THE IMPACT OF WEIGHT STATUS PERCEPTION ON PERCEIVED RISK FOR DIABETES AND DIABETES SCREENING

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DEDICATION

To my dog Phantom, who lay by my side while I studied till the day he died…

To my beloved Theri, who believed in me and supported me till the day she died…

To my son, who says every day, "You can do it, Amma!"…

To my beloved, Miles, who has been my rock and stood by my side as I completed my journey.

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ABSTRACT

Self-perceived weight status refers to how an individual assesses his or her own body weight and size. Misperception of weight status can occur in either direction, with underperception of weight status being more prevalent. Underperception of weight status is closely associated with BMI category, with those who are categorized as obese having a higher prevalence ratio (PR) of misperceiving their weight status of 5.31 (95% CI, 3.41-8.25) compared to those who have a healthy weight, even after adjusting for other covariates. Males, those identifying as Native Hawaiian or Other Pacific Islander and those who have ever served in the US Military are more likely to underperceive their weight status, even after adjusting for BMI category, whereas those in older age groups are less likely to underperceive their weight status compared to younger adults. Weight status underperception is associated with diabetes risk perception. Individuals who overperceive their weight status are more likely to perceive themselves to be at risk for diabetes (PR 1.42, 95% CI 1.14-1.76), whereas those who underperceive their weight status are less likely to do so (PR 0.76, 95% CI 0.60-0.97) compared to those with accurate weight status perception. Other factors associated with diabetes risk perception include being diagnosed at risk (PR 1.97, 95% CI 1.58-2.45), having a family history of diabetes (PR 1.77, 95% CI 1.39-2.24), and BMI category, with obese individuals being more likely to perceive themselves to be at risk compared to those who have a healthy weight (PR 2.07, 95% CI 1.46-2.93). Higher diabetes risk perception is associated with greater receipt of diabetes screening in the past three years (PR 1.31, 95% CI 1.05-1.62) even after adjusting for age and other potential confounders. The findings have important implications for correcting weight status perception and enhancing awareness of diabetes risk, with the goal of motivating those at risk to engage in lifestyle change efforts targeted at reducing their risk for diabetes.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADA	American Diabetes Association
BIC	Bayesian Information Criteria
BMI	Body Mass Index
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
COLLIN	Collinearity
DOH	Hawaii State Department of Health
DPP	Diabetes Prevention Program
FPL	Federal Poverty Level
HBM	Health Belief Model
HHDW	Hawaii Health Data Warehouse
HHI	Healthy Hawaii Initiative
MIDUS3	Midlife in the United States 3
NDPP	National Diabetes Prevention Program
NH	Native Hawaiian
NHANES	National Health and Nutrition Examination Survey
NHOPI	Native Hawaiian and Other Pacific Islander
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
OHSM	Office of Health Status Monitoring
PI	Other Pacific Islander
PR	Prevalence Ratio
RR	Relative Risk
RSE	Relative Standard Error
SNAP	Supplemental Nutrition Assistance Program
STB	Standardized Beta Coefficients
TOL	Tolerance
UK	United Kingdom
US	United States
USPSTF	US Preventive Services Task Force
VIF	Variance Inflation Factor
WHO	World Health Organization
n/r	Not Reportable
χ^2	Chi Square statistic

The Impact of Weight Status Perception on Perceived Risk for Diabetes and Diabetes Screening

INTRODUCTION

Overweight and Obesity Worldwide and in Hawaii

According to the World Health Organization (WHO), the prevalence of obesity has more than doubled since 1980.(1) In 2014, 13% of adults worldwide were obese, and 39% were overweight.(1) More than half of all obese individuals worldwide live in just ten countries, with the United States (US) leading the world in its contribution to the overall count.(2) According to the Centers for Disease Control and Prevention (CDC), the prevalence of obesity among adults in the US has risen significantly since the 1990s and continues to show an increasing trend.(3) Nearly two in five US adults (39.8%) meet criteria for obesity based on data gathered in the National Health and Nutrition Examination Survey (NHANES; 2015-16).(3) In 2013, the US accounted for 13% of all obese adults worldwide.(2)

The State of Hawaii has been ranked as the healthiest state in the nation for five consecutive years since 2012.(4) Obesity is one indicator considered in assigning these rankings.(4) With just over one in five adults (22.7%) meeting criteria for obesity, Hawaii ranked second lowest in obesity in the nation in 2015.(4) A recent report based on data gathered in 2016 indicates that Hawaii's ranking has slipped to fourth lowest in the nation.(5) Nonetheless, the overall low prevalence of overweight and obesity masks significant disparities within the state by race-ethnicity. For example, according to the Behavioral Risk Factor Surveillance System (BRFSS; 2014-15), prevalence proportions of obesity in Hawaii vary from a low of 16.7% among Japanese to 40.5% among Native Hawaiian (NH) and 55.3% among Other Pacific Islander (PI) adults.(6) Prevalence of obesity within PI populations in Hawaii, while alarming, match those reported internationally. In a study of global obesity (2013), countries with the highest obesity where prevalence exceeded 50% included Tonga, the Federated States of

Micronesia, and Samoa.(2) Those who identify as any part Native Hawaiians and Other Pacific Islanders (NHOPI) represent only 0.4% of the US population, compared to 25.1% of Hawaii.(7)

An additional consideration in interpreting Hawaii's low overall obesity prevalence may be the state's unique racial distribution. According to the US Census Bureau, those who identify as any part Asian represent 5.5% of the US population compared to 55.0% of Hawaii's population.(7) Studies have noted that when comparing individuals with the same amount of body fat, Asians have a lower body mass index (BMI) by 3-4 kg/m^2 compared to Whites.(8) The extent of disparity between BMI and body fat varies between Whites and Asian sub-groups, with the greatest differences observed when comparing Whites and Asian Indians.(8) Since BMI is often used as a proxy for body fat, the prevalence of excess body fat, and therefore risk for chronic conditions, is underestimated in a population with a larger proportion of Asians.(8)

Considerations for Interpreting Overweight and Obesity

In 2002, as a strategy to correct for the underestimation of body fat, a WHO Expert Consultation panel proposed lower BMI cut points for overweight and obesity for Asian populations.(9, 10) However, due to a lack of consensus, these recommendations were not adopted.(11) To date, standard BMI cutoffs continue to be applied to all race groups in the US,(12) with minimal impact on national obesity prevalence at this time due to the low overall prevalence of Asians. Based on the standard cutoffs, a BMI of 18.5-24.9 is healthy, 25-29.9 is considered overweight, and a BMI of 30.0 and above is obese; obese BMI is further divided into obesity grade I for individuals within the BMI range of 30.0-34.9, obesity grade II for those with BMIs between 35.0-39.9, and obesity grade III for those with BMIs of 40.0 and above.(13) Obesity grade III is also called severe or morbid obesity.(13) Although the recommended modified cutoffs for various Asian sub-groups are slightly different, the most commonly proposed standardized cutoffs that have not been formally adopted in the US assign a status of overweight to Asians with a BMI of 23.0-27.4, and obese to those with a BMI of 27.5 and higher.(14)

With Asian Americans representing the fastest growing race group in the US, the relative impact of incorrectly applying standard BMI cutoffs to this population to assess overweight and obesity is expected to increase.(14) Currently, the uniform application of standard BMI cutoffs has resulted in the existence of a growing but unrecognized Asian American obesity epidemic nationally, with differential impact on various Asian sub-groups.(14, 15) While the epidemic has a minimal impact on national obesity estimates at this time, the consequences are uniquely problematic for Hawaii. Specifically, the under-detection of body fat among Asians in Hawaii may substantially obscure a true understanding of the health of the state. It may also impact perception of weight status and risk for chronic conditions, and consequent behaviors, as described in the next sections.

Misperception of Weight Status

Self-perceived weight status refers to how an individual assesses his or her own body weight and size.(16) Several studies have examined the relationship between self-perceived weight status and BMI, focusing on the prevalence of misperception of weight, where there is discordance between an individual's actual and perceived weight status.(17) In 2006, a Pew Research Center study revealed that while 90% of Americans agree that most of their fellow Americans are overweight, and 70% believe that most people they know are overweight, only 40% believe that they themselves are overweight.(18) Approximately half of those who believe they are overweight consider themselves only a little overweight.(18)

Multiple studies have concluded that weight status misperception occurs in both directions, with healthy weight individuals misperceiving themselves to be overweight, and overweight or obese individuals believing themselves to be in the healthy weight range. For example, data collected by an annual household survey in the United Kingdom (UK) revealed that 7% of healthy weight adolescents overestimated their weight and felt 'too heavy' compared to 39% of overweight or obese adolescents who underestimated their weight and classified themselves as 'about the right weight' or 'too light.'(19) In a US study based on the NHANES, 77% and 43% of adolescents classified as overweight and obese respectively underperceived their weight status.(20) In another NHANES study among adults in the US, approximately 38% of overweight and 8% of obese adults misperceived their weight status to be 'underweight' or 'about the right weight.'(21) Misperception of weight occurred in the opposite direction as well, with 40% of underweight adults perceiving themselves to be 'about the right weight,' and 22% of healthy weight adults perceiving themselves to be 'overweight.'(21) Among UK adults, 65% and 35% of overweight or obese men and women respectively misperceived their weight to be 'about right.'(22) Similar findings were reported based on a study in Australia, where 54% of participants who were overweight or obese did not feel that their weight was a risk to their health.(23) The true extent of the misperception observed varied based on whether the studies used objective or self-reported measurements of height and weight to calculate BMI.(22) For example, using self-reported BMI, 42.7% of overweight or obese males and 19.3% of overweight or obese females underestimated their weight as being 'about right'; in comparison, using measured BMI, the true prevalence proportions of underperception were significantly higher at 54.7% and 30.9% respectively.(22)

In general, members of groups that have higher average BMIs are more likely to underperceive their weight status.(24) Race, rurality, socioeconomic status, educational status, and sex are demographic factors associated with weight status misperception.(21, 23, 25, 26) Overweight women are substantially less likely to misperceive their weight status compared to overweight men, whereas individuals identifying as Black are more than twice as likely to misperceive their weight compared to Whites.(21, 23, 25, 27, 28) Mexican Americans are also more likely to misperceive their weight status than Whites, but not to the same extent as Black Americans.(21) Across several studies in the US, higher socioeconomic status, higher educational attainment and urban living are protective against weight status underperception among overweight and obese individuals.(21, 25, 27) Among individuals who are obese, age is an additional factor associated with misperception, with younger obese individuals being more likely to underperceive their weight status compared to older obese individuals.(25, 27) Finally, birth cohort has been implicated to be associated with weight status misperception, with individuals in more recent birth cohorts who experienced higher prevalence of childhood obesity being more likely to misperceive their weight status.(24)

A small subset of the published studies has assessed change in weight status perception over time. In one paper, the authors Burke, Heiland & Nadler (2010) suggest a generational change in the general public's perception of what is normal versus overweight.(24) Comparing the extent of misperception of weight between two time periods in the US (1988-1994 versus 1999-2004), these authors observed a decline in the likelihood of individuals to classify themselves as overweight. This observation applied to individuals who were objectively classified as overweight or obese as well as those classified as normal weight.(24) Notably, younger individuals, normal weight women, and overweight men aged 20-45 years were even less likely than other groups to perceive themselves as overweight.(24) Collectively, these data showed a shift upwards over time in the BMI range at which individuals were likely to perceive themselves to be overweight.(24) The authors suggested that the pattern could reflect a shift in weight norms as the extant population has grown heavier.(24)

Another study comparing the same time periods noted similar increases in weight status misperception among overweight individuals in the US, with more people in the overweight range perceiving themselves to be within normal weight.(27) However, the extent of change in misperception varied by demographic groups.(27) Specifically: males, those earning lower incomes, and those identifying as Black experienced the greatest distortions in weight status perception, with increases in prevalence of misperception of overweight and obesity exceeding that of other groups.(27) Similarly, younger individuals experienced greater alteration in self-perception over the study periods than older individuals.(27) There was no increase in misperception among those categorized as obese with the majority self-perceiving themselves as 'overweight'; however, the question that assessed misperception did not require respondents to specify whether they identified themselves as overweight or obese.(27) Other studies have demonstrated that obese weight status is correctly identified only at and above the upper end of class II obesity (i.e. BMI > 39.0), suggesting that under-perception of obesity may persist among adults classified as obese.(29)

Causes of Weight Status Misperception

Self-evaluations regarding weight status are typically conducted using others in the individual's environment as reference points for comparison rather than clinical recommendations.(30) Studies on children and parents of children have shown that being surrounded by overweight and obese children influences children and parents to underestimate their own weight status, or that of their child, respectively.(31) One study by Robinson & Kirkham (2014) assessed the impact of increasing obesity on visual norming; in other words, the study strove to determine whether people's perception of what healthy weight looks like is altered in response to rising obesity prevalence, as they are increasingly surrounded by individuals with larger body weights.(31)

Via a series of experiments, Robinson & Kirkham (2014) demonstrated that exposure to photographs of obese males caused participants to be more likely to rate overweight males as being within a healthy weight range, and less likely to believe that the overweight males should consider weight loss.(31) This shift in perspective was mediated by a change in perception related to what was considered 'normal' weight for males.(31) The authors used the findings to explain that increased visual exposure to overweight and obese individuals alters visual perceptions of what is healthy weight, leading more overweight and obese individuals to underperceive their own weight status.(31) The authors also suggest that a shift in weight norms may change what weight is considered socially acceptable or attractive, reduce stigma associated with obesity, and impact weight-related judgments, such as desire to lose weight.(31) Another study found that greater frequency of exposure to heavier bodies leads to an upward drift in what individuals believe to be normal weight.(32)

Robinson & Christiansen (2014) studied the impact of perceptual exposure on attitudes, based on the hypothesis that increased exposure and greater norming can promote positive attitudes including attractiveness towards, and reduced stigmatization of, obese individuals.(33) Through experiments, the authors demonstrated that exposure to photographs of obese males marginally increased visual preference for an overweight male and was associated with less stigmatization as evidenced by higher ratings of the overweight male's intelligence and weight status.(33) The shift in attitude was mediated by a corresponding shift in visual preference towards heavier bodies secondary to exposure to photographs of obese males.(33)

To summarize, a substantial body of literature clearly demonstrates that as obesity has risen, social norms and visual perception of obesity has recalibrated.(16) As the average societal body size has inched upwards, perceptions of what is healthy and obese has also shifted towards higher BMIs.(16) Therefore, individuals today are more likely than ever before to fail to recognize overweight and obesity, both in themselves and in others.(16) The extent of misperception is enhanced among demographic groups that have higher prevalence of overweight and obesity.(16) The visual normalization theory, proposed by Robinson (2017) suggests that as we are surrounded by obesity, we are less likely to see it, both in ourselves and in others.(16)

Many socioecological factors influence self-perception of weight. For example, advertising and television continue to heavily promote thinness as a beauty ideal for women.(34-36) Based on Robinson's visual normalization theory, such exposure might counteract societal visual norms to an extent, and enhance the likelihood that women will correctly perceive their weight.(16) As noted earlier, the literature confirms that women are significantly less likely than men to misperceive their weight.(21, 25) Family and social norms may influence self-perception in either direction; familial validation and normalization of overweight and obese may result in greater self-misperception of weight.(37) One study showed that obesity spreads in social clusters, with an individual's chance of becoming obese increasing by 57%, 40% or 37% respectively if his or her friend, sibling or spouse became obese.(38)

Cultural norms may similarly normalize overweight and obese; for example, certain race/ethnicities (e.g. Black and Hispanic) and geographic regions (e.g. the Southern states) within the US are associated with higher obesity, and cultural practices related to eating associated with obesity, such as the overconsumption of starchy or fried foods.(37) The Black community may, in general, emphasize self-acceptance over physical appearance.(28) The literature confirms that these groups (e.g. those identifying as Black or Hispanic, and those living in rural areas) are less likely to correctly perceive themselves to be overweight than Whites and/or urban dwellers.(21, 25, 27, 28) Finally, recent grassroots, commercial and other governmental efforts have emerged to normalize plus sizes and promote self-acceptance.(39, 40) Toronto-based grassroots organization called "Pretty, Porky and Pissed Off" uses cabaret and street protests to challenge unattainable and misogynistic beauty ideas for women, and Dove's "Campaign for Real Beauty" strives to broaden beauty ideals to include larger bodies.(41) Using a different strategy, the clothing industry has also responded to the obesity epidemic; a study of garment sizes revealed that the clothing market adjusts clothing sizes to their target audience, with more expensive brands leaning towards more lenient measurements for the same clothing size, in turn obscuring consumers' self-perceptions of weight gain.(41, 42) These multiple conflicting messages undoubtedly influence and confound self-perception of weight status.(19)

Consequences of Weight Status Misperception

Much research on self-perception of weight status, especially among adolescents, has focused on overperception of weight status, and the relationship between weight status overperception and disordered eating behaviors.(43) As such, the literature on body dissatisfaction emphasizes the importance of size acceptance, regardless of whether the discontent is real or perceived, as heightened body dissatisfaction is associated with greater prevalence of disordered eating behaviors.(44) One study reported that overweight and obese youth who underperceived their weight were relatively protected from disordered eating behaviors.(43) Another study among Australian adults reported better psychosocial quality of life among both underweight and overweight or obese individuals associated with misperception in the direction of healthy weight.(45) However, while a protective factor that improves quality of life and reduces risk for eating disorders, under-perception of weight may also reduce motivation for weight loss.(46, 47)

As described by the Health Belief Model (HBM), misperceptions of weight status may have public health implications. The HBM suggests that four types of perceptions influence health behavior, namely vulnerability to a given condition (or self-perceived risk), severity of condition, efficaciousness of the recommended health actions, and barriers and challenges associated with adopting the recommendation.(48) Therefore, according to the HBM, weight status misperceptions may reduce perceived vulnerability to the consequences of obesity, and reduce motivation to adopt healthy behaviors. The research on consequences of weight status misperception is consistent with this theory. For example, individuals who are overweight or obese but misperceive themselves as being within a healthy weight range are less motivated to lose weight; they are less likely to want to lose weight as well as to have tried to lose weight within the past year.(17) They are substantially less likely to believe that their current weight poses a threat to their health.(49) They are also less likely to engage in any leisure time physical activity, and less likely to meet physical activity recommendations even when physically active.(17, 23) Such relationships between weight status perception and health behaviors may be more prominent among women and more pronounced among those identifying as Black.(17, 50) In fact, Black adults who misperceived their weight status are 77% less likely to have tried to lose weight in the past year.(48) Therefore, weight self-perception can serve as a key factor in the success of lifestyle change programs promoting healthy weight loss.(17)

In summary, while weight status misperception may protect from disordered attempts at weight loss, it may also deter individuals from successfully engaging in healthy attempts at weight loss and weight maintenance. Thus, weight status misperception decreases risk for eating disorders while simultaneously increasing risk for ramifications of overweight and obesity including a variety of chronic conditions. For Asian sub-groups living in the US, weight status misperception and under-recognition of risk for chronic conditions may be systematically worsened for several reasons. First, as noted earlier, the use of standard BMI cutoffs inaccurately categorizes calculated BMI for Asians; many Asians who are categorized as healthy weight may have body fat percentages that more closely resemble that of overweight and obese individuals. Nevertheless, having a BMI within the 'healthy' range may dissuade recognition of actual risk. Moreover, since self-perception of weight is often based on using others as a point of reference, Asians may see themselves as thinner compared to individuals of other race-ethnicities and misperceive their weight status and risk for chronic conditions. This misperception or under-recognition of risk may extend to the health system, where standard BMI cutoffs continue to be used to identify individuals at higher risk for chronic disease.

Despite being the state with the fourth lowest obesity prevalence, 57.5% of adults in Hawaii were classified as overweight or obese in 2014-15.(51) Further, this prevalence is based on self-reported height and weight, which tends to underestimate the true extent of overweight and obesity in the state; moreover, the prevalence is derived using standard BMI cutoffs.(51) Taken together, the adult population in Hawaii may severely underappreciate the extent to which it is impacted by overweight and obesity, and in turn, underestimate the extent to which it is at risk for the sequelae of obesity.

Risk for Diabetes and Other Chronic Diseases

Overweight and obesity are causally linked to several chronic diseases associated with premature mortality and substantial cost to society. Based on a meta-analysis by Guh et al. (2009), the relative risk (RR) of developing up to eighteen chronic conditions is elevated significantly by the presence of obesity, and to a smaller extent in most cases, by the presence of overweight.(52) The chronic condition with the highest RR is diabetes, with obese men and women having a 6.7 and 12.4 fold higher risk of developing diabetes compared to healthy weight men and women respectively.(52) Even among those who are overweight, the RR of developing diabetes is 2.4 for men and 3.9 for women.(52) Other chronic conditions include various cancers (breast, colorectal, endometrial, esophageal, kidney, ovarian, pancreatic, and prostate), cardiovascular diseases (hypertension, coronary artery disease, congestive heart failure, pulmonary embolism, and stroke), and other conditions including asthma, gallbladder disease, osteoarthritis, and chronic back pain.(52)

From a chronic disease prevention standpoint, misperception of weight status or under-recognition of risk for chronic disease may in turn lead to less active engagement in chronic disease prevention, and subsequently, higher rates of chronic disease, particularly diabetes. Diabetes is a complex chronic condition costing the United States $244 billion dollars in direct medical costs, and $78 billion in indirect costs per year. This statistic relates to both diagnosed and undiagnosed diabetes, pre-diabetes, and gestational diabetes.(53) In 2012, more than 29 million Americans were estimated to have diabetes, and 1 in 4 were not aware of their condition; an additional 86 million Americans have pre-diabetes with 9 out of 10 not aware of their condition.(54) In 2014, nearly one in ten (9.7%) adults in Hawaii had diagnosed diabetes, and an additional one in six (14.4%) had pre-diabetes, for a combined total of nearly one in four adults in the state with diagnosed diabetes or pre-diabetes.(51) The predicted prevalence of undiagnosed diabetes (4.2%) and pre-diabetes (41.5%) in the state suggests that approximately half of all adults in Hawaii with diabetes or pre-diabetes are unaware of their condition.(51, 53)

People of Asian descent have a uniquely elevated vulnerability to diabetes due to higher accumulation of body fat at lower BMI.(8) Hence studies have observed paradoxically higher prevalence of diabetes relative to reported obesity among Asian populations in the US.(15) The same paradox appears to be true in Hawaii, likely due to the high prevalence of Asians in the state. While Hawaii ranks 48th in the nation for obesity, it also ranks 23rd and 25th for hypertension and diabetes, respectively.(5) A national study modeling prevalence and cost of pre-diabetes, undiagnosed diabetes, and gestational diabetes by state predicted Hawaii to have the highest prevalence of all of these syndromes in the nation.(53)

Diagnosed Pre-Diabetes and Risk for Diabetes

Diagnosed risk for diabetes is differentiated from being at risk for diabetes, as individuals who are at risk may not have been diagnosed as being at risk. The prevalence of diagnosed risk for diabetes is impacted by access to the healthcare system, as it is strongly associated with screening;(55) in one study, individuals who reported having been tested for diabetes or pre-diabetes were up to eight times more likely to be diagnosed with their condition than those who had not been tested during the three years prior to being surveyed.(55) The U.S. Preventive Services Task Force (USPSTF) recommends routine screening for abnormal blood glucose for all adults aged 40–70 years who are overweight or obese.(56) This is a grade B recommendation, which means that screening is covered for all eligible adults by health plans subject to the Affordable Care Act.(57) Despite coverage, screening among those without diabetes remains sub-optimal. Some factors associated with receipt of diabetes screening include age and BMI category.(58) Adults in higher age groups are more likely to report having been screened for diabetes, compared to those in lower age groups; similarly, those in higher BMI categories are more likely to have been screened.(58) In a study conducted in Canada, rates of diabetes screening were significantly higher among women, adults in higher age groups, adults having a prior diagnosis of hypertension, and those with more frequent contact with the healthcare system.(59)

Finally, race is an important predictor of diabetes screening. One national study used BRFSS data collected between 2012 and 2014 to estimate the prevalence of diabetes screening among adults aged 45 years and older who met criteria for overweight or obesity.(58) That study reported screening prevalence ranging from 47.1% to 60.2% across various race groups.(58) Therefore, even among the race group with the highest screening prevalence, up to 40% of adults at high risk for diabetes reported not being screened for diabetes within the past 3 years. This suggests an overall low prevalence of diagnosed diabetes risk among adults at high risk for these conditions. Across all race groups analyzed, Asian Americans eligible for diabetes screening reported having the lowest prevalence of screening within the past three years, with fewer than half of those eligible having been screened for diabetes.(58) Asian Americans had a 34% lower odds for being screened for diabetes compared to Whites, and had the lowest prevalence of screening among all race groups nationally.(58) The authors hypothesized that Asian American patients may be less likely to recognize their risk, and therefore be less likely to request screening.(58) The authors also suggested that clinicians may similarly under-recognize elevated risks for diabetes in this population, and hence be less likely to recommend screening.(58)

The low prevalence of diabetes screening in the Asian American population may explain higher estimates of undiagnosed diabetes in the population. Nationally, over one in five Asian

American adults (21%) have diabetes, a prevalence that is approximately double that seen among non-Hispanic Whites (11%). Yet, only 10.0% of Asian Americans have been diagnosed with diabetes the US (nationally).(60) In support of this, Menke et al. (2015) reported that Asian Americans have the highest prevalence of undiagnosed diabetes (51%) among all race groups in the US.(60)

Recently, new data has been reported showing lower prevalence of undiagnosed diabetes among hospitalized patients in Hawaii, ranging between 2.5-3.9% across various race-ethnicity groups, including Asians.(61) As this was an analysis of hospitalized patients, the report may not reflect undiagnosed diabetes prevalence in ambulatory care settings or among those who do not access the healthcare system. Moreover, whereas a population-based estimate of diagnosed chronic conditions may be confounded by prior diagnosis of risk and recall biases, the hospital-based study identified undiagnosed cases based on the objective absence of a diagnosis in the patient's discharge codes.(61) Despite this, the estimates reported match other predictions on prevalence of undiagnosed diabetes in Hawaii.(53)

Perception of Risk for Diabetes

Unlike weight status misperception, substantially less research has been published on perceived risk for diabetes, the relationship between weight and risk perception, and screening for diabetes (altogether and separately). Much of the literature around diabetes risk perception and screening revolves around the central theorem that "perceived risk" dictates motivation to engage in risk-reducing behaviors and/or participate in screening. Following this logic, a larger perceived risk of harm is associated with a greater likelihood of engaging in actions to reduce risk.(62) Several studies have assessed perceived risk against actual risk for diabetes, calculated based on the presence of a variety of risk factors for diabetes.(63) Those that have looked at this association report a positive association between perceived and actual risk for diabetes.

Further, multiple studies have confirmed several risk factors for diabetes that are significantly associated with perceived risk for diabetes. These include: family history of diabetes, obesity, higher body fat percentage, clinical diagnosis of metabolic syndrome, and having poor general health. In addition to general clinical risk factors, several demographic characteristics are associated with greater perceived risk for diabetes, including sex, educational status, and age group; being female, having higher educational attainment, and being in a younger age group are associated with a greater likelihood of accurately perceiving risk for diabetes.(64) Those with higher perceived risk are also more worried about the disease.(63) On the other hand, higher perceived risk is not associated with greater motivation to adopt healthier lifestyles, meet physical activity recommendations, or follow nutritional guidelines.(63, 65)

Additionally, although individuals who are at higher risk are more likely to perceive themselves to be at risk, a substantial proportion do not believe themselves to be at risk for diabetes.(66) In one study assessing awareness of diabetes risk among African Americans in the US, one-third of those who did not believe themselves to be at risk and 40% of those who believed they would never develop diabetes were at high risk for diabetes.(66) In another study from Germany, approximately two thousand participants without previously diagnosed diabetes rated their probability of having undiagnosed diabetes and their future risk for developing diabetes.(64) Among these individuals, 4.3% were found to have undiagnosed diabetes and 35.4% had pre-diabetes.(64) Of those with undiagnosed diabetes, 75% had rated their risk to be low, very low, or negligible, and 65% believed that they were not at risk for developing diabetes in the next three years.(64) Among those with pre-diabetes, the proportion who rated themselves to be at low, very low, or negligible risk for having undiagnosed diabetes was even higher at 84%, and 72% believed they were not at risk of developing diabetes in the next three years.(64)

Unlike the relationship between actual and perceived risk for diabetes, the impact of perceived risk on screening behaviors is not as well understood. One study assessed the impact of perceived risk for diabetes on diabetes screening.(67) The study reported that risk perception was significantly associated with blood glucose screening, with 50.7% of those who perceived themselves to be at risk having been tested for diabetes compared to 38.4% who did not perceive themselves to be at risk.(67) Perception of risk remained significantly associated with diabetes screening after adjusting for other associated factors.(67) Adults in older age groups, those with higher socioeconomic status, and those with a family history of diabetes were more likely to be screened for diabetes, even after adjusting for diabetes risk perception.(67) More analysis is needed to understand the relationship between perceived risk for diabetes and screening. Further, if weight status misperception is associated with diabetes risk perception, it may confound the association between diabetes risk perception and receipt of regular diabetes screening.

PURPOSE

While the extent and impact of weight status misperception has been studied nationally, no study has assessed the extent and impact of weight status misperception in the State of Hawaii. In addition, little research has assessed the relationship between actual and perceived risk for diabetes, or between perceived risk for diabetes and diabetes screening. Finally, to the author's knowledge, no study has assessed the relationship between BMI category, perception of weight status, actual risk and diagnosed risk for diabetes, perceived risk for diabetes, and receipt of screening for diabetes in the same study population. This study aims to explore the relationships between weight status perception, perception of risk for diabetes, and screening behaviors. Critically, Hawaii provides a unique opportunity to explore the added impact of using alternative BMI cutoffs for specific ethnic populations. The objective of the study is to assess whether populations at risk for misperceiving their weight status and risk for diabetes are similar in characteristics, and whether such misperceptions are related to screening for diabetes.

RESEARCH QUESTIONS

Research Question I: Weight Status Misperception

The first investigation in my doctoral dissertation (Study 1) was a descriptive study designed to assess the prevalence and demographics of overweight and obesity, and weight status misperception, in Hawaii. Study 1 was used to identify the demographic correlates of overweight/obesity and weight status misperception, and assess whether there are demographic sub-groups in Hawaii that have a higher prevalence of weight status misperception. Study 1 included the following research questions and directions:

1. Who is classified as overweight or obese in Hawaii based on self-reported height and weight?
    a. What are demographic characteristics associated with overweight and obesity in Hawaii?
    b. How is the prevalence of overweight and obesity modified by applying Asian-specific BMI cutoffs to Asian groups in the state?
2. To what extent do adults in Hawaii in each weight status misperceive their weight status (in either direction)?
    a. What are the demographic characteristics associated with weight status perception (overperception, underperception and accurate perception) in Hawaii?
3. Are there demographic sub-groups that are more likely to misperceive their weight status, even after adjusting for BMI category?

Research Question II: Perceived Risk for Diabetes

The second investigation in my doctoral dissertation (Study 2) was a descriptive study designed to assess the prevalence and demographic correlates of actual and perceived risk for diabetes in Hawaii. The investigation also aimed to test the following hypothesis: After adjusting for demographic characteristics and potential confounders, is weight status perception associated with diabetes risk perception?

Null hypothesis (H_0): After adjusting for demographics characteristics and potential confounders, there is no association between weight status perception and diabetes risk perception.

Alternate hypothesis (H_1): After adjusting for demographics characteristics and potential confounders, there is an association between weight status perception and diabetes risk perception.

The research questions from this second part of my dissertation include the following.

1. Who is classified as being at risk for diabetes in Hawaii?
    a. What are demographic characteristics associated with diabetes risk in Hawaii?
    b. How does applying Asian-specific BMI cutoffs to Asian groups in the state modify what is known about who may be at risk for diabetes?
2. What proportion of adults at risk perceive themselves to be at risk for diabetes?
    a. Does perception of risk for diabetes vary by demographics in the State of Hawaii?
    b. What is the relationship between actual and perceived risk of diabetes?
3. Does weight status perception impact perception of risk for diabetes?
    a. After adjusting for demographic characteristics and potential confounders, is weight status perception associated with perception of risk for diabetes?

Research Question III: Screening and Awareness of Diabetes

The third part of my PhD dissertation (Study 3) is a descriptive study designed to assess the prevalence and demographic correlates of screening for diabetes in Hawaii. The design tested two hypotheses to assess the relationship between diabetes screening prevalence and (1) perceived risk for diabetes and (2) weight status perception respectively.

Hypothesis 1:

H_0: After adjusting for demographic characteristics and potential confounders, there is no association between diabetes risk perception and screening for diabetes.

H_1: After adjusting for demographic characteristics and potential confounders, there is an association between diabetes risk perception and screening for diabetes.

Hypothesis 2:

H_0: After adjusting for demographic characteristics, potential confounders, and diabetes risk perception, there is no association between weight status perception and screening for diabetes.

H_1: After adjusting for demographic characteristics, potential confounders, and diabetes risk perception, there is an association between weight status perception and screening for diabetes.

Research Question III include the following formulative questions:

1. What is the self-reported prevalence of diabetes screening in the State of Hawaii?
    a. Does screening for diabetes vary by demographics in the State of Hawaii?
2. Is prevalence of screening for diabetes related to perception of risk for diabetes and weight status perception?

a. After adjusting for demographic characteristics and potential confounders, is perception of risk for diabetes associated with screening for diabetes?

b. After adjusting for demographic characteristics and potential confounders, and perception of risk for diabetes, does weight status perception further explain differences in diabetes screening?

c. When present simultaneously, do weight status misperception and diabetes risk misperception have a combined effect on diabetes screening (either synergistic or antagonistic) that is beyond what is expected when either type of misperception is present by itself?

METHODS

Data Source and Description

The 2016-17 Healthy Hawaii Initiative (HHI) Survey was developed as a collaborative research initiative by the University of Hawaii at Manoa's Office of Public Health Studies and the Hawaii State Department of Health (DOH). The survey intended to gather data from a representative sample of Hawaii adults, focusing mainly on questions related to chronic disease prevention, prevalence, and management. The survey design, sampling strategy, fielding methodology, administration protocol, and weighting were aligned closely with the CDC BRFSS.(68)

Minor unavoidable deviations occurred in sampling, design, and weighting of the data. Sampling deviations included procurement of a part of the sample from sources other than that used by the BRFSS, including one non-random sample of listed landline telephone numbers; administration of each sample packet over a longer duration of time until exhaustion of the sample; permission to terminate the survey upon achievement of the desired sample size rather than the completion of the final sample packet; and division of landline samples into waves to enable close alignment with the timing of a pre-notification letter to participants.

Design deviations primarily related to the inclusion of non-BRFSS items in the survey. Survey items previously administered in local or national surveys were used and adapted minimally, if needed, to maximize item validity and enable comparisons of data gathered across surveys. Some questions were designed as multiple choices, deviating from BRFSS best practice recommendations, specifically the use of single choice questions; however, such questions were not included in the current analyses.

Weighting generally followed an iterative proportional fitting (i.e. raking) protocol developed similarly to that of the BRFSS; deviations included omission of some demographic variables not included in the HHI Survey, including the number of working cell phones available to the landline respondent, marital status, property ownership, and number of residential telephones in the household; and a different source for population estimates. The HHI Survey used 2010-14 American Community Survey data adapted using Hawaii BRFSS data to develop county and sub-county population estimates by Hawaii-specific race ethnicity using a classification methodology developed by the DOH Office of Health Status Monitoring (DOH-OHSM), and data collected by the National Center for Health Statistics. The BRFSS uses Neilsen Company population estimates for weighting purposes.

Additionally, as recommended by CDC for BRFSS, missing data for weighting variables were imputed. Except in the case of marital status and property ownership, other completely missing variables were assigned using various strategies; marital status and property ownership were eliminated from the raking process.

Weighting and administration of the BRFSS is described in detail elsewhere.(68) The survey was fielded between October 2016 and March 2017. The final weighted dataset was delivered in May 2017 and verified and finalized by staff at DOH in June 2017. A total of 1602 respondents were surveyed, and were weighted to represent the Hawaii adult population. The overall survey response rate, calculated using the same methodology as used for the BRFSS,(69) was 38.8% (Table 1). This response rate was comparable to BRFSS response rates reported across states nationally, and to those reported for the Hawaii BRFSS survey.(69)

Institutional Review Board (IRB) Approval

Approval to proceed with the dissertation studies was obtained from the University of Hawaii at Manoa, Human Studies Program.

Analytic Tools

All analyses were conducted using SAS 9.4 (Cary, NC) and SAS-Callable SUDAAN 11.0.1 (Cary, NC). The student had access to SAS 9.4 and SUDAAN 11.0.1 through a license provided to DOH by the Hawaii Health Data Warehouse (HHDW) Project, University of Hawaii at Manoa, Office of Public Health Studies.

Variable Definitions

<u>Body Mass Index:</u> Two questions in the survey were used to calculate body mass index (BMI): ‘About how much do you weigh without shoes?’ and ‘About how tall are you without shoes?’ The questions were adapted from the CDC BRFSS core survey.(70) The data were used to calculate BMI using the English formula, which applies a correction to the standard BMI formula to enable calculations using weight reported in pounds and height in inches, the units of measure used by the majority of respondents in the HHI Survey.(71) To correctly apply the English formula, responses provided in kilogram units (weights) or metric units (height) were converted to pounds and inches respectively. Respondents without information for either variable were coded as missing. To account for implausible values, respondents with height, weight, and BMI lower than 3 feet, 50 pounds, and 12 kg/m^2 or greater than or equal to 8 feet, 650 pounds, and 100 kg/m^2 respectively were excluded.(68, 72)

<u>BMI Categorization</u>: Two definitions of BMI categorizations were used, based on different BMI cutoffs (standard and Asian-specific).

1. BMI Category (Standard BMI Cutoffs): Calculated BMI was used to group respondents into standard weight categories of underweight (BMI < 18.5), normal weight ($18.5 \leq$ BMI < 25), overweight ($25 \leq$ BMI < 30), and obese ($30 \leq$ BMI). An expanded definition of weight, used to develop a diabetes risk score, parsed obese respondents by grade into obesity grade I ($30 \leq$ BMI < 35), grade II ($35 \leq$ BMI < 40), and grade III ($40 \leq$ BMI).
2. BMI Category (Asian BMI Cutoffs): Among those identifying as Asian (Japanese, Filipino, Chinese, Korean, Vietnamese, Asian Indian, Laotian, Cambodian, Malaysian, Fijian, or Other Asian), the BMI category assigned above was reclassified to overweight if $23 \leq$ BMI < 27.5 and obese if $27.5 \leq$ BMI. An expanded definition of weight, used to develop a diabetes risk score, parsed obese Asian respondents by grade into obesity grade I ($27.5 \leq$ BMI < 32.5), grade II ($32.5 \leq$ BMI < 37.5), and grade III ($37.5 \leq$ BMI).(10)

Weight Status Perception: The following question in the survey was used to assess weight status perception: 'Which of the following do you consider yourself?' The question was adapted from the Midlife in the United States 3 (MIDUS 3) Survey.(73) Weight status perception was considered accurate if the respondent's assigned BMI category matched their corresponding weight status perception category, underperception if the respondent's assigned BMI category exceeded their perceived weight status, and overperception if the respondent's perceived weight status exceeded their assigned BMI category (Table 2).

Having Diabetes: Those who respond with 'Yes' when asked 'Have you EVER been told by a doctor or other health professional that you have diabetes?' were coded as having diabetes. Those who respond with any other answer to the question were coded as not having diabetes. Those who did not know the answer, or refused to respond to the question were coded as missing. The question was adapted from the CDC BRFSS core survey.(70)

Having Pre-diabetes: Those whose responses were coded as ‘No, pre-diabetes or borderline diabetes’ when asked ‘Have you EVER been told by a doctor or other health professional that you have diabetes?’ or ‘Yes’ when asked ‘Have you EVER been told by a doctor or other health professional that you have pre-diabetes or borderline diabetes?’ were coded as having pre-diabetes. Those who responded with any other answer to both questions, did not report being diagnosed with diabetes, and did not refuse to answer either question were coded as not having pre-diabetes. The question was adapted from the CDC BRFSS core survey.(70)

Having Gestational Diabetes/Pre-diabetes: Those who responded with ‘Yes, but female told only during pregnancy’ when asked ‘Have you EVER been told by a doctor or other health professional that you have diabetes?’ or ‘Yes, during pregnancy’ when asked ‘Have you EVER been told by a doctor or other health professional that you have pre-diabetes or borderline diabetes?’ were coded as having had gestational diabetes/pre-diabetes. Those who responded with any other answer to both questions, did not report being diagnosed with diabetes, and did not refuse to answer either question were coded as not having gestational diabetes/pre-diabetes. The questions were adapted from the CDC BRFSS core survey.(70)

Having Hypertension: Those who respond ‘Yes’ to the question ‘Have you EVER been told by a doctor, nurse, or other health professional that you have high blood pressure?’ were coded as having hypertension. Those who responded with any other answer and did not refuse to answer the question were coded as not having hypertension. The question was adapted from the CDC BRFSS core survey.(70)

Having a Family History of Diabetes: Those who responded with ‘Yes’ to the question ‘Do you have immediate or extended blood relatives, such as your parents, siblings, children, or grandparents who have diabetes?’ were coded as having a family history of diabetes. Those who responded with any other answer and did not refuse to answer the question were coded as not having a family history of diabetes. The question was adapted from a survey commissioned by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) in 2006.(74)

Diabetes Risk Perception: Those who responded with 'Yes' to the question 'Do you think you could be at risk for diabetes?' were coded as perceiving themselves to be at risk for diabetes. Those who responded 'No' were coded as not perceiving themselves to be at risk for diabetes. Those with diabetes were automatically excluded from answering the question. The question was borrowed from a survey commissioned by the NIDDK in 2006.(74)

Diabetes Risk: Two definitions of diabetes risk were considered, and ultimately, one was chosen for inclusion in the analyses. One was derived using a risk score calculated based on an adapted diabetes risk calculator. A second was based on the respondent's interaction with the healthcare system resulting in a diagnosis with a chronic condition or a warning from a healthcare provider that directly indicated to the respondent that he or she was at risk for diabetes.

1. Diabetes/Pre-diabetes Risk Score: According to the American Diabetes Association (ADA), risk factors for diabetes include being male, having a history of gestational diabetes (for women), having a sibling or parent with diabetes, having a BMI categorized as overweight or higher, being 40 years or older, not meeting physical activity recommendations, or having hypertension.(75) Each of these risk factors is weighted differently and a score is calculated.(75)

   Of these risk factors, physical activity was not assessed in the HHI Survey. Also, the question on family history included children and grandparents among immediate or extended blood relatives. Therefore, based on available data, the factors used to determine a risk score for diabetes, and the number of points added to the score for having that risk factor, included being male (1); having a history of gestational diabetes (1); having a family history of diabetes (1); having a history of hypertension (1); having a BMI categorized as overweight (1), obesity grade I and II (2), or obesity grade III (3); and additional demographic risk factors including being 40-49 years (1), 50-59 years (2), or 60 years or older (3).(75)

Scores assigned to each risk factor are provided in parentheses, and the total score represents the sum of all individual risk factor scores. Based on the ADA calculator, the maximum possible score was 10, and a cut-off score of 5 or more points was used to dichotomize individuals into those at increased risk for diabetes, and those not at increased risk for diabetes.(75) However, the maximum possible points using the modified scale based on the HHI survey data was 9; therefore, a lower cut-off score of 4 was used to classify individuals into those at high risk for diabetes versus those not at high risk. The modified definition of high risk was used for chi square analyses and to describe the demographics of the at risk population. A second version of the diabetes risk score was calculated using BMI categories developed using Asian-specific cutoffs.

2. <u>Diagnosed Diabetes Risk:</u> Respondents who were diagnosed with pre-diabetes, gestational diabetes, or gestational pre-diabetes, or among those who perceived themselves to be at risk for diabetes, when asked ‘Why do you think you are at risk for diabetes?’ reported that they had either received a ‘Doctor warning’ or explicitly associated a different chronic condition with which they had been diagnosed with an increased risk for diabetes, including ‘High Blood Pressure,’ ‘High Blood Sugar,’ ‘High Cholesterol’ and ‘Hypoglycemia’ were coded as having a diagnosed risk for diabetes. The latter question was adapted from a survey commissioned by the NIDDK.(74)

Respondents who did not have diabetes, and did not refuse to answer the pre-diabetes question, were coded as not being aware of their risk for diabetes.

Diabetes/Pre-Diabetes Screening Status: Those whose responded with 'Yes' when asked 'Have you had a test for high blood sugar or diabetes within the past three years?' were coded as having been screened for diabetes within the past three years. Those who responded with 'No,' and did not refuse to answer the question were coded as not having been screened for diabetes within the past three years. This question was limited to adults without diabetes; therefore, the denominator automatically excluded those with diabetes. The question was adapted from the CDC BRFSS core survey.(70)

Diabetes-Related Chronic Condition Diagnosis: Respondents who were diagnosed with hypertension or, among those who perceived themselves to be at risk for diabetes, when asked 'Why do you think you are at risk for diabetes?' reported that they had either received a 'Doctor warning' or explicitly associated a different chronic condition with which they had been diagnosed with an increased risk for diabetes, including 'High Blood Pressure,' 'High Blood Sugar,' 'High Cholesterol' and 'Hypoglycemia' were coded as having a diabetes-related chronic condition. Respondents who did not have hypertension, and did not refuse to answer the questions about hypertension or perception of risk for diabetes, were coded as not having a diabetes-related chronic condition.

Meeting USPSTF Criteria for Diabetes Screening: Respondents who did not have diabetes, and were between the ages of 40-70 years old, and were classified as overweight or obese were considered to meet USPSTF criteria for diabetes screening. Those who were not between 40-70 years; were between 40-70 years but not categorized as overweight or obese; did not refuse to answer the questions pertaining to age; and who had a valid BMI value were considered to not meet USPSTF criteria for diabetes screening.

Demographic covariates:

Race-Ethnicity, based on responses to 'What group would you say best represents your ethnicity?' respondents were initially grouped into the standard ten DOH-OHSM race-ethnicity groupings of White, Native Hawaiian, Other Pacific Islander, Japanese, Chinese, Filipino, Other Asian, Black, American Indian/Alaskan Native, and Other. Those refusing to answer the question were coded as missing. The question was adapted from the Hawaii BRFSS survey.(76)

Age Group, based on responses to 'What is your age?' responses were grouped into 18-39 years, 40-49 years, 50-59 years, 60-69 years, and 70+ years. Those refusing to answer were coded as missing. The question was adapted from the CDC BRFSS core survey.(70)

Sex, based on answers to 'Are you…?' (either 'male' or 'female'), respondents were coded into males and females, and those refusing to answer were coded as missing. The question was adapted from the CDC BRFSS core survey.(70)

Socioeconomic/social determinants of health covariates considered for all analyses:

Educational Status, based on responses to 'What is the highest grade or year of school you completed?' respondents were initially grouped into less than high school, high school graduate, some college and college graduate. Those refusing to answer the question were coded as missing. The question was adapted from the CDC BRFSS core survey.(70)

Country of Birth, based on responses to 'In what country were you born?' respondents were grouped into U.S. Born or Foreign Born. Those refusing to answer were coded as missing. The question was adapted from the 2013-14 NHANES survey.(77)

County of Residence, based on responses to 'What island do you live on?' grouped into counties in Hawaii. Those refusing to answer were coded as missing. The question was adapted from the Hawaii BRFSS survey.(76)

Having ever served in the US military, based on responses to the question 'Have you ever served on active duty in the United States Armed Forces, either in the regular military on in a National Guard or military reserve unit?' were grouped into those who had ever served in the US military (i.e. active duty, national guard, or reserve; and Veteran, either retired or discharged) and those who had not. Those refusing to answer were coded as missing. The question was adapted from the CDC BRFSS core survey.(70)

Socioeconomic Indicators: Three indicators of socioeconomic status were developed.

1. Poverty Level was imputed based on responses to three questions in the survey, one assessing household income ('Is your annual household income from all sources…'), one assessing the number of adults in the household ('Excluding adults living away from home such as students away at college, how many members of your household, including yourself, are 18 years of age or older?') and another assessing the number of children in the household ('How many children less than 18 years of age live in your household?'). All three questions were adapted from the CDC BRFSS core survey.(70) The Federal Poverty Level (FPL) thresholds for Hawaii for each household size calculated were obtained.(78) Reported household income and FPL thresholds were used to categorize respondents into those who earned between 0-100% of the Federal Poverty Level (FPL), those who earned between 101-185% FPL, and those who earned at 186% FPL or higher based on a methodology developed by the HHDW.(79) The 100% and 186% FPL were chosen based on meaningful cut-offs used to determine

eligibility for various federal and state-based financial assistance programs.(78, 79) Respondents with missing data on any of the questions used to derive poverty level were coded as missing.

2. Receipt of food stamp benefits, based on responses to the question 'In the past 12 months, did you or any member of your household receive benefits from the Food Stamp Program or SNAP (the Supplemental Nutrition Assistance Program)? Do not include WIC (Women, Infants and Children Program), the School Lunch Program, or assistance from food banks,' respondents were coded as either receiving or not receiving SNAP benefits. Those refusing to answer were coded as missing. The question was adapted from the American Community Survey.(80)
3. Financial health, based on responses to the question 'During the past year, did your family…,' and coded as a categorical variable with four subgroups: those who saved money, those who 'just got by,' those who spent their savings, and those who spent savings and borrowed additional money. Those who refused to answer the question were coded as missing. This question was adapted from the World Values Survey, Wave 6.(81)

Health Care Coverage, based on responses to the question 'What is the primary source of your health care coverage? Is it…' grouped respondents into those who reported healthcare coverage through one or more plans, and those who reported no healthcare coverage. Those refusing to answer were coded as missing. The question was adapted from the Hawaii BRFSS survey.(76)

Prior to running any cross tabs or logistic regression analyses, the distributions of demographic covariates, including missing data, were analyzed. To accommodate complex survey design of the HHI Survey, weighting was applied to all analyses.(82) The unweighted N of respondents and weighted prevalence estimates were evaluated, along with 95% confidence intervals of the weighted prevalence. Applying BRFSS suppression protocols to the HHI survey dataset, demographic covariates without a minimum denominator of 50, or with one or more response categories exceeding a relative standard error (RSE) of 0.3 were eliminated or collapsed into smaller, meaningful categories.(68, 82)

Multivariable Models

1. *Study 1:* In prior studies assessing the relationship between BMI category and weight status perception, sex, race, age, socioeconomic status, living in an urban versus rural setting, and educational attainment have been identified as demographic factors associated with weight status misperception even after adjusting for BMI category. Additional factors associated with BMI category include country of birth. Therefore, all these variables were included in Study 1. Three versions of socioeconomic status were available based on the data collected, including poverty level, receipt of SNAP benefits, and the respondent's self-perceived financial health. All three were tested in the model. Because adequate geographic information was not available to distinguish between respondents living in urban versus rural settings, county of residence was considered a close proxy, with residents of Honolulu County presumed to be living in an urban county. The only additional demographic characteristic tested without a previously established association with weight status perception was having ever served in the US military.
2. *Study 2:* There are no prior studies that have assessed the relationship between weight status perception and diabetes risk perception. However, studies that have analyzed the relationship between weight status perception and attitudes/health behaviors associated with weight loss have found that sex, race, and educational status remain significantly

associated with the outcome even after adjusting for weight status perception. Moreover, a key confounder of the relationship between weight status perception and diabetes risk perception is objective risk for diabetes. Age, having a family history of diabetes, obesity and body fat, diagnosis with metabolic syndrome, and poor general health are factors associated with both objective and perceived risk for diabetes. Therefore, sex, race, age, educational status, family history of diabetes, and BMI category were tested for inclusion in the model in Study 2. In addition, a measure of diabetes risk was considered for inclusion, selected from two possible indicators: one derived based on a calculated risk score based on prevalent risk factors, and one based on the presence of a diagnosed condition directly associated with risk for diabetes. This measure, along with a diagnosis of hypertension (which was also available for inclusion in the model), served as a proxy for metabolic syndrome. Finally, because of the association between BMI and country of birth, as well as that between weight status perception and socioeconomic status, all four indicators (country of birth, poverty level, receipt of SNAP benefits, and financial health) were tested in the model. As with Study 1, ever having served in the US military remained the only covariate tested for inclusion without an established association with diabetes risk perception or weight status perception.

3. *Study 3:* Limited research has found a significant association between diabetes risk perception and diabetes screening. Additionally, age, socioeconomic status, and family history of diabetes are associated with diabetes screening, even after adjusting for diabetes risk perception. Many demographic variables are known to be related to diabetes screening, including sex, race, age, BMI, a diagnosis of hypertension, greater contact with the health system, rural versus urban living, and being an immigrant.

Therefore, age, race sex, socioeconomic status, family history of diabetes, BMI category, country of birth, county of residence, and a history of being diagnosed with a diabetes-related chronic condition (mainly hypertension) were considered for inclusion in the model in Study 3. All three indicators of socioeconomic status (poverty level, receipt of SNAP benefits, and financial health) were also considered for inclusion. In addition, educational status was included as it was known to be related to BMI category and weight status perception. Although the relationship between diabetes screening rates and meeting USPSTF screening criteria for diabetes screening is unknown, the variable was created based on age and BMI category, both known to be associated with the independent and outcome variables. Therefore, once again, the only variable tested for inclusion that had not previously been reported to be associated with the outcome or the independent variables was having ever served in the US military.

Since nearly all demographic covariates considered for inclusion, with the sole exception of having ever served in the US military, had previously been associated the independent and outcome variables in all three studies, a conservative model consisting of sex, race, age group, educational status, and BMI (covariates that were associated with all the independent and dependent variables across all three studies) along with the key independent variable(s) were tested in each study. In addition, family history of diabetes, risk for diabetes, and a diagnosis of hypertension (serving as proxies for metabolic syndrome) were included in the model for Study 2. Having a diabetes-related chronic condition (i.e. predominantly hypertension) and a family history of diabetes were included in the model for Study 3. These variables were not subject to exclusion or removal, even if they failed to meet other criteria for retention in the model.

On the other hand, a few variables (socioeconomic status, county of residence, country of birth, and meeting USPSTF screening criteria) were considered but not automatically retained in the models despite known or presumed associations with one or more of the outcome variables. For example, socioeconomic status was only retained in any of the three models if it met criteria for retention: this is because there were three possible indicators of socioeconomic status considered for inclusion in the models, and it was not clear which of the three indicators may be the best choice for each of the three studies. Further, county of residence was only retained if it met criteria for retention as it only served as a proxy for residence in an urban versus rural setting. Country of birth was known to be associated with a subset of independent and outcome variables and was retained only if it met criteria. And finally, the relationship between diabetes screening and meeting USPSTF screening criteria, while presumed, has not been formally studied. Therefore, like other variables, it was tested for inclusion, and retained if it met criteria.

Study 1 Methods: Weight Status Misperception

Descriptive Analysis

Weighted prevalence and corresponding 95% Confidence Intervals (CIs) of healthy weight, overweight and obese groups in Hawaii were calculated overall and by demographic sub-groups. The PROC SURVEYFREQ function within SAS 9.4 was used to create simple cross-tabs of BMI category by demographic covariates (sex, age group, race-ethnicity, educational status, country of birth, county, having ever served in the US military, poverty level, receipt of SNAP benefits, and financial health). Confidence intervals and chi square analyses were used to evaluate differences in weight status prevalence by demographic covariates. For each covariate (for example, race-ethnicity), a significant difference across groups existed if the calculated chi square value exceeded the critical chi square value (given the number of degrees of freedom for each cross-tab evaluated) at an alpha of 0.05; the critical chi square value is that value at or above which there is a 95% likelihood that a Type I error does not occur if the null hypothesis is rejected. Demographic covariates of weight status perception that met this criteria for statistical significance had chi square values with a P-value ≤ 0.05. In addition, sub-groups with non-overlapping confidence intervals were identified as having higher or lower prevalence proportions than others; this strategy was used to identify demographic sub-groups that were associated with a greater likelihood of weight status misperception than others.

Different prevalence was reported when Asian-specific BMI cutoffs were applied to Asian race groups within Hawaii. Next, demographic correlates of weight status perception (under-perception, accurate perception, and over-perception) were analyzed and reported using the same strategy. A chi square analysis of BMI category and weight status perception, and comparison of 95% CIs was also conducted, and the same methodology previously described was used to assess differences among sub-groups.

Logistic Regression and Model Building

A logistic regression was conducted to assess the relationship between BMI category (independent variable) and weight status perception (outcome variable). Modeling employed an overall purposeful approach to the selection of variables to include in the model.(83, 84) The RLOGIST option in SAS-callable SUDAAN 11.0.1 was used to run univariate logistic regressions modeled against each independent variable with weight status perception as the outcome variable (Reference level = Accurate Perception). The PREDMARG statement was used to request prevalence ratios and model-adjusted risks (i.e. model adjusted prevalence).(85) Because of small sample sizes, nearly all sub-categories assessing the prevalence of overperception of weight (overperception by demographics and overperception by BMI category) did not meet the threshold for reporting. Therefore, adults who overperceived their weight status were excluded from the logistic regression analysis; the analysis compared adults who accurately perceived their weight status to those who underperceived their weight status. Similarly, adults who were categorized as underweight were also excluded due to small sample sizes. Study 1 was therefore limited to adults who were categorized as being within the healthy weight, overweight or obese BMI categories, and who either accurately perceived or underperceived their weight status. Independent variables included BMI category and all demographic variables. To assess strength of association, all demographic covariates and the independent variable were entered simultaneously into a logistic regression model in SAS 9.4. The Standardized Beta coefficients (STB) statement in the PROC SURVEYLOGISTIC function was used to request standardized beta coefficients for all variables. The absolute values of the standardized beta coefficients were used to order the variables by strength of association with the outcome. This ranked order was then used in model building. Model building was carried out in three phases.

In the first phase of model building, the independent variable (BMI category) was added to the null model. Next, demographic covariates that were found in the literature to have statistically significant associations with the outcome variable were considered for inclusion in the model. Demographic covariates associated with all independent and outcome variables in all three studies (BMI category, weight status perception, diabetes risk, diabetes risk perception, and diabetes screening) included age group, sex, race, educational status, and BMI category. In the case of Study 1, BMI category was the independent variable. In the first phase, four of these variables including BMI category, age group, sex, and race-ethnicity were added to the model, in order, beginning with a model containing BMI category only, and adding the others by order of their strength of association with the outcome based on the standardized coefficients. Race, age group, and sex adjusted PRs were reported, along with 95% confidence intervals.

The second phase of model building added the remaining variables, in order of strength of association. The second phase retained variables included during the first phase of model building, without subjecting them to criteria for removal. All other variables besides the key independent variable (BMI category) and race, sex, and age group were retained if they were associated with the outcome. An association was said to exist if the 95% confidence interval of one or more PRs associated with that variable did not overlap 1.00. With the addition of each variable, the percent change in the magnitude of the point estimates associated with other variables in the model was calculated. Variables that resulted in a 10% or greater change in any other estimate in the model were flagged as potential confounders for inclusion in the next phase. Potential confounders were ordered by those that caused the largest magnitude of change in one or more estimates. Also, with each variable's addition, potential improvement in model fit was assessed. Model fit for nested models was assessed by taking the difference in the log likelihood ratios of the two models, and using the difference in the degrees of freedom between the models to assess whether the log likelihood different was statistically significant. If the log likelihood ratio of the expanded model was smaller, and the difference was larger than the critical chi square value for a given difference in degrees of freedom, then the second model was considered to have a better fit than the first. When a variable with a larger proportion of missing data was introduced (for example, poverty level), the log likelihood value of the null model, and the underlying number of observations used for modeling decreased. Therefore, when the log likelihood of the null model differed when comparing two models, the Bayesian information criteria (BIC) was used to compare the two models.(86)

In the third phase, potential confounders were added to the model in order of magnitude of confounding. They were retained if they continued to confound the relationship between any variable in the model and the outcome (weight status perception) by 10% or more, if they improved model fit, or if they were associated with the outcome. Next, any variables excluded during phase two that was not identified as a potential confounder but had been found to improve model fit during phase two was tested for inclusion. The variable was retained if it was found to be a confounder, if it improved model fit, or if it was associated with the outcome.

Finally, all other variables excluded earlier were reconsidered individually, in order of strength of association, and the same criteria were used to determine whether they should be retained in or removed from the model. At this stage, the remaining variable that was not subject to exclusion from the model (educational status) was retained even if it did not meet criteria for retention during the previous steps. Adjusted prevalence ratios (PRs) from the final model, along with 95% Confidence Intervals (CIs) for each variable were reported.

Study 2 Methods: Perceived Risk for Diabetes

Descriptive Analysis

Study 2 was limited to adults without diabetes in the State of Hawaii; therefore, respondents who said ‘Yes’ to the question ‘Have you EVER been told by a doctor or other health professional that you have diabetes?’ were excluded. The PROC SURVEYFREQ function within SAS 9.4 was used to create simple cross-tabs of diabetes risk perception and diabetes risk (both indicators, one based on the risk score, and the other, based on a diagnosed risk for diabetes) by demographic covariates. The weighted prevalence estimates, along with 95% CIs, were reported. Confidence intervals and chi square analyses were used to evaluate statistically significant differences in diabetes risk by demographics; covariates with a chi square statistic associated with a P-value ≤ 0.05 were considered to be significantly associated. Additionally, the 95% CIs of sub-groups were used to identify sub-groups with higher or lower risk for diabetes. Separate prevalence of diabetes risk as determined using the risk score was reported using Asian-specific BMI cutoffs applied as appropriate to Asian race groups within Hawaii. Next, the same method was employed to assess overall prevalence of perceived risk for diabetes, and demographic differences in perception of risk. Finally, PROC SURVEYFREQ was also used to report the prevalence of perceived risk for diabetes among individuals classified as being at high risk and not at high risk for diabetes based on their calculated risk score.

Logistic Regression and Model Building

A logistic regression analysis was conducted, limited to adults without diabetes, to assess the relationship between perceived risk for diabetes (outcome variable) and weight status perception (independent variable) after adjusting for demographic covariates and potential confounders. Modeling employed an overall purposeful approach to the selection of variables to include in the model.(83, 84) Potential confounders considered included diabetes risk and BMI category. Initially, both indicators of diabetes risk (one based on the calculated risk score, and the other based on a diagnosed risk for diabetes) were considered for inclusion in the model. Possible multicollinearity between the diabetes risk score and variables contributing to the risk score calculation (age group, sex, family risk score, and BMI category) was ruled out using the PROC REG function, by requesting and evaluating the variance inflation factor (VIF), tolerance (TOL), and collinearity (COLLIN) parameters.(87) The VIFs for all three variables was approximately 1.0 and less than the threshold used (VIF = 2.5) to ascertain the presence of multicollinearity.(88) Ultimately, the decision was made to leave the diabetes risk indicator derived based on the risk score out of model building, because all the variables used to create the score with the exception of hypertension prevalence were already included separately in the model. Rather, the diabetes risk indicator based on diagnosed risk for diabetes was considered for inclusion. Therefore, the confounders tested were diagnosed risk for diabetes, family history of diabetes, hypertension prevalence, and BMI category. Together, diagnosed risk for diabetes and hypertension prevalence identified patients who had been diagnosed with health conditions that increased their risk for diabetes. A diagnosed risk for diabetes was presumed if the respondent had a healthcare provider-diagnosed condition that increased their risk for diabetes (gestational diabetes or pre-diabetes, and pre-diabetes), if the respondent had been diagnosed with another chronic conditions that the respondent explicitly associated with an increased risk for diabetes, or if the respondent reported that they had been warned by a physician about their risk for diabetes.

The RLOGIST option in SAS-callable SUDAAN 11.0.1 was used to run univariate logistic regressions modeled against each independent variable with diabetes risk perception as the outcome variable. The PREDMARG statement was used to request prevalence ratios and model-adjusted risks (i.e. model adjusted prevalence).(85) Independent variables included weight status perception, all demographic variables, and four potential confounders (family history of diabetes, diagnosis with high blood pressure, diagnosed risk for diabetes, and BMI category). Unadjusted PRs, along with 95% confidence intervals, were reported.

Next, to assess strength of association, all demographic covariates, potential confounders, and the independent variable were entered simultaneously into a logistic regression model in SAS 9.4. The STB statement in PROC SURVEYLOGISTIC was input to request standardized beta coefficients for all variables. The absolute values of the standardized beta coefficients were used to order the variables in descending order by strength of association with the outcome. This ranked order was then used in model building. Model building was carried out in three phases.

In the first phase, the independent variable (weight status perception) was added to the null model. Next, demographic covariates that were found in the literature to have statistically significant associations with the outcome variable were considered for inclusion in the model. Demographic covariates associated with all independent and outcome variables in all three studies (BMI category, weight status perception, diabetes risk, diabetes risk perception, and diabetes screening) included age group, sex, race, educational status, and BMI category. In addition, Study 2 had three additional variables that were retained regardless of whether they met criteria for inclusion, including diagnosed risk for diabetes, family history of diabetes, and diagnosis of hypertension. In the first phase, to the model with weight status perception (independent variable), three of the eight variables that were not subject to exclusion criteria (race, age group, and sex) were added in order by strength of association based on the standardized coefficients. Race, age group, and sex adjusted PRs were reported, along with 95% confidence intervals.

The second phase of model building added the remaining variables, in order of strength of association. The second phase retained variables included during the first phase of model building, without subjecting them to criteria for removal. All other variables besides the key independent variable (weight status perception) and race, age group, and sex were retained if they were associated with the outcome. An association was said to exist if the 95% confidence interval of one or more PRs associated with that variable did not overlap 1.00. With the addition of each variable, the percent change in the magnitude of the point estimates associated with other variables in the model was calculated. Variables that resulted in a 10% or greater change in any estimate in the model were flagged as potential confounders for inclusion in the next phase. Potential confounders were ordered by those that caused the largest magnitude of change in one or more estimates. Also, with each variable's addition, potential improvement in model fit (as defined in Study 1) was assessed.

In the third phase, potential confounders were added to the model in order of magnitude of confounding. They were retained if they continued to confound the relationship between any variable in the model and the outcome (diabetes risk perception) by 10% or more, if they improved model fit, or if they were associated with the outcome. Next, any variables that had been found to improve model fit during phase two that had not been retained in the model were tested for inclusion. The variable was retained if it was found to be a confounder, if it improved model fit, or if the variable was associated with the outcome. Finally, all other variables excluded earlier were reconsidered individually and the same criteria were used to determine whether they should be retained in or removed from the model. At this stage, the remaining five variables that were not subject to exclusion criteria (educational status, BMI category, family history of diabetes, diagnosed risk for diabetes, and a diagnosis of hypertension) were retained even if they had not met criteria for retention during the previous steps. The PR and 95% CI associated with weight status perception in the phase three logistic regression model was used to test the null hypothesis. If weight status perception was found to be associated with the outcome (diabetes risk perception), the null hypothesis was rejected.

Study 3 Methods: Screening and Awareness of Diabetes

Descriptive Analysis

This study assessed the impact of diabetes risk perception on prevalence of diabetes screening among those without diabetes. Further, it assessed whether weight status perception was associated with diabetes screening, after adjusting for diabetes risk perception. The analysis was limited to adults who did not have diabetes in the State of Hawaii. Respondents who responded with 'Yes' to the question 'Have you EVER been told by a doctor or other health professional that you have diabetes?' were excluded. The PROC SURVEYFREQ function within SAS 9.4 was used to create simple cross-tabs of diabetes screening prevalence among adults without diabetes in Hawaii by demographic covariates. Weighted prevalence estimates, along with 95% confidence intervals of the weighted prevalence, were reported and chi square analyses were used to evaluate significant differences across demographic covariates; significantly related covariates are those with a chi square statistic associated with a P-value $\leq$ 0.05 obtained when evaluating the association between diabetes screening rates and that covariate. Among covariates that were significantly associated with the outcome, 95% CIs of sub-groups were used to identify sub-groups with higher or lower rates of diabetes screening.

Logistic Regression and Model Building

The logistic regression analysis additionally excluded respondents previously diagnosed with pre-diabetes or gestational diabetes. Among respondents without diabetes who had not previously been diagnosed with pre-diabetes or gestational diabetes, the analysis sought to assess the relationship between diabetes risk perception, and weight status perception, and diabetes screening. The potential confounders included in the current analysis included BMI category, meeting USPSTF criteria for diabetes screening, having a family history of diabetes, and diagnosis with a diabetes-related chronic condition by a healthcare provider that increased the respondent's risk for diabetes. The latter variable represented a composite variable of diagnosis with hypertension; diagnosis of any condition that the respondent explicitly associated with an increased risk of diabetes including high blood pressure, high cholesterol or hypoglycemia; or a doctor's warning of risk: all indicative of the respondent's interaction with the health system around health conditions closely tied to diabetes. USPSTF criteria for diabetes screening included adults aged 40-70 years who were overweight or obese. One variable not considered in Study 3 was diabetes risk. As noted in Study 2, the indicator of diabetes risk assessed based on the risk score was not included as the individual variables used to derive the risk score were already independently included in the model. Further, the indicator of diabetes risk based on a prior diagnosis was not included as adults with a history of diagnosed pre-diabetes or gestational diabetes were excluded from the sample used for Study 3.

Modeling employed an overall purposeful approach to the selection of variables to include in the model.(83, 84) The RLOGIST function in SAS-callable SUDAAN 11.0.1 was used to run univariate logistic regressions modeled against each independent variable with diabetes screening as the outcome variable, with the independent variables (diabetes risk perception and weight status perception), all potential confounders (having a diabetes-related chronic condition diagnosis, having a family history of diabetes, meeting USPSTF screening criteria, and BMI category), and demographic variables. The PREDMARG statement was used to request prevalence ratios and model-adjusted risks (i.e. model adjusted prevalence).(85) Unadjusted PRs, along with 95% confidence intervals, were reported.

Next, to assess strength of association, all demographic covariates, potential confounders, and the independent variable were entered simultaneously into a logistic regression model in SAS 9.4. The STB statement in PROC SURVEYLOGISTIC was input to request standardized beta coefficients for all variables. The absolute values of the standardized beta coefficients were used to order the variables in descending order by strength of association with the outcome. This ranked order was then used in model building. Model building was carried out in four phases.

In the first phase of model building, the independent variable (diabetes risk perception) was added to the null model. Demographic characteristics associated with independent and outcome variables in all three studies included age group, sex, race, educational status, and BMI category. In addition, Study 3 also included having been diagnosed with a diabetes-related chronic condition and family history of diabetes among variables not subject to exclusion. In the first phase, three of these variables including race, sex, and age group were added to the model, in order by strength of association, based on the standardized coefficients. Race, age, and sex adjusted PRs were reported, along with 95% confidence intervals.

The second phase of model building added the remaining variables, in order of strength of association. The second phase retained variables included during the first phase of model building, without subjecting them to criteria for removal. All other variables besides the key independent variable (diabetes risk perception) and race, sex, and age group were retained if they were associated with the outcome. An association was said to exist if the 95% confidence interval of one or more PRs associated with that variable did not overlap 1.00. With the addition of each variable, the percent change in the magnitude of the point estimates associated with other variables in the model was calculated. Variables that resulted in a 10% or greater change in any estimate in the model were flagged as potential confounders for inclusion in the next phase. Potential confounders were ordered by those that caused the largest magnitude of change in one or more estimates. Also, with each variable's addition, potential improvement in model fit (as defined in Study 1) was assessed.

In the third phase, potential confounders were added to the model in order of magnitude of confounding. They were retained if they continued to confound the relationship between any variable in the model and the outcome (diabetes screening) by 10% or more, if they improved model fit, or if they were associated with the outcome. Next, any variables that had been found to improve model fit during phase two that had not been retained in the model were tested for inclusion. The variable was retained if it was found to be a confounder, if it improved model fit, or if the variable was associated with the outcome. Finally, all other variables excluded earlier were reconsidered individually and the same criteria were used to determine whether they should be retained in or removed from the model. At this stage, the remaining four variables that were not subject to exclusion (educational status, meeting USPSTF screening criteria, having a family history of diabetes, and BMI category) were retained even if they had not met criteria for retention during the previous steps. The PR and 95% CI associated with diabetes risk perception in the phase three logistic regression model was used to test the first null hypothesis. If diabetes risk perception was found to be associated with the outcome (diabetes screening within the past three years), the first null hypothesis was rejected.

In the fourth phase, weight status perception was added to the model. An interaction term (perceived risk for diabetes x weight status perception) was also tested during phase four. The interaction term was removed if it was not significantly associated. The PR and 95% CI associated with weight status perception in the phase four logistic regression model was used to test the second null hypothesis. If weight status perception was found to be associated with the outcome, the null hypothesis was rejected. Finally, weight status perception was considered for inclusion in the final model and was retained if it improved model fit, was a confounder of the relationship between any variable in the model and the outcome, or if it was associated with the outcome. Depending on whether weight status perception was retained, the model at the end of the third or fourth phase was considered the final model. Adjusted PRs along with 95% CIs for each variable included in the final model were reported.

RESULTS

The complete sample set consisted of 1602 completed interviews. Data were weighted to be representative of Hawaii's adult population. Based on small sample sizes (n < 100) for certain subgroups, several categories were collapsed. Specifically: by race-ethnicity, "Other Asian," Black, and American Indian/Alaskan Native were collapsed into "Other"; and Native Hawaiians and Other Pacific Islanders were also collapsed into a single category. Therefore, five race-ethnicity groups (White, Native Hawaiian and Other Pacific Islander (NHOPI), Japanese, Filipino, and Other) were included in this analysis. Additionally, by educational status, those without a high school diploma, and those with a high school diploma but with no further education, were collapsed into a single category. The number of adults without healthcare coverage in the sample was less than 50; therefore, healthcare coverage was not used as a covariate in the model. Unweighted and weighted N, along with prevalence and 95% confidence intervals for the demographic distribution of the sample, as well as the number of records with missing information for each demographic covariate are provided in Table 3. The demographic covariate with the largest number of missing responses was the calculated Federal Poverty Level, with data missing on approximately one tenth (9.7%) of respondents.

Following on from this, the distributions of independent and dependent variables in the sample were analyzed. The total number of respondents who were classified as underweight was <50; therefore, this category was suppressed and not further analyzed. Additionally, each crosstab was assessed for any combinations with RSE > 0.3, and when found, prevalence proportions were suppressed.

Study 1 Results: Weight Status Misperception

Table 4 reports the prevalence of healthy weight, overweight and obesity in Hawaii, overall and by demographics. Overall, 28.3% of the state's adult population is obese and an additional 26.3% is overweight. Together, 54.6% of adults in Hawaii, or more than half, are overweight or obese. Among those who are classified as obese, 63.3% fall within obesity grade I, 18.6% are obesity grade II, and 18.0% of obese adults, approximately one in twenty adults in Hawaii, are considered morbidly or severely obese (obesity grade III; data not shown). Chi square analyses revealed statistically significant differences in weight status by race-ethnicity, country of birth, poverty level, and receipt of governmental financial assistance (i.e. SNAP benefits; Table 4).

Half (49.1%) of adults who identify as Native Hawaiian or Other Pacific Islander are obese, compared to only one in four (25.3%) White adults; this difference between race-ethnicity groups is statistically significant. Adults born outside the US are more likely than those born in the US to be within a healthy weight range: approximately two thirds (67.8%) of adults born outside the US are classified as being within a healthy weight range, compared to fewer than two-fifths (36.8%) of US born adults. In addition to demographic covariates that are significantly related to BMI category, some demographic differences are seen within subgroups that, as a whole, did not rise to the threshold of significance. For example, adults aged 18-39 years old are more than twice as likely to be obese (34.7%) compared to adults aged 70 years and older (15.9%; Table 4). When Asian-specific BMI cutoffs were applied to Asian subgroups in Hawaii, the overall prevalence of obesity in Hawaii increases to 32.4% (Table 5). The prevalence of obesity among Filipinos increases from 29.2% to 37.0%, and among Japanese from 19.2% to 30.6%, although these differences were not statistically significant based on the chi square test.

Weight status perception varied significantly by BMI category (Table 6). Over a third of adults in Hawaii (37.4%) underperceive their weight status, compared to fewer than one in ten (7.4%) who overperceive their weight status. Most adults who are within the healthy weight category accurately self-perceive their weight status (78.0%) compared to only about half of overweight adults (50.2%) or a quarter of obese adults (24.7%). By contrast, more than three quarters (75.3%) of obese adults underperceive their weight status compared to only 8.2% of healthy weight adults. By obesity grade, those in obesity grade I are most likely to underperceive their weight status, with over nine in ten (91.3%) adults in this category not correctly self-identifying as 'very overweight.'

Weight status self-perception varied by several demographics, including age group, sex, race, educational status, country of birth, and having ever served in the US military (Table 7). Nearly half (46.1%) of all males underperceive their weight status compared to just over one in four (28.7%) women. NHOPI adults are significantly less likely to accurately perceive and significantly more likely to underperceive their weight status than White adults: two-thirds of NHOPI adults (67.2%) underperceive their weight status.

Similar disparities are seen by educational status, where over half (52.0%) of adults with lower educational achievement (those who have earned a high school diploma or less) underperceive their weight status, a prevalence that is significantly higher than weight status underperception among adults with some college education (27.5%) or a college degree (28.9%). Adults who are born in the US are more than twice as likely to underperceive their weight status (42.0%) compared to adults born outside the US (19.7%). Similarly, adults who have ever served in the US military are significantly more likely to underperceive their weight status (54.9%) compared to adults who have not served in the Military (35.0%; Table 7).

Multivariable logistic regression modeling was conducted as described, and limited to adults who either accurately perceived or underperceived their weight. Unadjusted PRs; age, sex, and race adjusted PRs; and fully adjusted PRs in the final model are provided in Table 8. In the univariate models, BMI status was very strongly associated with weight status underperception, with overweight adults being 5 times more likely (PR 5.14, 95% CI 3.17-8.35) and obese adults being nearly 8 times more likely (PR 7.92, 95% CI 5.00-12.54) to underperceive their weight status compared to healthy weight adults. In addition, several additional demographic sub-groups demonstrated differences in perception of weight status: for example, adults aged 40-49 years are less likely to underperceive their weight status compared to adults aged 18-39 years (PR 0.60, 95% CI 0.36-0.98). Males are more likely to underperceive weight status compared to females (PR 1.48, 95% CI 1.09-2.01). NHOPI adults are nearly twice as likely to underperceive their weight status compared to White adults (PR 1.84, 95% CI 1.42-2.39). Those born outside the US are half as likely as adults born in the US to underperceive their weight status (PR 0.50, 95% CI 0.30-0.82). Adults with a history of serving in the US military have a 47% higher likelihood for weight status underperception (95% CI 1.10-1.97). Those who 'just got by' financially are 44% more likely than those who were able to save money during the past year to misperceive their weight status (95% CI 1.04-2.00), and adults with lower educational attainment, with a high school diploma or less are 78% more likely to underperceive their weight (95% CI 1.31-2.43; Table 8).

Next, the model with BMI category as the only independent variable was adjusted for race, age group, and sex, as these three covariates are associated with several independent and dependent variables across the three studies. Race, age group, and sex were added to the model in that order by strength of association with the outcome variable (data not shown). In the race-, sex- and age-adjusted model, BMI category remained the most important predictor of weight status underperception; moreover, all three covariates were associated with weight status perception. Based on the race-, sex- and age-adjusted model, adults aged 40-49 years are 35% less likely than adults aged 18-39 years to underperceive their weight status (PR 0.65, 95% CI 0.48-0.88), males are 45% more likely to underperceive their weight status than women (PR 1.45, 95% CI 1.18-1.78), and NHOPI adults are 41% more likely to underperceive their weight status than White adults (PR 1.41, 95% CI 1.13-1.76; Table 8).

In the second phase of model building, remaining variables were added to the model in order of strength of association with the outcome variable (data not shown). No variables were retained in the model, as none were found to be associated with the outcome variable (the 95% CIs associated with the PRs for the variables added spanned 1.00 for all variables). However, during this phase, poverty level was identified as a potential confounder; additionally, poverty level and financial health were found to improve model fit. Model fit was assessed based on a comparison of BICs across the models with and without the added variables. The BICs were used to assess model fit, even though the models were nested, because of substantial differences in the number of observations used for analysis, which in turn impacted the log likelihood values of the intercept only models, and made the log likelihood values of the adjusted models difficult to compare directly.

In phase three, the two variables identified for reconsideration in the model during phase two (poverty level, financial health) were added into the model in that order, and retained if their estimates were associated with the outcome, if they were potential confounders, or if they improved model fit. Both were retained in the model. Next, the variables that were eliminated during phase two (educational status, receipt of SNAP benefits, ever having served in the US Military, country of birth, and county of residence) were reconsidered for inclusion, individually. Educational status was retained in the model because it improved model fit, and ever having served in the US Military was retained because it was associated with the outcome. None of the other variables were either associated with the outcome, improved model fit, or confounded the relationship between the outcome and any other variable in the model. They were therefore removed from the model. The final model contained BMI category, age group, sex, race, educational status, poverty level, financial health, and ever having served in the US military.

In the final model, BMI category was strongly associated with weight status perception. In addition, age group, sex, race-ethnicity, and ever having served in the US military were associated with weight status perception, even after adjusting for other covariates. Table 9 provides calculated BIC values for each covariate tested for inclusion in the model in Phase 3. Table 8 provides adjusted prevalence ratios, and corresponding 95% CIs, for all covariates in the final model.

Even after adjusting for race, sex, age group, poverty level, having ever served in the US military, educational level, and financial health, BMI category remained the strongest predictor of weight status misperception; those who are classified as overweight are 3.50 times more likely to underperceive their weight compared to those in the healthy weight range (95% CI 2.30-5.34). Those who are obese are 5.31 times more likely to underperceive their weight (PR: 5.31, 95% CI 3.41-8.25). In addition, race, sex, and age group are all significantly associated with weight status perception, even after adjusting for BMI category. In the final model, those who are 40-49 years remain 34% less likely to underperceive their weight status (PR 0.66, 95% CI 0.49-0.88) compared to 18-39 year olds; adults in other older age groups are also less likely to underperceive their weight compared to 18-39 year olds, but the 95% CIs overlapped 1.00. For example, 60-69 year olds are 23% less likely to underperceive their weight status (PR 0.77, 95% CI 0.59-1.01).

Males are 38% more likely to underperceive their weight status compared to women (PR 1.38, 95% CI 1.13-1.68). By race-ethnicity, NHOPI adults are 36% more likely to underperceive their weight status than those identifying as White (PR 1.36, 95% CI 1.08-1.72). Finally, those who have ever served in the US military are 21% more likely to underperceive their weight (PR 1.21, 95% CI 1.01-1.44; Table 8). Based on the final model, after adjusting for multiple covariates, 46% (95% CI: 38-55) of overweight adults and 70% (95% CI: 59-79%) of obese adults underperceive their weight status, compared to the prevalence of underperception reported prior to controlling for confounders (48.0% and 75.3% for overweight and obese adults respectively, see Table 6; adjusted prevalence data not shown).

Study 2 Results: Perceived Risk for Diabetes

Table 10 shows the prevalence and demographic correlates of adults at risk for diabetes, as calculated based on a diabetes score of 4 or greater; adults at high risk based on both standard BMI cutoffs and Asian-specific BMI cutoffs applied as appropriate are reported. Table 10 also reports the overall prevalence and demographic correlates of diabetes risk perception among adults in Hawaii. Half of all adults (50.0%, 95% CI 43.9-56.1%) are at high risk for diabetes, as determined by their diabetes risk score, which is estimated based on a history of diagnosed hypertension; being overweight or obese; having a family history of diabetes; and certain demographic characteristics (being male and being in an older age group). When applying Asian-specific BMI cutoffs, a higher prevalence, 52.4% of adults (95% CI 46.3-58.5%), are at risk for diabetes. Yet, a lower proportion of adults, 44.9% (95% CI 39.0-50.8%), perceive themselves to be at risk for diabetes (Table 10).

The results of the chi square analyses demonstrate that the demographic covariates that are associated with being at risk for diabetes (calculated based on the risk score derived using standard BMI cutoffs) included age group, sex, educational status, country of birth, and a history of ever serving in the US military. The associations between diabetes risk and age, as well as diabetes risk and sex, are not discussed further as both variables are used to calculate the diabetes risk score. By educational status, those who have had a high school education or less appear to be more likely to be at risk for diabetes (60.0%, 95% CI 49.3-70.7%) compared to those who have had some college education (40.6%, 95% CI 30.5-50.7%), although the 95% CIs overlapped slightly. Those born in the US are more likely to be at risk for diabetes (53.5%, 95% CI 46.9-60.0%) compared to those born outside the US (35.5%, 20.2-50.8%). Those who have ever served in the US military are significantly more likely to be at risk for diabetes compared to those who have not served (74.4% (95% CI 61.8-86.9%) vs. 46.9% (95% CI 40.2-53.5%)). Three demographic covariates (race-ethnicity, educational status, and country of birth) were associated with diabetes risk perception. By race-ethnicity, Native Hawaiian and Other Pacific Islander adults have the highest likelihood of perceiving themselves to be at risk for diabetes (59.0%, 95% CI 44.5-73.6%). College graduates (49.0%, 95% CI: 41.3-56.7%) and those with a high school diploma or less (54.1%, 95% CI: 43.4-64.9%) have a significantly higher perception of risk for diabetes than those with some college education (30.8%, 95% CI: 22.2-39.4%), and those born in the US have a significantly higher perception of risk than those born in another country (50.0% (95% CI 43.6-56.3%) vs. 24.1% (95% CI 13.6-34.5%); Table 10).

Chi square analysis demonstrates the relationship between actual risk for diabetes (derived based on the risk score) and risk perception (Table 11). Among those classified as being at high risk for diabetes, 54.3% (95% CI: 45.6-62.9%) believe themselves to be at high risk; among those not at risk for diabetes, 66.1% (95% CI: 58.1-74.1%) correctly perceive themselves to not be at risk for diabetes (data not shown). In general, those at higher risk for diabetes are more likely to perceive themselves to be at risk ($\chi^2 = 56.79$, P=0.0008). However, in both groups, a substantial proportion of adults misperceive their true risk for diabetes.

The other definition of diabetes risk considered was based on having a diagnosed risk for diabetes. Table 12 provides the overall prevalence and demographic breakdown of diagnosed risk for diabetes, a composite variable derived from having a diagnosis of pre-diabetes, gestational diabetes, or gestational pre-diabetes; having another doctor-diagnosed condition that the respondent explicitly associated with increased risk for diabetes (including high blood pressure, high blood sugar, high cholesterol, and hypoglycemia); or the respondent reporting that they have been warned about their risk for diabetes by a doctor. Less than one in five adults without diabetes in Hawaii (14.0%; 95% CI: 10.4-17.6%) report having been diagnosed with pre-diabetes. In combination with those with gestational diabetes or pre-diabetes, nearly one in five adults without diabetes in Hawaii (18.0%, 95% CI 13.4-22.7%) report having been diagnosed with a condition (pre-diabetes or borderline diabetes, gestational pre-diabetes, or gestational diabetes) that puts them at risk for diabetes (data not shown). In addition, 7.6% (95% CI 4.3-11.0%) of adults without diabetes in Hawaii have been diagnosed with a condition that they associate with a risk for diabetes, or report having been warned about their risk for diabetes by a doctor (data not shown). Together, one in five adults (20.9%, 95% CI 15.9-26.0%) in Hawaii have a diagnosed risk for diabetes. Diagnosed diabetes risk varies by financial health, with those who report saving money (25.9%, 95% CI 17.3-34.5%) or ‘getting by’ during the past year (25.7%, 95% CI 15.8-35.7%) being more likely to have a diagnosed risk for diabetes than those who report having spent their savings and borrowed money in the past year (6.1%, 95% CI 2.4-9.8%; Table 12).

To contextualize other variables that contributed to being classified as being at high risk for diabetes using either definition, Table 12 also provides overall prevalence and demographic correlates of diagnosed hypertension (used in the risk score calculation) and pre-diabetes (used to identify those with a diagnosed diabetes risk) among adults in Hawaii. Fewer than 50 respondents reported having been diagnosed with gestational diabetes or gestational pre-diabetes; as a result, this data was suppressed and not reported separately. Overall, 14.0% of adults in Hawaii have been diagnosed with pre-diabetes, and nearly one in three (30.3%, 95% CI: 25.3-35.3%) have hypertension. As is observed with diagnosed risk for diabetes, pre-diabetes diagnosis varies by financial health, with prevalence of diagnosed pre-diabetes being higher among those with good financial health during the past year: for example, nearly twice as many adults who reported saving money during the past year (16.9%, 95% CI 10.7-23.0%) have been diagnosed with pre-diabetes compared to those who reported spending their savings during the same time period (8.5%, 95% CI 3.9-13.2%). In addition, pre-diabetes prevalence also varies by age group, with older adults being significantly more likely to be diagnosed with pre-diabetes ($\chi^2 = 76.18$, P=0.0004; Table 12).

Like with pre-diabetes, diagnosed hypertension also varied by several demographic characteristics. Age group and race were significantly associated with hypertension prevalence. By race-ethnicity, Japanese adults are more than twice as likely to have been diagnosed with hypertension compared to White adults (43.1% vs. 20.0%), and older adults are more likely to have been diagnosed with hypertension; for example, over half (54.8%, 95% CI 43.1-66.5%) of adults aged 70+ years have been diagnosed with hypertension compared to only 14.6% (95% CI 7.2-22.0%) of adults aged 18-39 years (χ^2 = 151.32, P<0.0001).

Comparing adults at high risk for diabetes based on the risk score and those identified based on a diagnosed risk for diabetes, only one third (29.1%, 95% CI 21.0-37.2%) of all adults classified as being at high risk for diabetes in Hawaii based on their risk score have been diagnosed with one or more conditions associated with a higher risk for diabetes. On the other hand, 31.0% (95% CI 17.4-44.6%) of adults who have been diagnosed with one or more conditions that are associated with higher risk for diabetes are classified at low risk for diabetes based on their diabetes risk score (data not shown). To determine which indicator of diabetes risk to use in the multivariable logistic regression, the relationship between each indicator and diabetes risk perception was assessed. Not surprising, regardless of definition, risk for diabetes was associated with diabetes risk perception: those who are at high risk for diabetes based on the risk score are more likely to perceive themselves to be at high risk for diabetes (54.3%, 95% CI 45.6-62.9%) compared to those not at risk (33.9%, 95% CI 24.9-41.9%; χ^2 = 56.79, P=0.0008). Those who have a diagnosed risk for diabetes are also more likely to perceive themselves to be at high risk for diabetes (79.6%, 95% CI 69.7-89.6%) compared to those not at risk (33.2%, 95% CI 29.8-41.7%; χ^2 = 182.04, P<0.0001). However, between the two indicators, those with a diagnosed risk for diabetes are more likely to perceive themselves to be at risk for diabetes compared to those who are identified as being at high risk based on their risk score. Therefore, diagnosed risk for diabetes, and not diabetes risk as ascertained by the calculated risk score, was used as a potential confounder in the logistic regression analysis.

Approximately half (53.8%, 95% CI 48.2-59.5%) of adults in Hawaii report having a family history of diabetes. Those who have a family history of diabetes are significantly more likely to perceive themselves to be at risk for diabetes (χ^2 = 134.34, P<0.0001; data not shown). Specifically, 60.3% (95% CI 51.3-69.2%) of those with a family history of diabetes perceive themselves to be at risk for diabetes compared to less than half (29.3%, 95% CI 22.1-31.5%) of those without a family history of diabetes.

The multivariable logistic regression, limited to adults without diabetes, assessed the relationship between diabetes risk perception and weight status perception, and considered the impact of additional potential confounders (diagnosed risk for diabetes, having a family history of diabetes, and BMI category) on the relationship between diabetes risk perception and weight status perception. Being at risk for diabetes, based on the modified risk score, was not considered as a potential confounder in the model as noted previously for two additional reasons. First, the composite variable was calculated based on five variables, four of which were included separately in the model (age group, sex, BMI category, and having a family history of diabetes). Next, the decision was made to include the fifth variable used to calculate the diabetes risk score (a diagnosis of hypertension) directly as a potential confounder in the model.

Multivariable logistic regression modeling was conducted as described to evaluate the relationship between weight status perception (independent variable) and diabetes risk perception (outcome variable). Unadjusted PRs; age, sex, and race adjusted PRs; and fully adjusted PRs in the final model are provided in Table 13. Univariate models tested the association between diabetes risk perception and the independent variable (weight status perception), demographic covariates, as well as potential confounders including diagnosed risk for diabetes, family history of diabetes, diagnosis of hypertension, and BMI category. They revealed an association between diabetes risk perception (outcome variable) and weight status perception, educational status, country of birth, diagnosed risk for diabetes, family history of diabetes, and BMI category. The 95% CI of the association with the outcome variable spanned 1.00 for a diagnosis of hypertension and the remaining demographic covariates.

Based on the univariate models, those who have a diagnosed risk of diabetes are 2.23 times more likely to perceive themselves to be at risk (95% CI: 1.81-2.75). Similarly, those with a family history of diabetes are 2.06 times more likely to perceive themselves to be at risk for diabetes (95% CI: 1.54-2.74). Those with only some college education are 37% less likely to perceive themselves to be at risk compared to college graduates (PR 0.63, 95% CI 0.46-0.87), and those born outside the US are less than half as likely to perceive themselves to be at risk (PR: 0.48, 95% CI 0.31-0.76). Also, there are differences by weight status, with those categorized as overweight or obese being 48% (95% CI 1.06-2.07) and 109% (95% CI 1.52-2.87) more likely to perceive themselves at risk for diabetes than those in the healthy weight range. Finally, those who overperceive their weight status appear to be more likely to perceive themselves to be at risk for diabetes, compared to those with accurate self-perception of weight status (PR 1.51, 95% CI 1.04-2.21; Table 13).

Next, the model with weight status perception as the only independent variable was adjusted for race, age group, and sex, as these three covariates are associated with several independent and dependent variables across the three studies. Race, age group, and sex were added to the model in order by strength of association with the outcome variable (data not shown). After adjusting for race, sex, and age group, those who overperceive their weight are more likely to also perceive themselves to be at high risk for diabetes (PR 1.43, 95% CI: 1.02-2.00; Table 13). The 95% CIs of the associations between race, age group, and sex with the outcome variable spanned 1.00. Based on the point estimates of the PRs, compared to White adults, NHOPI adults and Japanese adults are more likely, whereas Filipino and Other adults are less likely to perceive themselves to be at risk for diabetes.

In the second phase of model building, remaining variables were added to the model in order of strength of association with the outcome variable (data not shown). Four variables were retained in the model during Phase 2, as they were found to be associated with the outcome variable (the 95% CIs associated with the PRs for the variables added did not span 1.00); in addition, all four variables improved model fit and confounded the relationship between the outcome and other variables in the model. They included diagnosed risk for diabetes, having a family history of diabetes, BMI category, and educational attainment. In addition, during phase two, country of birth was identified as a potential confounder and poverty level and financial health were found to improve model fit: none of these variables met criteria for retention in phase two and were removed from the model.

In phase three, the three variables identified for reconsideration in the model during phase two (country of birth, poverty level, and financial health) were added into the model in that order, and retained if their estimates were associated with the outcome, if they were potential confounders, or if they improved model fit. Poverty level and financial health were retained in the model, whereas country of birth was excluded as it no longer confounded any associations in the model. Finally, the variables that were eliminated during phase two (receipt of SNAP benefits, ever having served in the US Military, county of residence, and hypertension diagnosis) were reconsidered for inclusion, one at a time. None of the variables were either associated with the outcome, improved model fit, or confounded the relationship between the outcome and any other variable in the model. Hypertension diagnosis was retained as it was one of the variables not subject to exclusion, but the remaining variables were removed. The final model contained weight status perception, race-ethnicity, age group, sex, diagnosed risk for diabetes, having a family history of diabetes, BMI category, educational status, poverty level, financial health, and a diagnosis of hypertension.

In the final model, weight status perception was associated with diabetes risk perception. In addition, race-ethnicity, educational status, diagnosed risk for diabetes, BMI category, having a family history of diabetes, and educational status were associated with diabetes risk perception, even after adjusting for other covariates. Table 14 provides calculated BIC values for each covariate tested for inclusion in the model in Phase 3. Table 13 provides adjusted prevalence ratios, and corresponding 95% CIs, for all covariates in the final model. After adjusting for other covariates, adults with a diagnosed risk for diabetes are nearly twice as likely to perceive themselves to be at risk for diabetes (PR: 1.97, 95% CI 1.58-2.45). Those who have a family history of diabetes are 77% more likely to perceive themselves to be at risk (95% CI 1.39-2.24). Those who are overweight (PR: 1.49, 95% CI 1.11-2.01) or obese (PR: 2.07, 95% CI 1.46-2.93) are more likely to perceive themselves to be at risk for diabetes than those at healthy weight.

Additionally, after adjusting for diagnosed risk for diabetes, family history of diabetes, BMI category and other covariates, Japanese adults are 40% more likely to perceive themselves to be at risk for diabetes compared to White adults (PR 1.40, 95% CI 1.16-1.69; Table 13). On the other hand, although the 95% CI spanned 1.00, Filipino adults may be less likely than White adults to perceive themselves to be at risk for diabetes (PR 0.73, 95% CI 0.50-1.09). Those with some college education are 35% less likely than college graduates to perceive themselves to be at risk for diabetes (PR: 0.65, 95% CI 0.50-0.85). In general, despite their 95% CIs spanning 1.00, the associations between some variables and the outcome are noteworthy. These included age group, with older adults seeming less likely to perceive themselves to be at risk for diabetes; for example, compared to 18-39 year olds, adults aged 40-49 years may have a 23% lower likelihood of perceiving themselves to be at risk (95% CI: 0.56-1.05). A diagnosis of hypertension is only weakly associated with perceived risk for diabetes after adjusting for the independent variable, other confounders and demographic covariates (PR 0.94, 95% CI 0.74-1.20).

Finally, after adjusting for several demographic covariates and potential confounders, weight status misperception is associated with diabetes risk perception in both directions. Those who overperceive their weight status are 42% more likely to perceive themselves to be at risk compared to those who accurately perceive their weight status (PR 1.42, 95% CI 1.14-1.76). On the other hand, those who underperceive their weight status are 24% less likely to perceive themselves to be at risk for diabetes compared to those with accurate weight status perception (PR 0.76, 95% CI 0.60-0.97; Table 13). Therefore the null hypothesis is rejected.

Study 3 Results: Screening and Awareness of Diabetes

Table 15 shows the prevalence of diabetes screening within the past three years overall, and by demographic covariates. Overall, more than half of all adults without diabetes in Hawaii (57.1%) report having been screened for diabetes within the past three years. Diabetes screening varied significantly by age, with adults aged 50 years and older being significantly more likely to have been screened than those between 18-39 years (χ^2=171.80, P<.0.0001); for example, 77.5% of adults aged 70 years and older (95% CI: 65.9-89.0%) report being screened for diabetes within the past three years, compared to only about half (37.2%, 95% CI: 26.3-48.1%) of 18-39 year olds. No other demographic covariates were significantly associated with diabetes screening based on the results of the chi square analysis (Table 15).

Three potential confounders assessed were (1) meeting USPSTF screening criteria, (2) having a family history of diabetes, and (3) being diagnosed with a diabetes-related chronic condition. Approximately one in four adults in Hawaii (27.2% (95% CI 22.7-31.7)) meet USPSTF screening criteria (adults aged 40-70 year old who were classified as overweight or obese) for diabetes. Meeting USPSTF screening criteria was significantly associated with having been screened for diabetes within the past three years; 67.5% of those eligible (95% CI 58.3-76.7%) report being screened for diabetes within the past three years, compared to 52.9% (95% CI 45.4-60.4%) of those who did not meet USPSTF screening criteria (χ^2 = 22.7, P=0.0198; data not shown).

Approximately half (53.8%, 95% CI 48.2-59.5%) of adults in Hawaii report having a family history of diabetes. Those who have a family history of diabetes are only slightly more likely to have been screened for diabetes within the past three years (61.7%, 95% CI 53.1-70.3%) compared to those who do not have a family history of diabetes (52.9%, 44.6-61.2%); this difference was not statistically significant (χ^2 = 10.90, P=0.1536; data not shown).

The other confounder evaluated was a history of having been diagnosed with a diabetes-related chronic condition. This is a composite of two variables described previously. To be specific: nearly one in three adults in Hawaii (30.3%, 95% CI: 25.3-35.3%) have hypertension; this prevalence includes adults with diabetes. In addition, 7.6% (95% CI 4.3-11.0%) of adults without diabetes in Hawaii who perceive themselves to be at risk for diabetes report having been diagnosed with a chronic condition related to diabetes (high cholesterol, hypoglycemia, or high blood pressure) that they associate with a risk for diabetes, or were warned about their risk for diabetes by a doctor (data not shown). Together, these variables represented one or more interactions between the respondent and their healthcare provider related to chronic conditions that increase their risk for diabetes. In combination, 28.1% (95% CI: 23.0-33.2%) adults without diabetes in Hawaii have been diagnosed with chronic conditions related to diabetes (data not shown). Those who meet criteria for having one or more diabetes-related chronic conditions are more likely to report having been screened for diabetes in the past three years (66.7%, 95% CI 54.4-79.0) compared to those without a diabetes-related chronic condition (51.7%, 95% CI 44.6-58.7, χ^2 = 22.94, P=0.0476).

Model building was performed as described above to evaluate the association between diabetes screening (outcome variable) and two independent variables, diabetes risk perception and weight status perception. Univariate models revealed an association between diabetes screening (outcome variable) and having a diabetes-related chronic condition, weight status perception, age group, race, and educational status. The 95% CI of the associations with the outcome variable spanned 1.00 for diabetes risk perception, meeting USPSTF screening criteria, BMI Category, having a family history of diabetes, and the remaining demographic covariates. According to the univariate models, adults who overperceive their weight status are more likely to have been screened for diabetes (PR 1.43, 95% CI 1.07-1.90) than adults with accurate weight status perception. Those who have a diabetes-related chronic conditions are 36% more likely to have been screened for diabetes (PR: 1.36, 95% CI 1.02-1.79). Also, adults in older age groups are significantly more likely to have been screened for diabetes. For example, compared to 18-39 year olds, those in the 50-59 year age group are 2.5 times more likely to have been screened (95% CI 1.74-3.60). NHOPI adults are 37% less likely to have been screened for diabetes within the past three years compared to Whites (PR: 0.63, 95% CI 0.41-0.95). Additionally, those with a high school diploma or less are less likely to have been screened for diabetes in the past three years compared to college graduates (PR: 0.72, 95% CI 0.54-0.97; Table 16).

In the race-, age group- and sex-adjusted model, only the first independent variable (diabetes risk perception) was included along with race, sex, and age group. In this model, associations between diabetes risk perception and age group with the outcome variable (diabetes screening) were found (Table 16). Those who perceive themselves to be at risk for diabetes are 29% more likely to get screened (PR 1.29, 95% CI 1.03-1.62). As with the univariate models, adults in older age groups are approximately twice as likely to get screened compared to those in the 18-39 year age group (Table 16). The 95% CIs of the associations of race and sex with the outcome variable spanned 1.00. Based on the point estimates of the PRs, compared to White adults, adults in all other race-ethnicity groups seem to have lower screening rates for diabetes. For example, those who identified as NHOPI may be up to 23% less likely to be screened compared to White adults (95% CI 0.53-1.11). Sex was only weakly associated with the outcome, with men being slightly less likely to be screened for diabetes than women after adjusting for race and age-group (PR 0.91, 95% CI 0.81-1.16).

In the second phase of model building, remaining variables, with the exception of weight status perception, were added to the model in order of strength of association with the outcome variable (data not shown). None of the variables met criteria for retention during phase two, since all the 95% CIs associated with the PRs for the variables added spanned 1.00. During phase two, the following potential confounders were identified, in order of magnitude of change in the estimates associated with one or more other variables in the model: poverty level, having a diabetes-related chronic condition diagnosis, meeting USPSTF criteria for diabetes screening, and country of birth. In addition, the following variables were found to improve model fit but were not potential confounders: BMI category, financial health, and having a family history of diabetes (data not shown). Therefore, in the third phase, these seven variables were reconsidered for inclusion in the model in that order, and retained if their estimates were associated with the outcome, if they were potential confounders, or if they improved model fit.

Poverty level, having a diabetes-related chronic condition, and meeting USPSTF eligibility criteria for diabetes screening were retained as they confounded the relationship between one or more variables in the model and the outcome; BMI category and having a family history of diabetes were retained as they improved model fit. Country of birth and financial health were removed, as they were not associated with the outcome, did not confound other associations in the model, and did not improve model fit. Finally, the remaining variables (educational status, county of residence, having ever served in the military, and receipt of SNAP benefits) were added individually to the model. County of residence was retained as it was associated with the outcome. Educational status was retained because it was not subject to exclusion. The remaining variables did not meet criteria for retention. At the end of phase 3, the model contained diabetes risk perception, race-ethnicity, sex, age group, poverty level, having a diabetes-related chronic condition, meeting USPSTF eligibility criteria for diabetes screening, BMI category, having a family history of diabetes, educational status, and county of residence.

In the phase 3 model, after adjusting for demographic covariates and multiple confounders, diabetes risk perception was associated with having been screened for diabetes within the past three years. In addition, age group and county of residence were associated with diabetes screening. In the fourth phase, weight status perception and an interaction term of diabetes risk perception and weight status perception were tested for inclusion in the model. Weight status perception was retained because it was found to confound the relationship between BMI category and diabetes screening even though the confidence interval of the association between weight status perception and diabetes screening spanned 1.00. Therefore, the final model included all the variables in the phase 3 model, and weight status perception.

In the final model, even after adjusting confounders and other covariates, those who are more likely to perceive themselves to be at risk for diabetes are also 31% more likely to have been screened (PR: 1.31, 95% CI 1.05-1.62). In addition, age group remained associated with having been screened for diabetes, with those in older age groups (40-49 years, 50-59 years, and 70+ years) being more likely to have been screened than 18-39 year olds. For example, adults aged 70 years and older were 94% more likely to have been screened (PR 1.94, 95% CI 1.28-2.94; Table 16). Adults in the 60-69 year age group may also be more likely to have been screened for diabetes (PR 1.64, 95% CI 1.00-2.69), although the 95% CI of the PR spanned 1.00. Several other demographic associations in the final model were noteworthy, despite their 95% CIs spanning 1.00. These included race-ethnicity, with adults in all other race groups having a lower likelihood of receiving diabetes screening compared to White adults, although the CIs were very wide. For example, Filipino adults may be up to 26% less likely than White adults to have received diabetes screening in the three years prior to the survey, but the confidence interval for the prevalence ratio estimate spanned 1.00 (PR: 0.74, 95% CI 0.50-1.10). By income, adults in the highest poverty level (0-100% FPL) appear to be more likely to get screened for diabetes after adjusting for weight, other demographic covariates including educational attainment, and potential confounders (PR 1.27, 95% CI 0.99-1.64). Adults residing in any of the neighbor island counties may be less likely to get screened than those living in Honolulu County. For example, Hawaii County residents are 23% less likely to report having been screened (PR 0.77, 95% CI 0.58-1.01).

When reviewing the association of potential confounders with the outcome, adults who have been diagnosed with a diabetes-related chronic condition may be more likely to get screened than those without such a condition (PR 1.20, 95% CI 0.94-1.53). BMI category also appeared to be associated with diabetes screening within the past three years, with overweight adults (PR 1.25, 95% CI 0.88-1.78) possibly being more likely and obese (PR 0.76, 95% CI 0.46-1.25) adults possibly being less likely to report having been screened for diabetes, although the 95% CI for both estimates spanned 1.00. Finally, weight status misperception was associated with diabetes screening, but the 95% CIs for the association between diabetes screening and both overperception and underperception spanned 1.00. Therefore, both associations failed to reject the second null hypothesis. The association between overperceiving weight status and diabetes screening is positive (PR 1.29, 95% CI 0.92-1.79) whereas that between underperceiving weight status and diabetes screening is negative (PR 0.97, 95% CI 0.73-1.27), suggesting that adults who overperceive their weight may be more likely to get screened for diabetes and vice versa. Adjusted prevalence ratios along with 95% CIs for all terms retained in the final model are presented in Table 16. Table 17 presents the final BIC value for each covariate tested for inclusion in the final phase of model building and reason(s) for retention or removal.

DISCUSSION

The Healthy Hawaii Initiative (HHI) Survey was completed by the Hawaii State Department of Health in March 2017 and represents the most recent picture of the State of Hawaii's health, using a comprehensive population survey that cuts across many pertinent chronic disease areas. The survey methodology followed the Hawaii BRFSS survey with minimal deviations. The BRFSS is the largest telephone based survey in the world, and its reliability and validity have been well established.(89) It is the longest running telephone-based survey in Hawaii, and is a key source of health data for the state.(76) Several national health reports utilize data gathered by the BRFSS to rank and compare states.(4) Ensuring that the HHI survey followed the BRFSS methodology for design, administration, and weighting assured the reliability and validity of the data collected; minimized the likelihood of obtaining unreliable or non-replicable estimates; and enabled the production of estimates comparable to the Hawaii BRFSS. In turn, comparability of health indicator data based on the HHI Survey to that reported by the Hawaii BRFSS survey enhanced confidence in indicators created based on questions that had not previously been included in the Hawaii BRFSS survey. The HHI survey response rate of 38.8% was comparable to BRFSS response rates reported across states nationally.(69) Data were weighted to represent the adult population in the State of Hawaii.

Weight Status

The analyses showed that over one in four adults in Hawaii (28.3%) are obese, with one in twenty adults in the state (5.1%) meeting criteria for severe or morbid obesity. This point prevalence of obesity is higher than that reported by the Hawaii BRFSS in 2016 (23.8%), although the confidence intervals of the Hawaii BRFSS 2016 (22.4-25.2%) and HHI survey 2016-17 (22.9-33.6%) obesity prevalence overlap.(5) The differences in prevalence may be attributable to several possible explanations including methodological differences between the surveys, random error from sampling, or potentially systematic error arising from non-response and other sources. One potential contributor to the higher obesity prevalence reported by the HHI survey is differences in weighting methodology. Unlike the BRFSS, which is weighted based on national race groupings, the HHI Survey is weighted based on an American Community Survey-based demographic study that provides population estimates specific to Hawaii-specific race-ethnicity groupings, and prioritizes Native Hawaiian classification per the guidelines of the Department of Health's Office of Health Status Monitoring (DOH OHSM). Therefore, underlying differences in population distribution may contribute to differences in weighted estimates across the two surveys.

The prevalence of obesity in Hawaii varied by race, affecting nearly half (49.1%, 95% CI 35.1-63.1%) of NHOPI compared to approximately one in four (25.3%, 95% CI 18.0-32.5%) White residents in Hawaii. The prevalence of obesity among NHOPI in Hawaii, as reported by the HHI survey, closely resemble that reported by the Hawaii BRFSS, and prevalence of obesity reported internationally in Pacific Island nations.(2, 6) These prevalence proportions are also comparable to national prevalence proportions of obesity reported among Black or African American adults (40.4%), American Indian or Alaskan Native (43.4%), and NHOPI adults (42.6%).(90) Health disparities among NHOPI adults across the US received recent national attention in a report released by CDC and confirmed that NHOPI populations experience significant disparities in health both here in Hawaii, and nationally. (90, 91) Because NHOPI represents over one fifth of the state of Hawaii's population, more attention, research and clinical care is needed to address the health disparities experienced by these peoples.

Japanese adults in Hawaii had the lowest prevalence of obesity in Hawaii when using standard BMI cutoffs, with only 19.2% of the population being categorized as obese. However, upon applying Asian-specific BMI cutoffs,(9, 14) nearly one in three Japanese adults (30.6%) in Hawaii may be obese, a prevalence that is higher than the obesity prevalence observed among White adults in Hawaii. Using Asian-specific cutoffs also suggests that the true prevalence of obesity among Filipinos in Hawaii may be 37.0%, rather than 29.2% as calculated when applying standard BMI cutoffs. The higher prevalence of obesity in Japanese and Filipino communities in Hawaii aligns closely with the higher prevalence of diabetes in these populations. According to the Hawaii BRFSS (2011-15), the point prevalence of diabetes among White, Filipino and Japanese adults in Hawaii are 5.1%, 10.5% and 11.7% respectively.(92) Therefore, the use of Asian-specific BMI cutoffs likely paints a more accurate picture of obesity in the state of Hawaii; using Asian-specific BMI cutoffs as appropriate elevated the overall obesity prevalence of the state to 32.4% (95% CI 27.0-37.9%). With 33.1% of the State of Hawaii's adult population grouped into either Japanese or Filipino ethnicities, which are the two most prevalent Asian ethnicity groups, further consideration and analyses are urgently needed to determine whether the standardized application of Asian-specific BMI cutoffs may be more appropriate for routinely assessing obesity prevalence for the state.

Besides race-ethnicity, country of birth was associated with obesity prevalence with adults born outside the US being significantly more likely to be categorized as healthy weight. Other studies have reported similar trends in obesity when comparing US born adults with immigrants.(93) Although immigrants have an overall lower prevalence of obesity than US born adults, the prevalence of obesity among our immigrant population is growing as well, and remains a cause for concern. Moreover, obesity varies by race-ethnicity of immigrants; for example, obesity prevalence among long-term Chinese, Filipino, and Other Asian and Pacific Islander immigrants are 3.2%, 12.6% and 8.8% respectively, whereas among other immigrant groups, prevalence proportions of obesity are higher.(93) For example, obesity prevalence proportions among long-term Mexican, Puerto Rican and Cuban immigrants are 30.8%, 32.7% and 24.2% respectively.(93) According to the Hawaii State Department of Business, Economic Development & Tourism, 83.6% of residents who were granted permanent residence in Hawaii in 2015 came from just eight Asian countries (China, Hong Kong, Japan, Korea, Philippines, Taiwan, Thailand, and Vietnam).(94) The high prevalence of Asian immigrants in Hawaii may explain the large difference in the prevalence of healthy weight between US born (36.8%) and foreign born (67.8%) residents reported in the HHI survey. As expected, when Asian-specific BMI cutoffs were applied, the prevalence of healthy weight among foreign born residents decreased to 49.2%, but still remained higher than the prevalence of healthy weight among US born residents (30.1%).

Weight Status Misperception

Weight status misperception occurs in both directions among Hawaii adults, with nearly half of all adults (44.9%) either overperceiving or underperceiving their weight status. These findings are comparable to other studies nationally. For example, in one study, 7.6% of men and 2.8% of women perceived themselves to be underweight compared to an actual underweight prevalence of 1.4% and 2.5% respectively.(24) In contrast, 47.3% and 65.3% of men and women, respectively perceived themselves to be overweight compared to an actual overweight/obesity prevalence of 66.9% and 59.8% respectively.(24) Although our current study demonstrates similar trends in misperception, an additional observation requiring exploration is the difference in magnitude of misperception reported in Hawaii compared to several national studies. In a national study based on NHANES data, Dorsey et al. (2009) reported that ~40% of overweight adults and 8% of obese adults underperceived their weight status compared to 40% of underweight and 22% of healthy weight adults who overperceived their weight status.(21) In the current study, a significantly larger proportion of residents (37.4%) underperceived rather than overperceived (7.4%) their weight. Also, the prevalence of underperception was higher among obese adults (75.3%) compared to overweight adults (48.0%). This finding, on surface, appears to contrast with studies that have reported a strong but negative association between higher BMI and lower rates of misperception.(95)

These differences are most likely attributed to the wording of the question in the HHI survey compared to the NHANES, the survey that has been used by most national studies of misperception.(17, 21, 24, 26, 27, 34, 50, 95) Whereas the NHANES asks participants to classify themselves into three groups, 'underweight,' 'overweight,' or 'about the right weight,' the HHI survey question item asks respondents to select from five categories, 'very overweight,' 'somewhat overweight,' 'about the right weight,' 'somewhat underweight,' and 'very underweight.'(96) Thus, the more nuanced question from HHI has enabled the present study to consider obese respondents who only considered themselves 'somewhat overweight' to be underperceiving their weight status, and overweight respondents who considered themselves to be 'very overweight' to be overperceiving their weight status. The NHANES studies, by contrast, were unable to truly describe the extent of underperception among obese participants, since they classified obese participants considering themselves 'overweight' as accurately perceiving their weight status.

As observed earlier, a Pew Research Center study found that nearly half of all Americans who believed themselves to be overweight only considered themselves a little overweight.(18)

In the present study, only 24.7% of obese participants correctly identified themselves to be 'very overweight.' Among the remaining 75.3%, more than two thirds (70.9%) classified themselves as 'somewhat overweight' (data not shown). In alignment with data reported in other studies, weight status underperception declined by obesity grade, from a prevalence of 91.7% among individuals with grade I obesity to 46.2% among those with grade II obesity (estimates among those with grade III obesity were too unstable to report). These estimates of weight status underperception among those with grade II obesity mirror findings reported elsewhere.(97)

Study 1 in this PhD dissertation reported that the strongest predictor of weight status misperception is actual weight status. Even after adjusting for other variables, obese individuals are over five times more likely than healthy weight individuals to underperceive their weight status. Overweight individuals are over three times more likely to do so as well. Without adjusting for BMI category, therefore, the association between any demographic covariates and weight status perception (as reported in Table 7) was confounded by actual weight status of the respondents in that category. The critical impact of actual weight status on weight status perception has been reported in NHANES-based national studies.(24, 34)

After adjusting for weight status, the demographic correlates of weight status misperception identified by Study 1 closely aligned with the findings of several other studies. For example, several studies have reported that men are more likely to underperceive their weight status,(21, 26, 34, 95) a finding strongly corroborated by Study 1. In addition, studies have reported that under-perception is more common among minority race ethnicities such as Black Americans and Mexican Americans as compared to Non-Hispanic Whites.(21, 24, 26, 28, 95) The higher prevalence of underperception is attributed to higher prevalence of obesity in these populations.(28) Hawaii has a unique race-ethnicity distribution with a very low prevalence of Black and Mexican Americans (Table 1). The race-ethnicity group with the highest prevalence of obesity, with a prevalence estimate exceeding those reported among Black and Mexican Americans nationally, is NHOPI. According to the visual normalization theory, the extent of visual norming of obesity is greater in communities with higher exposure to obesity.(16) As discussed herein, NHOPI in Hawaii have significantly higher prevalence of obesity than all other race-ethnicity groups; half of all NHOPI in Hawaii are obese. Therefore, the finding that weight status misperception is 36% higher among NHOPI populations compared to Whites in Hawaii even after adjusting for weight status is consistent with the visual normalization theory which suggests that visual norming for higher weight statuses may be more common among groups with higher rates of obesity; greater extent of weight misperception may in turn make weight loss efforts more challenging to implement among NHOPI populations in Hawaii. No other study has reported on the prevalence of weight status misperceptions among NHOPI populations in the US.

Another demographic correlate of weight status misperception that has been reported by other studies and corroborated by the present study is a generational effect, in which younger individuals are significantly more likely to underperceive their weight status, possibly due to greater social norming of higher body weight beginning in childhood.(16, 24, 33) In the present study, when 18-39 year olds were compared to 40-49 year olds, the older group was significantly less likely to underperceive their weight status than the younger individuals. Again, these findings strongly align with visual normalization theory, as individuals exposed to more obesity, especially from a younger age, are less able to discern healthy from unhealthy body weights, and are more likely to misperceive their own weight status.(16)

One finding in the present study that has not been reported elsewhere is the association between having ever served in the US military and weight status perception. Even after adjusting for BMI category and other covariates, those who had ever served in the US military were 21% more likely to underperceive their weight status. This finding is interesting and requires further corroboration. Some findings reported in other studies were not definitively replicated in the present study. For example, in univariate models, individuals with lower educational attainment are more likely to underperceive their weight status. However, after adjusting for BMI category and other covariates in the model, the 95% confidence interval of the estimate overlapped 1.00. Even still, those who only had a high school diploma or less were 22% more likely than those with a college degree to misperceive their weight status (95% CI 0.98-1.53).(21, 26) Similarly, socioeconomic status has been associated with weight status perception in the literature, with those in lower income levels and those receiving 'food stamps' being more likely to underperceive their weight.(26, 95) One study additionally noted that rurality was an important predictor of weight status misperception, *i.e.* those living in rural areas were more likely to underperceive their weight status.(25)

Our current study did not replicate these associations between poverty level and other measures of financial wellbeing, as well as rurality, and weight status perception. These differences have many and various explanations, and it is entirely possible that some of those relationships observed elsewhere do not exist in Hawaii. Additionally, Type II error cannot be ruled out of these analyses. Larger than desired type II error could be attributable to low sample size and/or differences in how each variable was operationalized across studies. This is, in part, attributed to the limitations of the questions included in the survey, and the survey instrument itself. For example, county of residence may not have been the most effective way to differentiate between those living in urban versus rural areas. Despite this, no other question included in the HHI survey was better suited to assess rurality. On the other hand, other studies have reported not seeing a significant effect of rural versus urban dwelling on weight status misperception after adjusting for other demographics.(34) Similarly, Federal Poverty Level (FPL) thresholds chosen in the current study (0-100%, 101-185% and 186%), although meaningfully selected to reflect cutoffs for various forms of governmental financial assistance, may not have adequately differentiated between those living under conditions of financial stress and those enjoying adequate financial comfort in Hawaii. One study that found a significant impact of income on weight status misperception compared respondents with an income at or below the 130% FPL to those with incomes above 350% FPL.(26) The present study also found a weak association between weight misperception and poverty level, with those in the 0-100% FPL range being 6% (95% CI 0.81-1.39) more likely than those earning at 186% or higher of the FPL to misperceive their weight status after adjusting for BMI category and other demographics.

Diabetes Risk

Study 2 assessed the prevalence and demographic correlates of diabetes risk and diabetes risk perception among adults in Hawaii, and described the relationship between diabetes risk perception and weight status perception. Diabetes risk was assessed in two ways. The first strategy used a modified scale adapted from the American Diabetes Association's diabetes risk score calculator.(75) No question on physical activity was available through the HHI Survey, and therefore this indicator was eliminated from risk score calculation. The cutoff threshold was adjusted to dichotomize respondents into those at high risk for diabetes in Hawaii, and those not at high risk. The use of the risk-score based classification revealed that half (50.0%) of adults in Hawaii may be at high risk for diabetes. Besides age group and sex (both being variables that contribute to the risk score) univariate analyses revealed few other demographic covariates that were associated with being at risk for diabetes (based on the modified risk score-based classification method employed here). For example, the prevalence proportion of adults at risk for diabetes was highest among those who had no more than a high school education (60.0%), followed by those who were college graduates (47.0%) and those who had completed some college (40.6%). Those born in the US had a higher prevalence of being at risk for diabetes compared to those born outside the US (53.5% vs. 35.5%). Also, those who had ever served in the US Military were at significantly higher risk for diabetes compared to those who had never served (74.4% vs. 46.9%). Despite having comparable prevalence of diabetes,(92) Japanese adults appeared to be at greater risk (56.1%) compared to Filipinos (43.3%).

The second indicator of diabetes risk was 'diagnosed risk for diabetes' an indicator that appeared to be a more direct assessment of contact with the health system resulting in the respondent being more likely to become aware of their risk for diabetes. An individual was considered to have a diagnosed risk for diabetes if they had been diagnosed with gestational diabetes or gestational pre-diabetes during a pregnancy, or had been diagnosed with pre-diabetes. Alternatively, an individual who had been diagnosed with another condition that they directly associated with increased risk for diabetes, or reported that their doctor had warned them about their risk for diabetes, was also considered to have a diagnosed risk for diabetes. The data indicated that 20.9% of Hawaii adults met criteria for having a diagnosed risk for diabetes based on the presence of one or more diagnosed conditions. Diagnosed risk for diabetes was higher among those with greater financial wellbeing, with 25.9% of those who saved money in the past year reporting being diagnosed with one or more conditions that conveyed a higher risk for diabetes, compared to only 6.1% of those who had spent their savings and borrowed money during the same time period.

Comparing diagnosed risk for diabetes among those classified at being at high risk for diabetes based on the risk score was informative. More than two-thirds of adults (69.0%) who had a diagnosed risk for diabetes were also classified as being at high risk for diabetes by the risk score calculator. However, only a third of adults (29.1%) who were classified at high risk for diabetes by the risk score calculator had a diagnosed risk for diabetes. Thus, the majority of those classified as being at risk by the risk calculator-based indicator were likely to be unaware of their risk, as they had not been diagnosed with a condition that informed them of their risk. In addition, 31.0% of adults who had a diagnosed risk for diabetes were classified as not being at high risk for diabetes based on the risk score calculator. In other words, although the risk calculator-based indicator identified nearly 2.5 times the number of adults as being at high risk for diabetes compared to the diagnosis-based indicator (50.0% vs. 20.9%), it misclassified one third of adults at high risk as not being at risk for diabetes.

A review of the indicators used to derive the risk score revealed a plausible confounder that reduced the accuracy of the risk-score based indicator: awareness of underlying risk factors for diabetes. For example, one point was added to the total diabetes risk score if the respondent had been diagnosed with hypertension. According to the data collected by the HHI survey, there are demographic differences in diagnosed hypertension: for example, Japanese adults and adults in older age groups in Hawaii have a higher prevalence of diagnosed hypertension. Also, although no Hawaii-specific estimates exist, national studies in the USA have established that up to 7 million adults nationwide are unaware of their hypertension diagnosis.(98) Therefore, differences in risk for diabetes identified based on the risk score may be confounded by disparities in awareness of underlying conditions (such as hypertension) that contributed to the diabetes risk score. These disparities in awareness may reflect underlying sociodemographic behaviors in accessing the healthcare system, and receiving screenings for chronic conditions. Such disparities do exist and are well documented: In Hawaii, by race-ethnicity, BRFSS data (2011-15) reveals that only 2.8% of Japanese adults report that they did not visit a doctor due to cost during the past 12 months, compared to 23.2% of Other Pacific Islander adults. Similar differences are seen by income level.(99) Nearly three quarters of Japanese adults reported having had a health checkup in the past year (71.3%) compared to only half all Other Pacific Islander adults (52.3%).(100) These differences in healthcare seeking behaviors across sociodemographic characteristics may in turn lead to diagnostic disparities, and in turn, awareness of underlying risk factors for other chronic conditions.

Adults who are unaware of their hypertension or other health conditions that increase the danger of diabetes occurrence may in turn be less likely to be identified as being "at risk" for diabetes when using diabetes risk calculators. Thus, a differential misclassification bias is suspected to impact the assessment of risk for diabetes in Hawaii (based on the use of the risk score), with several individuals at high risk for diabetes not being categorized as being at high risk because of differences in knowledge of undiagnosed risk factors.(83)

Beyond the scope of the current study, this type of differential misclassification seriously compromises the utility of diabetes risk assessment tools available to the general public, as they may provide false reassurance to individuals at risk and further widen the gap in awareness of risk for diabetes between individuals who maintain frequent contact with the health system and those who do not. Nevertheless, the promotion of online calculators and simple paper and pencil risk score tests to help adults without diabetes assess their risk for diabetes has become a popular public health strategy employed by federal, state and non-profit organizations alike.(75, 101, 102) In fact, the Hawaii State Department of Health launched the 'Prevent Diabetes' campaign in 2017 to promote the diabetes risk test as a strategy to increase awareness of the state's risk for diabetes.(102)

As noted earlier, based on the diagnosis-based indicator of diabetes risk one in five adults were at high risk for diabetes in Hawaii. These data were at odds with the risk-score based indicator, which found half of all adults to be at risk for diabetes. It is unclear what proportion of those who did not appear to be at risk using the diagnosis-based indicator were actually not at risk for diabetes. Based on the risk-score based indicator, nearly half (45%) of those classified as not being at risk for diabetes based on the absence of a diagnosis were actually at high risk for diabetes based on their risk score. A review of the methodology used to derive the diagnosed risk for diabetes once again provides a plausible explanation for why the diagnosed risk for diabetes indicator only identified a fraction of adults who may truly be at risk for diabetes in Hawaii: undiagnosed pre-diabetes. With a statewide prevalence of 14.0%, the prevalence of diagnosed pre-diabetes was significantly higher among Japanese adults, older adults, and those with greater financial wellbeing (16.9% and 17.4% among those who saved money or got by financially versus 8.5% among those who spent their savings in the past year).

Similar to hypertension (in fact, to an even larger extent) pre-diabetes prevalence is also impacted by differential misclassification bias. Nationally, 86 million people may be impacted by pre-diabetes, but up to 90% of adults may be unaware of their condition.(103) In Hawaii, the prevalence of pre-diabetes may be as high as 41.0%, affecting 442,000 adults in the state.(53) A prevalence proportion of 14.0% therefore indicates that the majority of cases in Hawaii remain undiagnosed at this time. Hawaii BRFSS data (2011-14) reveal variations in diabetes screening by race-ethnicity ranging from 67.2% among Caucasians to 48.0% in Other Pacific Islander adults; rates of screening were highest among adults with a greater household income.(104) These data provide context for the prevalence and demographic correlates of pre-diabetes in Hawaii.

Therefore, both indicators of diabetes risk (one based on the risk score, and the other based on a diagnosed risk for diabetes) were imprecise and impacted by unawareness of risk factors and underlying chronic conditions. Between the two, having a diagnosed risk for diabetes was more likely to confound the association between weight status perception and diabetes risk perception in Study 2 than diabetes risk ascertained based on the risk score. First, the positive predictive value of the indicator (diagnosed risk for diabetes) was high because those who had received a diagnosis from a healthcare provider were considered to be truly at risk for diabetes; the PPV of the risk-score based indicator was unknown. Studies of the ADA diabetes risk calculator, from which the risk score-based indicator was adapted suggests a relatively low PPV of 57% for the detection of pre-diabetes.(105) Next, in terms of which of the two indicators affected the outcome analyzed in Study 2 (diabetes risk perception), diagnosed risk for diabetes was the clear choice: the indicators used to derive the risk-score based indicator were already included in the model as individual risk factors. It was also anticipated that having a health care provider rendered diagnosis of one or more conditions directly associated with increased risk for diabetes likely influenced the respondent's awareness of and perception of risk for diabetes. Further, other papers have expressed concerns over inconsistent findings across studies that may have resulted from the potential confounding effect of unmeasured diabetes risk awareness on the relationship between actual and perceived risk.(63) Therefore, having a diagnosed risk for diabetes was included as a potential confounder in the model, because those who were diagnosed as being at risk for diabetes were more likely to be aware of their risk for diabetes and were presumed to also be more likely to perceive themselves to be at risk for diabetes, regardless of their weight status or their weight status self-perception.

Perceived Risk for Diabetes

Other studies have reported on actual versus perceived risk for diabetes.(64, 65, 106, 107) 'Actual risk' has been operationalized differently across several studies for example; one study used blood tests to ascertain risk, whereas another used risk scores based on self-reported risk assessment surveys as a proxy. Moreover, population demographics varied significantly across these studies making direct comparisons problematic. Despite these differences, in general most studies report lower than ideal diabetes risk perception among participants at high risk for diabetes.(106, 107) Indeed, a population-based study conducted in Holland reported 8.1% of subjects at low risk for diabetes perceived themselves to be at risk compared to 10.8% of those at high risk.(106) Another study of diabetes risk perception in an African American sample found that 55% of participants at risk for diabetes perceived themselves to be at risk compared to 36% of those who were not at risk.(66) In the latter study, a third of participants who did not believe themselves to be at risk were actually at high risk for diabetes.(66)

In our research, the use of the modified ADA diabetes risk assessment as the "gold standard" of actual risk was problematic because a differential bias in having a diagnosed risk for diabetes was noted. Therefore, having a diagnosed risk for diabetes (defined as having an actual diagnosis with pre-diabetes, gestational diabetes, gestational pre-diabetes, a doctor warning of risk for diabetes, or diagnosis with another chronic condition that the respondent felt put them at risk for diabetes) was used as the real, diagnosed risk. The majority (76.0%, 95% CI 64.6-87.4%) of those with a diagnosis-based risk for diabetes perceived themselves to be at risk for diabetes compared to 37.2% (95% CI 31.1-43.2%) of those without a diagnosis-based risk for diabetes (data not shown). Even after adjusting for weight status perception and other demographic covariates, those with a diagnosis-based risk for diabetes were twice as likely as those who did not have a diagnosed condition (PR: 1.97, 95% CI 1.58-2.45) to perceive themselves to be at risk for diabetes.

Another key predictor of diabetes risk perception identified by other studies is having a family history of diabetes.(63-65, 107, 108) The findings of this study supported the literature. In the final model, even after adjusting for diagnosed risk for diabetes, BMI category, other confounders and demographic covariates, having a family history of diabetes remained associated with diabetes risk perception. Adults with a family history of diabetes were 77% more likely to perceive themselves to be at risk (95% CI 1.39-2.24). Although the directionality of the impact of family history matched that seen in the literature, other studies have reported a larger effect size of family history: for example, studies have reported an approximate 2-4 fold increase in perceived risk for diabetes associated with having a family history of diabetes.(64, 65) The difference in the relative impact of family history of diabetes on diabetes risk perception may be attributable to several reasons. For example, most studies have typically asked about family history of diabetes focused on parents and siblings, not including extended family. The HHI survey question was worded more broadly, counting children and grandparents among immediate blood relatives. The impact of the wording may have been to increase the prevalence of family risk for diabetes, while diluting the relationship between the variable and diabetes risk perception. Another explanation may be that the study that found a four-fold difference used college students as its study population;(107) it may be true that family history is more strongly associated with perceived risk for diabetes among younger demographics. The population based study that assessed the impact of family risk reported a two-fold difference, which more closely matches the findings reported in the present study.(64)

Studies of diabetes risk perception have identified several demographic covariates that appear to be significantly associated. One example is the association between perception of risk and age: in one study, perception of risk decreased with age. Among those at high risk for diabetes, 15.5% of 50-54 year olds compared to 6.6% of 70-74 year olds considered themselves to be at risk for diabetes.(108) Similarly, our current study found increasing age to be associated with decreased risk perception. A plausible explanation for this association is based on the "accuracy hypothesis theory." This theory suggests that individuals may alter their perception of risk based on receiving accurate information.(62) Because older adults are more likely to be screened for diabetes, they may be more likely than younger adults to be aware of their real risk. Therefore, after adjusting for diagnosed risk for diabetes based on diagnosis with one or more conditions that are directly associated with increased risk for diabetes risk, older adults may correctly identify themselves to be at lower risk, as opposed to younger persons who may be in a medical advice 'vacuum.'

Being obese, having higher body fat, having a diagnosis of metabolic syndrome and having poor general health are all factors associated with greater perception of risk for diabetes.(63-65) Herein, even after adjusting for having a diagnosed risk for diabetes, individuals in higher BMI categories were more likely to perceive themselves to be at risk, which supports and is supported by the findings of other studies.(63-65) In fact, overweight individuals were nearly 50% more likely, and obese individuals were more than twice as likely to perceive themselves to be at risk for diabetes. However, no other study has assessed the association of weight status perception with diabetes risk perception after adjusting for BMI categories. Based on the findings of the current study, even after adjusting for BMI category, weight status perception is significantly associated with diabetes risk perception in both directions. Those who overperceive their weight are 42% more likely to perceive themselves to be at risk for diabetes, and those who underperceive their weight are 24% less likely to perceive themselves to be at risk. Therefore, weight status perception confounds the relationship between BMI category and diabetes risk perception. The addition of weight status perception to the model increases the prevalence ratio estimate of the association between being overweight and diabetes risk perception by 21.2% and that between being obese and diabetes risk perception by 27.8% (data not shown).

One investigation that assessed perceived risk for diabetes among college students reported that, in general, self-perception of risk for diabetes is low, but women are more likely to perceive themselves to be at risk than men.(107) After adjusting for actual weight status, weight status perception, having a diagnosis-based risk for diabetes, and other demographic covariates, this report did not find the same associations between sex and diabetes risk perception as previously reported.(107) The association was absent even in the univariate models. It is likely that differences in the study populations account for these discrepancies. Other correlates of diabetes risk perception include experiencing diabetes symptoms such as increased thirst.(107) This risk factor was not included in the current study, as data on reasons for perceiving themselves to be at risk (such as experiencing excessive thirst) were only collected among those who reported perceiving themselves to be at risk for diabetes.(107, 108)

Diabetes Screening

The third and final study in this doctoral dissertation assessed prevalence, demographic correlates and predictors of diabetes screening. A substantial proportion of adults in the state of

Hawaii (57.1%) report having been screened for diabetes within the past three years, with higher screening prevalence among older age groups. No other demographic covariate was significantly associated with diabetes screening in the HHI Survey. This finding appears to contradict data reported elsewhere. For example, Hawaii BRFSS data suggests significant disparities in diabetes screening by race-ethnicity, with the highest screening prevalence reported among Japanese adults, and lowest reported among Filipino and Other Pacific Islander adults in Hawaii.(104) Similar patterns were noted in the current study, with screening prevalence ranging from 49.3% among Filipinos to 64.4% among Japanese (Other Pacific Islander adult screening prevalence could not be assessed, as this group had been folded in with Native Hawaiians for the current study due to sample size). However, the differences noted in the HHI survey did not meet criteria for statistically significant differences between race-ethnicity groups. In the final multivariable models, the 95% confidence intervals of the associations spanned 1.00, although it appeared that non-White race-ethnicities in Hawaii were, in general, less likely to receive screenings for diabetes. The explanation could be one of inadequate sample size; a larger sample size, and/or several years of combined data may be needed, as is feasible with the BRFSS, to obtain more precise estimates that discern true differences in screening prevalence by race-ethnicity. Nonetheless, the patterns observed closely match the disparities in diabetes screening across race-ethnicity groups in Hawaii reported in other studies.(55) On the other hand, the findings of the current study do not corroborate findings of national studies that find Asian populations to have substantially lower prevalence of screening for diabetes.(58)

The key hypotheses tested in the third study were:

Hypothesis 1: After adjusting for demographic characteristics and potential confounders, there is an association between diabetes risk perception and screening for diabetes.

Hypothesis 2: After adjusting for demographic characteristics, potential confounders, and diabetes risk perception, there is an association between weight status perception and screening for diabetes.

Based on the findings of Study 2, it was established that a diagnosis with pre-diabetes, gestational diabetes or gestational pre-diabetes, or another condition that the respondent associated with increased risk for diabetes was strongly and significantly associated with diabetes risk perception. Also, individuals diagnosed with pre-diabetes, gestational diabetes, or gestational pre-diabetes were likely identified with their conditions through screening, and were expected to have a significantly higher prevalence of diabetes screening within the past three years compared to those without a diagnosis indicative of higher risk for diabetes.(55) Therefore, it was expected that diagnosed risk for diabetes would confound the relationship between diabetes risk perception and screening. Because our goal was to determine the relationship between diabetes risk perception and screening, and within that to identify predictors of screening among populations at risk for diabetes (that may not be aware of their diabetes or pre-diabetes status), we restricted the logistic regression analysis to adults without gestational diabetes or pre-diabetes; in turn, this decision reduced the sample size and the precision of estimates in the final model.

In addition to demographic characteristics, covariates included in the screening model included a diagnosis with a diabetes-related chronic condition (including hypertension). Given that diagnosis with chronic conditions such as metabolic syndrome are associated with greater diabetes risk perception, based on the literature review, it was of interest to ascertain whether a diagnosis with another chronic condition that is closely associated with risk for diabetes, such as hypertension, would also be associated with increased screening, and potentially confound the relationship between perceived risk for diabetes and screening. The analysis found that after adjusting for other covariates, having a diabetes-related chronic condition was retained in the model, but the 95% confidence interval of the estimate overlapped 1.00. Nevertheless, it appears that individuals who had a diabetes-related chronic condition were 20% more likely to be screened for diabetes than those who did not have such diagnosed conditions (PR 1.20, 95% CI 0.94-1.53). Because of the exclusion criteria, chronic conditions that were more strongly associated with diabetes, such as pre-diabetes or gestational diabetes, were not included among the diabetes-related chronic conditions tested. Therefore, the weak association is not surprising. Nevertheless, further studies are needed to understand whether the lack of a statistically significant association in this study is also attributable to a Type II error, or if a relationship does not exist between being diagnosed with a related chronic condition such as hypertension and receipt of diabetes screening.

Other potential confounders tested in the model were meeting USPSTF criteria for screening and the presence of a family history of diabetes. Both variables were retained in the final model. Meeting USPSTF criteria for screening was not strongly associated with diabetes screening within the past three years even in the univariate model. After adjusting for BMI category and age group, the two variables that were used to create the composite 'meeting USPSTF screening criteria' variable, the association was weak, and the confidence interval overlapped 1.00. In the final model, individuals who met USPSTF screening criteria were less likely to receive diabetes screening (PR 0.82, 95% CI 0.53-1.28). Because of the wide confidence interval, this finding is uninterpretable. Further studies are needed to assess the impact of the USPSTF recommendations on the receipt of screening for various chronic conditions in US populations.

The other confounder considered, family history of diabetes, has been associated with screening in other studies.(67) In one study, family history remained associated with diabetes screening even after adjusting for diabetes risk perception, with adults having a family history of diabetes being more likely to obtain screenings for diabetes.(67) In the present study, family history of diabetes and receipt of diabetes screening were not associated (PR 1.01, 95% CI 0.79-1.28); the same was true in the univariate models prior to adjusting for other variables. The finding is interesting and requires further exploration.

After adjusting for age, which remained strongly associated with diabetes screening, and other covariates, diabetes risk perception was significantly associated with diabetes screening. Those who perceived themselves to be at risk for diabetes were more likely to be screened for diabetes. Therefore, the first null hypothesis is rejected. Other findings requiring further confirmation include: an association between weight status perception and diabetes screening, with the findings of the current study suggesting that weight status overperception may be associated with greater likelihood of being screened for diabetes; the relationship between BMI category and diabetes screening, with the current study supporting the plausibility that overweight individuals are more likely, whereas obese individuals are less likely after adjusting for weight status perception and other correlates, to be screened for diabetes; the association between race and diabetes screening, with the current study suggesting that non-White race ethnicities have lower prevalence of being screened for diabetes after adjusting for other covariates; and the relationship between diabetes screening and county of residence, with the findings of the present study suggesting that residents of our Neighbor Island counties are less likely to report having been screened for diabetes within the past three years compared to those living in Honolulu County. These findings require further exploration and confirmation, as the

95% confidence intervals spanned 1.00 for the associations observed. The explanation for the wide confidence intervals is probably related to sample size: adequate numbers of respondents through a larger sample size, and several years of combined data may be needed to obtain more precise estimates that discern true differences in screening prevalence by the variables noted here. The third study suffered the largest reductions in sample size, as several exclusion criteria were applied to the study population. Since the associations between weight status perception and receipt of diabetes screening within the past three years were imprecise and spanned 1.00 in the final model, the second null hypothesis could not be rejected.

Multivariable Models

The variables included in Study 1 that were retained regardless of whether they met criteria for retention included BMI Category, age group, sex, race-ethnicity, and educational status. Study 1 included all adults in the survey with valid responses for all the indicators included in the model. The association between educational status and weight status perception requires further exploration, since the 95% CI of the prevalence ratio estimate overlapped 1.00. Associations between the remaining variables and weight status perception were found.

The variables included in Study 2 retained regardless of meeting criteria included all the variables discussed for Study 1, along with diagnosed risk for diabetes, a diagnosis of hypertension, and having a family history of diabetes. Study 2 narrowed Study 1's population to adults without a history of diabetes. The association between a diagnosis of hypertension and diabetes risk perception, as well as that between age group and sex and diabetes risk perception requires further exploration. Other variables that were retained in the model to test associations previously reported in the literature (race-ethnicity, BMI category, diagnosed risk for diabetes, and family history of diabetes) were also found to be associated with diabetes risk perception in

Study 2. After adjusting for these covariates and confounders, weight status perception was associated with the outcome variable.

The model in Study 3 included the variables in Study 1, along with having a diabetes-related chronic condition, meeting USPSTF criteria for screening, and having a family history of diabetes: this subset of variables were retained in the final model and not subject to exclusion criteria. Study 3 narrowed Study 2's population to adults without a diagnosis of pre-diabetes or gestational diabetes. Only age group and diabetes risk perception appeared to be definitively associated with receipt of diabetes screening within the past three year. Sex and having a family history of diabetes did not appear to be associated. The relationships between receipt of diabetes screening and race-ethnicity, BMI category, educational status, and the remaining two covariates included (having a diabetes-related chronic condition and meeting USPSTF criteria for screening) require further exploration, as the 95% confidence intervals for the estimates for these associations overlapped 1.00.

Overall Findings and Implications

Study 1 assessed the relationship between BMI category (based on self-reported weight) and weight status perception. Study 2 evaluated the relationship between being at risk for diabetes and diabetes risk perception, in turn assessing if weight status perception was associated with diabetes risk perception after adjusting for diabetes risk. Study 3 determined whether diabetes risk perception and weight status perception were associated with diabetes screening. Taken together, the analyses conducted across all three studies demonstrated that heavier individuals are more likely to misperceive their weight status; weight status overperception and underperception have opposite impacts on diabetes risk perception; and diabetes risk perception impacts screening for diabetes, and ultimately, they both together and independently affect awareness of diabetes risk. Awareness of one's perceived vulnerability to risk, and acknowledgement of that risk is a necessary precursor to preventive action.(109) Individuals who accurately perceive their risk for a condition are more likely to seek care, follow medical advice, and engage in preventive behaviors associated with reducing risk. (109) The behavior motivation hypothesis suggests that awareness of elevated personal risk prompts personal change.(62)

For people at high risk for diabetes, the National Diabetes Prevention Program (NDPP) is a promising, evidence-based lifestyle change intervention that is touted to reduce the risk of developing diabetes by up to 58%.(110) Accordingly, substantial public health efforts in recent years have focused on increasing the number of CDC-recognized Diabetes Prevention Programs (DPPs) nationwide, and enhancing enrollment of eligible patients in DPPs.(103) A key step in increasing enrollment is enhancing the pool of eligible participants through diabetes screening and identification of those with pre-diabetes.(111) With effective interventions available, efforts are needed to identify and address potential contributors to gaps in screening for diabetes. However a key barrier to enrollment in lifestyle change programs may be low risk perception.

The findings of these inter-linked studies suggest that weight status misperception, which has grown in concomitance with the rising obesity epidemic in the US, is associated with diabetes risk misperception. In turn, diabetes misperception is associated with lack of screening for diabetes. Critically, weight status misperception occurs in both directions; but underperception of weight status is far more prevalent, and significantly associated with BMI category. This is a worrying public health issue because individuals with higher weight statuses who are at greater risk for chronic diseases are also more likely to underperceive their own weight status. Weight status misperception is also significantly associated with diabetes risk perception. Respondents who oveperceive their weight are more likely to perceive themselves to be at risk for diabetes, whereas those who underperceive their weight are less likely to see themselves as being at risk for diabetes compared to those who accurately perceive their weight status. As such, individuals in higher weight categories who underperceive their weight status are also less likely to perceive themselves to be at risk for diabetes. Finally, diabetes risk perception is significantly associated with receipt of screening for diabetes. Individuals who do not perceive themselves to be at risk for diabetes are less likely to be screened. Taken together, the findings point to additional implications of the obesity epidemic: that due to visual normalization,(16) the obesity epidemic has promoted weight status underperception wherein individuals fail to accurately perceive their own weight status, and as a result, are less likely to perceive their risk for serious chronic conditions such as diabetes, and by extension, are less likely to engage in secondary prevention activities that increase the likelihood of early detection and better management of these chronic conditions. In turn, they are expected to be less likely to seek out preventive interventions such as lifestyle change programs that may reduce their risk for diabetes.

A key unmeasured factor in the studies presented in this dissertation is the extent to which weight status misperception and the visual normalization theory additionally impact healthcare providers and the health system in general. Healthcare providers are also susceptible to visual normalization.(16) One study of general practitioners (GPs) in Australia found that GPs have a low sensitivity for detecting overweight and obesity among their patients; only 63% were able to subjectively identify overweight or obese patients relative to actual BMI classification based on objective measures of height and weight.(112) Also, potentially due to a bias towards sicker patients who access the health system,(113) patients self-perception of weight status had greater sensitivity than their GPs.(112) These findings are well corroborated. A study of healthcare providers in Germany suggested that doctors underperceived weight status of the majority (70-80%) of their overweight and between 35-50% of their obese patients.(114) A study out of the US reported poor documentation and under-recognition of overweight and obesity by healthcare practitioners despite obese patients and those with comorbid chronic conditions having a higher odds of having their BMI properly documented, and their obesity included in their problem list.(115) Therefore, healthcare providers are subject to weight status misperception, and evidence exists to suggest that they may be even less able than patients to accurately identify overweight and obese patients. Weight status underperception among healthcare providers may, in turn, decrease recommendations for screening, lifestyle change interventions, and other key preventive health recommendations. This is, potentially, a key area for intervention.

The issues surfaced as a result of the findings presented herein are complex and require careful consideration. On the one hand, as noted previously, weight status underperception is associated with greater wellbeing and quality of life, and a reduced likelihood of eating disorders.(43, 45) On the other hand, misperception reduces motivation for and attempts at weight loss, and exacerbates misperceptions of risk for the sequelae of obesity, including diabetes.(17, 46-49) However, while increased risk perception is associated with more worry related to developing diabetes, and based on the findings of the current study, a greater likelihood of being screened for diabetes, it has not been associated with greater motivation to adopt healthy lifestyles or engage in weight loss behaviors.(63, 65) In fact, those who have a higher perceived risk for diabetes have lower self-efficacy for, and intention to engage in recommended weight loss behaviors, including physical activity and diet.(63, 65) In other words, although a lack of awareness and misperception reduces motivation for health behaviors, an increase in awareness and accurate perception of diabetes risk does not necessarily increase motivation for health behaviors. Therefore, it is important to carefully consider the context and impact of reducing weight status misperception among individuals who are overweight or obese, as it needs to be done in a way that enhances motivation to engage in risk reduction behaviors, such as attempts at weight loss and increased physical activity.

It has been demonstrated that physician diagnosis of overweight is significantly associated with weight loss attempts and successful weight loss by patients.(116) Another study conducted in the context of a DPP suggested that weight status underperception was associated with significantly higher weight loss at three months.(117) These studies suggest that adults who underperceive their weight status are more likely to undergo a critical adjustment of their perceived risk for chronic conditions in response to a corrective encounter with their healthcare providers, and be 'alarmed into' weight loss attempts and successful weight loss as a result.(117) Such findings provide hope and reinforce the important role that healthcare providers can play in correcting weight status misperception and catalyzing lifestyle change that reduce patients' risk for diabetes and other chronic conditions. They also suggest that setting and context within which weight status misperception is identified and addressed may critically impact outcomes. Greater communication of actual weight status and risk for diabetes within the healthcare setting, especially when tied to supportive programs for lifestyle change that provide education and resources to enhance patient self-efficacy, may help correct misperceptions of risk while simultaneously overcoming self-efficacy barriers patients typically experience to engagement in healthy behaviors. In turn, corrections of misperception tied to lifestyle change supports may help propel patients at risk towards self-awareness of diabetes risk and generate a positive and healthful response directed towards reducing their risk.

Limitations

There are several acknowledged limitations to these studies. Firstly, a critical parameter assessed herein is BMI, and not body fat, which is a more accurate measure of risk for diabetes.(118) Attempts have been made to correct for BMI based on what is known about the relationship between body fat and BMI in the literature, for example by developing race-specific cutoffs that account for higher body fat prevalence at lower BMIs among some race groups.(8) While any and all corrections are likely to increase accuracy, BMI will always remain, at best, a satisfactory proxy for body fat when assessing risk for diabetes and other disorders caused by overweight and obesity. Further, several sources of error could not be completely corrected. For example, Hawaii is a multicultural population with a substantial proportion of individuals identifying with two or more races. Therefore, the practice of using single race-ethnicity groupings that individuals self-identify with to determine Asian sub-groups is inherently limiting.(119) Secondly, the literature has documented the need to apply different BMI cutoffs across various Asian sub-groups;(8) therefore, a single set of threshold cutoffs used to re-categorize all Asian groups represents a compromise that may be expected to underestimate or overestimate actual body fat across various Asian subgroups in Hawaii.

Third, the use of self-measured BMI rather than objectively measured BMI is a clear limitation; other reports have shown that people routinely underestimate weight and over-report height in healthy surveys.(22) Therefore, the "objective" weight categories into which individuals are classified may still systematically underestimate the true prevalence of overweight and obesity in the state of Hawaii, and in turn underestimate the true prevalence of weight status misperception. Moreover, underreporting of weight may occur to different extents across different groups, resulting in differential misclassification bias. Fourth, it is unclear what standards respondents applied when describing their perceived weight status. Respondents may have used other adults in their environment, standards on television, and in some cases, objective clinical standards. Therefore, the reasons for misperception of weight cannot be fully explained.

We also need to acknowledge limitations of the survey, as they apply to this study. For example, the survey design deviated in several ways from the BRFSS, as noted in depth earlier. Therefore, findings of the study may not mirror that found in other national surveys. The sample size was significantly smaller than the typical sample sizes of the BRFSS in Hawaii, resulting in larger confidence intervals. In turn, the sample size may limit the precision of estimates and reduce the extent to which associations may be used for public health, policy, or clinical intervention planning. Some key questions that would have helped with the analysis of the current study (pregnancy status among women, and time since most recent health checkup) were not included.

Other limitations of phone-based survey designs apply to this study: first, population-based telephone surveys suffer from non-response bias.(120) The HHI survey had comparable response rates to the Hawaii BRFSS, but the overall response rate of 38.8% is still low. All adjustment techniques are predicated on the assumption of comparability of respondents and non-respondents, when in fact this assumption may not be true and systematically bias the data towards adults who are more likely to participate in telephone surveys.(120) Next, response patterns vary by survey modality.(121) Therefore, the findings of the study may vary if the same survey was administered via a different modality (for example, online, or paper and pencil). Poorly understood questions may generate invalid responses, although to the extent possible, the survey used for our investigations drew from questions previously validated in other national and international surveys that are likely to be safe and accurate.(70, 73, 74, 77, 80, 81) Other considerations include potential social desirability bias in reporting weight, and recall bias in reporting other health behaviors.(122) To the extent possible, the sequence of questions was carefully designed to prevent questions from being ordered in a way that might lead the respondent towards a certain response. However, the possibility remains that regardless of question order, the question itself elicited a socially desirable response from the respondent.

Finally, because the survey design is cross-sectional in nature, causal inferences made may be tenuous, and need further verification.(123) For example, studying the relationship between risk perception and behavior is ideally conducted in a longitudinal study where causality between risk perception and engagement in a particular health behavior (e.g., screening for diabetes) can be assessed with greater certainty based on the perception of risk occurring prior to the studied behavior. Also, as an observational study, despite statistical adjustment for underlying differences in demographics, residual confounding from a variety of sources including variables that could not be included in the analyses, within-category heterogeneity of covariates, misclassification of potential confounders, or other measurement error may have persisted.

CONCLUSION

All observational studies have limitations. Nevertheless, the series of studies conducted as part of this PhD dissertation have important findings and implications. First, they conclude that weight status misperception is common, and adults in higher BMI categories are more likely to misperceive their weight status. Even after accounting for BMI category, adults in certain sociodemographic groups, including those who identify as Native Hawaiian and Other Pacific Islander, males, younger adults and those who have ever served in the US military are more likely to underperceive their weight status. The greater likelihood of weight status misperception among younger adults, males and those with lower educational attainment has been documented extensively. The findings of increased weight status misperception among Native Hawaiians and Other Pacific Islanders is new, but reflects the underlying higher obesity prevalence in this population and aligns with the visual normalization theory. Further studies are needed to corroborate the finding of greater weight status misperception among those who have ever served in the US Military.

Next, the studies conclude that weight status misperception is associated with diabetes risk perception in both directions. Those who overperceive their weight status are more likely to perceive themselves to be at risk for diabetes and vice versa. The relationship between weight status perception and diabetes risk perception has not been reported elsewhere. Other factors associated with diabetes risk perception, including BMI category, prior diagnosis of diabetes risk based on conditions such as pre-diabetes and gestational diabetes, and having a family history of diabetes, have been reported in other studies and were corroborated by findings of the current analyses. Finally, diabetes risk perception is associated with receipt of diabetes screening with the past three years, with those who perceive themselves to be at greater risk also more likely to have been screened for diabetes. Separately, age is also strongly associated with screening with older adults being more likely to be screened for diabetes. Some associations reported in the literature could not be confirmed by the analyses conducted herein because of small sample sizes resulting in wide confidence intervals; other associations supported by the literature were not corroborated. Further studies with larger sample sizes may be needed to confirm these findings.

The series of studies presented in this dissertation provides insight into the impact of the obesity epidemic on weight status perception, diabetes risk perception, and diabetes screening in Hawaii. Viewed from the theoretical frame of the visual normalization theory, the findings suggest that the obesity epidemic has obscured accurate self-perceptions of weight, which in turn may affect perception of risk for diabetes and subsequent strategies to mitigate that risk via secondary prevention efforts such as receipt of regular diabetes screenings. The findings reveal that overweight and obese adults are at significant risk of underperceiving their weight, and in turn, misjudging their risk for diabetes. As a result, those who underperceive their weight status and risk for diabetes are also less likely to be screened, and less likely to take advantage of key health interventions that are able to reduce their risk for diabetes. Although healthcare providers are equally subject to weight status misperception, they may play a key role in intervening and correcting weight status misperception among adults with overweight and obesity, with a corresponding impact on behavioral change resulting in improved health outcomes. The study represents the first analysis of weight status perception and its impact on diabetes risk perception and diabetes screening among adults in Hawaii.

NEXT STEPS

Future studies need to further corroborate the relationship between weight status perception and diabetes risk perception, as well as that between diabetes risk perception and screening. Studies on larger samples are needed in Hawaii to confirm some findings, or lack thereof, reported here. The unique findings reported herein require further verification, namely, the higher prevalence for weight status misperception among Native Hawaiians and Other Pacific Islanders as well as those who have ever served in the US military; the relationship between overperception of weight status and greater perception of risk for diabetes; conversely, the relationship between underperception of weight status and lower perception of risk for diabetes; and the relationship between diabetes risk perception and screening. Larger studies are also needed to obtain more precise estimates of the relationship between weight status perception and diabetes screening; race-ethnicity and diabetes screening; and having one or more diabetes-related chronic conditions and receipt of diabetes screening. The findings of the studies conducted herein need to be used to plan public health interventions that carefully consider how to increase self-awareness of weight status and diabetes risk among adults at risk in a way that positively impacts the obesity and diabetes epidemics.

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TABLES

Table 1: Survey Response Rate Calculation

	Landline	**Cellphone**
Eligibility Factor	0.43	0.23
Resolution Rate	58.9	47.9
Interview Completion Rate	74.9	89.3
Cooperation Rate	64.6	86.7
Refusal Rate	10.8	5.0
Response Rate	32.2	41.5
Total Sample	5,944	14,743
Proportion of the Overall Sample	0.29	0.71
Weighted response rate	38.8	

Table 2: Classification of Weight Status Perception Based on Respondent's Body Mass Index Category and Self-Perceived Weight Status

BMI Category	**Underweight**	**Healthy Weight**	**Overweight**	**Obese**
Very underweight	Accurate	Under-perception	Under-perception	Under-perception
Slightly underweight	Accurate	Under-perception	Under-perception	Under-perception
About the right weight	Over-perception	Accurate	Under-perception	Under-perception
Slightly overweight	Over-perception	Over-perception	Accurate	Under-perception
Very overweight	Over-perception	Over-perception	Over-perception	Accurate

Table 3: Demographic Distribution of the Sample, Including Unweighted and Weighted Numbers and Prevalence, and Missing Data for Each Variable

Variable	**n**	**N (Weighted)**	**Weighted % (95% CI)**	**Missing (N, %)**
Age Group				22, 1.4%

	18-39 years	278	419,637	39.1% (33.2-45.0)	
	40-49 years	182	175,751	16.4% (12.2-20.5)	
	50-59 years	298	182,580	17.0% (13.3-20.6)	
	60-69 years	436	156,224	14.5% (11.4-17.6)	
	70+ years	386	140,182	13.0% (10.2-15.9)	
Sex					0, 0%
	Male	731	544,140	50.1% (44.5-55.7)	
	Female	871	541,975	49.9% (44.3-55.5)	
Race					18, 1.1%
	White	735	327,674	30.4% (25.9-34.9)	
	Native Hawaiian and Other Pacific Islander	274	223,653	20.7% (15.8-25.6)	
	Filipino	147	175,226	16.2% (11.5-21.0)	
	Japanese	284	182,502	16.9% (12.9-20.9)	
	Other	144	169,708	15.7% (11.1-20.4)	
Educational Status					4, 0.2%
	High school graduate or less	432	426,677	39.3% (33.6-45.1)	
	Some College	453	364,160	33.6% (28.1-39.0)	
	College Graduate	713	294,015	27.1% (23.0-31.2)	
Country of birth					1, 0.1%
	US Born	1397	867,756	79.9% (74.8-85.0)	
	Foreign Born	204	217,706	20.1% (15.0-25.2)	
County					3, 0.2%
	Honolulu	463	759,568	70.0% (66.5-73.4)	
	Hawaii	487	152,783	14.1% (11.6-16.6)	
	Kauai	327	52,896	4.9% (3.9-5.9)	
	Maui	322	120,269	11.1% (9.2-13.0)	
Financial Health (During Past Year)					55, 3.4%
	Saved money	596	371,715	35.1% (29.9-40.3)	
	Just got by	517	402,499	38.0% (32.3-43.7)	

	Spent savings	253	134,480	12.7% (9.4-16.0)	
	Spent savings and borrowed money	181	150,458	14.2% (9.8-18.6)	
Federal Poverty Level					156, 9.7%
	0-100% FPL	178	176,293	18.1% (13.5-22.7)	
	101-185% FPL	268	239,859	24.6% (18.8-30.4)	
	186%+ FPL	1000	557,860	57.3% (51.3-63.3)	
Military (Ever Served)					0, 0%
	Yes	249	134,516	12.4% (9.1-15.6)	
	No	1353	951,599	87.6% (84.4-90.9)	
Receiving SNAP[†] benefits					6, 0.4%
	Yes	177	179,849	16.7% (12.0-21.4)	
	No	1419	898,768	83.3% (78.6-88.0)	

[†]Supplemental Nutrition Assistance Program

Table 4: Prevalence of Healthy Weight, Overweight and Obesity in Hawaii, Including Demographic Distribution Using Standard Body Mass Index Cutoffs

		Underweight	Healthy Weight	Overweight	Obese	χ^2	P-value
Variable		**% (95% CI)**	**% (95% CI)**	**% (95% CI)**	**% (95% CI)**		
Overall		**n/r[†]**	**43.1% (37.4-48.8)**	**26.3% (21.7-30.9)**	**28.3% (22.9-33.6)**	536.86	<0.0001
	Obesity Grade I				17.9% (13.1-22.7)		
	Obesity Grade II				5.3% (2.9-7.6)		
	Obesity Grade III				5.1% (2.5-7.7)		
Age Group						67.36	0.0653
	18-39 years	n/r	41.2% (30.2-52.1)	21.7% (13.3-30.0)	**34.7% (23.8-45.5)**		
	40-49 years	n/r	40.9% (26.2-55.7)	26.0% (14.9-37.1)	31.1% (18.2-43.9)		
	50-59 years	n/r	42.8% (31.3-54.2)	31.1% (21.1-41.2)	25.7% (15.8-35.5)		
	60-69 years	n/r	40.9% (30.1-51.7)	36.2% (25.3-47.2)	21.8% (12.6-31.0)		
	70+ years	n/r	55.5% (44.2-66.7)	22.7% (15.6-29.7)	15.9% (8.4-23.5)		
Sex						26.25	0.1370
	Male	n/r	40.0% (31.0-48.9)	31.4% (23.9-38.9)	27.3% (19.8-34.8)		
	Female	n/r	46.3% (39.1-53.6)	21.2% (16.0-26.3)	29.2% (21.6-36.9)		

Race					162.21	<0.0001
White	n/r	**43.8% (36.4-51.3)**	29.6% (22.3-37.0)	25.3% (18.0-32.5)		
Native Hawaiian and Other Pacific Islander	n/r	18.4% (10.5-26.3)	31.8% (19.6-44.1)	**49.1% (35.1-63.1)**		
Filipino	n/r	**45.7% (28.9-62.4)**	20.9% (9.5-32.2)	29.2% (14.3-44.1)		
Japanese	n/r	**54.1% (41.3-66.9)**	22.8% (14.1-31.4)	19.2% (10.8-27.6)		
Other	n/r	**58.8% (43.1-74.4)**	22.5% (10.8-34.2)	n/r		
Educational Status					41.55	0.1184
High school graduate or less	n/r	34.6% (24.9-44.3)	27.8% (18.9-36.7)	34.8% (24.5-45.2)		
Some College	n/r	51.1% (40.9-61.3)	21.8% (15.2-28.4)	24.9% (16.6-33.3)		
College Graduate	n/r	45.7% (38.1-53.2)	29.5% (22.9-36.1)	23.0% (15.9-30.1)		
Country of birth					113.84	<0.0001
US Born	n/r	36.8% (31.1-42.6)	27.5% (22.5-32.5)	33.3% (27.1-39.4)		
Foreign Born	n/r	**67.8% (55.7-79.9)**	21.7% (11.2-32.2)	n/r		
County					25.01	0.0796
Honolulu	n/r	44.6% (36.9-52.4)	25.3% (19.1-31.4)	27.8% (20.6-35.0)		
Hawaii	n/r	41.3% (31.7-51.0)	22.8% (16.0-29.7)	35.1% (25.0-45.3)		
Kauai	n/r	35.2% (25.4-45.0)	**42.1% (31.1-53.2)**	21.6% (13.8-29.4)		
Maui	n/r	39.5% (31.3-47.7)	30.1% (22.7-37.4)	25.6% (17.9-33.3)		
Financial Health (During Past Year)					52.98	0.2289
Saved money	n/r	51.2% (42.3-60.0)	25.2% (17.6-32.7)	22.2% (15.2-29.2)		
Just got by	n/r	33.0% (23.4-42.6)	28.2% (20.0-36.3)	36.8% (26.4-47.2)		
Spent savings	n/r	45.5% (31.6-59.4)	23.9% (12.4-35.4)	26.0% (15.3-36.8)		
Spent savings and borrowed money	n/r	44.0% (26.3-61.6)	27.6% (14.9-40.3)	n/r		
Federal Poverty Level					85.76	0.0038
0-100% FPL	n/r	33.6% (20.7-46.5)	n/r	43.2% (28.8-57.6)		
101-185% FPL	n/r	49.4% (34.8-63.9)	19.4% (10.2-28.7)	30.5% (15.9-45.1)		
186%+ FPL	n/r	40.7% (33.6-47.7)	32.5% (26.0-39.0)	25.0% (18.8-31.2)		
Military (Ever Served)					9.75	0.2982
Yes	n/r	33.7% (20.9-46.6)	32.4% (19.3-45.6)	33.8% (20.7-47.0)		
No	n/r	44.4% (38.2-50.7)	25.4% (20.6-30.3)	27.5% (21.6-33.3)		
Receiving SNAP[††] benefits					45.30	0.0486

	Yes	n/r	33.7% (18.1-49.3)	18.6% (7.7-29.4)	44.8% (28.7-61.0)		
	No	n/r	45.1% (39.0-51.2)	27.9% (22.9-32.9)	24.8% (19.3-30.2)		

†Not reportable
††Supplemental Nutrition Assistance Program

Table 5: Prevalence of Healthy Weight, Overweight and Obesity in Hawaii, Including Demographic Distribution Using Asian-Specific Body Mass Index Cutoffs As Appropriate

		Underweight	Healthy Weight	Overweight	Obese	χ^2	P-value
Variable		**% (95% CI)**	**% (95% CI)**	**% (95% CI)**	**% (95% CI)**		
Overall		**n/r†**	**34.0% (28.7-39.3)**	**31.2% (25.9-36.6)**	**32.4% (27.0-37.9)**	433.20	<0.0001
	Obesity Grade I				20.2% (15.3-25.1)		
	Obesity Grade II				6.1% (3.6-8.6)		
	Obesity Grade III				6.2% (3.5-8.9)		
Age Group						68.73	0.0797
	18-39 years	n/r	36.3% (25.8-46.7)	24.0% (14.3-33.7)	37.2% (26.4-48.1)		
	40-49 years	n/r	27.1% (16.4-37.9)	30.9% (15.7-46.0)	40.0% (26.2-53.8)		
	50-59 years	n/r	31.6% (20.9-42.3)	40.2% (29.0-51.4)	27.8% (17.8-37.8)		
	60-69 years	n/r	32.8% (22.4-43.2)	37.6% (26.7-48.4)	28.6% (18.6-38.6)		
	70+ years	n/r	40.8% (29.2-52.5)	34.3% (23.5-45.1)	18.9% (11.1-26.8)		
Sex						46.90	0.0188
	Male	n/r	28.2% (20.3-36.0)	38.2% (29.5-46.9)	32.3% (24.5-40.1)		
	Female	n/r	39.9% (32.9-47.0)	24.2% (18.7-29.7)	32.6% (25.0-40.2)		
Race						126.25	0.0044
	White/Caucasian	n/r	**43.8% (36.4-51.3)**	29.6% (22.3-37.0)	25.3% (18.0-32.5)		
	Native Hawaiian and Other Pacific Islander	n/r	18.4% (10.5-26.3)	31.8% (19.6-44.1)	49.1% (35.1-63.1)		
	Filipino	n/r	26.5% (12.1-41.0)	32.3% (16.0-48.6)	37.0% (21.5-52.4)		
	Japanese	n/r	27.1% (15.9-38.2)	38.3% (24.1-52.5)	30.6% (20.2-41.1)		
	Other	n/r	**49.5% (32.6-66.3)**	25.5% (13.5-37.5)	22.3% (9.5-35.1)		
Educational Status						23.99	0.4683
	High school graduate or less	n/r	27.2% (18.9-35.4)	33.7% (23.6-43.7)	36.4% (26.1-46.7)		
	Some College	n/r	39.7% (29.3-50.1)	27.6% (18.6-36.7)	30.5% (21.6-39.4)		

College Graduate	n/r	37.0% (29.9-44.1)	31.9% (25.1-38.8)	29.2% (21.7-36.7)		
Immigration Status					72.91	0.0008
US Born	n/r	30.1% (25.1-35.2)	30.2% (24.6-35.9)	**37.2% (31.1-43.4)**		
Foreign Born	n/r	49.2% (34.2-64.2)	35.3% (21.1-49.6)	13.7% (5.8-21.6)		
County					15.30	0.4082
Honolulu	n/r	33.4% (26.2-40.5)	31.9% (24.5-39.2)	32.4% (25.1-39.8)		
Hawaii	n/r	37.4% (27.8-47.0)	24.8% (17.8-31.8)	37.0% (26.9-47.1)		
Kauai	n/r	31.9% (22.3-41.5)	36.0% (25.3-46.8)	31.0% (21.3-40.7)		
Maui	n/r	35.0% (27.0-43.1)	33.0% (25.4-40.7)	27.1% (19.3-34.9)		
Financial Health (During Past Year)					42.22	0.4398
Saved money	n/r	38.8% (30.4-47.1)	33.4% (24.3-42.5)	26.3% (18.9-33.7)		
Just got by	n/r	26.8% (17.6-36.1)	31.1% (22.4-39.8)	40.0% (29.7-50.4)		
Spent savings	n/r	40.7% (26.7-54.7)	24.3% (12.4-36.3)	30.4% (19.1-41.6)		
Spent savings and borrowed money	n/r	32.3% (17.3-47.3)	32.4% (15.2-49.6)	32.1% (15.8-48.3)		
Federal Poverty Level					62.56	0.0392
0-100% FPL	n/r	31.1% (18.6-43.7)	n/r	44.5% (30.1-58.9)		
101-185% FPL	n/r	38.1% (24.7-51.6)	25.8% (12.8-38.9)	35.3% (20.8-49.9)		
186%+ FPL	n/r	34.3% (27.3-41.3)	34.2% (27.7-40.7)	29.7% (23.3-36.2)		
Military (Ever Served)					8.62	0.3282
Yes	n/r	25.6% (15.0-36.2)	38.1% (24-52.1)	36.3% (23.1-49.6)		
No	n/r	35.2% (29.4-41.1)	30.3% (24.5-36)	31.9% (25.9-37.8)		
Receiving SNAP[††] benefits					30.41	0.1637
Yes	n/r	24.6% (13.5-35.7)	n/r	46.3% (30.2-62.4)		
No	n/r	36.0% (30.2-41.8)	32.3% (26.8-37.9)	29.5% (23.9-35.1)		

[†]Not reportable
[††]Supplemental Nutrition Assistance Program

Table 6: Self-Perception of Weight Status by Body Mass Index Category

	Overperception	Accurate Perception	Underperception	χ^2	P-value
Variable	**% (95% CI)**	**% (95% CI)**	**% (95% CI)**		
Overall	**7.4% (4.8-10.1)**	**55.1% (49.4-60.8)**	**37.4% (31.8-43.0)**	546.7	<0.0001

BMI Category (Standard)							
	Healthy Weight		13.8% (8.3-19.2)	**78.0% (71.6-84.5)**	8.2% (4.6-11.8)	530.6	<0.0001
	Overweight		n/r	**50.2% (40.7-59.7)**	**48.0% (38.3-57.6)**		
	Obese		n/r	24.7% (15.3-34.2)	**75.3% (65.8-84.7)**		
		Obese I	n/r	n/r	**91.3% (85.2-97.3)**		
		Obese II	n/r	n/r	46.2% (24.5-67.9)		
		Obese III	n/r	n/r	n/r		
BMI Category (Asian-specific cutoffs)						489.4	<0.0001
	Healthy Weight		12.5% (6.7-18.3)	**77.9% (70.9-85.0)**	9.5% (5.2-13.9)		
	Overweight		n/r	37.4% (28.5-46.4)	**61.0% (51.9-70.2)**		
	Obese		n/r	21.6% (13.3-29.9)	**78.4% (70.1-86.7)**		
		Obese I	n/r	n/r	**92.7% (87.5-98.0)**		
		Obese II	n/r	n/r	**59.9% (37.4-82.3)**		
		Obese III	n/r	50.2% (27.4-72.9)	n/r		

Table 7: Prevalence of Overperception, Accurate Perception and Underperception of Weight Status in Hawaii Based on Standard Body Mass Index Cutoffs, Including Demographic Distribution

		Overperception	Accurate Perception	Underperception	χ^2	P-value
Variable		**% (95% CI)**	**% (95% CI)**	**% (95% CI)**		
Overall		**7.4% (4.8-10.1)**	**55.1% (49.4-60.8)**	**37.4% (31.8-43)**	546.70	<0.0001
Age Group					93.40	0.0011
	18-39 years	n/r†	49.4% (38.3-60.5)	47.4% (36.3-58.5)		
	40-49 years	n/r	65.9% (53.0-78.7)	27.5% (15.4-39.7)		
	50-59 years	n/r	52.6% (41.2-64.0)	36.0% (24.9-47.0)		
	60-69 years	5.7% (2.7-8.7)	62.6% (51.6-73.6)	31.7% (20.7-42.8)		
	70+ years	n/r	53.5% (41.7-65.3)	28.4% (19.1-37.7)		
Sex					64.38	0.0021
	Male	n/r	49.9% (41.2-58.7)	**46.1% (37.4-54.7)**		
	Female	10.9% (6.6-15.2)	60.4% (52.9-67.8)	28.7% (21.4-36.0)		

Race				178.10	<0.0001
White	7.0% (3.4-10.6)	**57.0% (49.0-65.0)**	36.0% (27.8-44.1)		
Native Hawaiian and Other Pacific Islander	n/r	26.8% (17.3-36.3)	**67.2% (56.3-78.0)**		
Filipino	n/r	**60.0% (44.6-75.4)**	30.7% (16.9-44.5)		
Japanese	n/r	**62.4% (50.1-74.6)**	27.2% (17.0-37.5)		
Other	n/r	**74.5% (62.7-86.3)**	20.7% (9.9-31.6)		
Educational Status				92.10	0.0001
High school graduate or less	n/r	41.5% (31.6-51.4)	**52.0% (41.7-62.3)**		
Some College	8.3% (3.9-12.6)	**64.3% (55.5-73.0)**	27.5% (19.8-35.2)		
College Graduate	7.4% (4.1-10.8)	**63.6% (56.2-71.1)**	28.9% (21.7-36.2)		
Country of birth				56.36	0.0024
US Born	6.3% (3.8-8.9)	51.7% (45.6-57.8)	**42.0% (35.8-48.2)**		
Foreign Born	n/r	68.5% (56.3-80.6)	19.7% (10.4-29.1)		
County				11.33	0.3129
Honolulu	8.3% (4.6-11.9)	55.9% (48.2-63.6)	35.8% (28.2-43.4)		
Hawaii	2.9% (1.5-4.3)	52.7% (43.0-62.4)	44.4% (34.8-53.9)		
Kauai	n/r	54.4% (43.7-65.1)	38.0% (27.4-48.5)		
Maui	n/r	53.3% (44.8-61.8)	38.9% (30.6-47.2)		
Financial Health (During Past Year)				48.97	0.0519
Saved money	8.0% (4.3-11.7)	59.4% (50.7-68.0)	32.6% (24.1-41.1)		
Just got by	n/r	44.8% (34.8-54.7)	46.7% (36.4-57.0)		
Spent savings	n/r	54.6% (41.0-68.2)	39.3% (26.0-52.5)		
Spent savings and borrowed money	n/r	**69.3% (55.6-82.9)**	27.1% (14.1-40.2)		
Federal Poverty Level				21.85	0.4083
0-100% FPL	n/r	43.2% (29.1-57.3)	47.9% (33.8-62.0)		
101-185% FPL	n/r	58.9% (44.3-73.5)	37.4% (22.7-52.1)		
186%+ FPL	7.7% (4.8-10.6)	56.0% (48.9-63.1)	36.3% (29.2-43.3)		
Military (Ever Served)				29.79	0.0077
Yes	n/r	41.6% (28.4-54.8)	**54.9% (41.4-68.3)**		

	No	8.0% (5.0-10.9)	57.0% (50.9-63.2)	35.0% (29.0-41.0)		
Receiving SNAP[††] benefits					22.36	0.0684
	Yes	n/r	53.1% (37.2-69.1)	45.6% (29.7-61.6)		
	No	8.7% (5.6-11.8)	55.7% (49.6-61.7)	35.6% (29.7-41.6)		

[†]Not reportable
[††]Supplemental Nutrition Assistance Program

Table 8: Unadjusted Prevalence Ratios (PRs); Age, Sex, and Race Adjusted PRs; and Fully Adjusted PRs (Final Model) Describing the Association with Weight Status Underperception

Variable		Unadjusted PR (95% CI)	Age, Race, and Sex Adjusted PR (95% CI)	Fully adjusted PR (95% CI)
Overall				
BMI Category				
	Healthy Weight	1.00	1.00	1.00
	Overweight	**5.14 (3.17-8.35)**	**4.06 (2.57-6.42)**	**3.50 (2.30-5.34)**
	Obese	**7.92 (5.00-12.54)**	**6.32 (3.95-10.11)**	**5.31 (3.41-8.25)**
Age Group				
	18-39 years	1.00	1.00	1.00
	40-49 years	**0.60 (0.36-0.98)**	**0.65 (0.48-0.88)**	**0.66 (0.49-0.88)**
	50-59 years	0.81 (0.56-1.18)	0.84 (0.66-1.06)	0.85 (0.66-1.09)
	60-69 years	0.68 (0.45-1.03)	0.81 (0.61-1.07)	0.77 (0.59-1.01)
	70+ years	0.71 (0.49-1.03)	0.99 (0.77-1.27)	0.95 (0.74-1.24)
Sex				
	Female	1.00	1.00	1.00
	Male	**1.48 (1.09-2.01)**	**1.45 (1.18-1.78)**	**1.38 (1.13-1.68)**
Race				
	White	1.00	1.00	1.00
	Native Hawaiian and Other Pacific Islander	**1.84 (1.42-2.39)**	**1.41 (1.13-1.78)**	**1.36 (1.08-1.72)**
	Filipino	0.90 (0.55-1.49)	0.94 (0.66-1.35)	0.97 (0.73-1.30)

	Japanese	0.78 (0.51-1.21)	1.01 (0.76-1.33)	1.16 (0.90-1.51)
	Other	0.57 (0.32-1.00)	0.80 (0.50-1.29)	0.77 (0.44-1.36)
Educational Status				
	College Graduate	1.00		1.00
	Some College	0.97 (0.67-1.41)		0.92 (0.72-1.16)
	High school diploma or less	**1.78 (1.31-2.43)**		1.22 (0.98-1.53)
Financial Health (During Past Year)				
	Saved money	1.00		1.00
	Just got by	**1.44 (1.04-2.00)**		1.00 (0.81-1.22)
	Spent savings	1.23 (0.81-1.87)		1.23 (0.98-1.54)
	Spent savings & borrowed	0.81 (0.47-1.41)		0.86 (0.63-1.18)
Federal Poverty Level				
	186%+ FPL	1.00		1.00
	101-185% FPL	0.98 (0.63-1.51)		0.97 (0.78-1.21)
	0-100% FPL	1.37 (0.99-1.91)		1.06 (0.81-1.39)
Military (Ever Served)				
	No	1.00		1.00
	Yes	**1.47 (1.10-1.97)**		**1.21 (1.01-1.44)**
Receiving SNAP[†] Benefits				
	No	1.00		
	Yes	1.21 (0.82-1.77)		
Country of Birth				
	US Born	1.00		
	Foreign Born	**0.50 (0.30-0.82)**		
County				
	Honolulu	1.00		
	Hawaii	1.16 (0.86-1.56)		
	Kauai	1.05 (0.74-1.47)		
	Maui	1.10 (0.83-1.47)		

[†]Supplemental Nutrition Assistance Program

Table 9: Calculated Bayesian Information Criteria (BIC) Values and Phase 3 Model Building Decisions (Paper 1)

Model #	Model Description	BIC	BIC Difference (New Model - Original Model)	Difference in Degrees of Freedom	Chi Square Cut Off For Significance (P<.05)	Decision
1	BMI Category + Race + Sex + Age Group	1327.10				Retained- Race, Sex, and Age adjusted model
2	1 + Poverty Level	1229.75	-97.18	2	5.991	Retained - Improved model fit; confounded one or more associations by 10% or more; 95% CIs overlap 1.00
3	2 + Financial Health	1218.72	-11.03	3	7.815	Retained - Improved model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
4	3 + Educational Attainment	1212.70	-6.02	2	5.991	Retained- Improved model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
5	4 + Receipt of SNAP† Benefits	1215.84	3.14	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
6	4 + Military Status (Ever Served)	1212.91	0.22	1	3.841	Retained - Did not improve model fit; did not confound one or more associations by 10% or more; 95% CIs or one or more parameters do not overlap 1.00
7	6 + Country of Birth	1219.85	6.94	1	3.841	Removed - Worsened model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
8	6 + County of Residence	1232.79	19.88	3	7.815	Removed - Worsened model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00

†Supplemental Nutrition Assistance Program

Table 10: Overall Prevalence and Demographic Covariates of Adults at High Risk for Diabetes (based on Standard and Asian-specific Body Mass Index Cutoffs (BMI) as appropriate) and Diabetes Risk Perception among Adults in Hawaii

		At High Risk for Diabetes (Standard BMI Cutoffs)	χ^2	P-value	At High Risk for Diabetes (Asian-specific BMI Cutoffs)	χ^2	P-value	Believe themselves to be at risk	χ^2	P-value
Variable		**% (95% CI)**			**% (95% CI)**			**% (95% CI)**		

Overall	**50.0% (43.9-56.1)**	0.00	0.9940	**52.4% (46.3-58.5)**	3.11	0.4422	**44.9% (39.0-50.8)**	14.57	0.0930
Age Group		353.93	<0.0001		356.66	<0.0001		12.49	0.5138
18-39 years	24.5% (13.3-35.7)			26.2% (15.0-37.4)			46.3% (35.1-57.6)		
40-49 years	45.8% (30.2-61.5)			50.2% (35.1-65.4)			41.9% (28.5-55.4)		
50-59 years	**58.8% (46.6-71.0)**			**62.3% (50.3-74.4)**			52.1% (40.3-64.0)		
60-69 years	**91.6% (87.5-95.8)**			**92.7% (88.8-96.6)**			36.4% (26.2-46.7)		
70+ years	**84.6% (72.6-96.5)**			**86.9% (75.3-98.6)**			41.3% (29.0-53.6)		
Sex		42.56	0.0080		40.80	0.0098		0.126	0.8767
Male	**59.0% (49.2-68.7)**			61.2% (51.4-71.0)			45.4% (36.3-54.5)		
Female	41.2% (33.4-49.0)			43.8% (36.0-51.6)			44.5% (36.8-52.1)		
Race		22.83	0.4037		20.84	0.4689		64.97	0.0134
White	48.1% (40.1-56.2)			48.1% (40.1-56.2)			42.9% (34.6-51.3)		
NHOPI	59.3% (45.1-73.5)			59.3% (45.1-73.5)			**59.0% (44.5-73.6)**		
Filipino	43.3% (25.3-61.4)			47.3% (29.5-65.1)			38.0% (23.0-53.0)		
Japanese	56.1% (40.8-71.5)			61.9% (46.2-77.7)			55.1% (40.6-69.6)		
Other	41.8% (25.0-58.6)			47.1% (29.5-64.8)			27.2% (13.5-41.0)		
Educational Status		38.61	0.0112		27.70	0.0444		59.69	0.0007
High school graduate or less	60.0% (49.3-70.7)			60.9% (50.2-71.6)			**54.1% (43.4-64.9)**		
Some College	40.6% (30.5-50.7)			44.5% (33.9-55.0)			30.8% (22.2-39.4)		
College Graduate	47.0% (39.2-54.8)			49.7% (41.9-57.5)			**49.0% (41.3-56.7)**		
Country of birth		27.38	0.0423		23.30	0.0606		59.58	<.0001
US Born	53.5% (46.9-60.0)			55.6% (49.1-62.1)			**50.0% (43.6-56.3)**		
Foreign Born	35.5% (20.2-50.8)			39.1% (23.5-54.7)			24.1% (13.6-34.5)		
County		2.62	0.7096		2.73	0.7013		1.959	0.8097
Honolulu	50.0% (41.7-58.2)			52.7% (44.4-60.9)			43.9% (36.0-51.8)		
Hawaii	54.3% (43.7-64.9)			55.4% (44.8-66.0)			48.3% (37.7-58.8)		
Kauai	47.1% (35.8-58.3)			53.2% (41.5-64.9)			43.7% (32.5-54.9)		
Maui	45.7% (36.8-54.7)			46.4% (37.4-55.3)			48.0% (38.3-57.8)		
Financial Health (During Past Year)		29.97	0.0940		22.56	0.1991		25.04	0.1279
Saved money	44.6% (35.6-53.6)			47.6% (38.4-56.9)			42.2% (33.2-51.3)		
Just got by	58.1% (47.2-69.0)			59.5% (48.6-70.3)			53.0% (42.3-63.6)		
Spent savings	36.6% (24.0-49.2)			40.6% (27.0-54.2)			37.2% (24.2-50.2)		

	Spent savings and borrowed money	53.9% (36.0-71.7)			54.6% (36.8-72.4)			36.2% (21.2-51.2)		
Federal Poverty Level			12.26	0.3431		7.46	0.5230		4.313	0.6997
	0-100% FPL	59.8% (45.6-74.0)			59.8% (45.6-74.0)			51.4% (36.7-66.1)		
	101-185% FPL	54.7% (38.9-70.6)			56.6% (40.9-72.3)			43.0% (27.3-58.6)		
	186%+ FPL	47.4% (40.0-54.8)			50.4% (42.8-58.0)			44.8% (37.6-52.1)		
Military (Ever Served)			40.99	0.0007		33.81	0.0021		1.836	0.4665
	Yes	**74.4% (61.8-86.9)**			**74.5% (62.0-87.1)**			39.9% (26.4-53.5)		
	No	46.9% (40.2-53.5)			49.6% (42.9-56.3)			45.6% (39.1-52.0)		
Receiving SNAP[†] Benefits			2.27	0.5465		0.74	0.7313		1.891	0.5933
	Yes	54.6% (38.0-71.1)			54.9% (38.3-71.4)			48.7% (32.0-65.4)		
	No	49.1% (42.7-55.6)			51.8% (45.3-58.3)			43.9% (37.6-50.1)		

[†]Supplemental Nutrition Assistance Program

Table 11: Actual versus Perceived Risk for Diabetes Based On Risk-Score Based Cutoffs, Prevalence and 95% Confidence Intervals

		Classified as being at High Risk for Diabetes	
		Yes	*No*
Perceive Themselves to Be At Risk for Diabetes	*Yes*	27.1% (21.7-32.5)	17.0% (12.6-21.3)
	No	22.8% (17.6-28.0)	33.1% (27.1-39.0)

$\chi^2 = 56.79$, P=0.0008

Table 12: Overall Prevalence and Demographic Covariates of Adults with Diagnosed Risk for Diabetes, and Prevalence of Pre-Diabetes and Hypertension among Adults in Hawaii

		Diagnosed Risk For Diabetes	χ2	P-value	Pre-diabetes	χ2	P-value	Hypertension	χ2	P-value
Variable		**% (95% CI)**			**% (95% CI)**			**% (95% CI)**		
Overall		**20.9% (15.9-26.0)**	477.62	<0.0001	**14.0% (10.4-17.6)**	727.94	<0.0001	**30.3% (25.3-35.3)**	248.71	<0.0001
Age Group										
	18-39 years	n/r†	28.80	0.1708	n/r	76.18	0.0004	14.6% (7.2-22.0)	151.32	<0.0001
	40-49 years	18.0% (8.6-27.3)			n/r			30.5% (15.1-45.9)		
	50-59 years	29.0% (16.9-41.1)			**20.8% (10.2-31.4)**			**35.2% (23.8-46.6)**		
	60-69 years	28.4% (17.1-39.7)			**26.3% (15.0-37.7)**			**42.8% (31.9-53.6)**		
	70+ years	24.5% (15.8-33.2)			**21.9% (13.6-30.2)**			**54.8% (43.1-66.5)**		
Sex			17.72	0.0713		1.00	0.6170		2.54	0.4780
	Male	16.3% (9.8-22.8)			13.1% (7.8-18.3)			32.1% (24.4-39.9)		
	Female	25.4% (17.9-32.9)			14.9% (9.9-19.9)			28.5% (22.0-35.0)		
Race			25.75	0.3060		22.58	0.2098		49.89	0.0488
	White	14.7% (7.6-21.9)			8.7% (5.7-11.8)			20.0% (14.7-25.2)		
	Native Hawaiian and Other Pacific Islander	29.1% (14.1-44.1)			n/r			33.0% (20.5-45.4)		
	Filipino	17.1% (7.8-26.5)			n/r			35.5% (18.8-52.2)		
	Japanese	23.7% (12.3-35.1)			16.0% (7.4-24.7)			**43.1% (30.6-55.6)**		
	Other	n/r			n/r			28.2% (15.6-40.9)		
Educational Status			6.50	0.4973		0.85	0.8908		17.54	0.1319
	High school graduate or less	24.2% (13.8-34.5)			14.8% (7.8-21.8)			34.3% (24.7-43.9)		
	Some College	17.9% (11.1-24.6)			12.8% (7.7-17.9)			31.9% (23.1-40.6)		
	College Graduate	19.9% (13.3-26.5)			14.3% (8.2-20.3)			22.6% (17.0-28.3)		
Country of birth			5.24	0.2595		0.86	0.6401		1.43	0.6436
	US Born	22.1% (16.3-28.0)			14.4% (10.4-18.5)			29.6% (24.4-34.9)		
	Foreign Born	15.9% (7.3-24.4)			n/r			33.1% (19.1-47.0)		
County			4.42	0.5258		3.68	0.5818		6.61	0.2807
	Honolulu	21.4% (14.6-28.2)			13.4% (8.9-18.0)			31.9% (25.0-38.8)		
	Hawaii	24.0% (13.8-34.2)			18.3% (8.5-28.2)			29.6% (21.4-37.9)		

	Kauai	15.0% (8.3-21.7)			12.1% (6.0-18.3)			26.4% (18.4-34.5)		
	Maui	16.6% (10.8-22.4)			13.0% (7.7-18.3)			22.8% (16.1-29.6)		
Financial Health (During Past Year)			51.94	0.0005		29.08	0.0052		9.56	0.5821
	Saved money	**25.9% (17.3-34.5)**			**16.9% (10.7-23.0)**			29.7% (22.4-36.9)		
	Just got by	**25.7% (15.8-35.7)**			**17.4% (10.0-24.8)**			31.3% (22.6-40.0)		
	Spent savings	10.1% (5.1-15.2)			8.5% (3.9-13.2)			22.1% (13.3-30.9)		
	Spent savings and borrowed money	6.1% (2.4-9.8)			n/r			35.6% (17.1-54.0)		
Federal Poverty Level			0.21	0.9851		9.90	0.2542		3.19	0.7677
	0-100% FPL	21.5% (9.7-33.3)			n/r			35.5% (21.2-49.8)		
	101-185% FPL	n/r			9.0% (3.9-14.1)			31.9% (18.7-45.1)		
	186%+ FPL	20.3% (14.0-26.6)			13.5% (8.9-18.0)			29.7% (23.7-35.7)		
Military (Ever Served)			0.47	0.7205		2.51	0.3985		2.69	0.3956
	Yes	23.0% (11.1-34.8)			n/r			35.3% (22.9-47.7)		
	No	20.7% (15.2-26.1)			13.5% (9.7-17.3)			29.6% (24.1-35.1)		
Receiving SNAP†† benefits			0.001	0.9887		0.25	0.8186		2.43	0.5760
	Yes	21.1% (9.4-32.9)			n/r			34.5% (17.6-51.4)		
	No	21.0% (15.4-26.7)			13.8% (10.0-17.6)			29.7% (24.7-34.7)		

†Not reportable
††Supplemental Nutrition Assistance Program

Table 13: Unadjusted Prevalence Ratios (PRs); Age, Sex, and Race Adjusted PRs; and Fully Adjusted PRs (Final Model) Describing the Association with Diabetes Risk Perception

Variable		Unadjusted PR (95% CI)	Age, Race, and Sex Adjusted PR (95% CI)	Fully adjusted PR (95% CI)
Overall				
Weight Status Perception				
	Accurate Perception	1.00		1.00
	Overperception	**1.51 (1.04-2.21)**	**1.43 (1.02-2.00)**	**1.42 (1.14-1.76)**

Underperception	1.31 (0.99-1.74)	1.15 (0.88-1.51)	**0.76 (0.60-0.97)**
Age Group			
18-39 years	1.00	1.00	1.00
40-49 years	0.90 (0.60-1.35)	0.90 (0.60-1.36)	0.77 (0.56-1.05)
50-59 years	1.12 (0.81-1.57)	1.08 (0.77-1.51)	1.02 (0.79-1.31)
60-69 years	0.79 (0.54-1.14)	0.80 (0.55-1.16)	0.72 (0.47-1.11)
70+ years	0.89 (0.61-1.31)	0.90 (0.61-1.32)	1.02 (0.76-1.35)
Sex			
Female	1.00	1.00	1.00
Male	1.02 (0.78-1.33)	1.02 (0.79-1.32)	1.15 (0.94-1.43)
Race			
White	1.00	1.00	1.00
Native Hawaiian and Other Pacific Islander	1.38 (1.00-1.88)	1.30 (0.92-1.84)	0.95 (0.73-1.24)
Filipino	0.89 (0.57-1.37)	0.89 (0.58-1.38)	0.73 (0.50-1.09)
Japanese	1.28 (0.93-1.78)	1.29 (1.29-1.78)	**1.40 (1.16-1.69)**
Other	0.63 (0.37-1.09)	0.67 (0.67-1.14)	0.67 (0.33-1.34)
Educational Status			
College Graduate	1.00		1.00
Some College	**0.63 (0.46-0.87)**		**0.65 (0.50-0.85)**
High school diploma or less	1.11 (0.86-1.43)		1.04 (0.82-1.32)
Financial Health (During Past Year)			
Saved money	1.00		1.00
Just got by	1.25 (0.94-1.68)		1.00 (0.80-1.26)
Spent savings	0.88 (0.59-1.33)		1.12 (0.86-1.44)
Spent savings & borrowed	0.86 (0.54-1.37)		0.98 (0.69-1.39)
Federal Poverty Level			
186%+ FPL	1.00		1.00
101-185% FPL	0.96 (0.64-1.43)		0.89 (0.69-1.16)
0-100% FPL	1.15 (0.83-1.59)		0.83 (0.62-1.13)
Country of Birth			

US Born	1.00		
Foreign Born	**0.48 (0.31-0.76)**		
Diagnosed Risk for Diabetes			
No	1.00		1.00
Yes	**2.23 (1.81-2.75)**		**1.97 (1.58-2.45)**
Family History of Diabetes			
No	1.00		1.00
Yes	**2.06 (1.54-2.74)**		**1.77 (1.39-2.24)**
BMI Category			
Healthy weight	1.00		1.00
Overweight	**1.48 (1.06-2.07)**		**1.49 (1.11-2.01)**
Obese	**2.09 (1.52-2.87)**		**2.07 (1.46-2.93)**
Hypertension			
No	1.00		1.00
Yes	1.19 (0.9-1.56)		0.94 (0.74-1.20)
Military (Ever Served)			
No	1.00		
Yes	0.88 (0.61-1.27)		
Receiving SNAP[†] Benefits			
No	1.00		
Yes	1.11 (0.77-1.61)		
County			
Honolulu	1.00		
Hawaii	1.10 (0.83-1.46)		
Kauai	1.00 (0.73-1.36)		
Maui	1.09 (0.83-1.44)		

[†]Supplemental Nutrition Assistance Program

Table 14: Calculated Bayesian Information Criteria (BIC) Values and Phase 3 Model Building Decisions (Paper 2)

Model #	Model Description	BIC	BIC Difference (New Model -	Difference in Degrees of Freedom	Chi Square Cut Off For	Decision

			Original Model)		Significance (P<.05)	
1	Weight Status Perception + Race + Sex + Age Group	1859.02				Retained- Race, Sex, and Age adjusted model
2	1 + Diagnosed Risk for Diabetes	1667.80	-191.22	1	3.841	Retained- Improved model fit; confounded one or more associations by 10% or more; 95% CIs or one or more parameters do not overlap 1.00
3	2 + Family History of Diabetes	1573.29	-94.51	2	5.991	Retained- Improved model fit; confounded one or more associations by 10% or more; 95% CIs or one or more parameters do not overlap 1.00
4	3 + BMI Category	1471.37	-101.92	2	5.991	Retained- Improved model fit; confounded one or more associations by 10% or more; 95% CIs or one or more parameters do not overlap 1.00
5	4 + Educational Attainment	1421.60	-49.77	2	5.991	Retained- Improved model fit; confounded one or more associations by 10% or more; 95% CIs or one or more parameters do not overlap 1.00
6	5 + Country of Birth	1425.43	3.84	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
7	5 + Poverty Level	1300.81	-120.78	2	5.991	Retained - Improved model fit; confounded one or more associations by 10% or more; 95% CIs overlap 1.00
8	7 + Financial Health	1279.84	-20.97	3	7.815	Retained - Improved model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
9	8 + Receipt of SNAP[†] Benefits	1280.88	1.04	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
10	8 + Military Status (Ever Served)	1279.52	-0.32	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
11	8 + County of residence	1290.68	10.84	3	7.815	Removed - Worsened model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00
12	8 + Diagnosis of Hypertension	1286.07	6.23	1	3.841	Retained - Worsened model fit; did not confound one or more associations by 10% or more; 95% CIs overlap 1.00

[†]Supplemental Nutrition Assistance Program

Table 15: Overall Prevalence and Demographic Covariates of Diabetes Screening within the Past Three Years among Adults in Hawaii

		Diabetes Screening (Past 3 Years)	χ^2	P-value
Variable		**% (95% CI)**		
Overall		**57.1% (51.1-63)**	28.21	0.0211
Age Group			171.80	<0.0001
	18-39 years	37.2% (26.3-48.1)		
	40-49 years	60.1% (46.4-73.7)		
	50-59 years	**77.5% (69.2-85.9)**		
	60-69 years	**68.2% (57.5-78.9)**		
	70+ years	**77.5% (65.9-89.0)**		
Sex			14.30	0.0892
	Male	52.0% (42.6-61.4)		
	Female	62.0% (55.0-69.0)		
Race			17.66	0.5733
	White	61.4% (53.3-69.5)		
	Native Hawaiian and Other Pacific Islander	52.3% (37.6-67.0)		
	Filipino	49.3% (32.1-66.6)		
	Japanese	64.4% (49.5-79.4)		
	Other	53.7% (35.9-71.5)		
Educational Status			13.36	0.2482
	High school graduate or less	54.6% (44.0-65.3)		
	Some College	53.6% (42.4-64.7)		
	College Graduate	65.0% (57.9-72.0)		
Country of birth			14.59	0.1378
	US Born	59.5% (53.1-65.9)		
	Foreign Born	46.7% (31.1-62.4)		
County			2.00	0.8106
	Honolulu	58.3% (50.2-66.4)		
	Hawaii	54.7% (44.3-65.2)		
	Kauai	53.3% (42.0-64.6)		

	Maui	54.1% (44.5-63.6)		
Financial Health (During Past Year)			8.88	0.6270
	Saved money	56.4% (46.8-65.9)		
	Just got by	61.5% (51.1-71.8)		
	Spent savings	60.8% (47.3-74.2)		
	Spent savings and borrowed money	50.0% (32.1-67.9)		
Federal Poverty Level			11.09	0.4005
	0-100% FPL	67.4% (53.9-81.0)		
	101-185% FPL	53.3% (37.8-68.9)		
	186%+ FPL	59.5% (51.9-67.1)		
Military (Ever Served)			8.61	0.1382
	Yes	67.8% (54.0-81.6)		
	No	55.7% (49.2-62.2)		
Receiving SNAP[†] benefits			2.36	0.5532
	Yes	52.5% (35.7-69.3)		
	No	57.9% (51.6-64.2)		

[†]Supplemental Nutrition Assistance Program

Table 16: Unadjusted Prevalence Ratios (PRs); Age, Sex, and Race Adjusted PRs; and Fully Adjusted PRs (Final Model) Describing the Association with Diabetes Screening

Variable		Univariate Models	Age Race & Sex Adjusted Model	Fully Adjusted Model
Overall		PR (95% CI)	PR (95% CI)	PR (95% CI)
Diabetes Risk Perception				
	No	1.00	1.00	1.00
	Yes	1.24 (0.96-1.61)	**1.29 (1.03-1.62)**	**1.31 (1.05-1.62)**
Diabetes-Related Chronic Condition Diagnosis				
	No	1.00		1.00
	Yes	**1.36 (1.02-1.79)**		1.20 (0.94-1.53)
USPSTF Testing Eligibility Criteria				
	No	1.00		1.00
	Yes	1.28 (0.99-1.65)		0.82 (0.53-1.28)

BMI Category				
	Healthy weight	1.00		1.00
	Overweight	1.11 (0.83-1.48)		1.25 (0.88-1.78)
	Obese	0.74 (0.50-1.10)		0.76 (0.46-1.25)
Family History of Diabetes				
	No	1.00		1.00
	Yes	1.03 (0.79-1.35)		1.01 (0.79-1.28)
Weight Status Perception				
	Accurate Perception	1.00		1.00
	Overperception	**1.43 (1.07-1.90)**		1.29 (0.92-1.79)
	Underperception	0.80 (0.59-1.09)		0.97 (0.73-1.27)
Age Group				
	18-39 years	1.00	1.00	1.00
	40-49 years	**1.91 (1.23-2.95)**	**1.87 (1.20-2.90)**	**1.70 (1.05-2.75)**
	50-59 years	**2.50 (1.74-3.60)**	**2.34 (1.60-3.41)**	**1.97 (1.27-3.07)**
	60-69 years	**2.00 (1.34-2.98)**	**1.95 (1.28-2.95)**	1.64 (1.00-2.69)
	70+ years	**2.46 (1.66-3.63)**	**2.33 (1.57-3.47)**	**1.94 (1.28-2.94)**
Sex				
	Female	1.00	1.00	1.00
	Male	0.85 (0.65-1.10)	0.91 (0.81-1.16)	1.03 (0.82-1.30)
Race				
	White	1.00	1.00	1.00
	Native Hawaiian and Other Pacific Islander	**0.63 (0.41-0.95)**	0.77 (0.53-1.11)	0.76 (0.55-1.05)
	Filipino	0.71 (0.43-1.17)	0.85 (0.57-1.27)	0.74 (0.50-1.10)
	Japanese	1.01 (0.73-1.40)	0.90 (0.67-1.20)	0.86 (0.65-1.14)
	Other	0.71 (0.43-1.17)	0.81 (0.52-1.27)	0.72 (0.45-1.14)
Federal Poverty Level				
	186%+ FPL	1.00		1.00
	101-185% FPL	0.81 (0.54-1.22)		1.02 (0.71-1.46)
	0-100% FPL	1.11 (0.81-1.51)		1.27 (0.99-1.64)

Financial Health (During Past Year)				
	Saved money	1.00		
	Just got by	1.04 (0.76-1.43)		
	Spent savings	1.21 (0.87-1.69)		
	Spent savings & borrowed	1.00 (0.64-1.56)		
Educational Status				
	College Graduate	1.00		1.00
	Some College	0.77 (0.58-1.03)		1.06 (0.83-1.34)
	High school diploma or less	**0.72 (0.54-0.97)**		0.87 (0.65-1.17)
Country of Birth				
	US Born	1.00		
	Foreign Born	0.77 (0.49-1.22)		
Military (Ever Served)				
	No	1.00		
	Yes	1.30 (0.96-1.76)		
Receiving SNAP† Benefits				
	No	1.00		
	Yes	0.82 (0.51-1.32)		
County				
	Honolulu	1.00		1.00
	Hawaii	0.90 (0.67-1.20)		0.77 (0.58-1.01)
	Kauai	0.97 (0.71-1.32)		0.76 (0.56-1.04)
	Maui	0.97 (0.73-1.29)		0.82 (0.64-1.06)

†Supplemental Nutrition Assistance Program

Table 17: Calculated Bayesian Information Criteria (BIC) Values and Phases 3 & 4 Model Building Decisions (Paper 3)

Model #	Model Description	BIC	BIC Difference (New Model - Original Model)	Difference in Degrees of Freedom	Chi Square Cut Off For Significance (P<.05)	Decision
1	Diabetes Risk Perception + Race + Sex + Age Group	1400.65				Retained - Race, Sex, and Age adjusted model
2	1 + Poverty Level	1288.47	-112.18	2	5.991	Retained - Improved model fit; confounded one or more associations by 10% or more;95% CIs overlap 1.00
3	2 + Having a Diabetes-Related Chronic Condition	1269.40	-19.07	1	3.841	Retained - Improved model fit; confounded one or more associations by 10% or more;95% CIs overlap 1.00
4	3 + Meeting USPSTF Eligibility Criteria for Diabetes Screening	1260.61	-8.79	1	3.841	Retained - Improved model fit; confounded one or more associations by 10% or more;95% CIs overlap 1.00
5	4 + Country of Birth	1262.25	1.64	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00
6	4 + BMI Category	1216.34	-44.27	2	5.991	Retained - Improved model fit; confounded one or more associations by 10% or more;95% CIs overlap 1.00
7	6 + Financial Health	1212.59	-3.76	3	7.815	Removed - Did not improve model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00
8	6 + Family History of Diabetes	1202.63	-13.71	1	3.841	Retained - Improved model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00
9	8 + Educational Attainment	1208.17	5.54	2	5.991	Retained - Worsened model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00
10	9 + County of residence	1212.36	4.19	3	7.815	Retained - Did not improve model fit; did not confound one or more associations by 10% or more;95% CIs or one or more parameters do not overlap 1.00
11	9 + Military status (every served)	1218.69	6.33	1	3.841	Removed - Worsened model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00

12	9 + Receipt of SNAP[†] benefits	1216.63	4.27	1	3.841	Removed - Did not improve model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00
13	9 + Weight Status Perception	1220.45	8.09	2	5.991	Retained (independent variable) - Worsened model fit; confounded one or more associations by 10% or more;95% CIs overlap 1.00
14	13 + Weight Status Perception x Diabetes Risk Perception	1229.34	8.89	3	7.815	Removed - Worsened model fit; did not confound one or more associations by 10% or more;95% CIs overlap 1.00

[†]Supplemental Nutrition Assistance Program

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