 95%CI 0.32, 0.78; p=.002) were each associated with lower odds of a diabetes diagnosis (Table 7).

A multivariate logistic regression was performed to ascertain the effects of the following 12 variables on diabetes diagnosis status in Palau: age, gender, ethnicity, processed meat consumption, sugar sweetened beverages, self-rated health, BMI, hypertension, HDL cholesterol, physical activity, gender, education, and annual health exam (Table 6). These variables were included for based on a p-value of $<.05$, and/or theoretical reasons described in Chapter 3. The logistic regression model was statistically significant ($\chi^2(14)=56.65$, $p <.001$). The model explained 23.1% (Nagelkerke R^2) of the variance in diabetes diagnosis. Results of this regression model suggest that age, gender, ethnicity, sugar sweetened beverage consumption, and annual health exam are significant predictors of diabetes diagnoses in Palau (Table 6). Specifically, participants above age 65 had 12.14 times higher odds of having a diabetes diagnosis from a health care provider compared to participants under age 35, when controlling for all other independent variables in the model (OR=12.14, 95%CI 1.43, 102.99; p=.022). Palauans had 2.87 times higher odds of having a diabetes diagnosis compared to other ethnic groups (OR=2.87, 95%CI 1.35, 6.09; p=.006). Participants who consumed one or more servings of sugar sweetened beverages daily had about half the odds of having a diabetes diagnosis compared to participants who consumed zero servings per day (OR=0.51 95%CI 0.28, 0.92; p=.026). Additionally, participants who did not have an annual health exam had close to half the odds of having a diabetes diagnosis compared to participants who had an annual exam in the past year (OR=0.57, 95%CI 0.33, 0.99; p=.046). These results are shown in Table 7. There was no evidence of multicollinearity between variables (Table 5).

Chapter 5. Discussion

The current study presents meaningful findings about the socio-ecologic factors associated with diabetes status in Palau. Hybrid survey data indicate the diabetes prevalence in Palau to be about 20%. Most alarmingly, 65% of diabetics in Palau are undiagnosed. These data show how diabetes impacts individuals in Palau, with many not properly managing their illness and potentially unaware they have the disease. The following chapter offers comparisons, conclusions, and recommendations regarding the current study and its findings.

Comparison with Other Studies

Overall, the burden of diabetes in Palau is more severe compared to the mainland U.S. The 2017 National Diabetes Statistics Report estimates the prevalence of diabetes in the U.S. to be about 10%.[86] These data demonstrate that Palau has nearly double the prevalence of diabetes than the U.S. Furthermore, the report documents that approximately 25% of diabetics in the U.S. are undiagnosed, indicating that Palau has nearly triple the amount of undiagnosed diabetics.[86] These findings reveal the urgent need for diabetes health promotion programming in Palau. Public health practitioners should explore innovative strategies to increasing the percentage of diabetes diagnoses in Palau.

Several interesting findings emerged upon examining the socio-ecologic predictors of diabetes in Palau. Previous research studies document how individuals of lower socio-economic background have an increased risk of developing type 2 diabetes compared to individuals of a higher socio-economic background.[66] Education, used as a measure of socio-economic status, was not a significant predictor of diabetes in the current study. This suggests that socioeconomic status does not have the most profound influence on diabetes indicators in Palau. However, several other intrapersonal factors significantly impacted the two diabetes indicators under study. In this dataset, obese individuals were more likely to have diabetes than overweight and healthy individuals. Similarly, obese individuals have nearly two-thirds higher diabetes prevalence compared to overweight individuals in the U.S.[86] The dose-response relationship between diabetes risk and BMI indicates that obesity prevention is an important component of diabetes prevention and control. Results also demonstrate the overlapping of NCDs, with hypertensive individuals having nearly double the odds of diabetes. Low HDL cholesterol was also associated with increased odds for diabetes, however these results were not significant after controlling for other variables. Nonetheless, these findings support previous research on the metabolic syndrome, as these cluster of risk factors suggest high risk for developing type 2 diabetes.[50,51,53] Health educators in Palau should consider implementing chronic disease self-management programs that address each of these metabolic indicators. Additionally, health care providers should be proactive in screening for obesity, hypertension, cholesterol, and diabetes during routine health exams and community health fairs.

Given that almost three-fourths of diabetics were undiagnosed, understanding the socio-ecologic factors associated with diabetes diagnosis is crucial to prevention and control efforts in Palau. Data demonstrate that diabetes diagnoses vary be age, gender, and ethnic subgroups. A dose-response relationship was apparent between age and diagnosis status, as the number of diabetes diagnoses increased with age. These findings suggest that fewer young people are visiting their health care provider compared to older adults. These results are consistent with previous research, as several studies note that young adults have significantly lower rates of healthcare utilization compared with older age groups in the U.S.[87-89] Additionally, women and men had roughly the same rate of undiagnosed diabetes in the U.S..[86] In Palau, women were more likely to have a diabetes diagnosis compared to men, which suggests that women may have higher rates of healthcare utilization. Palauans had nearly triple the odds of a diabetes diagnosis compared to other ethnic groups. These findings indicate that Filipinos and other ethnic minorities may not be using healthcare services. More research is needed in this area to further explore the relationship between healthcare utilization trends and intrapersonal factors such as age, gender, and ethnicity in Palau.

Lifestyle behaviors were also significantly associated with diabetes diagnoses in Palau. Individuals who consumed one or more sugar sweetened beverages per day have about 50% lower odds of a diabetes diagnosis compared to individuals who did not consume any sugar sweetened beverages. These data suggest that individuals with a diabetes diagnosis may be making lifestyle modifications to manage their diabetes illness. Public health practitioners in Palau should encourage people to seek health care services, as a formal diagnosis may motivate diabetics to lead healthier lifestyles.

Overall, individuals who did not have an annual exam in the past year had approximately 50% lower odds of having a diabetes diagnosis. These data provide preliminary insight into the relationship between healthcare utilization and diabetes diagnoses in Palau. Given the limited number of tertiary services available on island, health educators should implement secondary prevention programs to help individuals detect and manage their diabetes at an earlier stage. Future researchers should further investigate institutional factors such as the healthcare system, CDEMS, CCM, and organizational funding and their influence on diabetes indicators in Palau.[10,17,22]

Strengths and Limitations

The main strength of the current study is that it uses population-based data from Palau and provides a baseline for routine chronic disease surveillance in the nation. The Hybrid Survey sampling methodology yielded a sample that closely mirrored Palau's 2015 Census Data, indicating that findings can be generalizable to the broader Palauan population. This is crucial as very few studies have explored trends related to diabetes prevalence and associated risk factors in Palau.[18,25,38] Additionally, current findings provide meaningful insight about the health issues of Palauans as it relates to chronic disease risk factors. Overall, this study is an important step forward to understanding the etiology of diabetes and diabetes diagnoses in Palau.

Response bias may be a limitation of the current study, as several of the variables include in analyses were self-reported. However, physical and biochemical measurements were collected for all of the NCD indicators to limit bias in this domain. The primary limitation of the current study is that it did not encompass all levels of the SEM. Incorporating theory into a secondary analysis can be challenging, as researchers are only able to use the variables collected in the initial study. The Hybrid Survey focused primarily on the intrapersonal risk factors for chronic disease, thus interpersonal and policy-level factors were limited in this dataset. In addition, the two institutional indicators (annual health exam and annual dental exam) may not have been the best fit for the theoretical model. Healthcare utilization is traditionally explored in an individual context, however given the unique healthcare infrastructure in Palau these were included as institutional-level variables. Future research studies should thoroughly investigate how each level of the SEM is associated with diabetes, and other NCDs in Palau.

Conclusions

Understanding the socio-ecologic influences of diabetes is critical to ameliorating the burden of NCDs in Palau. Overall, findings were consistent with previous research, indicating that individuals living in Palau have similar risk factors for diabetes. However, the high percentage of undiagnosed diabetics in Palau is cause for concern. Public health practitioners should encourage the population to visit a primary healthcare provider for diabetes screening and treatment. Health promotion activities such as community health fairs, health communication campaigns, and mobile clinics may be useful strategies for increasing diabetes diagnoses in Palau. Future research studies should also explore the lifestyle behaviors of undiagnosed and diagnosed diabetics to better understand the differences in how these individuals manage their health. In conclusion, the current study provides notable evidence about the socio-ecologic factors associated with diabetes status in Palau. Public health researchers and practitioners should prioritize Pacific Island populations such as Palau in the global fight against NCDs.

Appendices

Table 1: Study Sample Summary

	N (%)
Study Sample	N = 1671
Age	*Mean = 47.22 (sd = 14.86)*
<35	362 (21.7%)
35-64	1091 (65.3%)
65+	218 (13.0%)
Gender	
Male	839 (50.2%)
Female	832 (49.8%)
State	
Koror State	1088 (65.1%)
Airai	200 (12.0%)
Peleliu	64 (3.8%)
Ngaraard	50 (3.0%)
Ngarchelong	41 (2.5%)
Ngarmelengui	38 (2.3%)
Aimeliik	36 (2.2%)
Ngchesar	30 (1.8%)
Ngiwal	26 (1.6%)
Melekeok	27 (1.6%)
Ngardmau	25 (1.5%)
Ngatpang	20 (1.2%)
Angaur	16 (1.0%)
Kayangel	10 (0.6%)
Education Level	
Did not complete high school	259 (15.5%)
Only completed high school	822 (49.3%)
Completed an associate degree	357 (21.4%)
Completed a bachelor’s degree	182 (10.9%)
Completed a graduate or professional degree	48 (2.9%)
Ethnicity	
Palauan	1188 (71.1%)
Filipino	328 (19.6%)
Other	155 (9.3%)
Diabetes	
Yes	371 (22.2%)
No	1300 (77.8%)
Diabetes Diagnosis*	
Yes	127 (34.5%)
No	241 (65.5%)
Missing	3

*among diabetics only

Table 2: Descriptive Statistics – Socio-Ecologic Variables

	N (%)
Intrapersonal-level	
Lifestyle Behaviors	
Fruit and Vegetable Consumption	
5+ servings/day	171 (10.3%)
<5 servings/day	1488 (89.7%)
Processed Meat	
0 servings	920 (55.2%)
1+ servings	747 (44.8%)
Sugar Sweetened Beverages	
0 servings	387 (23.2%)
1+ servings	1284 (76.8%)
Physical Activity	
Moderate + High	849 (51.0%)
Low	817 (49.0%)
Self-Rated Health	
Good or better	853 (53.0%)
Fair or poor	757 (47.0%)
Smoking	
Yes	331 (19.8%)
No	1338 (80.2%)
Binge Drinking	
Yes	452 (27.1%)
No	1216 (72.9%)
Betel Nut Chewing	
Yes	861 (51.6%)
No	809 (48.4%)
Physical Measurements	
BMI	
Healthy	393 (27.5%)
Overweight	498 (34.8%)
Obese	539 (37.7%)
Hypertension	
Yes	563 (33.8%)
No	1103 (66.2%)
HDL Cholesterol	
40+ (Good HDL)	685 (47.1%)
<40 (Low HDL)	768 (52.9%)
Total Cholesterol	
<190	1041 (71.7%)
190+ (Elevated Cholesterol)	411 (24.6%)
Institutional-level	
Annual Health Exam	
Yes	871 (52.9%)
No	774 (47.1%)

Annual Dental Exam	
Yes	667 (40.5%)
No	980 (59.5%)
Community-level	
Secondhand Smoke	
Yes	405 (25.3%)
No	1194 (74.7%)

Table 3: Socio-Ecologic Predictors by Diabetes Status

	DM N (%)	No DM N (%)	*P*-value
Intrapersonal-level			
Demographics			
Age			
<35	27 (7.3%)	335 (25.8%)	**<.001**
35-64	260 (70.1%)	831 (63.9%)	
65+	84 (22.6%)	134 (10.3%)	
Gender			
Male	175 (47.2%)	664 (51.1%)	.184
Female	196 (52.8%)	636 (48.9%)	
Ethnicity			
Other	89 (24.0%)	394 (30.3%)	**.018**
Palauan	282 (76.0%)	906 (69.7%)	
Education			
Greater than HS	121 (32.6%)	466 (35.9%)	.238
HS or Less than HS	250 (67.4%)	831 (64.1%)	
Lifestyle Behaviors			
Fruit and Vegetable Consumption			
5+ servings/day	41 (11.2%)	130 (10.1%)	.524
<5 servings/day	325 (88.8%)	1163 (89.9%)	
Processed Meat			
0 servings	236 (64.1%)	684 (52.7%)	**<.001**
1+ servings	132 (35.9%)	615 (47.3%)	
Sugar Sweetened Beverages			
0 servings	106 (28.6%)	281 (21.6%)	**.005**
1+ servings	265 (71.4%)	1019 (78.4%)	
Physical Activity			
Moderate + High	173 (46.8%)	676 (52.2%)	.067
Low	197 (53.2%)	620 (47.8%)	
Self-Rated Health			
Good or better	150 (41.9%)	703 (56.2%)	**<.001**
Fair or poor	208 (58.1%)	549 (43.8%)	
Smoking			
Yes	73 (19.7%)	258 (19.9%)	.932
No	298 (80.3%)	1040 (80.1%)	
Binge Drinking			
Yes	94 (25.3%)	358 (27.6%)	.387
No	277 (74.7%)	939 (72.4%)	
Betel Nut Chewing			
Yes	204 (55.1%)	657 (50.5%)	.119
No	166 (44.9%)	643 (49.5%)	
Physical Measurements			
BMI			
Healthy	66 (19.4%)	327 (30.0%)	**<.001**

Overweight	121 (35.6%)	377 (34.6%)	
Obese	153 (45.0%)	386 (35.4%)	
Hypertension			
Yes	198 (53.4%)	365 (28.2%)	**<.001**
No	173 (46.6%)	930 (71.8%)	
HDL Cholesterol			
40+ (Good HDL)	148 (39.9%)	537 (41.3%)	**<.001**
<40 (Low HDL)	203 (54.7%)	565 (43.5%)	
Total Cholesterol			
<190	236 (67.4%)	805 (73.0%)	**.042**
190+ (Elevated Cholesterol)	114 (32.6%)	297 (27.0%)	
Institutional-level			
Annual Health Exam			
Yes	201 (54.9%)	670 (52.4%)	.392
No	165 (45.1%)	609 (47.6%)	
Annual Dental Exam			
Yes	156 (42.5%)	511 (39.9%)	.374
No	211 (57.5%)	769 (60.1%)	
Community-level			
Secondhand Smoke			
Yes	77 (21.8%)	328 (26.3%)	.085
No	276 (78.2%)	918 (73.7%)	

Bold values are significant at the alpha = 0.05 level

Table 4: Socio-Ecologic Predictors by Diabetes Diagnosis Status

	DMDx N (%)	No DMDx N (%)	*P*-value
Intrapersonal-level			
Demographics			
Age			
<35	2 (1.6%)	25 (10.4%)	**<.001**
35-64	82 (64.6%)	177 (73.4%)	
65+	43 (33.9%)	39 (16.2%)	
Gender			
Male	51 (40.2%)	123 (51.0%)	.123
Female	76 (59.8%)	118 (49.0%)	
Ethnicity			
Other	17 (13.4%)	72 (29.9%)	**.001**
Palauan	110 (86.6%)	169 (70.1%)	
Education			
Greater than HS	36 (28.3%)	84 (34.9%)	.448
HS or Less than HS	91 (71.7%)	157 (65.1%)	
Lifestyle Behaviors			
Fruit and Vegetable Servings			
5+ servings/day	13 (10.3%)	28 (11.8%)	.753
<5 servings/day	113 (89.7%)	209 (88.2%)	
Processed Meat			
0 servings	94 (75.2%)	139 (57.9%)	**.002**
1+ servings	31 (24.8%)	101 (42.1%)	
Sugar Sweetened Beverages			
0 servings	50 (39.4%)	54 (22.4%)	**.001**
1+ servings	77 (60.6%)	187 (77.6%)	
Physical Activity			
Moderate + High	57 (45.2%)	114 (47.3%)	.732
Low	69 (54.8%)	127 (52.7%)	
Self-Rated Health			
Good or better	53 (42.4%)	96 (41.7%)	.949
Fair or poor	72 (57.6%)	134 (58.3%)	
Smoking			
Yes	20 (15.7%)	53 (22.0%)	.248
No	107 (84.3%)	188 (78.0%)	
Binge Drinking			
Yes	13 (10.2%)	81 (33.6%)	**<.001**
No	114 (89.8%)	160 (66.4%)	
Betel Nut Chewing			
Yes	75 (59.1%)	127 (52.9%)	.490
No	52 (40.9%)	113 (47.1%)	
Physical Measurements			
BMI			
Healthy	18 (17.5%)	48 (20.4%)	.314
Overweight	43 (41.7%)	78 (33.2%)	

Obese	42 (40.8%)	109 (46.4%)	
Hypertension			
Yes	81 (63.8%)	116 (48.1%)	**.013**
No	46 (36.2%)	125 (51.9%)	
HDL Cholesterol			
40+ (Good HDL)	40 (37.0%)	107 (44.6%)	.399
<40 (Low HDL)	68 (63.0%)	133 (55.4%)	
Total Cholesterol			
<190	77 (72.6%)	157 (65.1%)	.170
190+ (Elevated Cholesterol)	29 (27.4%)	84 (34.9%)	
Institutional-level			
Annual Health Exam			
Yes	83 (65.9%)	116 (48.9%)	**.008**
No	43 (34.1%)	121 (51.1%)	
Annual Dental Exam			
Yes	53 (42.4%)	100 (41.8%)	.129
No	72 (57.6%)	139 (58.2%)	
Community-level			
Secondhand Smoke			
Yes	24 (20.2%)	53 (22.9%)	.549
No	95 (79.8%)	178 (77.1%)	

Bold values are significant at the alpha = 0.05 level

Table 5

Collinearity Diagnostics

Predictor	VIF
Age	1.20
Gender	1.12
Ethnicity	1.35
Education	1.03
Processed Meat	1.25
Fruit & Vegetable Servings	1.12
Sugar Sweetened Beverages	1.14
Physical Activity	1.09
Self-Rated Health	1.17
Annual Exam	1.13
BMI	1.25
Hypertension	1.15
HDL Cholesterol	1.11

*VIF greater than 10 indicates collinearity problem

Table 6: Logistic Regression Results
Crude (Bivariate) and Adjusted (Multivariable) Odds Ratios for Diabetes in Palau

	Crude OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Intrapersonal-level				
Demographics				
Age				
<35	Ref		Ref	
35-64	3.88 (2.56, 5.89)	**<.001**	2.71 (1.71, 4.28)	**<.001**
65+	7.78 (4.82, 12.54)	**<.001**	3.91 (2.23, 6.87)	**<.001**
Gender				
Male	Ref		Ref	
Female	1.17 (0.93, 1.47)	.185	1.17 (0.88, 1.54)	.282
Ethnicity				
Other	Ref		Ref	
Palauan	1.38 (1.06, 1.80)	**.018**	1.22 (0.86, 1.72)	.261
Education				
Greater than HS	Ref		Ref	
HS or Less than HS	1.16 (0.91, 1.48)	.239	1.19 (0.90, 1.58)	.230
Lifestyle Behaviors				
Fruit and Vegetable Servings				
5+ servings/day	Ref		Ref	
<5 servings/day	0.89 (0.61, 1.29)	.523	–	[1]
Processed Meat				
0 servings	Ref		Ref	
1+ servings	0.62 (0.49, 0.79)	**<.001**	0.84 (0.63, 1.11)	.211
Sugar Sweetened Beverages				
0 servings	Ref		Ref	
1+ servings	0.69 (0.53, 0.90)	**.005**	0.81 (0.60, 1.11)	.191
Physical Activity				
Moderate + High	Ref		Ref	
Low	1.24 (0.99, 1.57)	.067	0.91 (0.69, 1.21)	.526
Self-Rated Health				
Good or better	Ref		Ref	
Fair or poor	1.78 (1.40, 2.26)	**<.001**	1.64 (1.23, 2.17)	**.001**
Smoking				
Yes	0.99 (0.74, 1.32)	.932	–	[2]
No	Ref		Ref	
Binge Drinking				
Yes	0.39 (0.68, 1.16)	.387	–	[3]
No	Ref		Ref	

[1] Fruit and vegetable consumption was not included in the multivariate model due to a p-value of >.10.
[2] Smoking in the past 30 days was not included in the multivariate model due to a p-value of >.10.
[3] Binge drinking was not included in the multivariate model due to a p-value of >.10.

Betel Nut Chewing				
Yes	1.20 (0.95, 1.52)	.119	–	[4]
No	Ref		Ref	
Physical Measurements				
BMI				
Healthy	Ref		Ref	
Overweight	1.59 (1.14, 2.22)	**.007**	1.35 (0.93, 1.95)	.113
Obese	1.96 (1.42, 2.72)	**<.001**	1.56 (1.06, 2.29)	**.025**
Hypertension				
Yes	2.92 (2.30, 3.70)	**<.001**	1.94 (1.47, 2.57)	**<.001**
No	Ref		Ref	
HDL Cholesterol				
40+ (Good HDL)	Ref		Ref	
<40 (Low HDL)	1.30 (1.02, 1.66)	**.032**	1.24 (0.94, 1.64)	.137
Total Cholesterol				
<190	Ref		Ref	
190+	1.31 (1.01, 1.70)	**.042**	–	[5]
Institutional-level				
Annual Health Exam				
Yes	Ref		Ref	
No	0.90 (0.72, 1.14)	.39	1.01 (0.77, 1.33)	.932[6]
Annual Dental Exam				
Yes	Ref		Ref	
No	0.90 (0.71, 1.14)	.374	–	[7]
Community Level				
Secondhand Smoke				
Yes	0.78 (0.59, 1.04)	.086	–	[8]
No	Ref		Ref	

Bold values are significant at the alpha = 0.05 level

*****Nagelkerke R^2 for the adjusted model is .128

[4] Betel nut chewing was not included in the multivariate model due to a p-value of >.10.

[5] Total cholesterol was not included in the multivariate regression model for theoretical reasons (duplication of cholesterol measures).

[6] Annual health exam was included in the multivariate regression model for theoretical reasons (consistency between both models).

[7] Annual dental exam was not included in the multivariate model due to a p-value of >.10.

[8] Secondhand smoke was not included in the multivariate model due to a p-value of >.10.

Table 7: Logistic Regression Results
Crude (Bivariate) and Adjusted (Multivariable) Odds Ratios for Diabetes Diagnosis Status in Palau

	Crude OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Intrapersonal-level				
Demographics				
Age				
<35	Ref		Ref	
35-64	5.79 (1.34, 25.03)	**.019**	7.38 (0.94, 57.99)	.057
65+	13.78 (3.06, 62.02)	**.001**	12.14 (1.43, 102.99)	**.022**
Gender				
Male	Ref		Ref	
Female	1.55 (1.01, 2.40)	**.047**	2.23 (1.27, 3.90)	**.005**
Ethnicity				
Other	Ref		Ref	
Palauan	2.76 (1.54, 4.93)	**.001**	2.87 (1.35, 6.09)	**.006**
Education				
Greater than HS	Ref		Ref	
HS or Less than HS	1.35 (0.85, 2.16)	.206	1.67 (0.923, 3.02)	.090
Lifestyle Behaviors				
Fruit and Vegetable Servings				
5+ servings/day	Ref		Ref	
<5 servings/day	1.17 (0.58, 2.34)	.668	–	[9]
Processed Meat				
0 servings	Ref		Ref	
1+ servings	0.45 (0.28, 0.73)	**.001**	0.79 (0.44, 1.43)	.441
Sugar Sweetened Beverages				
0 servings	Ref		Ref	
1+ servings	0.45 (0.28, 0.71)	**.001**	0.51 (0.28, 0.92)	**.026**
Physical Activity				
Moderate + High	Ref		Ref	
Low	1.09 (0.71, 1.68)	.707	0.76 (0.42, 1.37)	.356
Self-Rated Health				
Good or better	Ref		Ref	
Fair or poor	0.97 (0.63, 1.51)	.904	0.97 (0.55, 1.70)	.911
Smoking				
Yes	0.66 (0.38, 1.17)	.155	–	[10]
No	Ref		Ref	
Binge Drinking				

[9] Fruit and vegetable consumption was not included in the multivariate model due to a p-value of >.10.
[10] Smoking in the past 30 days was not included in the multivariate model due to a p-value of >.10.

Yes	0.23 (0.12, 0.42)	**<.001**	–	[11]
No	Ref		Ref	
Betel Nut Chewing				
Yes	1.28 (0.83, 1.98)	.261	–	[12]
No	Ref		Ref	
Physical Measurements				
BMI				
Healthy	Ref		Ref	
Overweight	1.47 (0.76, 2.84)	.251	1.24 (0.57, 2.73)	.581
Obese	1.03 (0.54, 1.97)	.935	0.65 (0.28, 1.54)	.332
Hypertension				
Yes	1.90 (1.22, 2.95)	**.004**	1.12 (0.64, 1.96)	.688
No	Ref		Ref	
HDL Cholesterol				
40+ (Good HDL)	Ref		Ref	
<40 (Low HDL)	1.37 (0.86, 2.18)	.188	1.75 (0.99, 3.10)	.056
Total Cholesterol				
<190	Ref		Ref	
190+	0.70 (0.43, 1.16)	.171	–	[13]
Institutional-level				
Annual Exam				
Yes	Ref		Ref	
No	0.50 (0.32, 0.78)	**.002**	0.57 (0.33, 0.99)	**.046**
Annual Dental Exam				
Yes	Ref		Ref	
No	0.98 (0.63, 1.52)	.918	–	[14]
Community Level				
Secondhand Smoke				
Yes	0.85 (0.49, 1.46)	.553	–	[15]
No	Ref		Ref	

Bold values are significant at the alpha = 0.05 level

*****Nagelkerke R^2 for the adjusted model is .231

[11] Binge drinking was not included in the multivariate model due to theoretical reasons (associations with age and consistency between models)

[12] Betel nut chewing was not included in the multivariate model due to a p-value of >.10.

[13] Total cholesterol was not included in the multivariate regression model due to a p-value of >.10.

[14] Annual dental exam was not included in the multivariate model due to a p-value of >.10.

[15] Secondhand smoke was not included in the multivariate model due to a p-value of >.10.

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