91

THE EPIDEMIOLOGY OF CLUSTERED RISK FACTORS COMPATIBLE WITH METABOLIC SYNDROME IN HAWAI'I

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI'I IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PUBLIC HEALTH

MAY 2008

By
Robert Hirokawa

Dissertation Committee:

Alan Katz, Chairperson
Andrew Grandinetti
Eric Hurwitz
Jay Maddock
Jane Kadohiro

We certify that we have read this dissertation and that, in our opinion, it is satisfactory in scope and quality as a dissertation for the degree of Doctor of Public Health.

DISSERTATION COMMITTEE

Chairperson

ACKNOWLEDGEMENTS

I would like to thank all of the members of my dissertation committee for providing invaluable insight, expertise, and enthusiastic guidance throughout this learning process. I would especially like to thank Dr. Alan Katz for his guidance and support throughout my entire learning experience here at the University Hawaii, Department of Public Health Sciences. His dedication to higher learning and his commitment to his students at UH are truly inspirational.

I would also like to thank Lola Irvin, Jay Maddock, Katherine Benson and Bill Reger for their words of encouragement, support, and gentle nudging. I would not have been able to complete this without them.

Finally, I would like to thank my family for their support and understanding, and providing the space and time I needed to see this through.

ABSTRACT

Metabolic Syndrome (MetS) refers to the clustering of various cardiometabolic risk factors, including glucose intolerance, abdominal obesity, dyslipidemia and elevated blood pressure. Over the past two decades the world has experienced a sharp increase in the number of people with MetS. It is estimated that around 20 – 25 percent of the world's adult population now have metabolic syndrome.

This study had three main aims: (1) to describe the epidemiology of obesity in Hawaii using standard and proposed ethnic specific BMI definitions of obesity, (2) to describe the epidemiology of clustered risk factors compatible with MetS among Hawaii's population using standard and proposed ethnic-specific BMI definitions of obesity, and to (3) to estimate crude and adjusted prevalence ratios for clustered risk factors compatible with MetS.

This study used the Behavioral Risk Factor Surveillance System (2001 – 2005) to examine the prevalence of weight status (obesity) and MetS in Hawaii. The findings confirmed what is already known – obesity rates are high and disparities exist. However, when ethnic specific case definitions of weight status were applied, a dramatic shift in the distribution of obesity emerged. For example, when using World Health Organization (WHO) BMI thresholds, the major Asian groups had obesity rates in the 10% range. Applying ethnic specific BMI thresholds, obesity prevalence among Asians increased into the mid 40% range.

When using WHO BMI definitions of obesity, the prevalence of 3 – 4 MetS risk factors ranged from a low of 2.7% ("Other Asians") to a high of 18.8% ("Other Pacific

Islanders"), with a mean of 8.3%. When using ethnic specific definitions of obesity, the prevalence of 3 – 4 MetS risk factors ranged from a low of 3.6% (Blacks) to a high of 17.8% ("Other Pacific Islanders"), with a mean of 10.5%.

Poisson regression analysis showed that race / ethnicity was an independent risk factor for having 3 – 4 MetS risk factors when controlling for age, education, gender, poverty level, having healthcare coverage, and having a personal doctor.

This study provides a glimpse into the future burden Hawaii may be faced with as the prevalence of obesity and its associated conditions continue to rise.

TABLE OF CONTENTS

Acknowledgements....iii

Abstract....iv

List of Tables....vii

Chapter 1. Introduction....1
- Metabolic Syndrome....1
- Obesity....5
- Worldwide Diabetes....7
- Diabetes in United States....8
- Diabetes in Hawaii....9
- Diabetes Prevention....10
- Study Rationale....11
- Study Purpose....12
- Expected outcomes....13

Chapter 2. Methods....14
- Dataset....14
- Behavioral Risk Factor Surveillance System....14
- Obesity....16
- Metabolic Syndrome....17
- Exclusions....21
- Case Definitions....21

Chapter 3. Obesity....24
- Background....24
- Results....24

Chapter 4. Metabolic Syndrome....38
- Results....38
- Results of Poisson Regression....56

Chapter 5. Discussion....62
- Obesity....62
- Metabolic syndrome....64
- Opportunities....69
- Future studies....73
- Limitations....75
- Conclusions....78

References....79

LIST OF TABLES

Table		Page
1	New International Diabetes Federation (IDF) definition of MetS...........	3
2	Ethnic specific values for waist circumference..............................	4
3	Complications of childhood obesity..	6
4	Weight classes: WHO and ethnic-specific BMI cut-points......................	24
5	Frequencies of Hawaii BRFSS survey records, 2001 to 2005..............	25
6	Prevalence of selected population characteristics.............................	26
7	Prevalence of weight status by ethnicity, WHO BMI weight classes......	27
8	Prevalence of weight status by ethnicity, ethnic-specific BMI weight classes..	29
9	Prevalence of weight status by education, WHO BMI weight classes.....	30
10	Prevalence of weight status by education, ethnic-specific BMI weight classes..	31
11	Prevalence of weight status by gender, WHO BMI and ethnic specific BMI weight classes..	32
12	Prevalence of weight status by poverty level, WHO BMI and ethnic specific BMI weight classes...	33
13	Prevalence of weight status by adult age group, WHO BMI weight classes..	34
14	Prevalence of weight status by adult age group, ethnic specific BMI weight classes..	35
15	Prevalence of weight status by healthcare coverage, WHO BMI and ethnic specific BMI weight classes..	36
16	Prevalence (%) of weight status by personal doctor, WHO BMI and ethnic specific BMI weight classes..	37
17	Frequencies of Hawaii BRFSS respondents, years 2001, 2003, 2005......	38

Table		Page
18	Comparison of prevalence of selected population characteristics by excluded and included records	39
19	Prevalence of risk factor levels (0 – 4) compatible with MetS by ethnicity, WHO BMI definitions of obesity	41
20	Prevalence of risk factor levels (0 – 4) compatible with MetS by ethnicity, ethnic specific BMI definitions of obesity	42
21	Prevalence of risk factor levels (0 – 4) compatible with MetS by education level, WHO BMI definitions of obesity	44
22	Prevalence of risk factor levels (0 – 4) compatible with MetS by education level, ethnic specific BMI definitions of obesity	45
23	Prevalence of risk factor levels (0 – 4) compatible with MetS by gender, WHO BMI definitions of obesity	46
24	Prevalence of risk factor levels (0 – 4) compatible with MetS by gender, ethnic specific BMI definitions of obesity	47
25	Prevalence of risk factor levels (0 – 4) compatible with MetS by poverty level, WHO BMI definitions of obesity	47
26	Prevalence of risk factor levels (0 – 4) compatible with MetS by poverty level, ethnic specific BMI definitions of obesity	48
27	Prevalence of risk factor levels (0 – 4) compatible with MetS by healthcare coverage, WHO BMI definitions of obesity	49
28	Prevalence of risk factor levels (0 – 4) compatible with MetS by healthcare coverage, ethnic specific BMI definitions of obesity	50
29	Prevalence of risk factor levels (0 – 4) compatible with MetS by having a personal doctor, WHO BMI definitions of obesity	51
30	Prevalence of risk factor levels (0 – 4) compatible with MetS by having a personal doctor, ethnic specific BMI definitions of obesity	51
31	Prevalence of 3 – 4 clustered risk factors compatible with MetS comparing WHO BMI definitions of obesity with ethnic specific BMI definitions of obesity by race, age group, gender, education, poverty, having healthcare coverage, and having personal doctor	52

Table		Page
32	Prevalence of 3 – 4 clustered risk factors compatible with MetS comparing groups within the same category and column to a referent group. (A = WHO BMI definitions of obesity, B = ethnic specific BMI definitions of obesity)..	55
33	Crude and adjusted prevalence ratios for clustered risk factors compatible with MetS (0 – 2 risk factors vs. 3 – 4 risk factors), WHO BMI definitions of obesity, estimated by Poisson regression through 7 models, comparing Whites to all other DOH race / ethnicities................	58
34	Crude and adjusted prevalence ratios for clustered risk factors compatible with MetS (0 – 2 risk factors vs. 3 – 4 risk factors), ethnic specific BMI definitions of obesity, estimated by Poisson regression through 7 models, comparing Whites to all other DOH race / ethnicities..	60
35	Rank order of prevalence rates of 3 – 4 risk factors by ethnicity..........	65
36	Estimated frequency of adults with 3 – 4 risk factors compatible with MetS by ethnicity, WHO and ethnic specific definitions of obesity.......	66

CHAPTER 1. INTRODUCTION

Metabolic Syndrome

Metabolic syndrome (MetS) refers to the clustering of various cardiometabolic risk factors, including glucose intolerance (type 2 diabetes, impaired fasting glycemia, impaired glucose tolerance), abdominal obesity, dyslipidemia and elevated blood pressure.[1,2] Risk factors associated with MetS (also referred to as Cardiometabolic Syndrome) are likely to be linked to insulin resistance and co-occur more than expected by chance alone.[2] It is theorized that in individuals with MetS, the development of obesity and physical inactivity leads to insulin resistance and compensatory hyperinsulinemia. Most insulin-resistant individuals are able to maintain the degree of hyperinsulinemia required to prevent loss of glucose homeostasis. If pancreatic insulin secretion fails to increase adequately, impaired glucose tolerance or diabetes develops. Genetic factors also play a role.[3]

MetS is considered to be proinflammatory and prothrombotic, with glucotoxicity and lipotoxicity contributing to the metabolic and vascular abnormalities. Individuals with MetS are more likely to have abdominal obesity as opposed to lower body obesity. Abdominal obesity is associated with visceral fat, as opposed to lower body obesity which is associated more with subcutaneous fat. The issue here is that visceral fat is metabolically active. It produces free fatty acids and inflammatory cytokines that drain directly into the liver via the portal circulation. Fat deposits in the liver are associated with overproduction of very-low-density lipoprotein, leading to atherogenic dyslipidemia (elevated triglycerides, low high density lipoprotein (HDL) cholesterol levels, and small dense low-density lipoprotein [LDL] cholesterol particles). Although LDL cholesterol levels may not be elevated, the number of particles may be increased, and the small dense particles more readily enter the arterial wall and are oxidized, leading to atherosclerosis.[3]

Over the past two decades the world has experienced a sharp increase in the number of people with MetS.[2] For example, a study based on the National Health and Nutrition Examination Survey (NHANES) estimated that approximately 50 million people in the U.S. had MetS in 1990. That number increased to approximately 64 million people with MetS in 2000[4]. Furthermore, it is currently estimated that around 20 – 25 percent of the world's adult population now have MetS.[9] Associated with MetS are the epidemics of obesity, cardiovascular disease and diabetes, all of which are considered to be worldwide, and have emerged as a major public health threat of the 21st century. The clustering of cardiovascular disease risk factors that are associated with MetS is now considered to be central to the current CVD epidemic.[9] For example, a cohort study based on the Framingham Offspring Study found that men with MetS had a 2 fold increase in the risk for cardiovascular disease when compared to their non MetS counterparts. The study also found a four-fold increase in the risk of developing type 2 diabetes in both men and women with MetS when compared with those without MetS.[5] Both children and adults have been impacted by these epidemics, and they have struck both developed and developing countries.[13] The clinical and public health importance of MetS is that it is common; it identifies individuals who are at increased risk of cardiovascular disease and type 2 diabetes, both of which are major public health threats.[6] Ultimately, MetS provides a view into the health of a population. The increase in the prevalence of MetS is seen as a forecast of the future increases in diabetes and cardiovascular disease.[4]

The most commonly used clinical definition of MetS was proposed in 2001 by the National Cholesterol Education Program's Adult Treatment Panel III (ATPIII). The ATPIII defines MetS as the presence of any three of these five risk factors: central obesity, high triglycerides, low HDL cholesterol, high fasting glucose, and high blood pressure.[7, 8] Most recently, the International Diabetes Federation (IDF) has developed a clinical definition of MetS that has received worldwide consensus.[9] Table 1 describes the various aspects of the IDF clinical definition of MetS. The IDF defines MetS as having central obesity with at least two other risk factors that include raised triglycerides, reduced HDL cholesterol, raised blood pressure, or raised fasting plasma glucose.

Table 1. The new International Diabetes Federation (IDF) definition of MetS[9]

Central obesity (defined as waist circumference* with ethnicity specific values) plus any two of the following four factors:	
Raised triglycerides	$\geq$150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality
Reduced HDL cholesterol	< 40 mg/dL (1.03 mmol/L) in males < 50 mg/dL (1.29 mmol/L) in females or specific treatment for this lipid abnormality
Raised blood pressure	Systolic BP $\geq$ 130 or diastolic BP $\geq$ 85 mm Hg or treatment of previously diagnosed hypertension
Raised fasting plasma glucose	FPG) $\geq$ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes If above 5.6 mmol/L or 100 mg/dL, OGTT is strongly recommended but is not necessary to define presence of the syndrome.

*If BMI is >30, central obesity can be assumed and waist circumference does not need to be measured.

Table 2 describes the ethnic specific waist circumferences that define central obesity based on the IDF definition of MetS. The IDF definition specifies that in a person with a BMI of 30 or more, central obesity is assumed. For males, the waist circumference thresholds for obesity are higher in Europeans when compared with Asians.

Table 2. Ethnic specific values* for waist circumference[9]

Europids: In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes	Male	≥94 cm
	Female	≥80 cm
South Asians: Based on a Chinese, Malay and Asian-Indian population	Male	≥90 cm
	Female	≥80 cm
Chinese	Male	≥90 cm
	Female	≥80 cm
Japanese: Originally different values were proposed for Japanese people but new data support the use of the values shown above.	Male	≥90 cm
	Female	≥80 cm
Ethnic South and Central Americans	Use South Asian recommendations until more specific data are available	
Sub-Saharan Africans	Use European data until more specific data are available	
Eastern Mediterranean and Middle East (Arab) populations	Use European data until more specific data are available	

* There are no established cut offs for Native Hawaiians/Pacific Islanders

Although there is widespread agreement that MetS is a growing public health threat, there are others who believe that MetS is not a relevant clinical entity and that the risk factors that make up MetS are independent risk factors for cardiovascular disease irrespective of whether they are clustered or not.[3] For example, the American Diabetes Association and the European Association for the Study of Diabetes, through a joint statement concluded that 1) criteria for MetS are ambiguous or incomplete, and the rationale for thresholds are ill defined, 2) the value of including diabetes in the definition is questionable, 3) insulin resistance as the unifying etiology is uncertain, 4) there is no clear basis for including/excluding other CVD risk factors, 5) CVD risk value is variable and dependent on the specific risk factors present, 6) the CVD risk associated with MetS appears to be no greater than the sum of its parts, 7) treatment of MetS is no different than the treatment for each of its components, and 8) the medical value of diagnosing MetS is unclear.[10]

Obesity

The current obesity epidemic is at the core of the growing public health problem of MetS and its closely related conditions (type 2 diabetes and cardiovascular disease). Obesity is defined as an excess of body fat that adversely effect health and longevity and is now well recognized as a disease in its own right.[11] Moreover, it is also believed that obesity plays a central in the escalating burden of chronic diseases in general. For example, it is estimated that American businesses suffer productivity losses in the range of $1.1 trillion annually due to chronic illnesses, with obesity playing a major role.[12] It is estimated that globally, more than 1 billion adults are overweight, with 300 million of these individuals being obese.[13]

Children are not immune from the obesity epidemic. For example, it is predicted that the current child obesity epidemic will impact communities in four overlapping waves. The first wave is believed to have occurred in the 1970's and is still upon us. During this phase, the average weight of a typical child in the U.S., across all socioeconomic levels, all ethnic groups, and across all regions has progressively and dramatically increased. This change in the average weight of children has attracted attention, but little action was taken due to the fact that although childhood obesity was increasing, most obese children remained relatively healthy. Phase two, which is believed to be upon us now, is the manifestation of obesity-related disease in youth, and is the culmination of phase one. Health conditions such as type 2 diabetes, fatty liver, orthopedic problems, sleep apnea, and psychosocial problems are already on the rise. It is believed that phase three is still many years away. It will be a time where health complications of obesity will lead to life-threatening disease. Conditions such as limb amputation secondary to type 2 diabetes, coronary heart disease, kidney failure and premature death will be commonplace. Phase four will be marked with the acceleration of the obesity rate and its complications through transgenerational mechanisms.[14] Table 3 describes the common complications that are associated with childhood obesity.

Table 3. Complications of childhood obesity[14]

System	Condition
Psychosocial	Poor self-esteem, anxiety, depression, eating disorders, social isolation, lower educational attainment
Neurologic	Pseudotumor cerebri
Endocrine	Insulin resistance, type 2 diabetes, precocious puberty, polycystic ovaries, hypogonadism
Cardiovascular	

	Dyslipidemia, hypertension, coagulopathy, chronic inflammation, endothelial dysfunction
Pulmonary	Sleep apnea, asthma, exercise intolerance
Gastrointestinal	Gastroesophageal reflux, steatohepatitis, gallstones, constipation
Renal	Glomerulosclerosis
Musculoskeletal	Slipped capital femoral epiphysis, Blount's disease, forearm fracture, back pain, flat feet

Worldwide Diabetes

There is widespread agreement that type 2 diabetes is a growing and serious global epidemic as a direct consequence of the obesity epidemic. Aside from the obesity epidemic, the rise in diabetes is expected to occur because of population growth, aging, urbanization, and physical inactivity. It is estimated that the worldwide prevalence of diabetes in 2000 stood at 171 million among adults age 20 and above. By the year 2030, the worldwide prevalence of diabetes is expected to double, making the associated human and economic costs enormous.[16] Complications associated with uncontrolled diabetes are both numerous and serious. Diabetes can lead to cardiovascular disease (heart disease and stroke), kidney disease, eye complications and blindness, neuropathy, foot complications (diabetes is the leading cause of non-traumatic lower extremity amputations) and amputation, skin disorders, gastroparesis, and depression.[15] The expected parallel increase in the number of cardiovascular related illness and mortality will have a profound impact on healthcare systems across the globe.[9] The greatest increases in population rates are expected to occur in the Middle Eastern Crescent, sub-Saharan

Africa, and India. The greatest absolute increase in the number of people with diabetes is expected to occur in India.[16]

Diabetes in United States

The United States (U.S.) is in the midst of its own diabetes epidemic. For example, according to the Behavioral Risk Factor Surveillance System (BRFSS), the U.S. adult diabetes prevalence increased from 4.4% in 1995 to 7.5% in 2006.[17] The BRFSS diabetes estimates reflect the prevalence of adults with known or diagnosed diabetes. It does not take into account individuals who have diabetes but remain undiagnosed. There were two periods in recent U.S. history that saw rapid increases in diabetes prevalence: from 1963 to 1975, and again in 1990 when the prevalence sharply increased from 26.4 to 54.5 per 1000 people.[18]

Current estimates (2007) put the number of people with diabetes in the U.S. at 17.5 million. This is substantially higher than the 2002 estimate of 12.1million people with diabetes. This increase is attributed to the growth and aging of the population, the increasing prevalence of obesity, increased detection, decreasing mortality and an increase in minority groups with a higher prevalence of diabetes. The prevalence of diabetes may be growing by as much as 1 million people per year.[19]

The estimated U.S. economic cost, both direct and indirect, attributable to diabetes is staggering. A landmark study by the American Diabetes Association (ADA) estimated that in 2002, the cost of diabetes was approximately $132 billion, of which approximately $92 billion (70%) was additional health care expenditures and $40 billion (30%) was lost productivity due to disability and early mortality. Hospital inpatient care and nursing home care was the largest component of health care costs and comprised

41% of the national cost of diabetes. Outpatient care, at $20 billion in 2002, comprised 15% of the national cost of diabetes. At $17.5 billion, the cost of outpatient medication and supplies comprised 13% of the national cost of diabetes.[20]

The most recent estimate relating to the economic costs of diabetes in the U.S. has shown a dramatic increase and has grown from $132 billion in 2002 to $174 billion in 2007. The burden of diabetes is shared by all, but it weighs disproportionately on people with diabetes and their families.[19]

Diabetes in Hawaii

Findings in Hawaii reflect the national trend. Hawaii's adult diabetes prevalence more than doubled from 3.2% in 1995 to 8.2% in 2006.[21] During the same time period, Hawaii also experienced a doubling of its obesity rate (based on Body Mass Index (BMI) of 30 or more) from 9.1% in 1990 to 20.6% in 2006.[22] The burden that diabetes is placing on Hawaii is significant and is continuing to rise to unprecedented levels. For example, in 1995 there were 13,250 diabetes-related hospitalizations that occurred. That number rose to 22,660 in 2005. The corresponding cost rose as well. In 1995, hospitals in Hawaii charged third party payers a total of $243 million for diabetes related inpatient stays. In 2005 that figure increased to $686 million. The average charge per diabetes-related hospital discharge rose as well. In 1995, the average charge per discharge stood at $18,300. That figure rose to $30,300 in 2005. Of the diabetes-related hospital charges, about 50% was billed to Medicare, 30% was billed to private party insurers, and about 11% was billed to the State Medicaid system (unpublished data).

In 1995, there were about 405 diabetes-related hospitalizations due to non-traumatic LEA in Hawaii. That figure rose to 464 in 2005. During the same time period, the number of diabetes-related hospitalizations due to ischemic heart disease rose from 1615 to 2337. Similarly for stroke, the number of diabetes-related hospitalizations rose from 796 to 909 (unpublished data)

Interestingly, the rise in the burden of diabetes in Hawaii does not correspond with Hawaii's diabetes preventive care rates. In fact, Hawaii's diabetes preventive care rates have been shown to be the highest in the U.S. when compared with other states. According to the BRFSS (averaged over the years 2002 – 2004), Hawaii had the highest percentage of its adults with diabetes that received 2 A1C tests in a year at 86.4% (95% CI: 82.7--90.2). Hawaii also had the highest percentage of its adults with diabetes who had an annual dilated eye exam [79.4% (95% CI: 74.6--84.3)] and foot exam [83.3% (95% CI: 79.2--87.4)]. Finally, Hawaii had the highest percentage of adults with diabetes who had multiple preventive services (foot exam, eye exam, 2 A1C tests) in the country at 64% (95% CI: 58.3--69.8). The national average for multiple preventive services stood at 39.5%. Puerto Rico had the lowest percentage of multiple preventive services at 20.7% (95% CI: 17.6--23.7).[23]

Diabetes Prevention

It is quite clear that diabetes is a major public health threat that is continuing to worsen. In light of this, it is evident that efforts to slow down this epidemic are crucially needed. Until recently, the question remained as to whether diabetes could be prevented or not. A landmark study that was published in 2002 provided strong evidence that, indeed, diabetes could be prevented. The clinical trial, known as the Diabetes Prevention Program (DPP) set out to answer these questions: (1) does a lifestyle intervention or treatment with Metformin prevent or delay the onset of diabetes, (2) do these two interventions differ in effectiveness, and (3) does their effectiveness differ according to age, sex, or race or ethnic group?[24]

The study concluded that type 2 diabetes could be prevented or delayed in persons at high risk (pre-diabetes). The incidence of diabetes was reduced by 58% with the lifestyle intervention and by 31% with Metformin, when compared with placebo. These effects were similar in men and women and in all racial and ethnic groups. The intensive lifestyle intervention was at least as effective in older participants as it was in younger participants.[24]

Study Rationale

There have been studies that examined the epidemiology of MetS among Hawaii's multiethnic population; however, these studies have focused on a distinct geographic region – the North Kohala region of the Island of Hawaii.[1] The epidemiology of MetS across the entire population of Hawaii has not been examined. A better understanding of the epidemiology of MetS (clustered risk factors compatible with metabolic syndrome) within Hawaii's population will: (1) provide public health programs with the information necessary to focus their interventions where they are most needed, (2) provide insights into the future burden of diabetes and cardiovascular disease, and (3) provide a baseline prevalence measurement of MetS upon which population based trends can be established.

Hawaii's current population-based surveys, which serve as the main source of information for obesity surveillance, arise from the Hawaii BRFSS[25] and the Hawaii Health Survey.[26] Both surveys utilize a definition of obesity and weight status based on standard World Health Organization (WHO) BMI thresholds.[27] Many recent Hawaii State

Department of Health surveillance reports that include data and trends relating to obesity also utilize WHO BMI thresholds to determine weight status.[28,29] The concern here is that there is growing evidence that using standard WHO BMI thresholds to examine obesity and weight status may not be suitable for all ethnic groups, particularly among Hawaii's diverse ethnic mix. In fact, this may be underestimating the obesity rates among Asian populations and overestimating obesity prevalence rates among Pacific Islander populations. For example, Swinburn etal[30] concluded that at higher BMI levels, Polynesians were significantly leaner than Europeans, implying the need for separate BMI definitions of overweight and obesity for Polynesians. Swinburn[30] proposed that for clinical and epidemiological purposes, the definition for overweight for Polynesians should be a BMI of 26 to 32, and obesity should be defined as a BMI of greater than 32.[30] In contrast, there is evidence that while some Asian populations have a lower prevalence of obesity when compared to European populations, the health risks associated with obesity occur at a lower BMI in Asian populations.[50] The differences seen among Asians, Pacific Islanders and Europeans may be due to differences in body build, body composition, and fat distribution. These differences may also be related to differences in risk for cardiovascular disease and different pathways to type 2 diabetes. Ultimately, this points to the possible inadequacy of using universal BMI thresholds in estimating obesity among different ethnic groups.[31]

<u>Study Purpose</u>

This study has three main aims: (1) to describe the epidemiology of obesity in Hawaii using standard and proposed ethnic specific BMI definitions of obesity, (2) to describe the epidemiology of clustered risk factors compatible with MetS among

Hawaii's population using standard and proposed ethnic-specific BMI definitions of obesity, and to (3) to estimate crude and adjusted prevalence ratios (0 – 2 risk factors versus 3 – 4 risk factors) for clustered risk factors compatible with MetS.

Expected Outcomes

The findings of this study will : (1) provide a better understanding of the magnitude of obesity and MetS (clustered risk factors compatible with MetS) in Hawaii's population when taking into account ethnic-specific definitions of obesity based on BMI, (2) examine the association between clustered risk factors compatible with MetS and race / ethnicity when controlling for age, gender, education, poverty status, and healthcare access, (3) provide a glimpse into the future burden Hawaii will potentially face regarding cardiovascular disease and diabetes, and (4) provide a springboard for future research that examines causal relationships (outcomes) and health disparities related to clustered risk factors compatible with MetS.

CHAPTER 2. METHODS

Dataset

The Hawaii-specific BRFSS data for the years 2001 – 2005 was extracted from the Hawaii Health Data Warehouse (HHDW) and combined into a single dataset to be analyzed. The HHDW was created by the Hawaii Department of Health in partnership with the John A. Burns School of Medicine. The HHDW was designed to compile and integrate disparate DOH-owned health data into one place, and to be accessible through the web without any special software. It allows users to download reports and extracted data directly into their personal computers for statistical analysis. The HHDW has many uses which include benchmarking, comparative analyses, trending / forecasting, program planning / evaluation / resource allocation, federal reporting / grant application, policy analyses / legislative reporting, and research.[32] A combination of four software programs was used in the analysis: Business Objects XI, which is the querying software used by the HHDW; Excel 2003 and SPSS 12.0 for data management and formatting; and SAS 9.1.3 for statistical analysis.

Behavioral Risk Factor Surveillance System

The BRFSS is a state-based system of health surveys that generate information about health risk behaviors, clinical preventive practices, and health care access and use primarily related to chronic diseases and injury. It is a cross-sectional telephone (land line) survey conducted by state health departments with technical and methodological assistance provided by CDC. The majority of population-based disease and risk behavior prevalence estimates for Hawaii are derived from the BRFSS. The BRFSS was established in 1984 by CDC. The BRFSS is a self-report survey.[33] For example, diabetes prevalence is derived from the question, "Have you ever been told by a doctor that you have diabetes?"[34]

On a yearly basis, states conduct monthly telephone surveillance using a standardized questionnaire to determine the distribution of risk behaviors and health practices among non-institutionalized adults. Respondents to the survey are adults 18 years or older. Only one adult is interviewed per household. Participants are not compensated for their participation. The states forward the responses to the CDC, where the monthly data are aggregated for each state. The data are returned to the states, and then published on the BRFSS Web site. In turn, Hawaii also publishes its findings on the DOH website (http://www.hawaii.gov/health/statistics/brfss/index.html) and the Healthy Hawaii 2010 website (http://www.healthyhawaii2010.org/).

The BRFSS questionnaire is comprised of core questions and optional modules. There are three types of core questions. Fixed core questions are asked every year. Rotating core questions are asked every other year. Emerging core questions typically focus on "late-breaking" health issues. These questions are evaluated at the end of a survey year to determine if they are valuable. If BRFSS coordinators (state-based) decide to keep the questions, they are added to the fixed core, rotating core, or optional modules, whichever is most appropriate. All states must ask all core questions. The optional modules are standardized questions that are supported by the CDC that cover additional health topics or are more detailed questions on a health topic included in the core. Each year states must choose which optional modules they will use based on the data needs of their state.

BRFSS data are directly weighted for the probability of selection of a telephone number, the number of adults in a household, and the number of telephones in a household. A final post-stratification adjustment is made for non-response and non-coverage of households without telephones. The weights for each relevant factor are multiplied together to get a final weight.[35]

Obesity

A five-year combined dataset was used to estimate the prevalence (percent) and confidence intervals of weight status (underweight, normal weight, overweight, and obese) by DOH race-ethnicity, gender, age, educational level, poverty level, having healthcare coverage, and having a personal doctor. BMI was used as the only measure to estimate weight status, particularly obesity. BMI has been established as a common and practical method to examine population-based obesity.[38,50] However, other studies have shown that self-report surveys tend to underestimate weight and BMI when compared with direct measurement of weight and BMI.[36] Because of growing evidence that the standard WHO BMI thresholds to determine overweight and obesity may not be appropriate for use among Asian and Pacific Islander populations,[11,30,31,38,50,51] two sets of overweight and obesity definitions was used and compared. First, the standard World Health Organization (WHO) overweight and obesity definitions based on BMI was used to estimate the prevalence of underweight (BMI < 18.5), normal weight (BMI ≥ 18.5 and < 25), overweight (BMI ≥ 25 and < 30) and obese (BMI ≥ 30).[37] This was compared with ethnic-specific BMI definitions of overweight and obesity that are currently being proposed in the literature.[38,50,51] For Asians, overweight is defined as a BMI of 23 to 24.9, and obesity is defined as a BMI of 25 or more.[50] For Pacific Islanders, overweight is defined as a BMI of 26 to 31.9, and obesity is defined as a BMI of 32 or more.[51] Prevalence (percent) and confidence intervals were estimated using Proc SURVEYMEANS in the SAS 9.1.3 statistical package (SAS Institute, Cary, North Carolina) to account for the BRFSS complex survey sample design. Hawaii's BRFSS sample is stratified by "County" of the respondent, but does utilize clustering in its design.

Metabolic Syndrome (MetS)

A data subset made up of Hawaii BRFSS data for the years 2001, 2003, and 2005 was extracted from the combined dataset (2001 – 2005) and was used to estimate the prevalence of clustering of four risk factors (presence of 0, 1, 2, 3 or 4 risk factors) associated with MetS – self-reported high cholesterol, high blood pressure, obesity, and diabetes (glucose intolerance). The Hawaii BRFSS did not contain questions relating to cholesterol and blood pressure for the years 2002 and 2004. Therefore, those surveys were removed from the dataset.

Prevalence (percent) estimates and confidence intervals using two previously described definitions of obesity were calculated and compared across DOH race-ethnicity[39], gender, age group, educational level, poverty level, and two proxy measures of health care access: having health insurance, and having a personal doctor. The method employed here was modeled after a previous study that used the BRFSS to examine clustered risk factors of cardiovascular disease (0 – 4 risk factors) among residents of Louisiana.[40] These prevalence estimates represent a proxy measure of the true prevalence of MetS within Hawaii's population. MetS is a clinical diagnosis that depends on laboratory findings and anthropometric measures. In lieu of clinical and laboratory findings, this study relied on self-reported laboratory findings and anthropometric measures that indirectly estimate the prevalence of MetS. For example, the IDF criteria for MetS lists raised triglycerides or reduced HDL cholesterol as a risk factor.[9] The BRFSS, however, only asks the respondent if they were ever told by their doctor that they had "high cholesterol". The BRFSS does not ask the respondent to clarify what constitutes their "high cholesterol". The BRFSS does not ask any questions relating to triglycerides. The IDF also lists raised blood pressure as other criterion for the definition of MetS. The IDF defines hypertension as systolic blood pressure $\geq$ 130 or diastolic blood pressure $\geq$ 85 mm Hg or treatment of previously diagnosed hypertension.[9] The BRFSS only asks if the respondent was ever told they had or have "high blood pressure". Raised fasting plasma glucose is also listed as an IDF criterion for MetS and is defined as FPG $\geq$ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes.[9] The BRFSS only asks if the respondent has ever been told by a doctor they have diabetes. A criterion essential to the diagnosis of MetS is based on the IDF is central obesity, as defined by waist circumference. However, the IDF definition does state that in a person with a BMI of over 30, central obesity is assumed and waist circumference measurement is not necessary.[9] In this case, there is some concordance with the case definitions used to determine central obesity. The BRFSS does ask height and weight, allowing for the calculation of BMI, but does not ask for the respondent's waist circumference.

Aside from the differences in case definitions between the clinical measures listed in the IDF versus the BRFSS, another critical issue needs to be discussed. The BRFSS measures of hypertension, high cholesterol, and diabetes are lifetime prevalence estimates. The BRFSS asks if the respondent has "ever" been told by doctor they have a certain condition. In contrast, the IDF definition relies on current laboratory findings and anthropometric measures.

Prevalence ratios and confidence intervals for MetS risk factor clustering (0 – 2 risk factors versus 3 – 4 risk factors) using both definitions of obesity was estimated for each DOH race-ethnicity[39], and was compared with Whites (referent group). Poisson regression with Proc GENMOD within the SAS statistical package (SAS Institute, Cary, North Carolina) was employed to estimate prevalence ratios. It is common practice to use odds ratios estimated by logistical regression to examine the relative risk of categorical outcome measures. However, when the outcome of interest is common, as in the case of risk factors associated with MetS, the odds ratio can overestimate the relative risk. In these instances, using Poisson regression to estimate relative risk is preferred.[1,41,42] Many sample surveys (such as the BRFSS) employ a probability-based complex sample design.[43] The Hawaii BRFSS uses a disproportionate stratified sample (stratified by island and phone density).[44] To make statistically valid inferences from the sample to the study population (in this case, the population of Hawaii), the sample design must be taken into account. Traditional SAS procedures compute statistics under the assumption that the sample is obtained by simple random sampling. These procedures do not correctly estimate the variance when applied to a sample drawn through a complex design. SAS procedures such as SURVEYSELECT, SURVEYMEANS, and SURVEYREG do account for complex sampling designs.[43] However, the GENMOD (Poisson regression) procedure does not account for complex sampling design. As such, the standard errors that were calculated were probably underestimated, potentially creating narrower confidence intervals, which would impact the tests of statistical significance.[45]

Crude and adjusted prevalence ratios for MetS risk factor clustering (0 – 2 risk factors versus 3 – 4 risk factors) using two definitions of obesity were estimated through seven models: model one: crude prevalence ratios; model two: adjusted for age; model three: adjusted for age and gender; model four: adjusted for age, gender, and education; model five: adjusted for age, gender, education, and poverty; model six: adjusted for age, gender, education, poverty, and having health insurance; and model seven: adjusted for age, gender, education, poverty, having health insurance, and having a personal doctor.

The variables included in the models were used to adjust for potentially confounding effects. These variables were selected on the basis of statistical findings, prior knowledge of MetS risk factors, potential biases of the BRFSS dataset, and literature review. For example, age and gender have been determined to be risk factors in the development of MetS.[2] Previous analysis of Hawaii BRFSS data have shown that educational attainment is inversely related to diabetes prevalence in adults.[28] More recent analysis of Hawaii BRFSS data has shown that household income (this study uses federal poverty level guidelines as a measure of income) is inversely associated with obesity prevalence and high blood pressure prevalence.[29] Health care access has been suggested as a potential confounder in surveys such as the BRFSS that rely on self reporting as a mechanism to establish disease prevalence. Self report surveys such as the BRFSS assume that the individual has access to a doctor, which would allow for a diagnosis to be made. It could be argued that the likelihood of being diagnosed with a condition (e.g., diabetes) may be lower among individuals who do not have unimpeded access to healthcare. This raises the possibility of bias being introduced into the BRFSS, affecting the validity of its diabetes prevalence estimates.[1] To account for this potential bias, proxy measures of health care access were added to models six and seven. The BRFSS has been used by other investigators to assess access to healthcare. For example, Kim etal[46] used the BRFSS to examine whether ethnicity was an independent risk factor for differences in healthcare access. Kim used five BRFSS measures to quantify healthcare access: (1) whether the person had health insurance, (2) whether the individual could not see a doctor when needed due to cost, (3) whether the person had a primary care provider, (4) whether the person used an emergency room or urgent care center for primary care, and (5) whether the person's last physical examination was more than a year ago.[46] Of these measures, only two were used in this analysis: whether the person had healthcare coverage and whether the person had a primary care provider (personal doctor). The other healthcare access measures were not included in the models for two reasons: the response rate was too low, or the questions were not asked in all three BRFSS years (2001, 2003, 2005).

Exclusions

The BRFSS is an adult survey; therefore, individuals under the age of 18 were not represented in the dataset. Records with missing responses regarding self-reported high cholesterol, hypertension, diabetes, and BMI were also excluded from the dataset. Records that were missing "County" responses were also excluded. Demographic characteristics of survey records excluded from the final dataset due to missing data were compared with the demographic characteristics of the final dataset to examine the generalizability of the study results to the entire population of Hawaii.

Case Definitions

Weight status (underweight, normal weight, overweight, obese) was defined using two classifications based on BMI – the WHO standard definition[37] and proposed ethnic-specific BMI definitions for Asians[50] and Pacific Islanders.[51] High cholesterol was defined as those responding "yes" to the BRFSS question, "Have you ever been told you have high cholesterol by a health care professional?" Hypertension was defined as those responding "yes" to the BRFSS question, "Have ever been told you have high blood pressure by a health care professional?" Diabetes was defined as those reporting "yes" to the BRFSS question, "Have you ever been told you have diabetes by a health care professional?" Those responding that they had gestational diabetes, borderline, or pre-diabetes were treated as a "no" response. Educational level was categorized into five groups: those with education up thru the eighth grade, those with education from ninth to eleventh grade, those with a high school diploma, those with one to three years of college, and those with four or more years of college education. Poverty level was used as a proxy measure of income. Poverty level was categorized into three groups based on the Federal Poverty Level (FPL) guidelines used by the Food Stamp Nutrition Education (FSNE) program of the U.S. Department of Agriculture (USDA). The FSNE program defines its primary target population as those persons in the 0-130% FPL range and its second tier target population as those persons in the 131-185% FPL. Those at 186% FPL are not eligible for the FSNE program.[47] Healthcare access was defined using two measures: whether the person had health insurance and whether the person had a primary care provider (personal doctor).

Prior to 2002, the Hawaii BRFSS categorized respondents into mutually exclusive race / ethnicity groupings based on their response to the question, "what is your race?" Respondents were only allowed to make one choice. As of 2002, the Hawaii BRFSS used a similar method as the Hawaii Health Survey (HHS) to categorize respondents into mutually exclusive race/ethnicity groupings.[48] The HHS allows respondents to list up to four ethnicities for both their (and for each household member) mother and father. In addition, a respondent is allowed to specify another ethnicity if it is not listed, or they can reply they do not know, or refuse to answer. These eight possible choices are narrowed down into one race/ethnicity. Specifically, if Hawaiian is listed for the mother or father the person is coded to Hawaiian. Otherwise, the person is coded to the first ethnicity listed (other than Caucasian or unknown) for the Father. If the Father's responses are Caucasian and/or unknown, the person's ethnicity is coded to the first ethnicity listed (other than Caucasian or unknown) for the Mother. If there are no other responses other than Caucasian or unknown, the person is coded to Caucasian. Otherwise, the person is coded to do not know, refused, or missing.[49]

CHAPTER 3. OBESITY

Background

Because of its current public health significance, the prevalence of obesity must to be monitored and tracked at the population level in order to assess its burden on society. The most common and pragmatic way to measure obesity at the population level is the BMI. The different BMI weight classifications based on the WHO, proposed Asian thresholds, and proposed Pacific Islander thresholds are described in Table 4.

Table 4. Weight classification based on WHO and ethnic-specific BMI cut-points

Classification	WHO Defined BMI Cut-points[37]	Proposed Asian BMI Cut-points[50]	Proposed Pacific Islander BMI Cut-points[51]
Underweight	<18.5	<18.5	<18.5
Normal Weight	18.5 – 24.9	18.5 – 22.9	18.5 – 25.9
Overweight	25 – 29.9	23 – 24.9	26 – 31.9
Obese	30 or more	25 or more	32 or more

Results

Results from the 2001 to 2005 Hawaii BRFSS surveys were extracted from the HHDW and combined to create one dataset. The total number of records included in the combined dataset was 23,457. A total of 1251 records that were missing "County" and "BMI" data were removed from the dataset. Records that were missing "County" information were removed from the dataset because the Hawaii's BRFSS is stratified by "County". As such, "County" is needed to account for estimating weights based on a complex survey design when using SAS 9.1.3 (Proc SURVEYMEANS). The final sample size contained 22,206 individual records. When weighted, the 22,206 records represented 4,479,994 Hawaii adults over a 5-year period. Table 5 shows the distribution of BRFSS survey records, unweighted and weighted, by year.

Table 5. Unweighted and weighted frequencies of Hawaii BRFSS survey records for the Years 2001 to 2005

Survey Year	Unweighted Frequencies	Percent	Weighted Frequencies	Percent
2001	4269	19.2	877,922	19.6
2002	5669	25.5	882,521	19.7
2003	4022	18.1	890,773	19.9
2004	2028	9.1	881,711	19.7
2005	6218	28.0	947,067	21.1
Totals	22206	100	4,479,994	100

The weighted adult prevalence (percent) and confidence intervals of selected population characteristics of the five-year dataset are listed in Table 6. Whites (34.4%), Japanese (20.5%), Filipino (15.4%), Native Hawaiians (12%), and Chinese (7.2%) make the five major ethnic groups in Hawaii. There are no significant gender differences with males at 50.3% and females at 49.7%. Approximately 19.6% of the adult population is between the ages of 40-49. Approximately 90% of Hawaii's adults have a high school education or higher (high school: 31.5%, some college: 29.9%, four or more years of college: 32.8%). About 16.3% of Hawaii's adults live below 130% of the federal poverty level, with another 9.4% living between 130% and 185% of the federal poverty level. Approximately 91.8% of the adult population has some type of healthcare coverage and 82.4% report having a personal doctor.

Table 6. Prevalence (%) of selected population characteristics

Category	Population Characteristic	n	Prevalence (%)
Race / Ethnicity	Black	295	1.6 (1.4, 1.8)
	Chinese	1272	7.2 (6.7, 7.7)
	Filipino	2811	15.4 (14.6, 16.2)
	Japanese	4285	20.5 (19.7, 21.2)
	Native Alaskan/ American Indian	140	0.5 (0.4, 0.7)
	Native Hawaiian	2696	12.0 (11.4, 12.7)
	Other	600	2.9 (2.6, 3.3)
	Other Asian	374	2.3 (2.0, 2.6)
	Other Pacific Islander	282	2.2 (1.8, 2.6)
	White	9313	34.4 (33.5, 35.2)
	UNKNOWN	138	0.9 (0.6, 1.1)
Age	18-19	350	2.8 (2.4, 3.2)
	20-29	2670	18.1 (17.2, 18.9)
	30-39	3735	18.9 (18.1, 19.7)
	40-49	4812	19.6 (18.9, 20.4)
	50-59	4407	16.8 (16.1, 17.5)
	60-69	2824	10.8 (10.2, 11.3)
	70-79	2287	8.8 (8.3, 9.3)
	80+	1028	3.8 (3.5, 4.1)
	UNKNOWN	93	0.4 (0.3, 0.5)
Gender	Female	12890	49.7 (48.7, 50.7)
	Male	9316	50.3 (49.3, 51.3)
Education Level	Up to Grade 8	470	1.7 (1.5, 2.0)
	Grades 9 thru 11	888	3.9 (3.5, 4.3)
	Grade 12 or GED	6636	31.5 (30.6, 32.4)
	College 1 to 3 years	6536	29.9 (29.0, 30.8)
	College 4 years or more	7648	32.8 (31.9, 33.7)
	UNKNOWN	28	0.1 (0.1, 0.2)
Federal Poverty Level	0-130	3621	16.3 (15.8, 16.8
	131-185	2084	9.4 (9, 9.8)
	186+	12182	54.9 (54.2, 55.5)
	Unknown	4319	19.4 (18.9, 20)
Healthcare Coverage	Yes	20344	91.8 (91.2, 92.4)
	No	1831	8.2 (7.6, 8.8)
Personal Doctor	Yes	18511	82.4 (81.7, 83.2)
	No	3654	17.6 (16.8, 18.2)

Table 7 describes the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO BMI weight classifications by ethnicity, using Whites as the referent group. Other Pacific Islanders have a significantly higher prevalence of obesity (61.6, 95% CI: 53.4--69.8) than any other ethnic group. Native Hawaiians have the second highest prevalence of obesity (37.9, 95% CI: 35.1--40.8) compared with the remaining ethnic groups. Other Asians have the lowest prevalence of obesity (3.6, 95% CI: 0.8--6.5) among all the ethnic groups. When using Whites as the referent group, "Other Pacific Islanders", Native Hawaiians, Blacks, and "Others" have a significantly higher prevalence of obesity. Filipinos, Japanese, Chinese, and Other Asians have a significantly lower prevalence of obesity when compared to Whites.

Table 7. Prevalence (%) of weight status by ethnicity using WHO BMI weight classifications

Race / Ethnicity	Underweight	Normal Weight	Overweight	Obese
Black	2.1 (0.3, 3.8)	**36.3 (29.3, 43.3)**	35.7 (29.0, 42.3)	**25.9 (19.4, 32.5)**
Chinese	**5.9 (3.9, 7.8)**	**53.0 (49.4, 56.7)**	30.8 (27.4, 34.2)	**10.3 (8.2, 12.4)**
Filipino	1.9 (1.1, 2.6)	**51.0 (48.2, 53.9)**	34.6 (31.9, 37.2)	**12.5 (0.7, 14.3)**
Japanese	2.9 (2.3, 3.4)	**51.4 (49.4, 53.5)**	34.5 (32.6, 36.5)	**11.2 (9.9, 12.5)**
Native Alaskan / American Indian	1.2 (0.0, 2.4)	46.5 (33.1, 59.8)	30.8 (19.7, 41.8)	21.5 (10.9, 32.1)
Native Hawaiian	1.6 (0.6, 2.5)	**26.8 (24.3, 29.3)**	33.7 (31.1, 36.4)	**37.9 (35.1, 40.8)**
Other	1.8 (0.4, 3.2)	**37.4 (32.4, 42.5)**	36.3 (30.9, 41.7)	**24.5 (19.5, 29.4)**
	5.4	**61.0**	29.9	**3.6**

Other Asian	**(2.5, 8.2)**	**54.1, 68.0)**	(23.6, 36.3)	**(0.8, 6.5)**
Other Pacific Islander	**0.0** **(0.0, 0.1)**	**14.7** **(9.1, 20.3)**	**23.7** **(17.4, 29.9)**	**61.6** **(53.4, 69.8)**
White (referent)	2.5 (2.0, 3.0)	45.8 (44.3, 47.2)	34.1 32.7, 35.5)	17.6 (16.4, 18.8)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing each ethnic group to Whites (referent group)

Table 8 shows the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using ethnic-specific BMI weight classifications by ethnicity, using Whites as the referent group. While "Other Pacific Islanders" continue to have the highest prevalence of obesity (47.9, 95% CI: 38.6--57.3) than any other ethnic group, it is lower (non-significant) than the prevalence estimate using the WHO standard BMI definition (61.6, 95% CI: 53.4--69.8). Filipinos have the second highest prevalence of obesity (47.1, 95% CI: 44.3--49.9) followed by Japanese (45.7, 95% CI: 43.6--47.8) and Chinese (41.1, 95% CI: 37.5--44.7). However, these differences are all non-significant. Native Hawaiians have a lower prevalence of obesity (27.8, 95% CI: 25--30.5) than all Asian groups and these differences are significant except when compared with Other Asians (33.6, 95% CI: 26.9--40.2). When using Whites as the referent group, all other ethnic groups have significantly higher prevalence of obesity except for Alaska Natives / American Indians.

When comparing obesity prevalence rates within ethnic groups using the two BMI weight classifications (WHO versus ethnic specific thresholds), many significant differences are observed, especially among Asian groups. For example, among Chinese, the obesity prevalence rate increases from 10.3% (8.2--12.4) to 41.1% (37.5--44.7).

Among Filipinos, the obesity prevalence rate increases from 12.5% (0.7--14.3) to 47.1% (44.3--49.9). Among Japanese, the obesity prevalence rate increases from 11.2% (9.9--12.5) to 45.7% (43.6-- 47.8). Finally, among "Other Asians", the obesity prevalence rate increased from 3.6% (0.8--6.5) to 33.6% (26.9--40.2).

The differences in obesity prevalence rates among Pacific Islanders are also evident and are in contrast to what is observed among Asian groups. For example, the obesity prevalence rate among Native Hawaiians decreased from 37.9% (35.1--40.8) to 27.8% (25.0--30.5). Among "Other Pacific Islanders", the obesity prevalence rate decreased from 61.6% (53.4--69.8) to 47.9% (38.6--57.3).

Table 8. Prevalence (%) of weight status by ethnicity using ethnic-specific BMI weight classifications

Race / Ethnicity	Underweight	Normal Weight	Overweight	Obese
Black	2.1 (0.3, 3.8)	**36.3 (29.3, 43.3)**	35.7 (29.0, 42.3)	**25.9 (19.4, 32.5)**
Chinese	**5.9 (3.9, 7.8)**	**36.7 (33.2, 40.2)**	**16.3 (13.7, 19.0)**	**41.1 (37.5, 44.7)**
Filipino	1.9 (1.1, 2.6)	**30.0 27.3, 32.7)**	**21.1 (18.8, 23.4)**	**47.1 (44.3, 49.9)**
Japanese	2.9 (2.3, 3.4)	**31.8 (29.9, 33.7)**	**19.7 (18.0, 21.3)**	**45.7 (43.6, 47.8)**
Native Alaskan / American Indian	1.2 (0.0, 2.4)	46.5 (33.1, 59.8)	30.8 (19.7, 41.8)	21.5 (10.9, 32.1)
Native Hawaiian	1.6 (0.6, 2.5)	**36.0 (33.3, 38.7)**	34.7 (32.0, 37.3)	**27.8 (25.0, 30.5)**
Other	1.8 (0.4, 3.2)	37.4 (32.4, 42.5)	36.3 (30.9, 41.7)	**24.5 (19.5, 29.4)**
Other Asian	**5.4 (2.5, 8.2)**	37.5 (30.0, 45.0)	**23.5 (17.7, 29.4)**	**33.6 (26.9, 40.2)**
Other Pacific Islander	**0.0 (0.0, 0.1)**	**21.4 (15.0, 27.8)**	30.6 (22.9, 38.4)	**47.9 (38.6, 57.3)**

White	2.5 (2.0, 3.0)	45.8 (44.3, 47.2)	34.1 (32.7, 35.5)	17.6 (16.4, 18.8)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing each ethnic group to Whites (referent group)

The prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO BMI weight classifications by educational level, using those with four or more years of college as the referent group is listed in Table 9. In general, those with less education tend to have significantly higher prevalence rates of obesity, and are less likely to be of normal weight.

Table 9. Prevalence (%) of weight status by education using WHO BMI weight classifications

Education Level	Underweight	Normal	Overweight	Obese
Up to Grade 8	3.8 (1.6, 5.9)	49.0 (42.4, 55.5)	30.3 (24.5, 36.2)	17.0 (11.6, 22.3)
Grades 9 thru 11	3.4 (1.7, 5.1)	**39.9 (34.6, 45.2)**	34.7 (29.9, 39.5)	**22.0 (18.1, 25.9)**
Grade 12 or GED	2.6 (2.0, 3.2)	**40.8 (39.1, 42.6)**	34.1 (32.4, 35.7)	**22.5 (20.9, 24.0)**
College 1 to 3 years	2.7 (2.1, 3.3)	**45.0 (43.2, 46.8)**	32.6 (30.9, 34.2)	**19.7 (18.1, 21.2)**
College 4 years or more	2.3 (1.8, 2.7)	50.0 (48.4, 51.6)	34.5 (33.0, 36.0)	13.2 (12.1, 14.3)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing each educational level to persons with 4 or more years of college (referent group)

Table 10 displays the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using ethnic specific BMI weight classifications by educational level, using those with four or more years of college as the referent group. A similar pattern to Table 9 is seen. In general, obesity prevalence rates are significantly higher in the less educated groups when compared to those with four or more years of college education. There is a striking difference in the obesity prevalence rates within educational groups when comparing between the two BMI definitions of weight status and obesity. In this case, all educational groups have a significantly higher obesity prevalence rate (Table 10) when using ethnic specific BMI definitions compared to the obesity rates when using the standard WHO BMI definitions (Table 9).

Table 10. Prevalence (%) of weight status by education using ethnic-specific BMI weight classifications

Education Level	Underweight	Normal	Overweight	Obese
Up to Grade 8	3.8 (1.6, 5.9)	36.9 (30.7, 43.1)	27.0 (21.2, 32.9)	32.3 (26.0, 38.5)
Grades 9 thru 11	3.4 (1.7, 5.1)	34.8 (29.5, 40.1)	26.7 (22.4, 31.0)	**35.1** **(30.4, 39.9)**
Grade 12 or GED	2.6 (2.0, 3.2)	**34.5** **(32.8, 36.2)**	27.7 (26.2, 29.3)	**35.1** **(33.4, 36.9)**
College 1 to 3 years	2.7 (2.1, 3.3)	**37.2** **(35.4, 38.9)**	27.3 (25.8, 28.9)	**32.8** **(31.0, 34.5)**
College 4 years or more	2.3 (1.8, 2.7)	41.0 (39.5, 42.5)	28.1 (26.7, 29.5)	28.7 (27.2, 30.1)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing each educational level to persons with 4 or more years of college (referent group)

The prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO and ethnic specific BMI weight classifications by gender, using males as the referent group are shown in Table 11. Regardless of what BMI definition is used, females have a significantly lower prevalence rate of obesity when compared with males. Females also have a significantly higher prevalence rate of normal weight when compared with males. Similar to the findings when examining obesity by educational level, the obesity prevalence rate is significantly higher in both genders when using ethnic specific definitions of weight stratus and obesity.

Table 11. Prevalence (%) of weight status by gender using WHO BMI and ethnic specific BMI weight classifications

Gender (WHO BMI)	Underweight	Normal	Overweight	Obese
Female	**4.4 (3.8, 4.9)**	**54.2 (52.9, 55.4)**	**25.5 (24.5, 26.6)**	**15.9 (15.0, 16.9)**
Male (referent)	0.8 (0.5, 1.1)	36.4 (35.0, 37.8)	41.8 (40.4, 43.3)	20.9 (19.7, 22.2)
Gender (Ethnic BMI)	Underweight	Normal	Overweight	Obese
Female	**4.4 (3.8, 4.9)**	**46.3 (45.1, 47.6)**	**23.0 (22.0, 24.0)**	**26.3 (25.2, 27.4)**
Male (referent)	0.8 (0.5, 1.1)	28.8 (27.4, 30.1)	32.3 (31.0, 33.6)	38.1 (36.7, 39.6)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing females to males (referent group) in the same subgroup (WHO BMI, ethnic BMI)

Table 12 displays the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO definitions and ethnic specific BMI weight classifications by poverty level, using those in the 186+% category as the referent group. The obesity prevalence rate is significantly higher in the 0 – 130% poverty group when compared to the 186+% poverty group, but this in only true when using standard WHO definitions of obesity. In keeping with previous findings, the obesity prevalence rate is significantly higher in all poverty levels when using ethnic specific BMI definitions.

Table 12. Prevalence (%) of weight status by poverty level using WHO BMI and ethnic specific BMI weight classifications

Poverty level (WHO BMI)	Underweight	Normal	Overweight	Obese
0-130	3.2 (2.3, 4.1)	44.0 (41.4, 46.5)	**30.1 (27.8, 32.4)**	**22.7 (20.5, 24.9)**
131-185	2.4 (1.3, 3.5)	42.6 (39.1, 46.1)	33.7 (30.4, 36.9)	21.3 (18.0, 24.6)
186+ (Referent)	2.2 (1.8, 2.6)	45.4 (44.1, 46.7)	34.9 (33.7, 36.1)	17.5 (16.5, 18.6)
Poverty level (Ethnic BMI)	Underweight	Normal	Overweight	Obese
0-130	3.2 (2.3, 4.1)	37.2 (34.7, 39.6)	26.4 (24.2, 28.6)	33.2 (30.8, 35.6)
131-185	2.4 (1.3, 3.5)	35.4 (32.1, 38.7)	27.1 (24.1, 30.2)	35.0 (31.5, 38.6)
186+ (Referent)	2.2 (1.8, 2.6)	37.7 (36.4, 38.9)	28.1 (27.0, 29.2)	32.1 (30.8, 33.3)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing poverty levels to 186+ (referent group) in the same subgroup (WHO BMI, ethnic BMI)

The prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO BMI definitions of weight status and obesity, using 18 – 19 year olds as the referent group are shown in Table 13. In this case, the obesity prevalence rate is significantly higher among those in all the older age groups except for those in the 70 – 79 and 80+ age groups.

Table 13. Prevalence (%) of weight status by adult age group using WHO BMI weight classifications

Age group	Underweight	Normal	Overweight	Obese
18-19	6.2 (2.6, 9.8)	59.9 (52.8, 66.9)	24.3 (18.3, 30.3)	9.6 (5.4, 13.8)
20-29	3.1 (2.2, 4.1)	50.5 (47.8, 53.2)	28.3 (25.9, 30.6)	**18.1** **(15.7, 20.4)**
30-39	2.2 (1.6, 2.8)	**41.8** **(39.6, 44.0)**	**35.4** **(33.2, 37.5)**	**20.7** **(18.7, 22.6)**
40-49	**1.4** **(1.0, 1.9)**	**41.8** **(39.8, 43.8)**	**37.0** **(35.1, 39.0)**	**19.8** **(18.1, 21.5**
50-59	**2.0** **(1.4, 2.5)**	**39.5** **(37.4, 41.6)**	**36.7** **(34.6, 38.8)**	**21.8** **(19.9, 23.7)**
60-69	1.9 (1.3, 2.6)	**42.4** **(39.7, 45.1)**	**35.5** **(33.0, 38.1)**	**20.2** **(17.9, 22.4)**
70-79	4.3 (2.9, 5.7)	51.4 (48.5, 54.4)	32.6 (29.9, 35.3)	11.7 (9.7, 13.7)
80+	6.2 (4.3, 8.0)	61.6 (57.2, 65.9)	26.2 (22.2, 30.2)	6.1 (3.9, 8.3)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing age groups to the 18 – 19 age group (referent group)

Table 14 displays the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using ethnic specific BMI definitions of weight status and obesity by age group, using 18 – 19 year olds as the referent group. A similar pattern is seen, with the majority of older age groups having significantly higher obesity prevalence rates with the exception of in the 20 – 29, 70 – 79, and 80+ age groups. In keeping with previous findings, the obesity prevalence rate is significantly higher in all age groups when using ethnic specific BMI definitions.

Table 14. Prevalence (%) of weight status by adult age group using ethnic specific BMI weight classifications

Age group	Underweight	Normal	Overweight	Obese
18-19	6.2 (2.6, 9.8)	59.8 (52.8, 66.8)	12.9 (8.6, 17.3)	21.1 (15.2, 27.0)
20-29	3.1 (2.2, 4.1)	**45.9** **(43.3, 48.6)**	**24.7** **(22.4, 27.0)**	26.2 (23.7, 28.7)
30-39	2.2 (1.6, 2.8)	**35.7** **(33.6, 37.8)**	**28.7** **(26.7, 30.7)**	**33.4** **(31.2, 35.6)**
40-49	**1.4** **(1.0, 1.9)**	**33.4** **(31.5, 35.3)**	**29.5** **(27.7, 31.3)**	**35.7** **(33.7, 37.7)**
50-59	**2.0** **(1.4, 2.5)**	**31.4** **(29.5, 33.3)**	**29.3** **(27.3, 31.2)**	**37.4** **(35.2, 39.5)**
60-69	1.9 (1.3, 2.6)	**32.8** **(30.3, 35.4)**	**29.9** **(27.5, 32.3)**	**35.4** **(32.8, 38.0)**
70-79	4.3 (2.9, 5.7)	**37.9** **(35.1, 40.8)**	**28.3** **(25.8, 30.9)**	29.5 (26.7, 32.2)
80+	6.2 (4.3, 8.0)	48.9 (44.4, 53.3)	**24.2** **(20.3, 28.1)**	20.8 (16.9, 24.6)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing age groups to the 18 – 19 age group (referent group)

Table 15 describes the prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO definitions and ethnic specific BMI weight classifications by healthcare coverage, using those with healthcare coverage as the referent group. When using standard WHO BMI definitions of obesity, no significant differences exist between obesity prevalence rates of those with and without healthcare coverage. However, those without healthcare coverage have a significantly lower obesity prevalence rate compared to those who do have healthcare coverage when using ethnic specific BMI definitions. In keeping with previous findings, the obesity prevalence rate is significantly higher regardless of having healthcare coverage when using ethnic specific BMI definitions.

Table 15. Prevalence (%) of weight status by healthcare coverage using WHO BMI and ethnic specific BMI weight classifications

Healthcare coverage	Underweight	Normal	Overweight	Obese
Healthcare coverage – No (WHO BMI)	4.2 (2.8, 5.7)	46.9 (43.3, 50.5)	31.1 (27.9, 34.4)	17.7 (15.0, 20.5)
Healthcare coverage – Yes (WHO BMI)	2.4 (2.1, 2.7)	45.1 (44.1, 46.0)	34.0 (33.1, 34.9)	18.5 (17.7, 19.4)
Healthcare coverage – No (Ethnic BMI)	**4.2 (2.8, 5.7)**	**44.2 (40.6, 47.7)**	25.4 (22.4, 28.4)	**26.2 (23.2, 29.3)**
Healthcare coverage – Yes (Ethnic BMI)	2.4 (2.1, 2.7)	36.8 (35.9, 37.8)	27.9 (27.0, 28.8)	32.8 (31.8, 33.8)

*Bold font denotes statistically significant difference ($P < .05$) of prevalence comparing healthcare coverage – no, to healthcare coverage – yes (referent group) in the same subgroup (WHO BMI, ethnic BMI)

The prevalence (percent) and confidence intervals of weight status broken down into underweight, normal weight, overweight, and obese using standard WHO definitions and ethnic specific BMI weight classifications by personal doctor, using those with a personal doctor as the referent group are shown in Table 16. When using standard WHO BMI definitions of obesity, no significant differences exist between obesity prevalence rates of those with and without personal doctor. However, those without a personal doctor have a significantly lower obesity prevalence rate compared to those who do have healthcare coverage when using ethnic specific BMI definitions. This finding is consistent with the findings of the previous table (Table 15). In keeping with previous findings, the obesity prevalence rate is significantly higher regardless of having personal doctor when using ethnic specific BMI definitions.

Table 16. Prevalence (%) of weight status by personal doctor using WHO BMI and ethnic specific BMI weight classifications

Personal doctor	Underweight	Normal	Overweight	Obese
Personal Doctor - No (WHO BMI)	2.6 (1.9, 3.4)	46.3 (43.9, 48.7)	32.9 (30.7, 35.1)	18.2 (16.0, 20.3)
Personal Doctor - Yes (WHO BMI)	2.6 (2.2, 2.9)	45.0 (43.9, 46.0)	33.9 (32.9, 34.9)	18.5 (17.7, 19.4)
Personal Doctor - No (Ethnic BMI)	2.6 (1.9, 3.4)	**41.6 (39.2, 43.9)**	28.4 (26.3, 30.5)	**27.4 (25.0, 29.7)**
Personal Doctor - Yes (Ethnic BMI)	2.6 (2.2, 2.9)	36.6 (35.6, 37.6)	27.5 (26.6, 28.5)	33.3 (32.3, 34.3)

*Bold font denotes statistically significant difference (P < .05) of prevalence comparing personal doctor – no, to personal doctor – yes (referent group) in the same subgroup (WHO BMI, ethnic BMI)

CHAPTER 4. METABOLIC SYNDROME

Results

Results from the 2001, 2003 and 2005 Hawaii BRFSS surveys were extracted from the HHDW and combined to create one dataset. The total number of records included in the combined dataset was 15,255. After weighting, these records represented a three-year (2001, 2003, 2005) estimated population of 2,860,350 (Table 17).

Table 17. Unweighted and weighted frequencies of Hawaii BRFSS respondents for the Years 2001, 2003, 2005

Survey Year	Unweighted Frequencies	Percent	Weighted Frequencies	Percent
2001	4500	29.5	922470	32.3
2003	4339	28.4	961127	33.6
2005	6416	42.1	976753	34.1
Totals	15255	100.0	2860350	100

BRFSS surveys for the years 2002 and 2004 did not include questions related to cholesterol and hypertension and were removed from the dataset prior to analysis. A total of 3705 records from 2001, 2003, and 2005 that were missing data relating to BMI, hypertension status, cholesterol status, or diabetes were excluded from the dataset. Another 204 records that were missing "County" were also removed from the dataset. It was necessary to remove these records from the dataset because the Hawaii BFRSS stratifies its sample based on "County". "County" is used as the "Strata" variable in SAS Proc SURVEYMEANS to account for complex survey sample design.[52] The final dataset had a sample size of 11,346.

Demographic characteristics of the excluded records were compared with the demographic characteristics of the records that were included in the final dataset (relative to BMI, hypertension, cholesterol, and diabetes) and are shown in Table 18. Significant differences between the excluded and included groups were found. For example, the excluded group had significantly ($P < .05$) higher percentages of Filipinos (19.4% versus 13.7%), Native Hawaiians (13.5% versus 10.4%), and other Pacific Islanders (3.4% versus 1.5%) but significantly ($P < .05$) lower percentages of Japanese (15.5% versus 21.7%) and Whites (30.1% versus 36.6%). There were no significant gender differences between groups. As a whole, the excluded group was significantly younger, was less educated, was more likely to be living in poverty, had a higher percentage without healthcare coverage, and had a higher percentage without a personal doctor when compared with the included group.

Table 18. Comparison of prevalence (%) of selected population characteristics by excluded and included records

Category	Population Characteristic	Percent (Excluded Records)	Percent (Included Records)
Race / Ethnicity	Black	1.6 (1.0, 2.1)	1.8 (1.5, 2.2)
	Chinese	8.7 (7.3, 10.0)	7.9 (7.2, 8.6)
	Filipino	**19.4 (17.5, 21.3)**	**13.7 (12.8, 14.7)**
	Japanese	**15.5 (14.0, 17.1)**	**21.7 (20.7, 22.7)**
	Native Alaskan/ American Indian	0.4 (0.2, 0.7)	0.5 (0.4, 0.7)
	Native Hawaiian	**13.5 (12.1, 14.9)**	**10.4 (9.7, 11.2)**
	Other	3.6 (2.8, 4.4)	3.0 (2.6, 3.5)
	Other Asian	2.7 (1.9, 3.4)	2.1 (1.7, 2.5)
	Other Pacific Islander	**3.4 (2.6, 4.3)**	**1.5 (1.2, 1.9)**
	White	**30.1 (28.3, 32.0)**	**36.6 (35.4, 37.7)**
	UNKNOWN	1.0 (0.7, 1.4)	0.6 (0.5, 0.8)

Gender	Female	51.3 (49.2, 53.5)	49.5 (48.3, 50.8)
	Male	48.7 (46.5, 50.8)	50.5 (49.2, 51.7)
Age	18-19	**7.6 (6.2, 8.9)**	**1.4 (1.0, 1.7)**
	20-29	**34.1 (31.9, 36.2)**	**11.1 (10.2, 12.0)**
	30-39	**23.8 (22.0, 25.6)**	**17.1 (16.1, 18.1)**
	40-49	**15.7 (14.3, 17.2)**	**20.9 (19.9, 21.9)**
	50-59	**8.4 (7.3, 9.4)**	**19.6 (18.7, 20.6)**
	60-69	**3.8 (3.1, 4.5)**	**13.8 (13.0, 14.7)**
	70-79	**3.5 (2.8, 4.2)**	**10.9 (10.2, 11.7)**
	80+	**2.1 (1.6, 2.6)**	**4.6 (4.2, 5.1)**
	UNKNOWN	1.2 (0.8, 1.5)	0.5 (0.3, 0.7)
Education Level	Up to Grade 8	2.2 (1.5, 2.8)	1.9 (1.6, 2.3)
	Grades 9 thru 11	5.1 (4.1, 6.2)	3.8 (3.2, 4.3)
	Grade 12 or GED	**38.7 (36.6, 40.8)**	**27.6 (26.5, 28.7)**
	College 1 to 3 years	29.5 (27.5, 31.5)	29.3 (28.2, 30.5)
	College 4 years or more	**23.9 (22.2, 25.7)**	**37.2 (36.0, 38.4)**
	UNKNOWN	0.6 (0.3, 0.8)	0.2 (0.1, 0.3)
Federal Poverty Level	130	**25.3 (23.3, 27.2)**	**14.8 (13.9, 15.8)**
	185	11.0 (9.6, 12.3)	9.8 (9.0, 10.7)
	186+	**36.0 (34.0, 38.0)**	**55.7 (54.4, 57.0)**
	UNKNOWN	**27.8 (25.8, 29.8)**	**19.6 (18.6, 20.6)**
Healthcare coverage	No	**15.1 (13.5, 16.7)**	**5.0 (4.5, 5.6)**
	Yes	**84.9 (83.3, 86.5)**	**95.0 (94.4, 95.5)**
Personal doctor	No	**30.1 (28.1, 32.2)**	**13.4 (12.6, 14.3)**
	Yes	**69.9 (67.8, 71.9)**	**86.6 (85.7, 87.4)**

* Bold font denotes statistically significant differences ($P < .05$) of prevalence between included and excluded records.

Table 19 shows the prevalence of clustered risk factors compatible with MetS by DOH race/ethnicity using standard WHO BMI definitions of obesity. Chinese (43.7%), Filipino (46.5%), Japanese (39.8%), Native Alaskan / American Indians (31.7%) and Native Hawaiians (38.4%) all had significantly lower percentages of zero risk factors compatible with MetS when compared with Whites. Interestingly, this finding exists even when using standard WHO BMI thresholds to determine weight status and obesity. One would expect to find Asian groups with higher percentages of zero risk factors when compared with Whites. Conversely, the finding of "Other Pacific Islanders" and Native Hawaiians with lower percentages of zero risk factors was expected. On the other end of the spectrum (4 risk factors compatible with MetS) only Native Hawaiians (4.7%) had a significantly higher percentage when compared with Whites (1.1%).

Table 19. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by ethnicity based on WHO BMI definitions of obesity

	Number of risk factors for MetS based on standard WHO BMI definitions				
Race/ethnicity	0	1	2	3	4
Black	56.2 (46.5, 65.8)	**19.8 (12.6, 27.1)**	20.4 (11.5, 29.3)	3.1 (1.0, 5.2)	0.5 (0.0, 1.6)
Chinese	**43.7 (39.1, 48.3)**	33.8 (29.4, 38.2)	**18.6 (14.9, 22.3)**	**3.4 (1.7, 5.0)**	0.5 (0.0, 1.1)
Filipino	**46.5 (42.6, 50.5)**	29.2 (25.6, 32.9)	**17.3 (14.0, 20.5)**	5.7 (4.1, 7.3)	1.3 (0.4, 2.2)
Japanese	**39.8 (37.2, 42.4)**	33.3 (30.8, 35.7)	**20.5 (18.4, 22.6)**	5.5 (4.3, 6.8)	0.9 (0.4, 1.4)
Native Alaskan / American Indian	**31.7 (17.6, 45.7)**	38.5 (20.9, 56.0)	13.9 (4.2, 23.6)	12.2 (0.6, 23.9)	3.7 (0.0, 8.5)
Native Hawaiian	**38.4 (34.5, 42.2)**	27.2 (23.8, 30.5)	**19.3 (16.2, 22.4)**	**10.5 (8.3, 12.7)**	**4.7 (2.8, 6.5)**
Other	53.7 (46.2, 61.2)	28.4 (21.7, 35.1)	13.7 (8.2, 19.3)	3.3 (1.1, 5.6)	0.8 (0.1, 1.6)
Other Asian	52.2 (42.6, 61.7)	33.6 (24.0, 43.2)	11.5 (5.1, 17.9)	2.7 (0.0, 5.4)	
Other Pacific Islander	**28.9 (18.5, 39.3)**	39.4 (26.8, 52.0)	12.9 (6.0, 19.8)	12.3 (2.2, 22.4)	6.5 (0.0, 13.4)
White (referent)	52.4 (50.6, 54.3)	29.8 (28.1, 31.5)	12.1 (10.9, 13.4)	4.6 (3.8, 5.3)	1.1 (0.6, 1.5)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing each ethnic group to Whites (referent group)

The prevalence of clustered risk factors compatible with MetS by DOH race/ethnicity using ethnic specific BMI definitions of obesity are shown in Table 20. When using White as the referent group, significant differences continue to persist but the patterns change. For example, Chinese (30.7%), Filipino (301.1%), Japanese (25.3%), and Native Alaskan / American Indians (31.7%) continue to have lower percentages of zero risk factors when compared with Whites, but a new group, Other Asians (30.9%), also have a significantly lower percentage of zero risk factors. In fact, within this ethnic group, the percentage of zero risk factors significantly decreased from 52.2% (95% CI: 42.6--61.7) to 30.9% (95% CI: 22.9--38.8). When using standard WHO BMI thresholds, Pacific Islanders had a significantly lower percentage of zero risk factors compared with Whites.

Table 20. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by ethnicity based on ethnic specific BMI definitions of obesity

	Number of risk factors for MetS based on ethnic specific BMI definitions				
Race/ethnicity	0	1	2	3	4
Black	56.2 (46.5, 65.8)	**19.8 (12.6, 27.1)**	20.4 (11.5, 29.3)	3.1 (1.0, 5.2)	0.5 (0.0, 1.6)
Chinese	**30.7 (26.5, 35.0)**	34.9 (30.5, 39.3)	**22.5 (18.6, 26.5)**	**10.7 (7.7, 13.7)**	1.2 (0.2, 2.1)
Filipino	**30.1 (26.5, 33.7)**	34.9 (31.1, 38.7)	**21.9 (18.4, 25.4)**	**10.1 (7.8, 12.3)**	**3.1 (1.8, 4.3)**

Japanese	**25.3 (23.0, 27.6)**	**35.3 (32.7, 37.8)**	**25.4 (23.1, 27.7)**	**12.0 (10.2, 13.7)**	2.1 (1.4, 2.7)
Native Alaskan / American Indian	**31.7 (17.6, 45.7)**	38.5 (20.9, 56.0)	13.9 (4.2, 23.6)	12.2 (0.6, 23.9)	3.7 (0.0, 8.5)
Native Hawaiian	**42.5 (38.6, 46.4)**	27.0 (23.5, 30.4)	**17.8 (14.8, 20.7)**	**8.6 (6.7, 10.6)**	**4.1 (2.3, 5.9)**
Other	53.7 (46.2, 61.2)	28.4 (21.7, 35.1)	13.7 (8.2, 19.3)	3.3 (1.1, 5.6)	0.8 (0.1, 1.6)
Other Asian	**30.9 (22.9, 38.9)**	**41.4 (32.0, 50.8)**	21.6 (13.4, 29.8)	6.1 (0.5, 11.6)	
Other Pacific Islander	39.2 (27.2, 51.3)	32.5 (20.7, 44.2)	10.5 (4.4, 16.6)	14.4 (3.8, 25.0)	3.4 (0.0, 8.9)
Unknown	56.5 (39.7, 73.4)	18.9 (5.7, 32.0)	17.8 (4.4, 31.3)	6.8 (0.0, 17.6)	
White	52.4 (50.6, 54.3)	29.8 (28.1, 31.5)	12.1 (10.9, 13.4)	4.6 (3.8, 5.3)	1.1 (0.6, 1.5)

*Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing each ethnic group to Whites (referent group)

Table 21 displays the prevalence of clustered risk factors compatible with MetS by education using WHO BMI definitions of obesity. When compared with those who completed four or more years of college, all other educational groups had a significantly lower prevalence of zero risk factors. Conversely, all other educational groups had a significantly higher prevalence of two and three risk factors when compared to those with four or more years of colleges except those with an eighth grade or less level of education with three risk factors. There also appears to be a dose response (non significant) between the prevalence 4 risk factors and educational attainment.

Table 21. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by education level based on WHO BMI definitions of obesity

	Number of risk factors for MetS based on WHO BMI definitions of obesity				
Education level	0	1	2	3	4
Up to Grade 8	**32.9 (24.2, 41.6)**	32.3 (23.6, 40.9)	**22.8 (16.1, 29.4)**	7.1 (2.8, 11.5)	4.9 (0.0, 10.1)
Grades 9 thru 11	**29.9 (23.7, 36.1)**	29.6 (22.3, 36.8)	**27.2 (21.0, 33.4)**	**9.3 (5.8, 12.8)**	4.0 (0.9, 7.1)
Grade 12 or GED	**40.5 (38.1, 43.0)**	32.4 (30.1, 34.8)	**18.4 (16.5, 20.3)**	**6.6 (5.5, 7.7)**	**2.1 (1.3, 2.8)**
College 1-3 years	**46.3 (44.0, 48.6)**	29.3 (27.3, 31.4)	**17.1 (15.1, 19.0)**	**6.1 (4.9, 7.2)**	1.2 (0.7, 1.7)
College 4 or more years	52.9 (50.9, 54.8)	30.0 (28.2, 31.8)	12.5 (11.2, 13.7)	3.9 (3.1, 4.6)	0.8 (0.4, 1.1)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing each educational group to those with four or more years of college education (referent group)

Table 22 displays the prevalence of clustered risk factors compatible with MetS by education using ethnic specific BMI definitions of obesity. The results seen here are similar to what was observed in the previous table. For example, comparing all educational groups with those with four or more years of college regarding the prevalence of zero risk factors yielded the same results – all other educational groups had a significantly lower prevalence of zero risk factors. Conversely, all other educational groups had a significantly higher prevalence of two and three risk factors when compared to those with four or more years of colleges except those with an eighth grade or less level of education with three risk factors and those with one to three years of college education and two risk factors. Similar to the previous table, the dose response (non significant) between the prevalence of four risk factors and educational attainment persisted. What is also evident is that the distribution of risk factor percentages among all educational groups shifts toward four risk factors when using ethnic specific definitions of obesity. For example, in all educational groups, the prevalence of zero risk factors is lower when using ethnic specific definitions of obesity. These differences are significantly lower among those with high school education (35.2% versus 40.5%), those with some college (40.7% versus 46.3%), and among those with four or more years of college (45.3% versus 52.9%).

Table 22. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by education level using ethnic specific BMI definitions of obesity

	Number of risk factors for MetS using ethnic specific BMI definitions of obesity				
Education level	0	1	2	3	4
Up to Grade 8	**28.2 (19.7, 36.6)**	29.0 (20.8, 37.3)	**26.7 (18.9, 34.5)**	10.9 (6.2, 15.6)	5.3 (0.1, 10.4)
Grades 9 thru 11	**25.1 (19.3, 30.9)**	32.4 (25.2, 39.7)	**23.7 (17.9, 29.5)**	**15.6 (10.6, 20.5)**	3.2 (0.5, 5.9)
Grade 12 or GED	**35.2 (32.8, 37.5)**	32.5 (30.2, 34.9)	**20.4 (18.4, 22.4)**	**9.2 (7.9, 10.6)**	**2.6 (1.8, 3.4)**
College 1-3 years	**40.7 (38.4, 43.0)**	31.1 (29.0, 33.2)	17.8 (15.9, 19.7)	**8.7 (7.3, 10.2)**	1.7 (1.1, 2.3)
College 4 or more years	45.3 (43.3, 47.2)	31.8 (30.0, 33.7)	16.0 (14.5, 17.5)	5.7 (4.8, 6.6)	1.2 (0.8, 1.7)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing each educational group to those with four or more years of college education (referent group)

The prevalence of clustered risk factors compatible with MetS by gender using WHO BMI definitions of obesity are shown in Table 23.. The only significant difference between males and females is the prevalence rate of zero risk factors. Females have a significantly higher prevalence rate of zero risk factors at 48.4% when compared to males at 44.4%. Otherwise, no other significant differences are observed.

Table 23. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by gender using WHO BMI definitions of obesity

	Number of risk factors for MetS using WHO BMI definitions of obesity				
Gender	0	1	2	3	4
Female	**48.4 (46.8, 50.0)**	29.7 (28.2, 31.2)	14.9 (13.8, 16.1)	5.4 (4.6, 6.1)	1.6 (1.2, 2.0)
Male	44.4 (42.5, 46.3)	31.3 (29.5, 33.0)	17.4 (15.9, 18.9)	5.7 (4.8, 6.5)	1.3 (0.8, 1.8)

* Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing females to males (referent group)

Table 24 shows the prevalence of clustered risk factors compatible with MetS by gender using ethnic specific BMI definitions of obesity. Females have a significantly higher prevalence of zero risk factors when compared with males. Females also a have significantly lower prevalence rate of one and two risk factors when compared with males.

Table 24. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by gender using ethnic specific BMI definitions of obesity

	Number of risk factors for MetS using ethnic specific BMI definitions of obesity				
Gender	0	1	2	3	4
Female	**44.0 (42.4, 45.6)**	**30.1 (28.6, 31.5)**	**16.6 (15.4, 17.8)**	7.4 (6.5, 8.3)	2.0 (1.5, 2.5)
Male	36.2 (34.4, 38.0)	33.6 (31.8, 35.4)	19.8 (18.2, 21.4)	8.6 (7.6, 9.7)	1.8 (1.2, 2.3)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing females to males (referent group)

Table 25 shows the prevalence of clustered risk factors compatible with MetS by federal poverty levels (FPL) using WHO BMI definitions of obesity. Those in the 0-130% FPL have a significantly lower prevalence of zero risk factors when compared with those in the 186+% FPL. Those in the 0 – 130% FPL also have a significantly higher prevalence of two and three risk factors when compared with those in the 186+% FPL.

Table 25. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by poverty level using WHO BMI definitions of obesity

	Number of risk factors for MetS using WHO BMI definitions of obesity				
Federal Poverty Level	0	1	2	3	4
0 – 130% federal poverty level	**41.7 (38.1, 45.3)**	27.8 (24.5, 31.2)	**19.7 (16.7, 22.8)**	**8.3 (6.5, 10.1)**	2.4 (1.2, 3.6)
131 – 185%	47.4	30.8	16.5	4.2	1.2

federal poverty level	(43.0, 51.7)	(26.8, 34.7)	(13.2, 19.8)	(2.6, 5.7)	(0.4, 2.1)
186+% federal poverty level	47.9 (46.4, 49.5)	30.8 (29.3, 32.2)	15.1 (13.9, 16.2)	5.1 (4.4, 5.8)	1.2 (0.8, 1.5)

* Bold font denotes statistically significant differences (P < .05) of prevalence comparing each federal poverty level group to the 186+% federal poverty level group (referent group)

Table 26 shows the prevalence of clustered risk factors compatible with MetS by federal poverty levels (FPL) using ethnic specific BMI definitions of obesity. Those in the 0 – 130% FPL have a significantly higher prevalence of three risk factors when compared with those in the 186+% FPL.

Interestingly, using ethnic specific BMI definitions of obesity significantly affects the prevalence of risk factors for the 186+% FPL group only. For example, among the 186+% FPL group, the prevalence of zero risk factors significantly decreases from 47.9% to 41.2% and the prevalence of three risk factors significantly increases from 5.1% to 7.3%.

Table 26. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by poverty level using ethnic specific BMI definitions of obesity

	Number of risk factors for MetS using ethnic specific BMI definitions of obesity				
Federal Poverty Level	0	1	2	3	4
0 – 130% federal poverty level	36.8 (33.3, 40.3)	29.6 (26.2, 33.0)	19.8 (16.8, 22.9)	**10.7 (8.6, 12.8)**	3.0 (1.8, 4.3)

131 – 185% federal poverty level	40.6 (36.3, 44.9)	31.8 (27.9, 35.7)	18.8 (15.2, 22.3)	7.4 (5.2, 9.6)	1.4 (0.5, 2.3)
186+% federal poverty level	41.2 (39.6, 42.7)	32.5 (31.0, 34.0)	17.4 (16.2, 18.6)	7.3 (6.5, 8.2)	1.6 (1.1, 2.0)

*Bold font denotes statistically significant differences (P < .05) of prevalence comparing each federal poverty level group to the 186+% federal poverty level group (referent group)

Table 27 displays the prevalence of clustered risk factors compatible with MetS by healthcare coverage using WHO BMI definitions of obesity. Those without healthcare coverage have a significantly higher prevalence of having zero and one risk factor when compared to those with healthcare coverage. This paradoxical finding is similar to what was seen when comparing obesity rates among those with and without healthcare coverage. As previously discussed, this finding may be due to the fact that a person without healthcare coverage would be less likely to be diagnosed with a condition, and could potentially increase the likelihood of a person having one or more of the MetS risk factors without knowing it.

Table 27. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by healthcare coverage using WHO BMI definitions of obesity

	Number of risk factors for MetS using WHO BMI definitions of obesity				
Healthcare coverage	0	1	2	3	4
No	**57.2 (51.6, 62.7)**	**23.5 (18.8, 28.3)**	14.4 (10.2, 18.6)	**3.2 (1.5, 4.9)**	1.7 (0.5, 2.9)

Yes	45.8 (44.5, 47.1)	30.9 (29.7, 32.1)	16.3 (15.3, 17.2)	5.6 (5.1, 6.2)	1.4 (1.1, 1.8)

*Bold font denotes statistically significant differences (P < .05) of prevalence comparing healthcare coverage – no, to healthcare coverage – yes (referent group)

Table 28 presents the prevalence of clustered risk factors compatible with MetS by healthcare coverage using ethnic specific BMI definitions of obesity. Similar to Table 27, those without healthcare coverage have a lower prevalence of risk factors when compared to those with healthcare coverage.

Table 28. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by healthcare coverage using ethnic specific BMI definitions of obesity

	Number of risk factors for MetS using ethnic specific BMI definitions of obesity				
Healthcare coverage	0	1	2	3	4
No	**49.3 (43.8, 54.9)**	29.2 (24.0, 34.4)	15.0 (10.6, 19.3)	**4.9 (2.9, 6.9)**	1.6 (0.4, 2.9)
Yes	39.6 (38.3, 40.8)	32.0 (30.8, 33.2)	18.4 (17.4, 19.4)	8.2 (7.5, 8.9)	1.9 (1.5, 2.3)

*Bold font denotes statistically significant differences (P < .05) of prevalence comparing healthcare coverage – no, to healthcare coverage – yes (referent group)

Table 29 shows the prevalence of clustered risk factors compatible with MetS by personal doctor using WHO BMI definitions of obesity. Those without a personal doctor have a significantly higher prevalence of zero risk factors, and a significantly lower prevalence of one, two, three, and four risk factors. This finding is similar to what is seen when examining obesity prevalence by personal doctor.

Table 29. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by having a personal doctor using WHO BMI definitions of obesity

	Number of risk factors for MetS using WHO BMI definitions of obesity				
Personal Doctor	0	1	2	3	4
No	**62.2 (58.9, 65.5)**	**26.6 (23.6, 29.6)**	**8.0 (6.2, 9.9)**	**2.8 (1.7, 4.0)**	**0.4 (0.0, 0.9)**
Yes	43.9 (42.6, 45.2)	31.1 (29.9, 32.4)	17.4 (16.4, 18.5)	5.9 (5.3, 6.5)	1.6 (1.3, 2.0)

*Bold font denotes statistically significant differences (P < .05) of prevalence comparing personal doctor – no, to personal doctor – yes (referent group)

Table 30 shows the prevalence of clustered risk factors compatible with MetS by personal doctor using ethnic specific definitions of obesity. Those without a personal doctor have a significantly higher prevalence of zero risk factors, and a significantly lower prevalence of two, three, and four risk factors.

Table 30. Prevalence (%) of risk factor levels (0 – 4) compatible with metabolic syndrome by having a personal doctor using ethnic specific BMI definitions of obesity

	Number of risk factors for MetS using ethnic specific BMI definitions of obesity				
Personal doctor	0	1	2	3	4
No	**54.6 (51.2, 58.0)**	32.5 (29.3, 35.7)	**9.0 (7.1, 11.0)**	**3.4 (2.0, 4.7)**	**0.5 (0.0, 1.0)**
Yes	37.8 (36.5, 39.1)	31.7 (30.5. 33.0)	19.6 (18.5, 20.7)	8.7 (8.0, 9.5)	2.1 (1.7, 2.5)

*Bold font denotes statistically significant differences (P < .05) of prevalence comparing personal doctor – no, to personal doctor – yes (referent group)

The prevalence of 3 or 4 clustered risk factors compatible with MetS are displayed in Table 31. When comparing WHO BMI definitions of obesity versus ethnic specific BMI definitions of obesity (Column A versus Column B), many differences exist. For example, there are significant increases in the prevalence of 3 or 4 risk factors among Chinese (3.9% versus 11.8%), Filipinos (7% versus 13.1%), and Japanese (6.4% versus 14%). A non-significant increase is also seen among "Other Asians" (2.7% versus 6.1%). This finding is expected, given the fact that ethnic specific BMI definitions of obesity are more stringent for Asians. Conversely, non-significant decreases in prevalence of 3 or 4 risk factors are seen among Native Hawaiians (15.2% versus 12.7%) and "Other Pacific Islanders" (18.8% versus 17.8%). The trend toward lower prevalence of MetS among Native Hawaiians and "Other Pacific Islanders" is also expected given the fact that ethnic specific BMI definitions of obesity for this group are less stringent. Significant increases in prevalence of 3 or 4 risk factors are also seen among the older age groups, both males and females, those with a high school or college education, those at 186%+ poverty level, across those with and without health care coverage, and among those with a personal doctor.

Table 31. Prevalence (%) of 3 to 4 clustered risk factors compatible with metabolic syndrome comparing WHO BMI definitions of obesity with ethnic specific BMI definitions of obesity by race, age group, gender, education, poverty, having healthcare coverage, and having personal doctor

Category	Population Characteristic	Column A: Prevalence (%) of 3-4 risk factors using WHO BMI definition of obesity*	Column B: Prevalence (%) of 3-4 risk factors using ethnic specific BMI definition of obesity*
Race / Ethnicity	Black	3.6 (1.3, 6.0)	3.6 (1.3, 6.0)
	Chinese	**3.9 (2.1, 5.6)**	**11.8 (8.7, 14.9)**
	Filipino	**7.0 (5.2, 8.8)**	**13.1 (10.6, 15.6)**
	Japanese	**6.4 (5.1, 7.8)**	**14.0 (12.2, 15.9)**
	Native Alaskan/ American Indian	15.9 (3.9, 27.9)	15.9 (3.9, 27.9)
	Native Hawaiian	15.2 (12.4, 17.9)	12.7 (10.2, 15.3)
	Other	4.2 (1.8, 6.5)	4.2 (1.8, 6.5)
	Other Asian	2.7 (0.0, 5.4)	6.1 (0.6, 11.6)
	Other Pacific Islander	18.8 (7.6, 30.1)	17.8 (6.6, 29.0)
	White	5.6 (4.8, 6.5)	5.6 (4.8, 6.5)
Age	20-29	1.1 (0.2, 2.0)	1.1 (0.2, 2.0)
	30-39	2.5 (1.5, 3.4)	3.8 (2.6, 5.0)
	40-49	6.5 (5.2, 7.8)	7.9 (6.4, 9.3)
	50-59	**9.9 (8.1, 11.7)**	**14.4 (12.3, 16.6)**
	60-69	**12.1 (10.1, 14.1)**	**16.7 (14.3, 19.1)**
	70-79	**10.8 (8.4, 13.2)**	**16.5 (13.8, 19.3)**
	80+	**5.4 (3.0, 7.8)**	**9.5 (6.5, 12.6)**
Gender	Female	**7.0 (6.1, 7.8)**	**9.4 (8.4, 10.4)**
	Male	**7.0 (6.0, 7.9)**	**10.4 (9.3, 11.6)**
Education level	Up to Grade 8	12.1 (5.7, 18.4)	16.2 (9.6, 22.7)
	Grades 9 thru 11	13.3 (8.8, 17.9)	18.8 (13.3, 24.2)
	Grades 12 or GED	**8.6 (7.3, 9.9)**	**11.9 (10.4, 13.4)**
	College 1 to 3 years	**7.3 (6.0, 8.5)**	**10.4 (8.9, 11.9)**
	College 4 or more years	**4.6 (3.8, 5.5)**	**6.9 (5.9, 7.9)**
Poverty level	130 federal poverty level	10.8 (8.6, 12.9)	13.8 (11.4, 16.2)
	185 federal poverty level	5.4 (3.6, 7.1)	8.9 (6.5, 11.2)
	186+ federal poverty level	**6.2 (5.5, 7.0)**	**8.9 (8.0, 9.8)**
Healthcare coverage	No	**4.9 (2.8, 7.0)**	**6.5 (4.2, 8.8)**
	Yes	**7.1 (6.4, 7.7)**	**10.1 (9.3 , 10.9)**
Having a personal doctor	No	3.2 (1.9, 4.4)	3.9 (2.4, 5.3)
	Yes	**7.6 (6.8, 8.3)**	**10.8 (10.0, 11.7)**

*Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing Column A to Column B.

Table 32 shows the prevalence of 3 or 4 clustered risk factors compatible with MetS, comparing groups within the same category to a referent group, within the same column. When making comparisons within categories (and within the same column), many notable differences exist. When comparing ethnic groups (using Whites as the referent group) within Column A (using WHO BMI definitions of obesity), Native Hawaiians (15.2%) and Other Pacific Islanders have significantly higher prevalence of 3 – 4 risk factors when compared to Whites (5.6%). Making the same comparison in Column B (using ethnic specific definitions of obesity) yields a much different result. In this case Chinese (11.8%), Filipino (13.1%), and Japanese (14%) groups all have significantly higher prevalence compared to Whites (5.6%). This is expected given the fact that ethnic specific BMI definitions of obesity for Asians are much more stringent. Additionally, Native Hawaiians (12.7%) and "Other Pacific Islanders" (17.8%) continue to have a significantly higher prevalence of 3 – 4 risk factors compared to Whites even when using ethnic specific BMI definitions of obesity. Significant differences in prevalence are also seen within age groups. In general, older adults had a significantly higher prevalence when compared to young adults (20 – 29 year olds, referent group). This holds true when using either BMI definition of obesity. There are significant differences in prevalence within education as well, regardless of what obesity definition is used. In both instances, an inverse relationship exists. Higher educational attainment is associated with a lower prevalence. There are significant differences by poverty level as well. Those in the 0 – 130% poverty level have a significantly higher prevalence when compared to those in the 186+% poverty level, regardless of what obesity definition is used. When examining healthcare access (healthcare coverage and having a personal doctor) some noteworthy findings emerged. For example, the prevalence among those who reported having a personal doctor was higher when compared to those without a personal doctor. This finding holds true regardless of what BMI definition of obesity is used. This finding is consistent with the previous discussion regarding the potential effect healthcare access may have on the likelihood of a person being told by a doctor they have a certain condition.[1] A similar finding was seen when examining healthcare coverage. Those with healthcare coverage had a significantly higher prevalence when compared to those without healthcare coverage. This finding only occurred when using the ethnic specific definition of obesity.

Table 32. Prevalence (%) of 3 to 4 clustered risk factors compatible with metabolic syndrome comparing groups within the same category and column to a referent group. (A = WHO BMI definitions of obesity, B = ethnic specific BMI definitions of obesity)

Category	Population Characteristic	Column A: Prevalence (%) of 3-4 risk factors using WHO BMI definition of obesity*	Column B: Prevalence (%) of 3-4 risk factors using ethnic specific BMI definition of obesity*
Race / Ethnicity	Black	3.6 (1.3, 6.0)	3.6 (1.3, 6.0)
	Chinese	3.9 (2.1, 5.6)	**11.8 (8.7, 14.9)**
	Filipino	7.0 (5.2, 8.8)	**13.1 (10.6, 15.6)**
	Japanese	6.4 (5.1, 7.8)	**14.0 (12.2, 15.9)**
	Native Alaskan/ American Indian	15.9 (3.9, 27.9)	15.9 (3.9, 27.9)
	Native Hawaiian	**15.2 (12.4, 17.9)**	**12.7 (10.2, 15.3)**
	Other	4.2 (1.8, 6.5)	4.2 (1.8, 6.5)
	Other Asian	2.7 (0.0, 5.4)	6.1 (0.6, 11.6)
	Other Pacific Islander	**18.8 (7.6, 30.1)**	**17.8 (6.6, 29.0)**
	White**	5.6 (4.8, 6.5)**	5.6 (4.8, 6.5)**
Age	20-29**	1.1 (0.2, 2.0)**	1.1 (0.2, 2.0)**
	30-39	2.5 (1.5, 3.4)	**3.8 (2.6, 5.0)**
	40-49	**6.5 (5.2, 7.8)**	**7.9 (6.4, 9.3)**
	50-59	**9.9 (8.1, 11.7)**	**14.4 (12.3, 16.6)**
	60-69	**12.1 (10.1, 14.1)**	**16.7 (14.3, 19.1)**
	70-79	**10.8 (8.4, 13.2)**	**16.5 (13.8, 19.3)**
	80+	**5.4 (3.0, 7.8)**	**9.5 (6.5, 12.6)**
Gender	Female**	7.0 (6.1, 7.8)	9.4 (8.4, 10.4)

	Male	7.0 (6.0, 7.9)	10.4 (9.3, 11.6)
Education level	Up to Grade 8	**12.1 (5.7, 18.4)**	**16.2 (9.6, 22.7)**
	Grades 9 thru 11	**13.3 (8.8, 17.9)**	**18.8 (13.3, 24.2)**
	Grades 12 or GED	**8.6 (7.3, 9.9)**	**11.9 (10.4, 13.4)**
	College 1 to 3 years	**7.3 (6.0, 8.5)**	**10.4 (8.9, 11.9)**
	College 4 or more years**	4.6 (3.8, 5.5)	6.9 (5.9, 7.9)
Poverty level	130 federal poverty level	**10.8 (8.6, 12.9)**	**13.8 (11.4, 16.2)**
	185 federal poverty level	5.4 (3.6, 7.1)	8.9 (6.5, 11.2)
	186+ federal poverty level**	6.2 (5.5, 7.0)**	8.9 (8.0, 9.8)**
Healthcare coverage	No	4.9 (2.8, 7.0)	**6.5 (4.2, 8.8)**
	Yes**	7.1 (6.4, 7.7)**	10.1 (9.3 , 10.9)**
Having a personal doctor	No	**3.2 (1.9, 4.4)**	**3.9 (2.4, 5.3)**
	Yes**	7.6 (6.8, 8.3)**	10.8 (10.0, 11.7)**

*Bold font denotes statistically significant differences ($P < .05$) of prevalence comparing with category group to corresponding referent group

**Denotes referent group for the category

Results of Poisson Regression

Table 33 displays the unadjusted and adjusted prevalence ratios of clustered risk factors compatible with MetS (0 – 2 risk factors versus 3 – 4 risk factors), using WHO BMI definitions of obesity. In all models presented, ethnicity was the main independent variable, using Whites as the referent group. Age, gender, education, poverty level, healthcare coverage, and having a personal doctor were added to the models in order to control for their effects. Model one represents the unadjusted prevalence ratios, comparing each ethnic group to Whites. Filipinos (1.43, 95% CI: 1.12--1.82), Native Alaskan / American Indians (2.22, 95% CI: 1.10--4.49), and Native Hawaiians (2.71, 95% CI: 2.22--3.30) had significantly higher crude prevalence ratios of 3 – 4 risk factors when compared with Whites. "Other Asians" was the only ethnic group that had a lower crude prevalence ratio (0.25, 95% CI: 0.06--0.99) when compared to Whites. Model two shows the prevalence ratios adjusted for age. After adjusting for age, Filipinos, Native

Alaskan / American Indians continued to have significantly higher prevalence ratios. Adding age to the model had three interesting effects: (1) the prevalence ratio for "Other Pacific Islanders" (2.59, 95% CI: 1.33--5.06) reached statistical significance, (2) the prevalence ratio for "Other Asians" was no longer significant (0.27, 95% CI: 0.07--1.07) and (3) adding age to model had an overall effect of increasing the size of the prevalence ratios among the ethnic groups except for Japanese and Chinese. This suggests that in the majority of the ethnic groups studied here, their mean age is probably younger than Whites, except in the case of Japanese and Chinese where their mean ages are probably older than Whites. Model three shows the prevalence ratios adjusted for age and gender. Adding gender to model also had an overall effect of increasing the prevalence ratios. Model four shows the prevalence ratios adjusted for age, gender, and education. Adding education to the model had an overall effect of attenuating the prevalence ratios. However, the four ethnic groups with significantly higher prevalence ratios persisted. Model five shows the prevalence ratios adjusted for age, gender, education, and poverty level. Adding poverty level to the model also had an attenuating effect. However, as in model four, the prevalence ratios of the four ethnic groups continued to be significantly higher compared to Whites. Model six shows the prevalence ratios adjusted to age, gender, education, poverty level, and healthcare coverage. Adding healthcare coverage had very little overall effect. Model seven shows the prevalence ratios adjusted for age, gender, education, poverty level, healthcare coverage, and having a personal doctor. Adding "having a personal doctor' to the model had an overall attenuating effect. However all four ethnic groups continued to have significantly higher prevalence ratios compared to Whites. In addition, "Other Asians" had a significantly lower prevalence ratio (0.24, 95% CI: 0.06--.97) compared to Whites.

Table 33. Crude and adjusted prevalence ratios for clustered risk factors compatible with metabolic syndrome (0 – 2 risk factors versus 3 – 4 risk factors) using WHO BMI definitions of obesity, estimated by Poisson regression through 7 models*, comparing Whites to all other DOH race/ethnicity categories

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Black	1.00 (0.50-2.03)	1.17 (0.55-2.48)	1.16 (0.55-2.47)	1.10 (0.52-2.33)	1.09 (0.51-2.31)	1.10 (0.52-2.33)	1.09 (0.51-2.32)
Chinese	0.83 (0.55-1.25)	0.78 (0.52-1.18)	0.78 (0.52-1.18)	0.78 (0.51-1.17)	0.77 (0.51-1.16)	0.77 (0.51-1.17)	0.75 (0.50-1.13)
Filipino	**1.43 (1.12-1.82)**	**1.52 (1.19-1.94)**	**1.54 (1.20-1.97)**	**1.40 (1.09-1.81)**	**1.38 (1.08-1.78)**	**1.40 (1.09-1.80)**	**1.35 (1.05-1.74)**
Japanese	1.19 (0.96-1.48)	1.00 (0.81-1.25)	1.01 (0.82-1.26)	0.96 (0.78-1.20)	0.98 (0.79-1.22)	0.99 (0.79-1.23)	0.96 (0.77-1.19)
Native Alaskan/ American Indian	**2.22 (1.10-4.49)**	**2.28 (1.13-4.60)**	**2.29 (1.13-4.64)**	**2.25 (1.11-4.55)**	**2.25 (1.11-4.55)**	**2.25 (1.11-4.55)**	**2.18 (1.08-4.42)**
Native Hawaiian	**2.71 (2.22-3.30)**	**2.89 (2.37-3.53)**	**2.94 (2.41-3.59)**	**2.59 (2.11-3.19)**	**2.54 (2.06-3.12)**	**2.55 (2.08-3.14)**	**2.46 (2.00-3.03)**
Other	1.15 (0.70-1.88)	1.45 (0.89-2.37)	1.47 (0.90-2.40)	1.29 (0.78-2.12)	1.27 (0.77-2.09)	1.28 (0.78-2.10)	1.24 (0.76-2.05)
Other Asian	**0.25 (0.06-0.99)**	0.27 (0.07-1.07)	0.26 (0.07-1.06)	0.25 (0.06-1.01)	0.25 (0.06-1.01)	0.25 (0.06-1.01)	**0.24 (0.06-0.97)**
Other Pacific Islander	1.87 (0.96-3.63)	**2.59 (1.33-5.06)**	**2.62 (1.34-5.11)**	**2.22 (1.14-4.35)**	**2.04 (1.04-4.01)**	**2.10 (1.07-4.12)**	**2.05 (1.04-4.02)**
White	-	-	-	-	-	-	-

*Model 1: unadjusted, model 2: adjusted for age, model 3: adjusted for age and gender, model 4: adjusted for age, gender, and education, model 5: adjusted for age, gender,

education, and poverty level, model 6: adjusted for age, gender, education, poverty level, and health insurance coverage, model 7: adjusted for age, gender, education, poverty level, health insurance coverage, and having a personal doctor

**Bold font denotes statistically significant differences (P < .05), comparing each ethnic group to Whites (referent group)

Table 34 shows the unadjusted and adjusted prevalence ratios of clustered risk factors compatible with MetS (0 – 2 risk factors versus 3 – 4 risk factors), using ethnic specific BMI definitions of obesity. As in the previous table, ethnicity was the main independent variable, with Whites acting as the referent group. Age, gender, education, poverty level, healthcare coverage, and having a personal doctor were also controlled for in the models shown here as well. Model one (unadjusted), when contrasted with model one of the previous table, shows some noteworthy differences. For example, in the previous model one (Table 33), Filipinos (1.43, 95% CI: 1.12--1.82), Native Alaskan / American Indians (2.22, 95% CI: 1.10--4.49), and Native Hawaiians (2.71, 95% CI: 2.22--3.30) had significantly higher crude prevalence ratios and "Other Asians" was the only ethnic group that had a lower crude prevalence ratio (0.25, 95% CI: 0.06--0.99) when compared to Whites. In this model one, Chinese (2.01, 95% CI: 1.56--2.58), Filipino (2.58, 95% CI: 2.15--3.1), Japanese (2.48, 95% CI: 2.12--2.91), and Native Hawaiians (2.35, 95% CI: 1.95--2.85) had significantly higher prevalence ratios, and no ethnic group had a significantly lower prevalence ratio than Whites. In general, the prevalence ratios increased for the Asian groups and decreased for the Pacific Islander groups. When adjusted for age (model two), Alaskan Native / American Indian, "Other", and "Other

Pacific Islander" groups joined the Chinese, Filipino, Japanese, and Native Hawaiian groups as having significantly higher prevalence ratios when compared to Whites. After adjusting for education (model four), the prevalence ratio for the "Other" ethnic group lost significance. When adjusting for poverty (model five), the prevalence ratio for the "Other Pacific Islander" ethnic group also lost significance. Ultimately, the Chinese, Filipino, Japanese, Alaskan Native / American Indian and Native Hawaiian ethnic groups all had significantly higher prevalence ratios when compared to Whites, even after adjusting for age, gender, education, poverty level, healthcare coverage, and having a personal doctor (model seven). There were no ethnic groups with significantly lower prevalence ratios than Whites.

Table 34. Crude and adjusted prevalence ratios for clustered risk factors compatible with metabolic syndrome (0 – 2 risk factors versus 3 – 4 risk factors) using ethnic specific BMI definitions of obesity, estimated by Poisson regression through 7 models*, comparing Whites to all other DOH race/ethnicity categories

Ethnic Group	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Black	1.22 (0.67-2.23)	1.45 (0.77-2.72)	1.43 (0.76-2.70)	1.37 (0.73-2.58)	1.08 (0.51-2.28)	1.09 (0.51-2.31)	1.08 (0.51-2.30)
Chinese	**2.01 (1.56-2.58)**	**1.87 (1.46-2.41)**	**1.89 (1.47-2.43)**	**1.88 (1.46-2.41)**	**1.87 (1.41-2.48)**	**1.89 (1.42-2.50)**	**1.82 (1.37-2.41)**
Filipino	**2.58 (2.15-3.10)**	**2.78 (2.31-3.34)**	**2.84 (2.36-3.41)**	**2.60 (2.15-3.13)**	**2.57 (2.09-3.16)**	**2.61 (2.12-3.21)**	**2.50 (2.03-3.08)**
Japanese	**2.48 (2.12-2.91)**	**2.11 (1.79-2.47)**	**2.14 (1.82-2.51)**	**2.05 (1.74-2.41)**	**2.09 (1.75-2.50)**	**2.11 (1.77-2.53)**	**2.04 (1.71-2.44)**
Native Alaskan/ American Indian	1.93 (0.96-3.90)	**2.04 (1.01-4.12)**	**2.07 (1.02-4.17)**	**2.03 (1.00-4.10)**	**2.27 (1.12-4.59)**	**2.26 (1.12-4.58)**	**2.19 (1.08-4.44)**

Native Hawaiian	**2.35 (1.95-2.85)**	**2.53 (2.09-3.07)**	**2.60 (2.15-3.15)**	**2.33 (1.91-2.83)**	**2.28 (1.84-2.82)**	**2.30 (1.86-2.85)**	**2.21 (1.78-2.74)**
Other	1.33 (0.87-2.03)	**1.65 (1.08-2.53)**	**1.68 (1.10-2.57)**	1.50 (0.98-2.30)	1.30 (0.79-2.13)	1.31 (0.80-2.15)	1.27 (0.77-2.09)
Other Asian	0.78 (0.39-1.58)	0.82 (0.41-1.65)	0.83 (0.41-1.68)	0.79 (0.39-1.60)	0.63 (0.26-1.53)	0.63 (0.26-1.53)	0.61 (0.25-1.48)
Other Pacific Islander	1.66 (0.88-3.11)	**2.28 (1.21-4.28)**	**2.29 (1.22-4.32)**	**1.98 (1.05-3.74)**	1.88 (0.92-3.82)	1.93 (0.95-3.93)	1.88 (0.92-3.83)
White	-	-	-	-	-	-	-

*Model 1: unadjusted, model 2: adjusted for age, model 3: adjusted for age and gender, model 4: adjusted for age, gender, and education, model 5: adjusted for age, gender, education, and poverty level, model 6: adjusted for age, gender, education, poverty level, and health insurance coverage, model 7: adjusted for age, gender, education, poverty level, health insurance coverage, and having a personal doctor

**Bold font denotes statistically significant differences (P < .05), comparing each ethnic group to Whites (referent group)

CHAPTER 5. DISCUSSION

Obesity

This study examined the prevalence of weight status, with a primary focus on obesity in Hawaii. The findings of the analysis confirmed what is already known – obesity rates are quite high and disparities in obesity rates exist among Hawaii's major ethnic groups. In general, what is widely known is that Native Hawaiians and Pacific Islanders have higher rates of obesity in contrast to Asians who typically have lower rates of obesity. What this study did discover however, is when proposed ethnic specific case definitions of weight status are applied to Hawaii's population, particularly to Pacific Islanders and Asians, a dramatic shift in the distribution of obesity emerges. For example, when using the WHO standard BMI thresholds, the major Asian groups in Hawaii (Chinese, Filipino, and Japanese) all have obesity rates in the 10% range. Applying ethnic specific BMI thresholds dramatically increases the obesity prevalence rate among Hawaii's Asian population into the mid 40% range. This would have significant public health implications on many fronts.

First, if future research confirms that ethnic specific BMI thresholds to determine weight status are more predictive of health outcomes associated with obesity, Hawaii in particular would be faced with the enormous challenge of dealing with a dramatic increase in the future burden related to diabetes, cardiovascular disease, and any other condition related to obesity. It would require a tremendous shift in the allocation of resources needed to contain the obesity epidemic.

Second, if Hawaii were to adopt the use of ethnic specific BMI thresholds to determine weight status and obesity, public health reporting on the epidemiology of obesity would be dramatically affected. This would potentially have far reaching effects, from the insurability of individuals to political fallout. For example, Hawaii has long been touted as one of the healthiest states in the U.S. with a relatively low obesity rate relative to the rest of the country. Redefining obesity using ethnic specific BMI thresholds would dramatically worsen the perception of Hawaii's overall health.

Third, and probably most thought provoking of all, using ethnic specific BMI thresholds to determine weight status and obesity could potentially shift the focus of obesity away from ethnic groups traditionally thought of as experiencing a higher burden of obesity and its related disorders towards Asians, which for the most part, have not been thought of as having a high burden of obesity. In fact, when using ethnic specific BMI thresholds, Native Hawaiians have the second lowest obesity rate at 27% (lowest is White at 17%) when compared with the major ethnic groups in Hawaii (Chinese, Filipino, Japanese, Native Hawaiian, White). Conversely, Filipinos have the highest obesity rate at 47%, followed Japanese at 45%, and Chinese at 41%. This could potentially impact the allocation of funds (or at the very least, create a lot of confusion) that currently focus on specific ethnic groups.

Fourth, using ethnic specific BMI thresholds to determine weight status and obesity would potentially change the way healthcare providers "profile" an individual regarding the risk for obesity related disease. For example, if ethnic specific BMI thresholds were widely adopted within Hawaii's healthcare community, healthcare providers would be more apt to examine patients of Asian background for the presence of obesity related conditions, even in the absence of typical anthropometric signs of obesity. This would lead to increased case ascertainment among Hawaii's Asian populations, ultimately increasing the prevalence rates of MetS, diabetes, other cardiovascular risk factors and cardiovascular disease itself.

<u>Metabolic Syndrome</u>

The findings of this study have shown that the prevalence of clustered MetS risk factors appears to be quite common among Hawaii's population, but it is not evenly distributed. In fact, disparities appear to exist by ethnicity, poverty level, education level, and age. In general, using ethnic specific BMI definitions of obesity increases the prevalence rate of MetS and in many cases increases the disparity.

When using WHO BMI definitions of obesity, the prevalence of 3 – 4 risk factors compatible with MetS among Hawaii's ethnic groups ranges from a low of 2.7% ("Other Asians") to a high of 18.8% ("Other Pacific Islanders"), with a mean of 8.3%, and a median of 6.0%. When using ethnic specific definitions of obesity, the prevalence of 3 – 4 risk factors compatible with MetS ranges from a low of 3.6% (Blacks) to a high of 17.8% ("Other Pacific Islanders"), with a mean of 10.5%, and a median of 12.3%. The rank order of ethnic groups based on prevalence of 3 – 4 risk factors changes noticeably depending on what BMI definition is used. Table 35 shows the rank order based on prevalence. Regardless of what BMI definition is used, "Other Pacific Islanders" have the highest prevalence of 3 – 4 risk factors. Interestingly, the prevalence of 3 – 4 risk factors for Native Hawaiians (12.7%) drops below that of Japanese (14%) and Filipinos (13.1%) when using ethnic specific BMI definitions of obesity. This finding is similar to what was seen when examining obesity.

Table 35. Rank order of prevalence of 3 – 4 risk factors by ethnicity

Prevalence of 3 – 4 risk factors	Rank order from lowest to highest prevalence based on WHO BMI definition of obesity	Rank order from lowest to highest prevalence based on ethnic specific BMI definition of obesity	Prevalence of 3 – 4 risk factors
2.7%	Other Asian	Black	3.6%
3.6%	Black	Other	4.2%
3.9%	Chinese	White	5.6%
4.2%	Other	Other Asian	6.1%
5.6%	White	Chinese	11.8%
6.4%	Japanese	Native Hawaiian	12.7%
7.0%	Filipino	Filipino	13.1%
15.2%	Native Hawaiian	Japanese	14.0%
15.9%	Native Alaskan / American Indian	Native Alaskan / American Indian	15.9%
18.8%	Other Pacific Islander	Other Pacific Islander	17.8%
8.33%	mean	mean	10.49%
6.03%	median	median	12.29%

When trying to understand the burden of a disease on a given population, an estimate of the number of persons affected by the condition is a much more useful indicator than a rate or percentage. Estimates on the number of persons with a condition provide the information needed for appropriate public health planning and resource allocation. Table 36 provides an estimate of the number of persons by race / ethnicity that have 3 – 4 MetS risk factors based on the findings of this study. The denominators used to calculate these figures were derived from the 2006 BRFSS. However, the rates used to calculate the figures in Table 36 were derived from a combined dataset comprised of three years of BRFSS surveys (2001, 2003, and 2005). It needs to be emphasized here that the figures in Table 36, in all probability, underestimate the true prevalence of MetS for reasons that are described in the Limitations section. Nevertheless, Table 36 was provided as a way to comprehend the current burden that MetS may be placing on Hawaii. Table 36 shows two possible scenarios: (1) the estimated number of persons with 3 – 4 MetS risk factors using WHO BMI definitions, and (2) the estimated number of persons with 3 – 4 MetS risk factors using ethnic specific BMI definitions. In either case, the numbers are quite staggering and increase dramatically when using ethnic specific BMI definitions of obesity. In fact, the total number of estimated adults increases from 70,049 to 96,733. There are also substantial increases among Asians and a moderate decrease among Native Hawaiians and Pacific Islanders. When considering the fact that MetS substantially increases the risk for type 2 diabetes and cardiovascular disease[5], it is clear to see that the current prevalence of MetS (risk factors compatible with MetS) has the potential to place an additional burden on to an already strained healthcare system. Moreover, this burden will be felt disproportionately across Hawaii's population, affecting more Asians, Native Hawaiians, and Pacific Islanders, as well as those in the lower socioeconomic strata.

Table 36. Estimated frequency* of adults with 3 – 4 risk factors compatible with MetS by ethnicity, using WHO and ethnic specific definitions of obesity

Estimated number of adults with 3 – 4 MetS risk factors using WHO BMI definitions of obesity	Race / ethnicity	Estimated number of adults with 3 – 4 MetS risk factors using ethnic specific BMI definitions of obesity
521	Black	521
911	Other	911
17951	White	17951
784	Other Asian	1771

1826	Chinese	5526
18379	Native Hawaiian	15357
10853	Filipino	20310
13320	Japanese	29137
706	Native Alaskan / American Indian	706
4799	Other Pacific Islander	4543
70049	Total	96733

*Denominators derived from Hawaii BRFSS 2006. Rates derived from Hawaii BRFSS 2001, 2003, and 2005

Poisson regression revealed some noteworthy characteristics related to the epidemiology of 3 – 4 risk factors compatible with MetS in Hawaii. The results of this study provide some evidence that race / ethnicity is independently associated with clustered MetS risk factors. Regardless of what BMI definition was used, Filipinos, Native Hawaiians, and Alaskan Native / American Indians had significantly higher prevalence ratios when compared to Whites. Japanese and Chinese also had significantly higher prevalence ratios, but only when using ethnic specific BMI definitions of ethnicity. These associations persisted even after adjusting for other demographic and socioeconomic measures. The question here is how much of this relationship between race / ethnicity and MetS risk factors is attributable to genetic factors or cultural beliefs and practices or a combination of the two. Disentangling this apparent relationship is beyond the scope of this study and requires further study (see Future Studies section).

Regression analysis also demonstrated that age (older age groups are at higher risk), gender (females are at lower risk), poverty (persons at 0-130% FPL are at greater risk), and healthcare access (persons with no personal doctor are less likely to have 3 – 4 risk factors) are also independently associated with MetS risk factors. Previous discussion has alluded to the fact that persons with no personal doctor, in all likelihood, have a decreased chance of being told they have a condition, giving the appearance in the analysis that it "protects" against having MetS risk factors. More than likely, the underlying issue is that in persons with restricted healthcare access, these risk factors along with any other healthcare condition they may have; do not have the same probability of being diagnosed. This really points to the fact that a significant portion of the population may actually have MetS or diabetes but not even know they have it. In fact, CDC estimates that of all the people who currently have diabetes, about 25% to 30% are not aware they have the disease.[53] If this is the case, the estimates shown in this study are probably underestimating the true prevalence of clustered risk factors associated with MetS.

This study demonstrates that using ethnic specific BMI definitions of obesity influences the magnitude of prevalence ratios of 3 – 4 risk factors among Asian groups and Pacific Islander groups. In essence, this study demonstrates that using ethnic specific BMI definitions of obesity substantially increases the potential burden of MetS risk factors, particularly among Filipinos, Japanese, and Chinese. Using ethnic specific BMI definitions has the opposite effect on Native Hawaiians and "Other Pacific Islanders". In this case, prevalence rates are lowered. However, the magnitude of the effect appears to be larger among Asians. Aside from ethnicity, age, education, poverty, healthcare access (healthcare coverage and/or having a personal doctor) are all independent risk factors for having 3 – 4 MetS risk factors. Finally, the clinical and public health importance of MetS is that it is common; it identifies individuals who are at increased risk of cardiovascular disease and type 2 diabetes, both of which are epidemics that are significantly impacting societies across the world.

Opportunities

Judging from what the data are saying, it appears the perfect storm may be headed to Hawaii in the not-too-distant future. For example, it is clear that the number of people with MetS, diabetes, and cardiovascular disease will continue to rise across the globe, Hawaii being no exception. At the same time, federal funds (CDC) earmarked for public health chronic disease prevention (mostly secondary prevention) is continuing to shrink. Shrinking federal funds in turn, trickle down to individual states (Hawaii included) who rely heavily on federal funds to maintain public health programs. For example, Hawaii's Diabetes Prevention and Control Program (HiDPCP) relies solely on CDC funding to remain operational. It does not receive any state funds. The HiDPCP has endured two years of cut backs from CDC, making it extremely difficult to maintain its current statewide presence.

Aside from the dwindling sum of money states are currently receiving, the majority of public health funds (CDC) allocated for chronic disease prevention is focused primarily on secondary prevention. Very little attention has been paid to primary prevention. So the question remains, if federal funds for secondary prevention continue to diminish, where are states going to find the resources necessary to carry out more expensive and time intensive primary prevention? In this scenario, it is possible to imagine a situation where the incidence of MetS, diabetes and cardiovascular disease continue to rise unabated due to a lack of a concerted and sustained primary prevention counterattack, leading to a burgeoning population of people living with their disease, leading to an increase in the incidence of costly complications, ultimately resulting in early mortality. This forecast of the future is not a new concept. In fact, there is widespread agreement that the obesity, diabetes, and cardiovascular epidemic is upon us, has global implications, and is rapidly worsening. There is also widespread agreement that efforts to stem the tide of this multiple public health threat must occur and must be comprehensive and coordinated. The question that remains is how. This has prompted the Chronic Disease Directors (CDD) to publish a report that provides a conceptual framework needed to implement primary prevention efforts across the country. The report is entitled, "The Primary Prevention of Diabetes: Recommendations from the Chronic Disease Directors Project".[54] The Diabetes Primary Prevention Project (DPPP) was created by the Association of State and Territorial Chronic Disease Program Directors (CDD), and the Division of Diabetes Translation (DDT), CDC, in an effort to develop effective approaches for state health departments to address the primary prevention of diabetes.[54]. The report named the following key constructs with accompanying recommendations that would be needed to carry out comprehensive efforts centered on the primary prevention of diabetes.

1. Leadership

Recommendations to state departments of health include (1) the identification of a leader for diabetes primary prevention who is an influential, high-level person within a state department of health, (2) the securing sufficient resources to establish a state infrastructure for diabetes prevention, training, to support cross-program collaboration and integration, and for social marketing and media interventions, (3) working with external partners to support policy changes to promote primary prevention.

Recommendations to CDC include (1) the encouragement of programs within the Coordinating Center for Health Promotion to work together as role models for state programs and (2) to provide a clear charge in program guidance for diabetes prevention programs.

2. Epidemiology and Surveillance

Recommendations to state health departments include (1) the reporting and use of surveillance data collected to educate the public and partners, formulate policy, target resources, identify target groups, track progress, secure funding, and provide accountability for programs. Recommendations to CDC include (1) working together to select indicators for diabetes prevention and specific data needed to monitor them and to (2) provide adequate resources to states to conduct surveillance, data management and reporting functions related to primary prevention.

3. Partnerships

Recommendations to state health department include (1) engaging external stakeholders from multiple sectors of the community to participate in all aspects of prevention programming, (2) inviting external partners to serve on advisory and networking committees and (3) working to develop strong, long-term relationships with external partners by using a participatory and inclusive planning process. Recommendations to CDC include (1) allowing the maximum time for proposal development and program planning to allow partners to be engaged in the processes.

4. State Plans

Recommendations to state health departments include (1) working with external and internal partners to ensure the inclusion of strategies to prevent diabetes in comprehensive chronic disease prevention plans and (2) working with external and internal partners to ensure the inclusion of strategies to prevent diabetes in related categorical chronic disease plans (e.g. obesity, stroke and heart disease, comprehensive cancer).

5. Intervention

Recommendations to state health departments include (1) using an inclusive planning process to develop primary prevention messages and interventions, (2) developing key messages that are evidence-based, (3) working with partners to identify specific groups within the state to whom to target interventions, (4) working with partners to select and develop interventions appropriate for each target group and (5) facilitating the sharing of lessons learned between intervention groups.

6. Evaluation

Recommendations to CDC and state health departments include (1) working together to develop national and state-level systems to evaluate diabetes prevention program processes, and intermediate and long-term outcomes.

7. Program Management and Administration

Recommendations to state health departments include (1) recruitment of committed leadership, (2) developing steering groups for diabetes prevention projects, (3) developing mechanisms for breaking down categorical program silos, and (4) developing processes to ensure that internal partners commit to collaborate and are written into program plans. Recommendations to CDC and state health departments include (1) ensuring adequate internal staff support, (2) ensuring that sufficient resources are available to develop infrastructure and for social marketing campaigns, and (3) utilizing existing primary prevention resources in the development of prevention programs. Recommendations to CDC include (1) allowing for the sharing of funds across categorical programs, and (2) allowing for sufficient time in diabetes prevention projects so that teams can develop a "shared vision" and conduct planning processes using social marketing theory to develop messages and interventions appropriate for the target audiences.

This framework should be adopted by Hawaii's public health entities, both private, non-profit and public. It should be used as a rallying point to get all stakeholders to coalesce and work together in an effort to enhance and align MetS, diabetes, cardiovascular disease, and obesity primary prevention activities across the state. In this way, interventions could be targeted to where they are most needed, can be carried out in a coordinated fashion and across existing silos. This would also minimize duplication of efforts and wasting of finite resources, both human and financial.

Future Studies

The aim of this study was to describe the epidemiology of obesity and MetS risk factors within Hawaii's population using two different obesity definitions. This study also tested the association between clustered MetS risk factors and ethnicity when controlling for demographic and socioeconomic characteristics and found that associations do exist. Further inquiry that aims to understand why certain ethnic groups in Hawaii are more likely to have MetS, type 2 diabetes, and cardiovascular disease needs to be expanded. It is obvious that health inequities within Hawaii's diverse ethnic groups continue to persist. Is it genetic predisposition or is it tied to cultural behaviors that are shared by those within certain ethnic groups, or is it a combination? Disentangling the core determinants of MetS, type 2 diabetes, and cardiovascular disease (and health inequities in general) that are bundled into the construct of ethnicity will help shape meaningful and targeted interventions, both at the primary and secondary level.

There is a serious need for translational research to be carried out in order to gain a better understanding of how to effectively implement population-based strategies to mitigate this growing problem among Hawaii's diverse ethnic populations. A good example of this is the DPP. The DPP has clearly demonstrated that primary prevention carried out in populations that are at-risk for diabetes works. However, not everything is as clear as it seems. There are many questions that remain. How does a community implement, pay for, and sustain such a program? What type of infrastructure is needed in order to successfully implement a primary prevention program of the magnitude and scale of the DPP? What agency(s) is / are best suited to lead the way? What about cultural issues, especially those that are unique to Hawaii? What level of political will is needed in order to succeed? How does one deal with competing interests? Who are the essential stakeholders needed for success? What defines success? How does one gauge the "readiness" of a community to participate? As one can see, the types of questions that are posed here are not typical of clinical trials, conventional epidemiological studies or outcome studies. It really involves the study of the process of how one carries out a successful intervention in a "real world" setting. It is believed that translational research carried out in Hawaii will provide some of the answers to these daunting questions. But there is a question, one that is more philosophical in nature, that in some ways is really at the core – does the ultimate responsibility reside within the individual person or is at a societal responsibility?

Limitations

Because the Hawaii BRFSS "fits" a person into a particular ethnic group that is mutually exclusive, the use of ethnic specific BMI thresholds to determine weight status may be problematic. For example, if a respondent is both Native Hawaiian and White, according to the algorithm that BRFSS uses, this individual would be categorized as Native Hawaiian. In this case, it is not clear as to what BMI definition of weight status should be used. In Hawaii, this issue is of particular concern due to its ethnically diverse population.

As previously discussed, in 2002, the Hawaii BRFSS changed the methodology it employs to determine the ethnicity of its survey respondents. Prior to 2002, the Hawaii BRFSS would allow the respondent to name all of their race / ethnicities. This would be followed up with another question that would enable the respondent to pick one ethnicity that best described them. The response to this question formed the basis for categorizing respondents into mutually exclusive race / ethnicity categories. As of 2002, the BRFSS uses a method that is similar to the one employed by the Hawaii Health Survey (previously discussed). Because of this change in methodology, there may be some loss of continuity between BRFSS datasets prior to and after 2002 regarding how ethnicity is coded.

In general, the records that were excluded from the analysis that examined clustered risk factors compatible with MetS were more likely to be: (1) Filipino or Native Hawaiian, (2) younger, (3) of lower level of educational level, and (4) living in poverty.

According to the findings of this study, all of these characteristics are associated with a higher prevalence of 3 – 4 risk factors associated with MetS. This brings to light two important issues. First, because there are significant differences between the two groups (excluded records versus included records) the findings of this study may not be representative or reflective of the entire population of Hawaii. Second, because the excluded group had higher levels of those characteristics associated with MetS risk factors this study may be underestimating the true prevalence of clustered risk factors among Hawaii's population.

The diagnosis of MetS is clinically derived, and is based on current laboratory and anthropometric measures of the individual. The IDF defines MetS in an individual who has increased central obesity (waist circumference or BMI or 30 or more) plus any two of the following laboratory or clinical findings: low HDL, high triglycerides, hypertension, or impaired fasting plasma glucose. However, this study used self-reported measures from the BRFSS to estimate the prevalence of clustered risk factors compatible with MetS. This study used a looser definition of MetS. That is, this study used these four self-reported risk factors derived from the BRFSS in any combination (three or more): BMI of 30 or more, told by doctor they had high cholesterol, told by doctor they had high blood pressure, and told by doctor they had diabetes. It could be argued that the case definition employed by this study is more sensitive than the IDF case definition because it uses any combination of risk factors, as long as it adds up to three or more. However, the key here is that the BRFSS relies on a person being told by a doctor they had one these conditions (aside from BMI). Put another way, each person would need the opportunity to be told by a doctor they had a certain condition. If a person did not have this opportunity, as in those that do not have access to a doctor, the likelihood of being diagnosed would be decreased. The findings of this study support this. This study found that those without a personal doctor were less likely to have 3 – 4 risk factors when compared with those who did. This provides additional evidence that the methods employed by this study most likely underestimate the true prevalence of 3 – 4 clustered risk factors, especially among those in the lower socioeconomic strata. Another limitation of this study in estimating the prevalence of MetS is the fact that the BRFSS measures lifetime prevalence. For example, the BRFSS asks the respondent is they were ever told by a doctor they had or have a certain condition. Hypothetically, one could have had at one moment in his/her life, high cholesterol or hypertension, but could have eliminated it through lifestyle changes and / or medication. In this case, the BRFSS could possibly overestimate the point prevalence of MetS.

Lastly, the BRFSS uses a stratified random sampling design which needs to be taken into account during statistical analysis. Proc SURVEYMEANS (SAS 9.1.3), which takes into account the complex sampling design used by BRFSS, was used to calculate prevalence and confidence intervals (bivariate analysis). However, when estimating prevalence ratios, proc GENMOD was used. Proc GENMOD (SAS 9.1.3) does not take into account complex survey design and assumes sampling is simple and random. In this situation, Proc GENMOD would have the tendency to underestimate standard errors, leading to underestimated confidence intervals as well. Due to this fact, it is possible that the findings of the Poisson regression analysis may have an additional degree of type I error. That is, in some cases where prevalence ratios were deemed to be statistically different from each other, in actuality they may not be.

Conclusions

This study has shown that the magnitude of obesity and MetS (clustered risk factors compatible with MetS) in Hawaii's population is high. This study has also shown that employing ethnic specific BMI definitions of obesity effects obesity and MetS prevalence estimates, significantly increasing prevalence estimates among Asian groups and moderately decreasing prevalence rates among Native Hawaiians and "Other Pacific Islanders". Regardless of what BMI definition is used, the obesity and MetS burden in Hawaii is high and is disproportionately distributed.

Regression analysis (Poisson) has demonstrated that associations exist between MetS risk factors (3 – 4) and ethnic groups and that these associations persist even when controlling for education, poverty, gender, age, and healthcare access.

Finally, this study provides a glimpse into the future burden Hawaii may be faced with as the prevalence of obesity and its associated conditions continue to rise. It is hoped that this study will serve as a springboard for future investigations that aim to examine causal relationships, especially as it relates to health inequities / disparities. It is also hoped that future research carried out in Hawaii will attempt to understand what is needed to translate research into real world public health practice.

REFERENCES

[1] Grandinetti A, Kaholokula J, Theriault A, Mor, J, Chang H, Waslien C. Prevalence of Diabetes and Glucose Intolerance in an Ethnically Diverse Rural Community of Hawaii. Ethn Dis, 2007; 17: 250-255

[2] Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet 2005; 365: 1415-1416

[3] Johnson L, Weinstock R. The Metabolic Syndrome: Concepts and Controversy. Mayo Clin Proc, 2006; 81:1615-1620

[4] Ford E, Giles W, Mokdad A. Increasing Prevalence of the Metabolic Syndrome Among U.S. Adults. Diabetes Care, 2004; 27: 2444–2449

[5] Wilson P, D'Agostino R, Parise H, Sullivan L, Meigs J. Metabolic Syndrome as a Precursor of Cardiovascular Disease and Type 2 Diabetes. Circulation, 2005; 112: 3066-3072

[6] Chew GT, Gan SK, Watts GF. Revisiting the metabolic syndrome. Med J Aust 2006; 85: 445-449

[7] Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA, 2001; 285: 2486–2497

[8] Saely C, Koch L, Schmid F, Marte T, Aczel S, Langer P, Hoefle G, Drexel H. Adult Treatment Panel III 2001 but not International Diabetes Federation 2005. Criteria of the Metabolic Syndrome Predict Clinical Cardiovascular Events in Subjects Who Underwent Coronary Angiography. Diabetes Care, 2006; 29: 901–907, 2006

[9] International Diabetes Federation. The IDF consensus worldwide definition of the metabolic syndrome, 2006.

[10] Kahn, R, Buse J, Ferrannini E, Stern M. The Metabolic Syndrome: Time for a Critical Appraisal. Joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care, 2005; 28: 2289-2304

[11] Moon OR, Kim NS, Jang SM, Yoon TH, Kim SO. The relationship between body mass index and the prevalence of obesity-related diseases based on the 1995 National Health Interview Survey in Korea. Obes Rev, 2002; 3: 191–196

[12] Smerd J. Obesity must be curbed to cut cost of chronic illness, study says. Workforce Management, November 8, 2007. [cited 2007 Nov 20]. Available from: http://www.workforce.com/section/00/article/25/21/10.html

[13] Wang J, Armour T, Geiss L, Engelgau M. Obesity and diabetes: dual epidemics on the rise. Current Opinion in Endocrinology and Diabetes, 2005; 12: 174-180

[14] Ludwig D. Childhood Obesity – The Shape of Things to Come. N Engl J Med, 2007; 357: 2325-2327

[15] American Diabetes Association [homepage on the internet]. Type 2 diabetes complications. [cited 2008 Jan 15]. Available from http://www.diabetes.org/type-2-diabetes/complications.jsp

[16] Wild S, Roglic, G, Green A, Sicree R, King H. Global Prevalence of Diabetes – Estimates for the Year 2000 and Projections for 2030. Diabetes Care 2004; 27: 1047-1053

[17] Centers for Disease Control and Prevention [homepage on the internet]. BRFSS – Turning Information into Health. [cited 2007 Nov 9]. Available from http://www.cdc.gov/brfss/

[18] Geiss, LS, Albright A. U.S. Diabetes Rate Soars: No End in Sight as Diabetes Epidemic Gains Speed. American Diabetes Association 67th Annual Scientific Sessions, Chicago, June 22-26, 2007. [cited 2007 June 25]. Available from http://diabetes.webmd.com/news/20070625/US-diabetes-rate-soars

[19] American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2007. Diabetes Care, 2008; 31: 1–20

[20] American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2002. Diabetes Care, 2003; 26: 917–932

[21] Hawaii State Department of Health [homepage on the internet]. Behavioral Risk Factor Surveillance System. [cited 2007 Nov 9]. Available from http://www.hawaii.gov/health/statistics/brfss/index.html

[22] Centers for Disease Control and Prevention [homepage on the internet]. Behavioral Risk Factor Surveillance System, Trend Data, Hawaii. [cited 2007 Nov 9]. Available from http://apps.nccd.cdc.gov/brfss/Trends/trendchart.asp?qkey=10010&state=HI

[23] Centers for Disease Control and Prevention. Prevalence of Receiving Multiple Preventive-Care Services Among Adults with Diabetes — United States, 2002—2004. MMWR Morb Mortal Wkly Rep, November 11, 2005; 54 (44): 1130-1133

[24] Diabetes Prevention Program Research Group. Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin. N Engl J Med, 2002; 346: 393–403

[25] Hawaii State Department of Health [homepage on the internet]. Behavioral Risk Factor Surveillance System. [cited 2008 Jan 8]. Available from http://www.hawaii.gov/health/statistics/brfss/index.html

[26] Hawaii State Department of Health [homepage on the internet]. Hawaii Health Survey. [cited 2008 Jan 8]. Available from http://www.hawaii.gov/health/statistics/brfss/index.html

[27] Hawaii State Department of Heath [homepage on the internet]. Behavioral Risk Factor Surveillance System. [cited 2007 Nov 15]. Available from http://www.hawaii.gov/health/statistics/brfss/brfss2006/2006/demo06/bmi.html

[28] Hirokawa R, Huang T, Pobutsky A, Nogues M, Salvail F, Nyugen HD. (2004) Hawaii Diabetes Report, 2004. Hawaii State Department of Health. Honolulu, Hawaii State Dept. of Health

[29] Balabis J, Pobutsky A, Baker K, Tottori, C, Salvail F. (2007) The Burden of Cardiovascular Disease in Hawaii 2007. Hawaii State Department of Health. Honolulu, Hawaii

[30] Swinburn BA, Ley SJ, Carmichael HE, Plank LD. Body size and composition in Polynesians. Int J Obes, 1999; 23: 1178-1183

[31] Rush E, Plank L, Chandu V, Laulu M, Simmons D, Swinburn B, Yajnik C. Body size, body composition, and fat distribution: a comparison of young New Zealand men of European, Pacific Island, and Asian Indian ethnicities. N Z Med J, 2004; 117: 1-9

[32] Hirokawa, R. Hawaii Health Data Warehouse / Healthy Hawaii 2010 Website. Hawaii Primary Care Association Annual Conference 2007; 2007 Oct 23; Honolulu, Hawaii

[33] Centers for Disease Control and Prevention [homepage on the internet]. Behavioral Risk Factor Surveillance System, BRFSS Freqeuntly Asked Questions. [cited 2007 Nov 15]. Available from http://www.cdc.gov/brfss/about.htm

[34] Hawaii State Department of Health [homepage on the internet]. Behavioral Risk Factor Suveillance System. [cited 2007 Nov 15]. Available from http://www.hawaii.gov/health/statistics/brfss/brfss2006/2006/demo06/diabete2.html

[35] Centers for Disease Control and Prevention [homepage on the internet]. Behavioral Risk Factor Surveillance System, BRFSS Frequently Asked Questions. [cited 2008 Jan 15]. Available from http://www.cdc.gov/BRFSS/faqs.htm#17

[36] Gorber SC, Tremblay M, Moher D, Gorber B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. Obes Rev, 2007; 8: 307–326

[37] World Health Organization [homepage on the internet]. BMI Classification. [cited 2007 Oct 18]. Available from http://www.who.int/bmi/index.jsp?introPage=intro_3.html

[38] Razak F, Anand S, Shannon H, Vuksan V, Davis B. Defining Obesity Cut Points in a Multiethnic Population. Circulation 2007; 115: 2111-2118

[39] Sorensen C, Wood B, Prince E. Race and Ethnicity Data: Developing a Common Language for Public Health Surveillance in Hawaii. Californian J Health Promot, 2003; 1 (Special Issue): Hawaii 91-104

[40] Meriwhether R, Kohn M. Prevalence of Cardiovascular Disease Risk-Factor Clustering Among Persons Aged greater than or equal to 45 Years--Louisiana, 1991-1995. MMWR Morb Mortal Wkly Rep, 1997; 46(25): 585-588

[41] Robbins A, Chao S, Fonseca, V. What's the Relative Risk? A Method to Directly Estimate Risk Ratios in Cohort Studies of Common Outcomes. Ann Epidemiol, 2002; 12: 452-454

[42] Spiegelman D, Hertzmark E. Easy SAS calculations for Risk or Prevalence Ratios and Differences. Am J Epidemiol, 2005; 162: 199-200

[43] An A, Watts D. New SAS Procedures for Analysis of Sample Survey Data. SAS Institute, Inc., Cary, North Carolina. [cited 2008 Jan 30]. Available from http://support.sas.com/rnd/app/papers/survey.pdf

[44] Florentina Salvail, Hawaii BRFSS Coordinator, Hawaii Department of Health. Personal communication on November 1, 2007

[45] Linda Tompkins L, Siller A. Analyzing Complex Sample Survey Data: A New Beginning. CDC/National Center for Health Statistics, Hyattsville, MD [cited 2007 Nov 19]. Available from http://www2.sas.com/proceedings/sugi25/25/po/25p238.pdf

[46] Kim C, Sinco B, Kieffer E. Racial and Ethnic Variation in Access to Health Care, Provision of Health Care Services, and Ratings of Health Among Women With Histories of Gestational Diabetes Mellitus. Diabetes Care, 2007; 30: 1459–1465

[47]. US Department of Agriculture, Food and Nutrition Service, Food Stamp Program. Food Stamp Nutrition Plan Guidelines, March 2007

[48] Katherine Benson, IS Administrator, Hawaii Health Data Warehouse. Personal communication on January 17, 2008

[49] Hawai`i Department of Health Office of Health Status Monitoring [homepage on the internet]. Hawaii Health Survey HHS Introduction 2001, Honolulu, Hawaii June 2002. [cited 2008 Jan 15]. Available from http://www.hawaii.gov/health/statistics/hhs/hhs_01/hhs01doc.pdf

[50] International Diabetes Institute. The Asia-Pacific Perspective: Redefining Obesity and its Treatment. February 2000. Health Communications Australia Pty Limited (Publisher)

[51] Ministry of Health. 2003. Food and Nutrition Guidelines for Healthy Adults: a background paper. Wellington. Ministry of Health

[52] Chapter 61: The SURVEYMEANS Procedure. SAS OnlineDoc, Version 8. [cited 2007 Nov 19]. Available from http://faculty.smu.edu/slstokes/stat6380/surveymeans.pdf

[53] Linda Geiss, Division for Diabetes Translation, Centers for Disease Control and Prevention. Personal communication, 2007

[54] Chronic Disease Directors, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention. The Primary Prevention of Diabetes: Recommendations from the Chronic Disease Directors Project, 2005