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Associations Between Substance Use and Obesity Among Native American Adolescents

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Walden University
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Abstract

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by

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MSc, California University of Pennsylvania 2007

BS, Marywood University, 2008

BS, University of Scranton, 1993

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Health

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May 2023

Abstract

Obesity and substance use are two significant public health issues among Native American adolescents. Despite much evidence linking obesity and substance use during adolescence to several long-term health conditions and increased morbidity and mortality, evidence describing the relationship between current substance use and obesity among Native American adolescents is lacking. The purpose of this quantitative study was to investigate associations between current substance use – specifically alcohol, marijuana, and tobacco products – and obesity among Native American high school students, when adjusted for sex, soda consumption, and physical activity. Rosenstock's health belief model served as the theoretical foundation for this investigation which used a cross-sectional study design to investigate these associations among Native American high school students using data from the 2019 Youth Risk Behavior Survey. Chi Square Tests of Independence determined that there was a significant relationship between obesity and sex ($\chi^2(1) = 6.206$, $p = .013$) and current physical activity and sex ($\chi^2(1) = 7.567$, $p = .006$) while a two-step hierarchical binary logistic regression determined that the odds of being obese were 25.6% more likely for males than females (95% CI [.072-.902]). The results of this study can be used to provide a better understanding of the impact of specific adolescent behaviors on health among Native American adolescents, foster collaboration among healthcare providers and school district personnel who prioritize obesity prevention interventions among Native American adolescents, and develop new or enhance existing programs designed to discourage substance use among Native American adolescents.

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Section 1: Foundation of the Study and Literature Review

Introduction

Obesity and substance use are two significant public health issues among Native American adolescents. As such, this study examines associations between current substance use and obesity among Native American high school students. This section provides background about the study, including a problem statement and purpose, outlines the research questions and their associated hypotheses, explores the theoretical framework used to develop the study, explains the nature of the study and the literature search strategy employed, reviews current literature related to key variables and concepts, provides operational definitions of key terms, describes relevant assumptions, limitations, delimitations, and offers an explanation of the study's significance.

Background

As a major risk factor for noncommunicable conditions such as cardiovascular disease, diabetes, musculoskeletal disorders, and cancer, obesity is among the most troublesome public health issues worldwide. Highlighting rapid changes in prevalence rates, the World Health Organization (WHO; 2021) reported that global rates of obesity tripled between 1975 and 2016. But while obesity among adults is a significant public health issue, the WHO reported that 6% of girls and 8% of boys worldwide met the criteria for obesity in 2016. Even more concerning, the National Center for Health Statistics (NCHS) reported that the prevalence rate of obesity among children and adolescents in the United States reached nearly 20% in 2020 (NCHS, 2021).

Alcohol, marijuana, and tobacco are among the most used substances in the United States. Despite state laws that prohibit the purchase, possession, and use of alcohol, marijuana, and tobacco by minors, adolescents have been shown to use these substances at alarmingly high rates. Among high school students who participated in the 2019 Youth Risk Behavior Survey, 29% reported drinking alcohol, 22% reported using marijuana, and 37% reported using tobacco products at least once during the 30 days prior to the survey (Underwood et al., 2020). Researchers have demonstrated that prolonged use of these substances has been linked to several adverse health conditions including addiction, cardiovascular disease, cancer, suicide ideation, and brain damage (Kahn & Wilcox, 2020; Vergara et al., 2017).

This study explored the unknown relationship between current substance use and obesity among Native American adolescents. There is ample evidence that prevalence rates of both obesity and substance use are higher among Native Americans than national averages. There is also plentiful data that describes the relationship between obesity and long-term health outcomes among adolescent populations as well as the relationship between substance use and long-term health outcomes among adolescent populations. Unfortunately, there is a marked gap in the literature regarding the association between substance use and obesity among Native American high school students. Eitle and Eitle (2018) noted that the relationship between weight status and the use of substances can be influenced by a variety of environmental and cultural factors and called for future research to explore the relationship between weight status and obesity among differing racial and ethnic populations. Since issuing this call in 2018, there has been little to no

data published that describes associations between the use of substances and obesity among Native American high school students.

The lack of evidence describing associations between obesity and substance use among Native American high school students contributes to challenges addressing these two concerning public health issues. As such, an investigation of these associations is needed to develop more effective and culturally sensitive preventive interventions, support policy change, and inform public health campaigns designed to promote behaviors that protect against obesity and substance use among Native American adolescents.

Problem Statement

Obesity and substance use are two significant public health issues among Native American adolescents. Currently, Native American adolescents are 30% more likely to be obese than non-Hispanic white high school students (Office of Minority Health, 2020) while rates of substance use, including alcohol and tobacco products, are significantly higher among Native American adolescents that their non-Hispanic white peers (Zhao et al., 2022).

Obesity and substance use during adolescence have both been linked to a variety of long-term health conditions. For example, Weihrauch-Blüher et al. (2019) described a strong association between childhood obesity and increased morbidity and mortality due to cardiovascular disease and diabetes in adulthood. Similarly, Probst and Rehm (2018) reported that substance use contributed to increasing premature mortality rates in the United States, especially among low socioeconomic populations. Consequently, Native

Americans are nearly three times more likely to be diagnosed with diabetes and almost 2.5 times more likely to die from diabetes than non-Hispanic whites (The Office of Minority Health, 2020). Native Americans are also 50% more likely to be diagnosed to cardiovascular disease than non-Hispanic whites (The Office of Minority Health, 2020).

Since the constructs of the health belief model (HBM) have been shown to successfully predict the performance of detrimental and beneficial health behaviors (Sulat et al., 2018; Shmueli, 2021; Zewdie et al., 2022), the specific research problem addressed through this study is the unknown relationship between past 30-day substance use and obesity among Native American adolescents. There is ample evidence that prevalence rates of both obesity and substance use are higher among Native Americans than national averages. There is also plentiful data that describes the relationship between obesity and long-term health outcomes among adolescent populations as well as the relationship between substance use and long-term health outcomes among adolescent populations. Unfortunately, there is a marked gap in the literature regarding the association between substance use and obesity among Native American high school students. Eitle and Eitle (2018) noted that the relationship between weight status and the use of substances can be influenced by a variety of environmental and cultural factors and called for future research to explore the relationship between weight status and obesity among differing racial and ethnic populations. Since issuing this call in 2018, there has been little to no data published that describes associations between the use of substances and obesity among Native American high school students.

Study Purpose

The purpose of this quantitative study is to investigate associations between current substance use–specifically alcohol, marijuana, and tobacco products–and obesity among Native American high school students, when adjusted for sex and health behaviors including soda consumption and physical activity.

Research Questions and Hypotheses

This study includes four unique research questions that are constructed with obesity as the dependent variable, current substance use (alcohol, marijuana, and tobacco products) as the independent variables, and sex, soda consumption, and rates of physical activity as control variables.

Research question 1: What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Research question 2: What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity

Alternative hypothesis: There is a significant association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Research question 3: What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity

Alternative hypothesis: There is a significant association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity

Research question 4: What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Theoretical Foundation

Rosenstock's health belief model (Skinner et al., 2015) serves as the theoretical foundation for this study. The HBM emerged in the 1950s based on the work of social scientists from the U.S. Public Health Service to predict health behaviors and design preventive interventions for many different health issues and is currently among the most popular conceptual frameworks used by health behavior researchers. Skinner et al. (2015) noted that this popularity stems from the model's ability to successfully predict the adoption or rejection of behaviors that can help to identify, control, or prevent health conditions based on the assumptions that people want to avoid illness/injury.

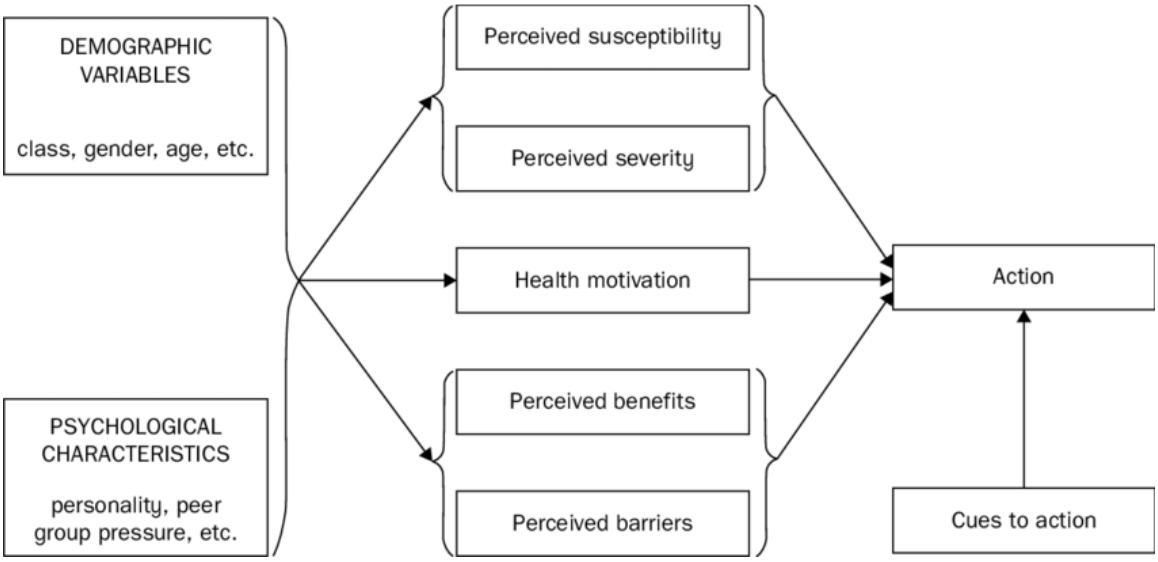
The HBM, as depicted in Figure 1, has been used by social science researchers and public health practitioners throughout the world to develop and assess the effectiveness of interventions designed to change health behaviors of individuals. The HBM includes two important assumptions: that people wish to avoid illness or injury and that certain behaviors or actions can prevent illness or injury. Based on these assumptions, Skinner et al. (2015) noted that the HBM can be easily applied to many disparate health issues and conditions and includes the following basic constructs:

1. Perceived susceptibility, defined as the risk of developing illness/disease or sustaining an injury perceived by an individual.

2. Perceived benefits, defined as the outcomes or effects of actions designed to prevent illness/disease or injury.
3. Perceived severity, defined as the seriousness of developing illness/sustaining injury perceived by an individual.
4. Perceived barriers, defined as the effects of impediments on actions designed to prevent illness/injury.
5. Self-efficacy, defined as an individual's confidence in their own ability to perform a behavior correctly.
6. Cues to action, defined as internally or externally focused factors that prompt an individual to perform a behavior.

Figure 1

The Health Belief Model



Many researchers have used the model's constructs to forecast the performance or adoption of beneficial and detrimental health behaviors. For example, Sulat et al. (2018) completed a scoping review and reported that multiple constructs were predictive of health behaviors, though the strength of the associations were varied. The authors noted that perceived barriers and perceived benefits were the strongest predictors of behavior, and that perceived severity was the weakest predictor of behavior.

More specifically, Tehrani et al. (2022) used the HBM as the framework for a cross-sectional study to predict the use of complementary and alternative medicine (CAM) among individuals with type II diabetes. The authors reported that the constructs of the HBM predicted more than one-third (37%) of the variance of using CAM. The authors noted that the constructs of perceived threat, perceived barriers, and cues to action had the most significant effect on predicting the behavior of using CAM

Additionally, Jorvand et al. (2018) conducted a descriptive-analytical cross-sectional study of employees working in a healthcare network using the HBM to predict participation in physical activity as a strategy to prevent cardiovascular disease. The authors reported that perceived severity and self-efficacy were significant predictors of daily and weekly regular physical activity, predicting 23.3% of the behavior. The authors also reported that gender had the strongest relationship with perceived barriers of physical activity participation, marital status and occupation had the strongest relationship with self-efficacy, and age had a significant statistical relationship with perceived severity and perceived benefits of physical activity.

Demonstrating relevance to this study, many researchers have utilized the HBM as a foundational framework to investigate behaviors associated with obesity and substance use among diverse populations. For example, McArthur et al. (2018) used the HBM to test the ability of HBM constructs to predict body mass index (BMI) among college students. The authors reported that perceived severity, perceived susceptibility, external cues to action, perceived barriers, and perceived benefits successfully predicted body mass index (BMI) among study participants, with perceived benefits of health eating and participation in physical activity identified as the strongest predictor of BMI.

Similarly, Saghafi-Asl (2021) completed a cross-sectional study of female college students to assess the ability to predict BMI using HBM constructs. The authors reported that perceived severity, perceived barriers, and self-efficacy in dietary behaviors were predictive of BMI and that higher levels of perceived susceptibility and severity (classified as perceived threats), perceived benefits, self-efficacy in exercise, and self-efficacy in dietary behaviors were associated with greater intent to manage body weight.

Alternately, Kaufman et al. (2018) utilized data from adult smokers in a sub-study of the National Lung Screening Trial to determine relationships between self-efficacy and smoking cessation. The authors reported that smoking cessation was more likely among participants reporting higher perceived severity of smoking-related diseases, greater self-efficacy for quitting smoking, and fewer perceived barriers to quitting smoking.

Additionally, Üstün et al. (2020) used the HBM to conduct a cross-sectional quantitative study to investigate differences in perceptions of leisure-time physical activity and nutritional attitudes of athletic and sedentary university students. The authors

reported that self-efficacy was the only HBM construct that favorably impacted physical activity participation among the athletic and sedentary study groups.

Finally, Hanauer et al. (2021) evaluated associations between perceived risk of harm and self-reported binge drinking, cigarette smoking, and marijuana smoking among young adults (aged 19 to 28 years) and found that engagement in all three behaviors was less likely when perceived risk was high. The authors also reported that age moderated the association between perceived risk and self-reported marijuana smoking, with younger participants demonstrating a stronger relationship between perceived risk of smoking marijuana and self-reported marijuana smoking.

Despite disregarding the influence of economic and environmental factors and social acceptability on health behaviors and assuming equal access to health information across populations (Skinner et al., 2015), the HBM is an appropriate foundational framework for this study. The HBM is rooted in the assumptions that people want to avoid illness/injury, that certain behaviors can prevent these illnesses/injuries, and that an individual's actions are linked to their perceptions of the benefits of an action and the barriers associated with performing these actions (Skinner et al., 2015). Acknowledging these limitations and assumptions, each of the constructs that comprise the HBM can be applied to behaviors associated with the prevention of obesity. Perceptions of the susceptibility to and severity of obesity as a health condition in combination with perceptions of the benefits of and barriers to actions that prevent obesity have been shown to successfully predict the performance of obesity prevention behaviors (Saghafi-Asl, 2021). Additionally, confidence in one's own ability to perform behaviors and the

presence of behavioral cues that prompt action has also demonstrated predictive effects on behaviors linked to obesity prevention such as physical activity and dietary habits (Üstün et al., 2020).

Nature of this Study

To address the research questions in this quantitative study, I used a cross-sectional study design to investigate associations between self-reported past 30-day use of alcohol, marijuana, and tobacco and obesity among Native American high school students using an analysis of secondary data from CDC's Youth Risk Behavior Surveillance System (YRBSS) 2019 dataset. To complete this study, I downloaded the 2019 YRBSS national dataset from the Data and Documentation website and converted the ASCII file to a SPSS dataset. This dataset contained all the variables needed to conduct this study including:

1. Dependent variable: obesity (had obesity; students who were $\geq$ 95th percentile for body mass index, based on sex- and age-specific reference data from the 2000 CDC growth charts)
2. Independent variables: current tobacco product use, current alcohol use, and current marijuana use (self-reported past 30-day use)
3. Control variables: sex, current physical activity, and current soda consumption

Literature Search Strategy

To inform this study, I used the Walden University library to search the CINAHL and MEDLINE combined databases for peer-reviewed articles published between 2018 and 2022. The keywords used for this search included *obesity, overweight, obese,*

unhealthy weight, high BMI, alcohol use, marijuana use, cannabis, weed, pot, THC, tobacco use, smoking, cigarettes, smoking, physical activity, sugar-sweetened beverages, soda, adolescents, teenagers, high school, school students, Native American, American Indian, Alaska Native, Indigenous peoples, United States, and Health Behavior Model. While most articles included in the review of relevant literature were published within the past five years, seminal works and publications specific to the HBM published prior to 2018 have also been included. To further inform this literature review, a snowballing technique using references of relevant articles was employed during the literature search.

Literature Review Related to Key Variables

As a major risk factor for non-communicable conditions such as cardiovascular disease, diabetes, musculoskeletal disorders, and cancer, obesity is among the most troublesome public health issues worldwide. Highlighting rapid changes in prevalence rates, the WHO (2021) reported that global rates of obesity tripled between 1975 and 2016. But while obesity among adults is a significant public health issue, the WHO reported that 6% of girls and 8% of boys worldwide met the criteria for obesity in 2016. Even more concerning, the National Center for Health Statistics (NCHS) reported that the prevalence rate of obesity among children and adolescents in the United States reached nearly 20% in 2020 (NCHS, 2021).

Alcohol, marijuana, and tobacco are among the most used substances in the United States. Prolonged use of these substances has been linked to several adverse health conditions including addiction, cardiovascular disease, cancer, suicide ideation, and brain damage (Kahn & Wilcox, 2020; Vergara et al., 2017). Despite state laws that

prohibit the purchase, possession, and use of alcohol, marijuana, and tobacco by minors, adolescents have been shown to use these substances at alarming rates. Among high school students who participated in the 2019 Youth Risk Behavior Survey, 29% reported drinking alcohol, 22% reported using marijuana, and 37% reported using tobacco products sometime during the month prior to the survey (Underwood et al., 202A0). This literature review explores several aspects of obesity and substance use among adolescents in the United States.

Adolescent Obesity: Definition, Etiology, and Risk Factors

Obesity is a common chromic health condition among adolescents that can result from a combination of environmental, behavioral, developmental, genetic, prepartum, biological, and intergenerational factors (Qasim et al., 2018). Because obesity is an increasingly common issue that contributes to a significant public health burden, many researchers have thoroughly investigated its etiology and its risk factors to develop more effective disease management protocols and prevention strategies.

Definition

Body mass index (BMI) is among the most common methods used to estimate weight status despite the development of more accurate and sophisticated technology over the past several decades. BMI is calculated by dividing an individual's body weight (in kilograms) by body height (in meters squared) with the resulting value rounded to one decimal place (CDC, 2021). Since body composition varies significantly between girls and boys during childhood and adolescence, BMI calculations are expressed as percentiles relative to peers of the same age and sex (CDC, 2021). For the purposes of

this study, obesity among adolescents is defined as a BMI that is equal to or greater than the 95th percentile based on growth charts developed by CDC for children ages 2 to 19 years (Sanyaolu et al, 2019).

Etiology

Obesity is a chronic noncommunicable disease that is characterized by the excessive accumulation of body fat (Sanyaolu et al, 2019). While most experts agree that obesity occurs as the result of complex individual and societal factors, many researchers have focused on energy imbalance (excessive caloric intake and/or inadequate energy expenditure) when investigating the etiology of adolescent obesity. Kohut et al. (2019) noted that the energy imbalance is the primary cause of adolescent obesity, which can be linked to physical activity levels, environmental issues, psychosocial status, and/or dietary habits, while secondary causes of obesity among adolescents include developmental delays, neurologic and endocrine dysfunction, and use of pharmacologic therapies such as antiepileptics, psychotropics, steroid hormones, and antidiabetic agents. Similarly, Kamboj (2020) suggested that obesity among adolescents most often results from consuming too many calories and expending too little energy, contributing to the storage of excess body fat that leads to an increased BMI.

Risk Factors

Risk factors for adolescent obesity are often categorized as modifiable and non-modifiable. Mihrshahi and Baur (2018) described caloric intake, dietary behaviors, poor sleep quality, parenting styles, and sedentary activity including prolonged screen time as modifiable risk factors for adolescent obesity. Additionally, Kansra et al. (2021)

identified developmental factors including feeding practices during infancy and environmental factors including access to post-partum health care services as modifiable risk factors. Furthermore, Zhao et al. (2022) investigated behavioral risk factors for obesity among Native Americans and found that rates of controlled substance use (including alcohol, marijuana, and tobacco products) are higher among Native American adolescents than non-Hispanic White adolescents.

Researchers have also identified many non-modifiable risk factors for adolescent obesity, including birthweight, sex, ethnicity, season of birth, maternal age at time of delivery, maternal use of tobacco, maternal social class, maternal education levels, maternal BMI during pregnancy/at conception, and source of nutrition (breast milk vs. formula) (Sanyaolu et al, 2019). Additionally, Kansra et al. (2021) identified monogenic and polygenic mutations and biologic factors such as hormone regulatory control, levels of circulating hormones, and sensory stimulation as nonmodifiable risk factors for adolescent obesity.

Food insecurity has also been identified as a nonmodifiable risk factor for adolescent obesity in the recent literature. For example, Oberle et al. (2019) reported that children from households with food insecurity presented with higher BMIs than their food-secure peers. Similarly, St. Pierre et al. (2022) completed a systematic review of 13 peer-reviewed journal articles and reported that food insecurity served as a risk factor for childhood obesity, especially among girls and among children who experience multiple periods of food insecurity.

Adolescent Obesity: Prevalence and Recent Trends

Obesity among adolescents in the United States is an increasingly prevalent public health issue. Obesity prevalence among adolescents aged 12 to 19 years was recently reported as 22.2% NCHS, 2021). Sanyaolu et al. (2019) reported that adolescent obesity has become an epidemic in the United States, with prevalence rates having increased dramatically over the past two decades. More specifically, the NCHS (2021) reported that the prevalence of obesity among adolescents (aged 12 to 19 years) increased from 14.8% in 2000 to 21.2% in 2018.

Additionally, many researchers have noted that obesity rates among U.S. adolescents have increased dramatic during the COVID-19 pandemic. Wu et al. (2022) investigated changes in obesity prevalence rates among youth in Massachusetts during the COVID-19 pandemic (2018 – 2020) and found that prevalence rates increased at a faster rate among children aged 2 to 17 years from 2019 to 2020 than in any period prior to 2019. Similarly, Lange et al. (2021) reported that the rate of increase in BMI among children and adolescents almost doubled during the COVID-19 pandemic compared to a pre-pandemic period of similar duration (Figure 2). Additionally, Woolford et al. (2021) found that relative increases in overweight or obesity was 13.4% among adolescents aged 12 to 15 years and 8.3% among adolescents aged 16 to 17 years during the COVID-19 pandemic.

Obesity Prevalence by Sex

Demographic factors such as sex and race reveal interesting trends in obesity prevalence among adolescents. For example, obesity rates among adolescent females

increased from 14.8% in 2000 to 19.9% in 2018 while obesity rates among adolescent males increased from 14.8% in 2000 to 22.5% in 2018 (NCHS, 2021). Across a broader timeline, NCHS (2018) reported that prevalence rates of obesity among adolescent males increased from 4.5% in 1970 to 20.2% in 2016 while obesity rates among adolescent females increased from 4.7% in 1970 to 20.9% in 2016.

Obesity Prevalence by Race

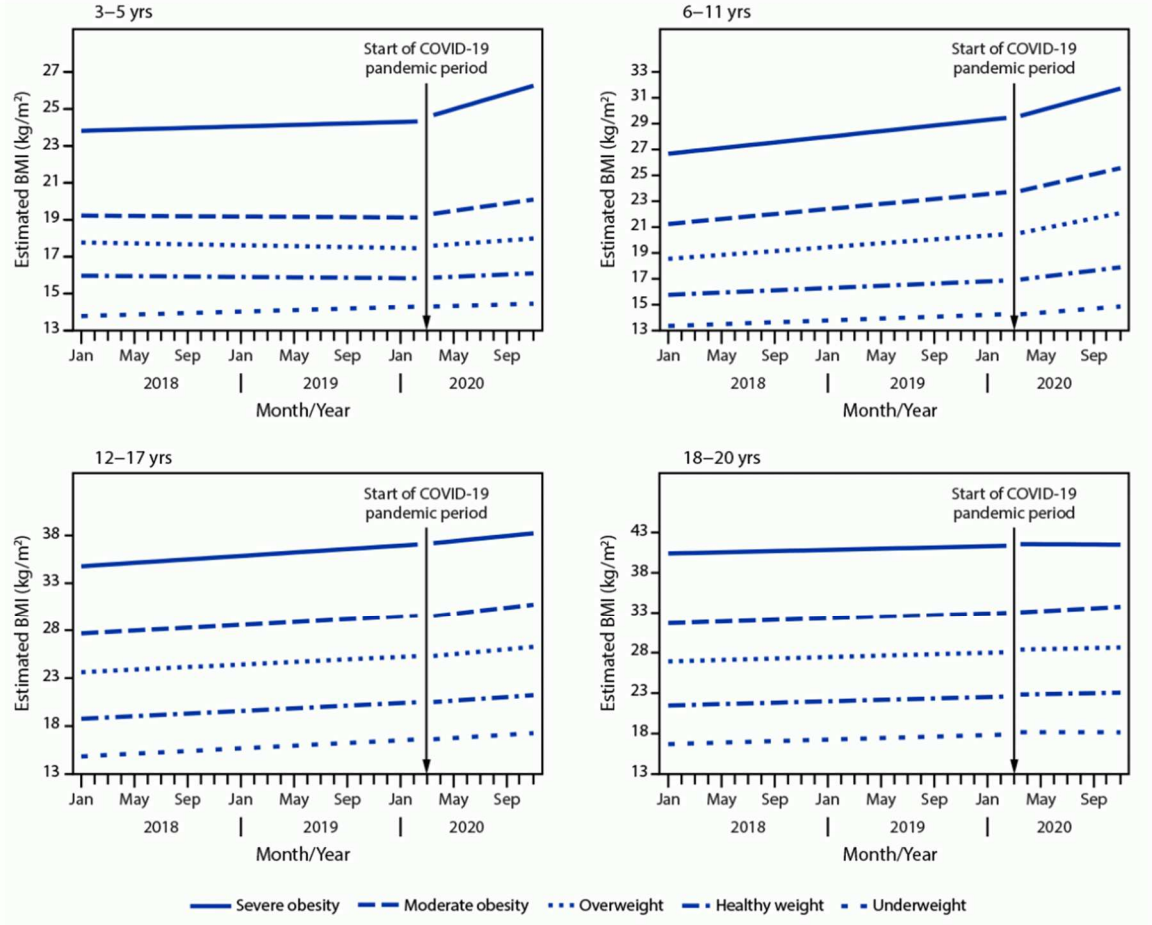
Adolescent obesity is more common among certain racial and ethnic groups, including non-Hispanic Blacks, Hispanics, and Native Americans. Considering changes in prevalence rates by race, obesity rates among children and adolescents increased from 18.8% in 2000 to 24.2% in 2018 among non-Hispanic Blacks and from 11.0% in 2000 to 16.1% in 2018 among non-Hispanic Whites (Ogden et al., 2020). Additionally, Ogden et al. (2020) noted that obesity rates among Hispanic children and adolescents increased from 21.0% in 2008 to 25.6% in 2018. Although obesity prevalence data specific to Native American adolescents is limited, Bullock et al. (2017) used data from the Indian Health Service National Data Warehouse and found that the prevalence rate of obesity was 29.7% among Native Americans aged 2 to 19 years in 2015 - significantly higher than the national average for all U.S. children. Interestingly, Bullock et al. also noted that Native American boys had markedly higher rates of obesity than Native American girls (31.5% vs. 27.9%). Additionally, the Office of Minority Health (2020) reported summary health statistics from the 2018 National Health Interview Survey and noted that Native American adolescents were 30% more likely to be obese than their non-Hispanic white peers.

Adolescent Obesity: Impact on Health

To better understand the natural history of obesity, many researchers have studied the short-term and long-term impacts of obesity on health among adolescents. For example, Kansra et al. (2021) identified numerous health issues associated with childhood and adolescent obesity including asthma, fatty liver disease, hormonal issues, musculoskeletal conditions, polycystic ovary syndrome, disordered sleep and sleep apnea, body dysmorphia and eating disorders, depression and anxiety, and cardiovascular disease risk factors such as hypertension, diabetes mellitus type II, and dyslipidemia. While many of the health issues associated with obesity can impact adolescents in the short-term, there is much evidence demonstrating that these issues can negatively impact health across the lifespan.

Figure 2

Estimated Body Mass Index Before and During the COVID-19 Pandemic, January 2018–November 2020



Obesity-Related Health Issues During Adolescence

Researchers have described a variety of physical and mental health issues that affect obese adolescents. When considering physical health condition that negatively impact obese adolescents, Twig et al. (2020) reported that obese male and female teenagers are at increased risk of developing diabetes mellitus type II during adolescence and early adulthood, with a hazard ratio of 1:26 for males and 1:45 for females. Zamora-Kapoor et al. (2021) used data from the National Longitudinal Study of Adolescent to

Adult Health to investigate the relationship between adolescent obesity and hypertension and found that higher body mass index was associated with an increased risk of hypertension among Native American, Hispanic, non-Hispanic Black, and non-Hispanic White adolescents. Additionally, adolescent obesity has been associated with the development of several severe comorbidities including nonalcoholic fatty liver disease, cardiovascular disease, and a variety of non-cardiometabolic conditions. Kohut et al. (2019) completed a systematic review and reported that among obese adolescents, nonalcoholic fatty liver disease was present in one-third of boys and a quarter of girls. Interestingly, Karaağaç et al. (2019) reported that systolic and early diastolic ventricular function among obese adolescents improved with weight loss. Gohil (2018) demonstrated that prevalence rates and severity of obstructive sleep apnea increase with higher BMI scores while Kessler et al. (2018) found that obese adolescents had an increased risk of developing osteochondritis dessicans at the elbow (3.1 times higher risk), ankle (3.0 times higher risk), and knee (1.8 times higher risk) than their normal-weight peers. Whitaker et al. (2018) reported that adolescent obesity was predictive of sleep difficulty and decreased quality of life scores.

When considering mental health issues that negatively impact obese adolescents, Chu et al. (2019) reported that adolescents with obesity were often found to suffer from psychological disorders including depression, impaired body image, low self-esteem, eating disorders, and stress. More specifically, Wang et al. (2019) completed a meta-analysis of case-control studies on the prevalence of depression and anxiety among obese adolescents and found that the prevalence of depression (21.7%) and anxiety (39.8%)

among obese adolescents was significantly higher than in normal-weight adolescents (18.0% and 14.0%, respectively). Similarly, Çolpan et al. (2018) completed a case-control study and demonstrated that irritability, self-esteem, emotional and behavioral problems, attention deficit-hyperactivity disorder, problems in peer relationships, and social skills were significantly worse among obese adolescents than their non-obese peers.

Obesity-Related Health Issues During Adulthood

While many conditions have been identified that impact the health of obese adolescents in the short-term, many serious physical and mental health issues have been found to impact individuals who were obese as adolescents later in life. When considering long-term physical health conditions, Sommer and Twig (2018) reported that obesity during adolescence increased the incidence rates of cardiovascular disease risk factors and was associated with higher risks of cardiovascular morbidity and mortality as adults. These authors also reported that obese adolescents were found to have a greater likelihood of developing cardiovascular comorbidities such as ischemic heart disease and stroke later in life (Sommer & Twig, 2018). Similarly, Weihrauch-Blüher et al. (2018) studied the epidemiology, underlying factors, and long-term health impacts of adolescent obesity and found that childhood obesity leads to increased morbidity and mortality due to cardiovascular disease in adulthood. Additionally, Similarly, Bjerregaard et al. (2018) reported that an abnormally high weight status at age 7 years and 13 years was associated with an increased risk of developing diabetes mellitus type II after age 30. Finally, Furer et al. (2020) estimated hazard ratios for incident cases of cancer and found that the

adjusted hazard ratio for men was 1:26 and 1:27 for women who were obese as adolescents.

When considering long-term mental health issues associated with adolescent obesity, Ruiz et al. (2020) reported that adolescents with obesity demonstrate increased levels of stress, depressive symptoms, and reduced resilience during adulthood. Similarly, Reinehr (2018) reported that adolescents with obesity that continues into adulthood is associated with a wide range of social problems including difficulties securing employment or finding a partner. Additionally, Gibson-Smith et al. (2020) studied the association between childhood obesity and depressive symptoms later in life and found that being overweight or obese at 8 years of age was associated with an increased risk of lifetime major depressive disorder.

Substance Use: Relevant Definitions and Risk Factors for Use

Alcohol, marijuana, and tobacco are among the most used substances in the United States. Alcohol is a psychoactive chemical present in beer, wine, and liquor that is produced by fermentation using sugar and yeast (NCI Dictionary of Cancer Terms, n.d.). Marijuana is a mixture of the dried flowers of the *Cannabis sativa* plant that contains more than five hundred chemicals including the psychoactive chemical delta-9-tetrahydrocannabinol (THC) (*What Is Marijuana,* 2021). Tobacco is a crop that is harvested for its leaves which are dried and fermented before being incorporated into products that can be smoked, chewed, or sniffed (*Cigarettes and Other Tobacco Products DrugFacts*, 2022). Tobacco contains more than 7,000 chemical compounds, including the psychoactive chemical nicotine. Prolonged use of each of these substances has been

linked to several adverse health conditions, prompting their regulation in the United States.

Each state in the United States possesses the authority to regulate the production, sale, distribution, and use of alcohol, marijuana, and tobacco. According to the U.S. Department of Justice's Drug Enforcement Administration (DEA), marijuana is considered a Schedule I controlled substance under the Controlled Substances Act (*Drug Scheduling*, n.d.). The Schedule I designation indicates that the substance has a high potential for abuse, has no currently accepted medical use in treatment, and has a lack of accepted safety for use under medical supervision (*Drug Scheduling*, n.d.). Despite widespread calls from public health officials for regulation of alcohol and tobacco under the Controlled Substances Act, these substances are not legally defined as controlled substances by the DEA.

Risk Factors for Adolescent Substance Use

Like obesity, researchers have described many risk factors associated with substance use among adolescents. Schuler et al. (2019) reported that adolescent substance use was associated with perceived best friend use and with perceived sibling and adult use. Similarly, Cambron et al. (2018) utilized data from the Seattle Social Development Project reported to complete a multiethnic longitudinal cohort study and found that social factors such as living in more socioeconomically disadvantaged neighborhoods, lower levels of family income, lower levels of general family functioning, more permissive family smoking environments, and affiliation with deviant peers were associated with increased tobacco use. Additionally, the authors noted that lower family functioning,

more permissive family alcohol use environments, and deviant peers were associated with increased alcohol use (Cambron et al., 2018). Bierhoff et al. (2019) also conducted a longitudinal cohort study and found that greater ADHD symptoms predicted alcohol and cannabis use and that tobacco use was predicted by greater depressive and anxiety symptoms. Rusby et al. (2018) also investigated risk factors for alcohol use among adolescents and reported that poorer youth-parent relationships and lower levels of parental monitoring were associated with alcohol and marijuana use, parent binge drinking was predictive of alcohol use, and parental report of poor youth-parent relationship predicted marijuana use.

Considering risk factors specific to marijuana use, Guttmannova et al. (2019) collected longitudinal data from more than 2000 adolescents in 12 different communities and found that perceptions of limited enforcement of laws regarding and perceived low harm from use, were predictive of marijuana use throughout adolescence. Alternately, Dugas et al. (2018) found that male sex, higher levels of family stress, use of alcohol, cigarettes, and other tobacco products, tobacco use by a parent, sibling, and/or friend, higher body mass index, higher impulsivity, and lower self-esteem were risk factors of marijuana use among adolescents. Additionally, De la Peña-Arteaga et al. (2019) completed a systematic review of marijuana use risk factors and found that childhood physical or sexual abuse were strong risk factors for marijuana use.

Kim et al. (2020) reported that level of parent education, parent smoking status, high levels of sensation-seeking behavior and impulsivity, delinquent behavior, depression and anxiety, and cigarette advertising receptivity were strong risk factors for

tobacco use among adolescents while Simon et al. (2018) found that exposure to tobacco advertisements was a significant risk factor for tobacco use among adolescents. Considered collectively, this wide variety of risk factors may provide insight into prevalence rates of substance use among U.S. adolescents.

Substance Use: Recent Prevalence

Despite state and federal regulations that prohibit use by minors, use of alcohol, marijuana, and tobacco products are common among adolescents in the United States. Jones et al. (2020) analyzed the Youth Risk Behavior Surveillance System survey results from 2019 and reported that 29.2% of U.S. high school students reported consuming at least one drink of alcohol and 21.7% reported using marijuana at least once during the 30 days prior to being surveyed. Additionally, Creamer et al. (2020) analyzed the same dataset and reported that 36.5% of U.S. high school students reported past 30-day use of tobacco products.

Substance Use: Recent Trends

Since prevalence rates of alcohol, marijuana, and tobacco use among adolescents have been reported at regular intervals for at least two decades in the United States, many researchers have reported longitudinal changes in substance use rates among adolescents. When considering alcohol use, Jones et al. (2020) reported that the percentage of students who reported consuming at least one drink of alcohol in the 30 days prior to being surveyed to decreased from 41.8% in 2009 to 29.2% in 2019. Demonstrating a similar but more prolonged trend, the National Institute on Alcohol Abuse and Alcoholism (2021)

reported that the past 30-day alcohol consumption prevalence rate for high school students decreased from 50.8% in 1991 to 29.2% in 2019.

When considering marijuana use, Jones et al. (2020) reported that past 30-day use of marijuana among high school students increased from 20.8% in 2009 to 21.7% in 2019. Interestingly, Dai (2019) found that among high school students who only used marijuana, prevalence rates of past 30-day use increased from 0.6% in 1991 to 6.3% in 2017.

When considering tobacco use, Meza et al. (2020) reported that past 30-day tobacco use (of all types) among adolescents increased from 1991 to 1998, but then decreased steadily to 2019. Alternately, Sun et al. (2021) used nicotine product days (NPD) data (defined as the number of days that an individual consumed tobacco products in the past 30 days) from the National Youth Tobacco Survey and found that NPDs decreased from 5.6 days per month in 1999 to 2.2 days per month in 2017, increased to 4.6 days per month in 2019, and then decreased to 3.6 days per month in 2020. Additionally, Tam and Brouwer (2021) reported that rates of past-30-day use of e-cigarettes significantly increased from 2014 to 2018 among high school students who never, formerly, and currently smoked. Much like trends in obesity prevalence rates, demographic factors such as sex and race offer interesting insights into the prevalence of substance use among adolescents over the past two decades.

Substance Use: Prevalence and Recent Trends by Sex

The National Institute on Alcohol Abuse and Alcoholism (2021) reported that past 30-day alcohol use among adolescent females decreased from 47.4% in 1999 to

31.9% in 2019 while past 30-day alcohol use among adolescent males decreased from 52.3% in 1999 to 31.9% in 2019. Yu et al. (2021) reported that past 30-day marijuana use decreased from 21% in 1978 to 5% in 1993, with a steady increase to 12% in 2016 among adolescent females while post 30-day marijuana use among adolescent males decreased from 34% in 1978 to 10% in 1992 before increasing to nearly 18% in 2016. Additionally, past 30-day use of tobacco among adolescent females decreased from 36.9% in 1999 to 36.6% in 2019 while past 30-day use of tobacco among adolescent males decreased from 41.4% in 1999 to 36.3% in 2019 (Creamer, 2019).

Substance Use: Prevalence and Recent Trends by Race

Like the differences in rates of substance use based on sex, rates of substance use vary among racial and ethnic groups including non-Hispanic Blacks, non-Hispanic Whites, Hispanics, and Native Americans. Considering changes in substance use prevalence rates by race over the past two decades, The National Institute on Alcohol Abuse and Alcoholism (2021) reported the following prevalence rates of substance use by race:

Past 30–day alcohol use:

- decreased from 39.9% in 1999 to 16.8% in 2019 among non-Hispanic Blacks
- decreased from 52.5% in 1999 to 34.2% in 2019 among non-Hispanic Whites
- decreased from 52.8% in 1999 to 28.4% in 2019 among Hispanics

Prevalence rates of past 30–day marijuana use:

- decreased from 26.4% in 1999 to 21.7% in 2019 among non-Hispanic Blacks
- decreased from 26.4% in 1999 to 22.1% in 2019 among non-Hispanic Whites

- decreased from 28.2% in 1999 to 22.4% in 2019 among Hispanics

Prevalence rates of past 30–day tobacco use:

- decreased from 25.7% in 1999 to 24.7% in 2019 among non-Hispanic Blacks
- decreased from 43.3% in 1999 to 42.0% in 2019 among non-Hispanic Whites
- decreased from 35.5% in 1999 to 33.8% in 2019 among Hispanics

Also, Banks et al. (2017) found that Native American adolescents were more likely than their White peers to use marijuana and cigarettes while Swaim et al. (2018) reported that lifetime and current substance use rates were significantly higher among Native American youth than national averages. Additionally, Terry-McElrath and Patrick (2018) investigated patterns of alcohol use among U.S. high school seniors by race/ethnicity and found that prevalence rates of alcohol use among Native American students were among the highest of all races/ethnicities studied.

Considering changes in substance use prevalence rates specifically among Native American high school students, rates of past 30-day alcohol use decreased from 51.4% in 2001 to 32.6% in 2019, rates of past 30-day marijuana use decreased from 36.4% in 2001 to 33.8% in 2019, and rates of past 30-day tobacco use increased from 48.5% in 2001 to 52.4% in 2019 (The National Institute on Alcohol Abuse and Alcoholism, 2021). Substance use remains high among U.S. high school students despite many sex- and race-specific decreases over the past two decades, contributing to significant impacts on health within this population.

Substance Use: Impact on Health

To better understand the health impacts of substance use among adolescents, researchers have investigated a variety of physical and mental health issues that are associated with alcohol, marijuana, and tobacco product use. For example, while Lees et al. (2020) reported that adolescent alcohol use contributed to changes in brain structure and neurologic function while Morin et al. (2018) reported that numerous cognitive issues were associated with the use of alcohol and marijuana by adolescents. Similarly, Kwon et al. (2019) reported that alcohol, marijuana, and tobacco product use among adolescents was associated with sleep disturbances that broadly impact health.

Since substance use contributes to many negative health conditions, co-use of substances such as alcohol, marijuana, and tobacco among adolescents is a significant concern among healthcare practitioners. Roche et al. (2019) reported that the use of alcohol, marijuana, and tobacco each increased the odds of simultaneous use of one of the two remaining substances, with co-use of alcohol and cigarettes being predictive of the same-day use of marijuana and the co-use of marijuana and cigarettes being predictive of the same-day use of alcohol. Additionally, D'Amico et al. (2020) reported that time spent with peers who use alcohol and marijuana and positive use expectations contributed to a greater likelihood of co-use of alcohol and marijuana while increases in use of tobacco and marijuana and time spent around peers who use tobacco and marijuana led to a greater likelihood of co-use of tobacco and marijuana among young adults. While many researchers have identified concerning health issues that are common among individuals

who use alcohol, marijuana, and tobacco, there is much evidence demonstrating adverse physical and mental health conditions that are unique to each substance.

Health Issues Related to Alcohol Use

Many researchers have described unique physical and mental health issues that affect individuals who consume alcohol. When considering the physical health conditions that negatively impact alcohol users, Spear (2018) reported that the consumption of alcohol during adolescence is associated with deficits in verbal learning, attention, and visuospatial and memory tasks while other researchers reported that adolescent alcohol use can lead to disrupted growth, delayed sexual development, and memory deficits (Jones et al., 2020; Olson and Crosnoe, 2018). Additionally, other investigations have found that heavy alcohol consumption early in life is associated with the development of hypertension, cardiovascular disease, and heart failure Goel et al. (2018), Roerecke et al., 2018). Similarly, Kushner et al. (2020) described strong associations between early life alcohol use and fatty liver disease, cirrhosis, and liver failure. Furthermore, LoConte et al. (2017) reported that drinking alcohol was a cause of cancers of the oral cavity, pharynx, larynx, esophagus, breast, liver, and colorectum.

When considering adverse mental health conditions that impact adolescents who consume alcohol, Quigley et al. (2019) reported that alcohol use during adolescence is associated with an increased risk of anxiety, depression, sleep disturbance, and self-harm as well as higher rates of high-risk sexual and criminal behaviors. Additionally, McHugh et al. (2019) found that individuals with alcohol use disorder major are nearly three times

more likely to have major depressive disorder and almost 2 times more likely to have dysthymia than individuals who do not have alcohol use disorder.

Health Issues Related to Marijuana Use

As with alcohol use, several physical and mental health conditions have been associated specifically with the use of marijuana. When considering the physical health issues associated with marijuana use, Hammond et al. (2020) reported that marijuana use among adolescents was associated with cognitive impairments, worse academic and occupational outcomes, and increased prevalence of psychotic, mood, and addictive disorders. Marijuana or Cannabis Use Disorder, defined as the inability to cease using marijuana despite the development of health and social problems, has been estimated to effect approximately 30% of marijuana users (Mennis, 2020, Cerda et al., 2020). Additionally, Browne et al. (2020) estimated that past-12-month and lifetime cannabis use disorder prevalence among non-medical cannabis users were 24.4% and 17.4%, respectively.

Health Issues Related to Tobacco Use

Like alcohol and marijuana, the use of tobacco products has also been linked to a multitude of unique physical and mental health conditions. The U.S Department of Health and Human Services (2017) reported that cigarette smoking increases the risk of coronary heart disease and stroke by 2-4 times and is linked to 90% of all lung cancer deaths and 80% of all deaths from chronic obstructive pulmonary disease (COPD). Yang et al. (2020) found that tobacco use was associated with a wide variety of oral health sequelae including gum disease, tooth loss, and oral cancers. Additionally, Boykan et al.

(2019) reported that e-cigarette use among adolescents was associated with early onset nicotine addiction, a condition that Becker et al. (2020) reported leading to elicit drug use and mental health comorbidities including depression, anxiety, suicidality, eating disorders, and attention-deficit/hyperactivity disorder, and conduct disorder.

Adolescent Health Behaviors: Physical Activity and Soda Consumption

Physical activity and soda consumption are two health behaviors that can impact of the weight status of adolescents. Many researchers have identified associations between obesity and the lack of physical activity and the consumption of sugar-sweetened beverages like soda. When considering physical activity, Psaltopoulou et al. (2019) reported that increases in physical activity and decreases in sedentary behaviors were effective in reducing obesity among adolescents. When considering soda consumption, Magripilis et al. (2021) reported that the consumption of foods and beverages that contain added sugars increased the likelihood of overweight and obesity among youth, regardless of other macronutrient consumption.

Relevant Definitions

For this investigation, physical activity refers to aerobic, muscle-strengthening, or bone-strengthening activities. Examples of these activities include walking or biking to and from school, weightlifting, climbing, and participating in organized sports such as soccer, basketball, and tennis. CDC (2019) recommends that adolescents perform at least 60 minutes of moderate-to-vigorous physical activity daily to promote health and fitness.

Also, for this investigation, soda refers to a carbonated beverage that is sweetened with a form of sugar such as corn syrup, fructose, maltose, sucrose, or dextrose (CDC,

2022). For individuals 2 years of age and older, CDC (2022b) recommends that less than 10% of total daily calories should come from added sugars (two hundred calories for an individual following a 2,000-calorie diet).

Physical Activity and Soda Consumption: Prevalence and Recent Trends

The lack of adequate physical activity and the consumption of sugar-sweetened beverages like soda are common behaviors among adolescents in the U.S. CDC (2020a) reported that in 2019, only 23.2% of U.S. high school students reported being physically active for 60 minutes per day on all 7 days during the 7-day period prior to being surveyed. Similarly, Tulchin-Francis et al. (2021) reported that Child mGodin Leisure-Time Score Index (LSI) scores among children and adolescents decreased from 56.6 to 44.6 during the COVID-19 pandemic and that moderate-to-vigorous physical activity levels decreased from 46.7 to 34.7. As shown in Figure 3, CDC (202a) noted that the percentage of high school students who reported being physical active for 60 minutes per day on all 7 days prior to being surveyed decreased from 28.7% in 2011 to 23.2% in 2019.

When considering soda consumption, CDC (2020a) reported that 15.1% of U.S. high school students reported drinking sugar-sweetened soda at least one time per day during the 7 days prior to being surveyed. As shown in Figure 4, CDC (2020a). noted that the percentage of high school students who reported drinking sugar-sweetened soda at least one time per day during the 7 days prior to being surveyed decreased from 29.2% in 2009 to 15.1% in 2019.

Figure 3

Percentage of high school students who engaged in physical activity during the 7 days before the survey - Youth Risk Behavior Survey, United States, 2019

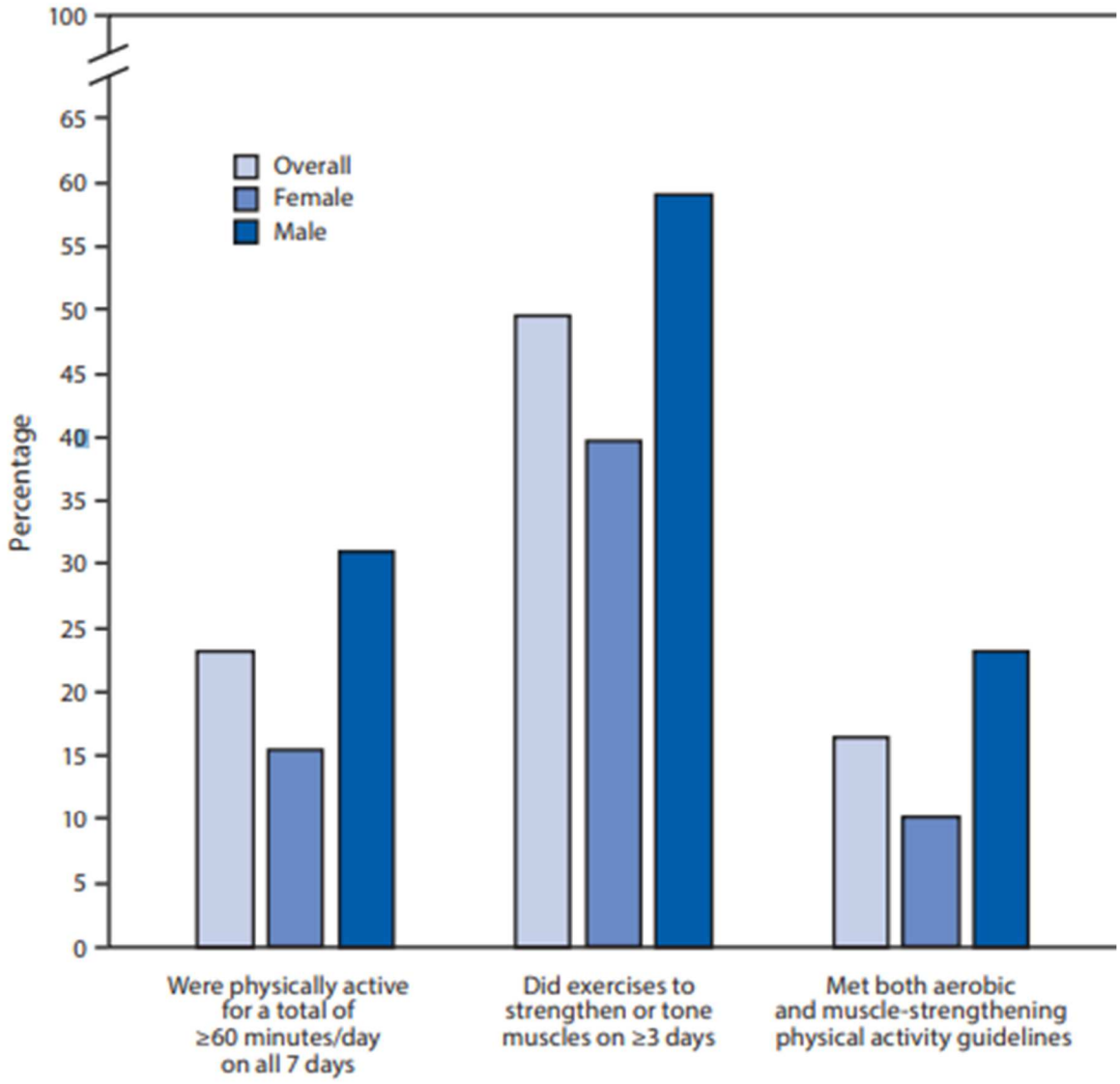
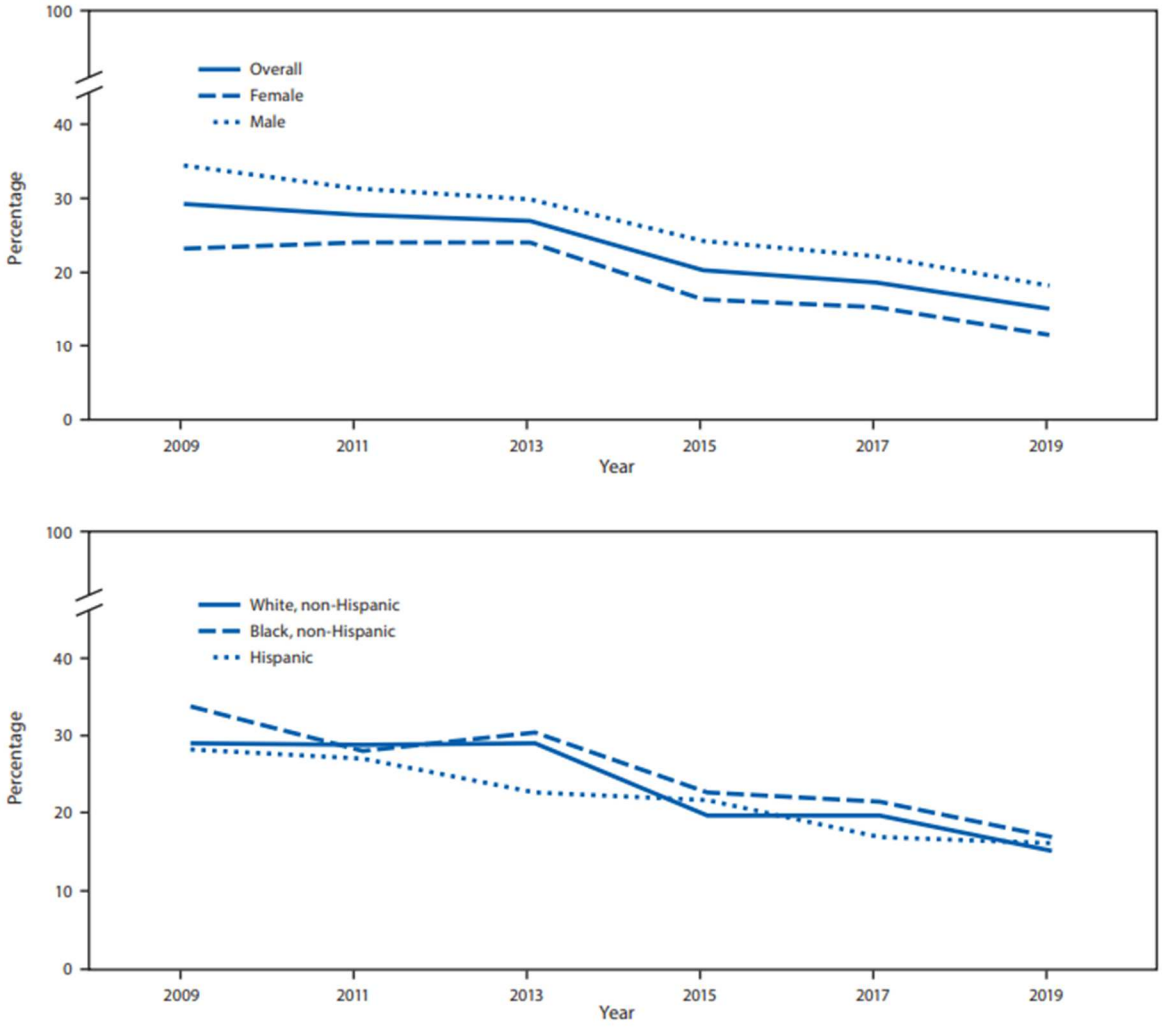


Figure 4

Percentage of high school students who had drunk sugar-sweetened soda or pop at least once per day during the 7 days before the survey - Youth Risk Behavior Survey, United States, 2009–2019



Assumptions

This study was completed with no significant assumptions since it utilizes data from the 2019 YRBSS dataset. The YRBSS utilizes a national, biannual, school-based survey to measure the prevalence of health conditions, including obesity, and health behaviors, including substance use and physical activity, among U.S. high school students (CDC, 2020a). Eliminating assumptions of representative sampling that are common in survey studies, Underwood et al. (2020) reported that a three-stage cluster sample design was utilized to generate a nationally representative sample of U.S. high school students in grades 9 – 12 from both public and private schools.

Scope and Delimitations

This study was specifically designed to evaluate associations between substance use and obesity among Native American high school students using survey data from the 2019 YRBSS. The methodology utilized to conduct the survey study provides important insight into the scope and delimitations in this secondary analysis study. In addition to the sampling process discussed previously, Underwood et al. (2020) described four additional methodologies that guided data collection during the 2019 survey. First, the questionnaire completed by survey participants was comprised of eighty-nine questions, most of which were multiple choice (Underwood et al., 2020). Other than questions assessing height, weight, and race, the remaining multiple-choice questions offered up to eight responses and a test-retest analysis of the full survey demonstrated good reliability (Underwood et al., 2020). Second, CDCs Institutional Review Board approved this study based on anonymous and voluntary participation of students, collection of parental

permission, and data collection during a single class period using a scannable answer booklet (Underwood et al., 2020). Third, data was processed from a total of 13,872 questionnaires, including 195 were not included in the final analysis because less than 20 responses remained after cleaning and editing or the same answer was given for at least 15 consecutive questions (Underwood et al., 2020). Fourth, Underwood et al. (2020) reported that weighting based on participant sex, race/ethnicity, and grade was utilized to account for nonresponses and oversampling of black and Hispanic participants for the 2019 survey.

The variables used to complete this secondary data analysis were all contained within the 2019 YRBSS dataset, including weight status (listed as 'had obesity'), current (past 30-day) alcohol, marijuana, and tobacco product use, sex, current (past 7-day) physical activity and current (past 7-day) soda consumption. The results of this secondary analysis explore associative relationships between variables and are not generalizable to broader populations.

Limitations

This study has multiple limitations that should be considered when interpreting the findings. First, the data utilized for this investigation was collected specifically for the 2019 Youth Risk Behavior Survey and not as primary data for this study. Supporting the limitations associated with the use of secondary data, Cheng and Phillips (2014) reported that access to specific variables is an inherent limitation of secondary data analyses. Second, the 2019 Youth Risk Behavior Survey collected data from children who attend public or private schools, resulting in a dataset that may not represent all high school-

aged individuals. Third, the reporting accuracy by survey participants cannot be determined, though researchers have found that the test-retest reliability of the survey questions has been determined to be good (Brener et al., 2002; Brener et al., 2003). Fourth, high school students from several types of schools, including alternative schools, vocational schools, and schools operated by the Bureau of Indian Education, were excluded from the 2019 Youth Risk Behavior Survey (Underwood et al., 2020). Fifth, Underwood et al. (2020) reported that participant race/ethnicity was determined using two survey questions. The authors noted that the first question, "Are you Hispanic/Latino?" offered response options of "yes" or "no", and the second, "What is your race?", offered response options of "American Indian or Alaska Native", "Asian", "Black or African American", Native Hawaiian or other Pacific Islander", or "White" and allowed participants to select multiple answers. Race/ethnicity was determined to be Hispanic, if the first question was answered "yes," regardless of their response to the second question; Black, if the first question was answered "no" and the response to the second question was only "Black or African American"; White, if the first question was answered "no" and the response to the second question was only "white"; or Missing, if either the first or second question was unanswered.

While individual races were reported for survey participants who answered "no" to the first question and selected only a single race for the second question, the national survey report aggregates race/ethnicity data into only four categories: Black, Hispanic, White, and Other, making it difficult to fully understand differences in health behaviors among American Indians/Alaska Natives, Asians, and Native Hawaiians/Pacific

Islanders. Finally, the Youth Risk Behavior Survey is a cross-sectional cohort survey that can be used to identify associations between variables but cannot be used to explain reasons for trends or to determine causality.

Significance

This study is significant in that it describes the association between substance use and obesity among Native American adolescents, which is limited or absent in the current literature. Considering the call to action from Eitle and Eitle (2018) to explore differences in the relationship between substance use and obesity among various racial/ethnic populations, the significance of this study is that it may provide a better understanding of the impact of specific adolescent behaviors on health among the well-defined and underserved population of Native American adolescents. Findings from this study may be used to support policy changes at the tribal, district, state, or national level. Additionally, findings can be leveraged for the development of obesity prevention interventions that meet the specific and unique needs of Native American adolescents throughout the United States.

This study also presents multiple opportunities to elicit meaningful social change. First, the findings from this investigation can be used to foster collaboration among healthcare providers and school district personnel that prioritize obesity prevention interventions among Native American adolescents. For example, Redmond et al. (2019) described a multilevel, multicomponent (MLMC) obesity prevention program termed OPREVENT (Obesity PRevention and Evaluation of InterVention Effectiveness in NaTive North Americans) that was developed by the Department of International Health

and Human Nutrition at Johns Hopkins University and implemented by in community food stores, worksites, schools, and media in five rural Native American communities over the course of one year. The authors reported that the school-based component of the program was designed to educate elementary school children in the classroom and motivate them to act as change agents within their household (Redmond et al., 2019). Data from this study may help to inform the design of similar MLMC obesity prevention programs in the future by providing insights on health behaviors associated with obesity among Native American adolescents.

Additionally, public health practitioners may also use findings from this study to develop new or enhance existing programs designed to discourage substance use among Native American adolescents. The Tribal Law and Order Act (TLOA), signed into law by President Barack Obama in 2010, helps to "ensure that justice, safety, education, youth, and alcohol and substance misuse prevention and treatment issues relevant to Indian Country remain the subject of consistent focus for the federal government." (*About the Tribal Law and Order Act*, n.d.). As a requirement of this act, the Secretary of the Department of Health and Human Services, the Secretary of the Interior, and the United States Attorney General, in coordination with the Substance Abuse and Mental Health Services Administration (SAMHSA), are required to determine the scope of substance misuse among the Native American population, identify resources and programs that could be used to address substance misuse, and coordinate existing substance misuse programs with those established under the TLOA (*About the Tribal Law and Order Act*, n.d.). Data from this study may help to support the development of new or to enhance

existing TLOA substance misuse prevention programs for Native American adolescents by providing information about associations between substance use and adverse health conditions such as obesity.

Summary and Conclusion

Among Native American adolescents, obesity is a costly health condition, and the use of alcohol, marijuana, and tobacco products are concerning health behaviors. The Office of Minority Health (2020) reported that Native American adolescents are 30 percent more likely to be obese than non-Hispanic white high school students while Zhao et al. (2022) reported that rates of substance use, including tobacco and alcohol, are significantly higher among Native American adolescents that their non-Hispanic white peers. Despite considerable evidence linking both obesity and substance use to short- and long-term health issues among Native Americans, evidence describing associations between substance use and obesity among Native American adolescents is notably lacking.

The Health Belief Model (HBM) serves as the theoretical foundation for this secondary data analysis. Despite its limitations, the HBM is an appropriate framework for this study based on its inherent assumptions that people generally want to avoid illness or injury, that certain behaviors can prevent these illnesses/injuries, and that an individual's actions are linked to their perceptions of the benefits of an action and the barriers associated with performing these actions Skinner et al., 2015). The six constructs that comprise the HBM can be readily applied to behaviors associated with the prevention of obesity and support this study's research questions, which include:

1. What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?
2. What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?
3. What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?
4. What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

These questions were developed based on a gap identified by searching recently published literature. When considering obesity and substance use among Native American high school students, many researchers have quantified recent prevalence rates and reported on trends over the past several decades (Stierman et al., 2021; Sanyaolu et al., 2019; Woolford et al., 2021; Bullock et al., 2017; Jones et al., 2020; The National Institute on Alcohol Abuse and Alcoholism, 2021; Meza et al., 2020). Additionally, researchers have described multiple adverse health conditions resulting from obesity and substance use (Twig et al., 2020; Kapoor et al., 2021; Karaağaç et al., 2019; Gohil, 2018; Kessler et al., 2018; Morin et al., 2018; Kwon et al., 2019; Roche et al., 2019; Spear, 2018; Kushner et al., 2020; Hammond et al., 2020; Yang et al., 2020; Becker et al.,

2020). Unfortunately, there is little evidence describing associations between obesity and substance use among Native American high school students, contributing to challenges addressing these two concerning public health issues. The investigation of these associations is significant in that findings from this study may be used to support policy change, develop more effective and culturally sensitive preventive interventions, and inform public health campaigns designed to promote behaviors that protect against obesity and substance use among Native American adolescents. The second section of this study builds upon this foundational information by describing this study's design, methodology, and operationalization of theoretical constructs.

Section 2: Research Design and Data Collection

Introduction

Obesity and substance use are two significant public health issues among Native American adolescents. The purpose of this quantitative study is to examine associations between current substance use and obesity among Native American high school students, when adjusted for sex and two specific health behaviors: soda consumption and physical activity. This section explains the research design, describes the study methodology, including the study population, relevant sampling procedures, the instrumentation and operationalization of constructs, and data analysis plan, and details all applicable threats to validity.

Research Design and Rationale

According to Underwood et al. (2020), the Youth Risk Behavior Surveillance System (YRBSS) catalogs health-related behaviors, conditions, and experiences among U.S. high school students. The YRBSS includes a national, Youth Risk Behavior Survey (YRBS) which collects data about behaviors that contribute to causes of mortality, morbidity, and social problems (Underwood, 2020). CDC (2020b) noted that the YRBS has been conducted biannually since 1991 and currently includes questions related to violence and behaviors that lead to unintentional injury, tobacco use, alcohol and drug use, sexual behaviors, dietary behaviors, physical and sedentary activities, and respondent demographics.

Data from participants in the 2019 YRBS who self-identified as *Native American or Alaska Native* were used to conduct this study. The dependent variable of obesity, the

independent variables of current (past 30-day) alcohol use, current (past 30-day) marijuana use, and current (past 30-day) tobacco product use, and the control variables of sex, current (past 7-day) physical activity, and current (past 7-day) soda consumption are all extracted from the dataset and categorized as dichotomous.

Relative to these variables, this study includes four distinct research questions:

1. What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

2. What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

3. What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

4. What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

To effectively answer these research questions, a cross-sectional study design was employed to investigate associations between current use of alcohol, marijuana, and tobacco products and obesity among Native American high school students. This study design was not impacted by constraints on time, resources, or scope.

Cross-sectional studies are a type of observational study that examines a defined population at a single time point (The Medical College of Wisconsin, 2022). While widely utilized by public health practitioners, cross-sectional studies produce low levels of evidence but offer researchers many advantages including cost-efficiency and ease of execution (Spector, 2019; Wang & Cheng, 2020). Cross-sectional studies have historically contributed to public health knowledge by providing information about the prevalence of disease or health conditions among specific populations (Wang & Cheng, 2020), but have also advanced knowledge in the public health domain by evaluating the etiology of disease and to obtain information about the health status of a population (Kogevinas and Chatzi, 2021). Large cross-sectional studies are used by researchers in many countries around the world to collect prevalence and etiological data that is critical to the development of programs and policies that safeguard population health.

Methodology

Population

The YRBSS monitors the health behaviors, conditions, and experiences of U.S. high school students (CDC, 2020a). Between August 2018 and June 2019, a total of 13,872 surveys were completed by public and private school students in Grades 9 through 12 from 136 schools throughout the U.S. (Underwood et al. (2020). Of these surveys, 195 failed quality control measures and were removed from the dataset, leaving a total of 13,677 surveys for analysis (Underwood et al., 2020). In total, the school response rate was 75.1%, the student response rate was 80.3%, and the overall response rate 60.3% (Underwood et al., 2020).

Sampling Procedures

The YRBSS uses a complex sampling process to ensure that survey participants are representative of U.S. high school students (CDC, 2020a). According to Underwood et al. (2020), all private, parochial, and public (including charter) schools in the U.S. (including the District of Columbia) with students in at least one grade between ninth and 12th comprised the sampling frame. Schools with less than 40 total students across grades nine through twelve, alternative schools, vocational schools with students who attended other schools, and schools operating by the U.S. Department of Defense or the Bureau of Indian Education were excluded from the sampling process (Underwood et a., 2020). The sampling frame was created from datasets from the Common Core of Data for public schools and the Private School Universe Survey for non-public schools (Underwood et al., 2020) These data sets were subsequently compiled by the National Center for Education (NCES) and Market Data Retrieval, Inc. (Underwood et al., 2020).

A nationally representative sample of U.S. high school students was developed for the 2019 YRBS using a three-stage cluster sampling process (Underwood et al., 2020). The first stage included a total of 1,257 primary sampling units (PSUs) that were derived from full counties, multiple small, adjacent counties, or sections of large counties (Underwood et al., 2019). These PSUs were organized into sixteen strata based on the percentage of Hispanic and non-Hispanic black students in each PSU. The second stage involved creating 177 secondary sampling units (SSUs) that were comprised of singular schools with grades nine through twelve or multiple schools that when combined included all four grades (Underwood et al., 2020). The third sampling stage included the

random selection of one or two classes in each grade from a required subject or period (Underwood et al., 2020).

Data Collection

The 2019 YRBS included a total of 99 questions – 89 taken from the standard questionnaire and ten additional questions that represented areas of specific interest of CDC and other external stakeholders (CDC, 2020a). Prior to survey administration, all questions were reviewed for format, readability, and clarity as well as test-retest analysis which indicated good reliability (Underwood et al., 2020). The survey was anonymized and voluntary, and all questions, except for those that asked participants to record their height and weight, were constructed as multiple choice with a maximum of eight mutually exclusive responses (Underwood et al., 2020). Underwood et al. (2020) reported that CDCs Institutional Review Board approved the 2019 YRBS study protocol, and that parental consent was provided at the local level. Participants completed the 2019 survey during a single class period using a computer-scannable booklet to record their responses (Underwood et al., 2020).

Data Availability and Dissemination

Together with data documentation and analysis guides, YRBS data from 1991 to 2019 is publicly available in various formats on the YRBSS website (https://www.cdc.gov/healthyyouth/data/yrbs/data.htm) (CDC, n.d.-a). YRBSS data is also available through Youth Online – a tool that allows users to conduct data analyses and customized data visualizations (https://nccd.cdc.gov/Youthonline/App/Default.aspx) (CDC , 2020a) and through YRBS Explorer (https://yrbs-explorer.services.cdc.gov/#/) –

an application that allows for the comparisons of national, state, and local data (CDC, n.d.-b).

Data Quality

According to Underwood et al (2020), YRBSS is the largest public health surveillance system in the United States, having collected data from nearly five million high school students since 1991. Contributing to the reputability and quality of the data, CDC continually updates reliability testing procedures, revises questions to reflect relevant changes in the public health domain, and maintains overall response rates greater than 60% (Underwood et al., 2020). Considering these actions and the availability of all variables needed to answer the proposed research questions, the YRBS is the best source of data for this study.

Operationalization of Constructs

The 2019 YRBSS dataset contains all the variables needed to conduct this study including the dependent variable obesity, the independent variables current alcohol use, current marijuana use, and current tobacco product use, and control variables sex, current physical activity, and current soda consumption. All variables utilized in this study are dichotomous (Yes/No). Table 1 includes definitions and operationalization information for all variables utilized in this study.

Data Analysis Plan

Prior to data analysis, the 2019 YRBS national dataset was downloaded from the YRBSS Data and Documentation website, converted from the native ASCII file into an SPSS dataset, and sorted to only include responses from survey participants who

identified as American Indian or Alaska Native. Underwood et al. (2020) reported that data from the national dataset was cleaned and edited for inconsistencies and that missing data was not statistically assigned. The statistical analyses for this study was completed using SPSS version 28.0 (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp).

Research Questions

This data analysis answers the following research questions:

1. What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

2. What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

3. What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

4. What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Statistical Analyses

After reporting descriptive statistics, a multiple binary logistic regression model was used to determine associations between each single independent variable (alcohol

use, marijuana use, and tobacco product use) and the dependent variable obesity when controlling for sex, current physical activity, and current soda consumption. Additionally, multiple binary logical regression was also used to determine associations between all independent variables and the dependent variable obesity, again controlling for sex, current physical activity, and current soda consumption.

Multiple logistic regression models include several assumptions. Kwak and Clayton-Matthews (2002) reported that multinomial logistic regression models assume that dependent variables are nominal and independent variables are continuous, ordinal, or nominal, dependent variable categories are mutually exhaustive, there is no multicollinearity among independent variables, there is a linear relationship between continuous independent variables and the transformed dependent variable, and that there are no outliers. These assumptions are thoroughly addressed as part of the data analysis process.

Power Analysis

One of the most important components of study design is the power analysis. Kemal (2020) noted that a power analysis is a mathematical calculation that approximates the smallest sample population needed to conduct a meaningful statistical analysis. Additionally, Bujang (2021) reported that while power analyses have historically been integral to the design of experimental studies, they are becoming increasingly more common in observational studies. For this observational study, an online a-priori sample size calculator for multiple logistic regression was used to determine the minimum sample size needed to adequately power the data analysis (Universität Düsseldorf:

G*Power, 2022). Using an anticipated effect size of 0.15, a statistical power level of 80%, 6 predictor variables, and a probability level of 0.05, a minimum sample size of 98 was calculated for this analysis.

Threats to Validity

The concept of validity in quantitative, experimental research is associated with outward expressions of the truth. Burkholder et al. (2016) reported that valid research findings truthfully describe and correctly represent the concepts being investigated while seeking to confirm causality between variables. Internal validity refers to the degree to which a cause-and-effect statement about specific variables is accurate while external validity refers to the ability to reproduce research results in different contexts and situations (Burkholder et al., 2016). Since this quantitative investigation uses a cross-sectional study design to investigate associations between self-reported past 30-day use of alcohol, marijuana, and tobacco products and obesity among Native American high school students through an analysis of secondary data from the 2019 YRBSS 2019 dataset, potential threats to internal or external validity of the primary dataset have been addressed in the literature.

While no study has been completed to assess the validity of each behavioral variable included in the YRBS, Brenner et al. (2013) reported that CDC conducted an empirical literature review to assess situational and cognitive factors that could threaten the validity of the behavioral self-reporting process employed by the YRBSS. In this review, Brener et al. (2003) reported that despite self-reported health risk behaviors being influenced by situational and/or cognitive factors, these factors do not threaten the

validity of each type of self-reported behavior equally and that there are marked differences in the extent to which self-reporting can be objectively validated. Additionally, Brener et al. (2003) studied the validity of YRBS questions on self-reported height and weight and found that self-reported measures of height and weight were reliable, despite study participants over-reporting height by an average of 2.7 inches and under-reporting their weight by 3.5 pounds. Brener at al. (2003) noted that this discrepancy may contribute to the underestimation of overweight and obesity within the YRBSS.

Ethical Procedures

Anonymity, often described as the inability to identify responses or outcomes associated with research subjects, is an important ethical consideration when conducting quantitative research. Babbie (2017) reported that research anonymity guarantees that neither the readers of research findings nor the researchers themselves can identify the study participants. Additionally, Walford (2005) reported that anonymity is the ethical norm among education, sociologic, and psychologic research associations, despite challenges with always ensuring anonymity. The YRBS participation is voluntary, and the survey does not collect any type of identifying information (Brener et al., 2013). All 2019 YRBS participants provided consent prior to data collection, which eliminates ethical concerns for this secondary analysis. Describing additional safeguards of anonymity, Brener at al. (2013) reported that students were positioned throughout the classroom space to limit their ability to see others' responses and were encouraged to use a blank page or envelope to cover their responses when actively completing the survey

(Brener et al., 2013). Brener at al. (2023) also reported that CDC does not report subgroup data if the group included less than 100 survey participants to help protect participant anonymity.

Summary

Obesity and substance use are two significant public health issues among Native American adolescents. Data from participants in the 2019 YRBS who self-identified as *Native American or Alaska Native* were used to conduct this quantitative study to examine associations between current substance use and obesity among Native American high school students, when adjusted for sex and two specific health behaviors: soda consumption and physical activity. The dependent variable of obesity, the independent variables of current (past 30-day) alcohol use, current (past 30-day) marijuana use, and current (past 30-day) tobacco product use, and the control variables of sex, current (past 7-day) physical activity, and current (past 7-day) soda consumption were extracted from the national dataset, categorized as dichotomous, and analyzed using multiple binary logistic regression models to answer four unique research questions. This study design is not impacted by constraints on time, resources, or scope and does not include significant ethical concerns. The third section of this study builds upon the study design, methodology, and operationalization of theoretical constructs by presenting all relevant results and findings.

Table 1

Operationalization of Study Variables

Variable Name	Variable Type	Definition	Coding Methodology
Obesity	Dependent	BMI percentile $\geq$ 95th percentile based on 2000 CDC Growth Charts (calculated using YRBS variables age, sex, height, and weight)	Coded as 0 = No; 1 = Yes
Current alcohol use	Independent	At least one drink of alcohol on at least one day during the 30 days before the survey	Coded as 0 = No; 1 = Yes
Current marijuana use	Independent	Used marijuana one or more times during the 30 days before the survey	Coded as 0 = No; 1 = Yes
Current tobacco product use	Independent	Smoked cigarettes or cigars or used smokeless tobacco or used electronic vapor products on at least one day during the 30 days before the survey	Coded as 0 = No; 1 = Yes
Sex	Control		Coded as 0 = Female, 1 = Male
Current physical activity	Control	Were physically active for at least 60 minutes per day on all 7 days during the 7 days before the survey	Coded as 0 = No; 1 = Yes
Current soda consumption	Control	Drank a can, bottle, or glass of soda (pop) one or more times per day during the 7 days prior to the survey	Coded as 0 = No; 1 = Yes

Section 3: Presentation of the Results and Findings

Introduction

The purpose of this quantitative study is to examine associations between current substance use and obesity among Native American high school students, when adjusted for sex and two specific health behaviors: soda consumption and physical activity. This study includes four unique research questions that are constructed with obesity as the dependent variable, current substance use (alcohol, marijuana, and tobacco products) as the independent variables, and sex, soda consumption, and physical activity.as control variables.

Research question 1: What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Research question 2: What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Research question 3: What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Research question 4: What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Null hypothesis: There is no significant association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

Alternative hypothesis: There is a significant association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity.

This section provides a review of the study's research questions and hypotheses, explains the procedures used to access the 2019 YRBS dataset, and presents the results of the statistical analyses used in this study.

Secondary Data Access and Analysis

To address the research questions in this quantitative study, a cross-sectional study design was used to investigate associations between self-reported past 30-day use of alcohol, marijuana, and tobacco and obesity among Native American high school students using an analysis of secondary data from CDCs Youth Risk Behavior Surveillance System (YRBSS) 2019 dataset. To complete this study, the 2019 YRBSS national dataset was downloaded from the Data and Documentation website and the ASCII file was converted to a SPSS dataset. The 2019 YRBSS dataset contains all the variables needed to conduct this study including:

1. Dependent variable: obesity (had obesity; students who were $\geq$ 95th percentile for body mass index, based on sex- and age-specific reference data from the 2000 CDC growth charts)
2. Independent variables: current alcohol use, and current marijuana use, and current tobacco product use (self-reported past 30-day use)
3. Control variables: sex, physical activity, and soda consumption

Data Collection Timeframe and Response Rates

The YRBSS monitors the health behaviors, conditions, and experiences of U.S. high school students (CDC, 2020a). Between August 2018 and June 2019, a total of 13,872 surveys were completed by public and private school students in grades 9 through 12 from 136 schools throughout the U.S. (Underwood et al. (2020). Of these surveys, 195 failed quality control measures and were removed from the dataset, leaving a total of 13,677 surveys for analysis (Underwood et al., 2020). In total, the school response rate was 75.1%, the student response rate was 80.3%, and the overall response rate 60.3% (Underwood et al., 2020).

Dataset Variables and Analysis

From the 13,677 valid survey responses included in the 2019 YRBS dataset, filtering was used to identify responses from individuals who identified exclusively as American Indian/Alaska Native, with a total of 202 survey responses identified (1.5% of all valid surveys). Four variables related to tobacco use (past 30-day cigarette use, past 30-day electronic vapor product use, past 30-day chewing tobacco use, and past 30-day cigar use) were combined, transformed, and recoded as current tobacco product use to permit secondary analysis. Data for at least one of the study variables was missing from 85 respondents, resulting in a final study sample of 117 valid responses (0.86% of all valid surveys).

The analysis for this study was completed using SPSS 28.0 (IBM SPSS Statistics for Windows, Armonk, NY). Frequency distributions were derived for all variables and crosstabs were completed to identify significant associations between key variables.

Results

This quantitative cross-sectional study used a secondary data analysis to determine associations between obesity and substance use among Native American high school students when controlling for sex and two specific health behaviors - soda consumption and physical activity.

Frequency Distributions

Of the 117 valid responses included in this analysis, 63 respondents identified as female (53.8%) and 54 identified as male (46.2%). Sixteen respondents were categorized as obese (13.7%), defined as BMI percentile > 95th percentile based on 2000 CDC Growth Charts (calculated using 2019 YRBS variables age, sex, height, and weight), of which 4 (25.0%) identified as female and 12 (75.0%) identified as male. Thirty-one respondents reported current alcohol use (26.5%), defined as having at least one drink of alcohol on at least one day during the 30 days before the survey, of which 18 (58.1%) identified as female and 13 (41.9%) identified as male. Twenty-three respondents reported current marijuana use (19.7%), defined as having used marijuana one or more times during the 30 days before the survey, of which 10 (43.5%) identified as female and 13 (56.5%) identified as male. Thirty-seven respondents reported current tobacco product use (31.6%), defined as having smoked cigarettes or cigars or used smokeless tobacco or used electronic vapor products on at least one day during the 30 days before the survey, of which twenty (54.1%) identified as female and 17 (45.9%) identified as male. Thirty respondents reported current soda consumption (25.6%), defined as having drank a can, bottle, or glass of soda (pop) one or more times per day during the 7 days prior to the

survey, of which 18 (60.0%) identified as female and 12 (40.0%) identified as male. Forty-one respondents reported being physically active (35.0%), defined as having been physically active for at least 60 minutes per day on all 7 days during the 7 days before the survey, of which 15 (36.6%) identified as female and 26 (63.4%) identified as male. The results of these frequency distribution analyses are presented in Tables 2 and 3.

Table 2

Frequency Distributions – Study Variables

Variable	Frequency	Percentage
Sex		
Female	63	53.8%
Male	54	46.2%
Obesity		
Yes	16	13.7%
No	101	86.3%
Current alcohol use		
Yes	31	26.5%
No	86	73.5%
Current marijuana use		
Yes	23	19.7%
No	94	80.3%
Current tobacco use		
Yes	37	31.6%
No	80	68.4%
Current soda consumption		
Yes	30	25.6%
No	87	74.4%
Current physical activity		
Yes	41	35.0%
No	76	65.0%

Table 3

Frequency Distributions – Study Variables by Sex

Variable	Frequency	Percentage
Obesity	16	
Female	4	25.0%
Male	12	75.0%
Current alcohol use	31	
Female	18	58.1%
Male	13	41.9%
Current marijuana use	23	
Female	10	43.5%
Male	13	56.5%
Current tobacco use	37	
Female	20	54.1%
Male	17	45.9%
Current soda consumption	30	
Female	18	60.0%
Male	12	40.0%
Current physical activity	41	
Female	15	36.6%
Male	26	63.4%

Bivariate Analysis

Bivariate analyses using Chi Square Tests of Independence were completed to evaluate associations between sex and each study variable. These analyses determined that there is a significant relationship between obesity and sex ($\chi^2(1) = 6.206$, $p = .013$) with a small effect size (.230) and a significant relationship between current physical activity and sex ($\chi^2(1) = 7.567$, $p = .006$) with a small effect size (.254). Additionally, these analyses determined that there is not a significant relationship between current alcohol use and sex ($\chi^2(1) = .302$, $p = .583$), there is not a significant relationship between current marijuana use and sex ($\chi^2(1) = 1.28$, $p = .266$), there is not a significant relationship between current tobacco product use and sex ($\chi^2(1) = .001$, $p = .976$), and there is not a significant relationship between current soda consumption and sex ($\chi^2(1) = .615$, $p = .433$). The results of this analysis are presented in Table 4.

Bivariate analyses using Chi Square Tests of Independence were also completed to evaluate associations between the dependent variable obesity and each independent and control variable. These analyses determined that there is a trend toward a significant relationship between current marijuana use and obesity ($\chi^2(1) = 3.736$, $p = .053$) with a small effect size (.179). These analyses also determined that there is not a significant relationship between current alcohol use and obesity ($\chi^2(1) = .021$, $p = .884$), there is not a significant relationship between current tobacco product use and obesity ($\chi^2(1) = .001$, $p = .972$), there is not a significant relationship between current soda consumption and obesity ($\chi^2(1) = .462$, $p = .497$), and there is not a significant relationship between current

physical activity and obesity ($\chi^2(1) = .049$, $p = .825$). The results of this analysis are presented in Table 5.

Table 4

Bivariate Analyses: Sex and Study Variables

Variable	Pearson Chi-Square	Asymptotic Significance	Cramer's V (Effect Size)
Obesity	**6.206**	**.013**	**.230**
Current alcohol use	.302	.583	
Current marijuana use	1.238	.266	
Current tobacco use	.001	.976	
Current soda consumption	.615	.433	
Current physical activity	**7.567**	**.006**	**.254**

Table 5

Bivariate Analyses: Obesity and Study Variables

Variable	Pearson Chi-Square	Asymptotic Significance	Cramer's V (Effect Size)
Current alcohol use	.021	.884	
Current marijuana use	3.736	.053	.179
Current tobacco use	.001	.972	
Current soda consumption	.462	.497	
Current physical activity	.049	.825	

Multivariate Analysis: Research Questions 1 - 3

To address research questions 1, 2, and 3, a two-step hierarchical binary logistic regression was used to analyze the relationship between each independent variable (current alcohol use, current marijuana use, and current tobacco product use) and the dependent variable (obesity). The first step of each model included only the control variables (sex, current soda consumption, and current physical activity) as predictors with obesity as the dependent variable. Each independent variable was subsequently added to the control variables in the second step of the model with differences between the two steps evaluated and findings reported specific to each research question.

Since binary logistic regression models include several assumptions (Kwak & Clayton-Matthews, 2002), several assumptions were evaluated prior to running the analysis. The first assumption, that dependent variables are nominal and independent

variables are continuous, ordinal, or nominal was evaluated with the dependent variable of obesity found to be a dichotomous, nominal variable, categorized as Yes or No, the independent (current alcohol use, current marijuana use, and current tobacco product use) and control variables (current soda consumption and current physical activity) found to be dichotomous, nominal variables, categorized as Yes or No, and the independent variable Sex was found to be a dichotomous, nominal variable categorized as Female or Male.

The second assumption, that dependent variable categories are mutually exhaustive was evaluated with the categories of the dependent variable (obesity) found to be mutually exhaustive since this variable is categorized as Yes or No.

The third assumption, that there is no multicollinearity among independent variables, was evaluated using a correlation coefficient table that included all independent and control variables with no coefficients with a value of .70 or higher identified – indicating that the variables used in the model are not correlated with each other. These results are presented in Table 6.

The fourth assumption, that there is a linear relationship between continuous independent variables and the transformed dependent variable did not require evaluation since the analysis does not include a continuous independent variable. Similarly, the fifth assumption, that there are no outliers also did not require evaluation since the analysis does not include a continuous independent variable.

Table 6

Correlation Coefficients Evaluating Multicollinearity

			Alcohol use	Marijuana use	Tobacco use	Sex	Soda consumption	Physical activity
Spearman's rho	Alcohol use	Correlation Coefficient	1.000	.288**	.550**	.051	.047	-.035
		Sig. (2-tailed)	.	.002	<.001	.586	.618	.708
		N	117	117	117	117	117	117
	Marijuana use	Correlation Coefficient	.288**	1.000	.404**	-.103	-.143	-.138
		Sig. (2-tailed)	.002	.	<.001	.270	.125	.138
		N	117	117	117	117	117	117
	Tobacco use	Correlation Coefficient	.550**	.404**	1.000	.003	-.063	.040
		Sig. (2-tailed)	<.001	<.001	.	.976	.503	.670
		N	117	117	117	117	117	117
	Sex	Correlation Coefficient	.051	-.103	.003	1.000	.072	-.254**
		Sig. (2-tailed)	.586	.270	.976	.	.437	.006
		N	117	117	117	117	117	117
	Soda consumption	Correlation Coefficient	.047	-.143	-.063	.072	1.000	.061
		Sig. (2-tailed)	.618	.125	.503	.437	.	.513
		N	117	117	117	117	117	117
	Physical activity	Correlation Coefficient	-.035	-.138	.040	-.254**	.061	1.000
		Sig. (2-tailed)	.708	.138	.670	.006	.513	.
		N	117	117	117	117	117	117

**. Correlation is significant at the 0.01 level (2-tailed).

Research Question 1

What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Relevant Findings

Addressing research question 1, a two-step, hierarchical binary logistic regression was performed to evaluate the effects of the control variables (sex, current soda consumption, and current physical activity) and current alcohol use on the likelihood that participants are obese. The first step of the model was not statistically significant, $\chi 2(3) = 6.814$, $p = .078$. The Nagelkerke R Square statistic indicated that step one of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables, only sex was found to be statistically significant ($p = .019$, 95% CI [.066-.785]). The results of this analysis are presented in Table 7.

Table 7

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, and Current Physical Activity

							95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.479	.631	5.496	1	.019	.228	.066	.785
	Soda consumption(1)	-.351	.697	.254	1	.614	.704	.180	2.758
	Physical activity(1)	-.233	.589	.156	1	.693	.792	.250	2.515
	Constant	3.136	.874	12.866	1	<.001	23.010		

a. Variable(s) entered on step 1: Sex, Soda consumption, Physical activity.

The second step of the model was also not statistically significant, $\chi 2(4) = 6.814$, $p = .146$. The Nagelkerke R Square statistic again indicated that step two of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables and the independent variable current alcohol use, only sex was found to be statistically significant ($p = .019$, 95% CI [.066-.785]). The results of this analysis are presented in Table 8.

Table 8

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, Current Physical Activity and Current Alcohol Use

								95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.480	.632	5.488	1	.019	.228	.066	.785
	Soda consumption(1)	-.352	.699	.253	1	.615	.704	.179	2.767
	Physical activity(1)	-.233	.589	.156	1	.693	.792	.250	2.516
	Alcohol use(1)	.007	.641	.000	1	.992	1.007	.287	3.535
	Constant	3.131	.973	10.362	1	.001	22.906		

a. Variable(s) entered on step 1: Alcohol use.

Research Question 2

What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Relevant Findings

Addressing research question 2, a two-step, hierarchical, binary logistic regression was performed to evaluate the effects of the control variables (sex, current soda consumption, and current physical activity) and current marijuana use on the likelihood that participants are obese. The first step of the model was not statistically significant, $\chi 2(3) = 6.814$, $p = .078$. The Nagelkerke R Square statistic indicated that step one of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases.

Of the three control variables, only sex was found to be statistically significant (p = .019, 95% CI [.066-.785]). The results of this analysis are presented in Table 9.

Table 9

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, and Current Physical Activity

							95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.479	.631	5.496	1	.019	.228	.066	.785
	Soda consumption(1)	-.351	.697	.254	1	.614	.704	.180	2.758
	Physical activity(1)	-.233	.589	.156	1	.693	.792	.250	2.515
	Constant	3.136	.874	12.866	1	<.001	23.010		

a. Variable(s) entered on step 1: Sex, Soda consumption, Physical activity.

The second step of the model was also not statistically significant, $\chi 2(4) = 8.933$, p = .061. The Nagelkerke R Square statistic again indicated that step two of the model explained 13.5% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables and the independent variable marijuana use, only sex was found to be statistically significant (p = .030, 95% CI [.070-.871]). The results of this analysis are presented in Table 10.

Table 10

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, Current Physical Activity, and Current Marijuana Use

							95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.397	.642	4.734	1	.030	.247	.070	.871
	Soda consumption(1)	-.190	.711	.071	1	.789	.827	.205	3.334
	Physical activity(1)	-.114	.608	.035	1	.851	.892	.271	2.936
	Marijuana use(1)	.930	.616	2.278	1	.131	2.535	.757	8.485
	Constant	2.201	1.066	4.260	1	.039	9.030		

a. Variable(s) entered on step 1: Marijuana use.

Research Question 3

What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Relevant Findings

*A*ddressing research question 3, a two-step, hierarchical, binary logistic regression was performed to evaluate the effects of the control variables (sex, current soda consumption, and current physical activity) and current marijuana use on the likelihood that participants are obese. The first step of the model was not statistically significant, $\chi 2(3) = 6.814$, $p = .078$. The Nagelkerke R Square statistic indicated that step one of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases.

Of the three control variables, only sex was found to be statistically significant (p = .019, 95% CI [.066-.785]). The results of this analysis are presented in Table 10.

Table 11

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, and Current Physical Activity

							95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.479	.631	5.496	1	.019	.228	.066	.785
	Soda consumption(1)	-.351	.697	.254	1	.614	.704	.180	2.758
	Physical activity(1)	-.233	.589	.156	1	.693	.792	.250	2.515
	Constant	3.136	.874	12.866	1	<.001	23.010		

a. Variable(s) entered on step 1: Sex, Soda consumption, Physical activity.

The second step of the model was also not statistically significant, $\chi 2(4) = 6.814$, p = .146. The Nagelkerke R Square statistic again indicated that step two of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables and the independent variable current tobacco product use, only sex was found to be statistically significant (p = .019, 95% CI [.066-.786]). The results of this analysis are presented in Table 12.

Table 12

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, Current Physical Activity, and Current Tobacco Product Use

								95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.479	.631	5.486	1	.019	.228	.066	.786
	Soda consumption(1)	-.352	.698	.254	1	.614	.703	.179	2.763
	Physical activity(1)	-.231	.592	.153	1	.696	.793	.248	2.534
	Tobacco use(1)	-.014	.602	.001	1	.982	.986	.303	3.207
	Constant	3.145	.959	10.754	1	.001	23.219		

a. Variable(s) entered on step 1: Tobacco use.

Multivariate Analysis: Research Question 4

To address research question 4, a two-step hierarchical binary logistic regression was used to analyze the relationship between the three independent variables (current alcohol use, current marijuana use, and current tobacco product use) and the dependent variable (obesity). The first step of each model included only the control variables (sex, current soda consumption, and current physical activity) as predictors and obesity as the dependent variable. The independent variables were subsequently included with the control variables in the second step of the model. Differences between the two steps were evaluated with findings reported in the following sections.

Research Question 4

What is the association between current alcohol use, current marijuana use, and current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity?

Relevant Findings

*A*ddressing research question 4, a two-step, hierarchical, binary logistic regression was performed to evaluate the effects of the control variables (sex, current soda consumption, and current physical activity) and current alcohol use, current marijuana use, and current tobacco product use on the likelihood that participants are obese. The first step of the model was not statistically significant, $\chi 2(3) = 6.814$, $p = .078$. The Nagelkerke R Square statistic indicated that step one of the model explained 10.3% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables, only sex was found to be statistically significant ($p = .019$, 95% CI [.066-.785]). The results of this analysis are presented in Table 13.

Table 13

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, and Current Physical Activity

							95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.479	.631	5.496	1	.019	.228	.066	.785
	Soda consumption(1)	-.351	.697	.254	1	.614	.704	.180	2.758
	Physical activity(1)	-.233	.589	.156	1	.693	.792	.250	2.515
	Constant	3.136	.874	12.866	1	<.001	23.010		

a. Variable(s) entered on step 1: Sex, Soda consumption, Physical activity.

The second step of the model was also not statistically significant, $\chi 2(6) = 9.691$, $p = .138$. The Nagelkerke R Square statistic again indicated that step two of the model explained 14.5% of the variance in obesity and correctly classified 86.3% of cases. Of the three control variables and the independent variables current alcohol use, current marijuana use, and current tobacco product usefdf, only sex was found to be statistically significant ($p = .034$, 95% CI [.072-.902]). The results of this analysis are presented in Table 14.

Table 14

Logistic Regression Predicting the Likelihood of Obesity Based on Sex, Current Soda Consumption, Current Physical Activity, Current Alcohol Use, Current Marijuana Use, and Current Tobacco Product Use

								95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Sex(1)	-1.364	.643	4.497	1	.034	.256	.072	.902
	Soda consumption(1)	-.148	.723	.042	1	.838	.862	.209	3.559
	Physical activity(1)	-.040	.618	.004	1	.949	.961	.286	3.225
	Tobacco use(1)	-.512	.780	.432	1	.511	.599	.130	2.761
	Alcohol use(1)	-.141	.763	.034	1	.853	.869	.195	3.877
	Marijuana use(1)	1.243	.733	2.878	1	.090	3.467	.824	14.578
	Constant	2.330	1.103	4.462	1	.035	10.273		

a. Variable(s) entered on step 1: Tobacco use, Alcohol use, Marijuana use.

Summary

This study included four unique research questions that are constructed with obesity as the dependent variable, alcohol, marijuana, and tobacco product use as the independent variables, and sex, soda consumption, and rates of physical activity as control variables. Bivariate analyses using a Chi Square Test of Independence to evaluate the relationship between each independent and control variable and obesity determined that there is a statistically significant relationship between obesity and sex ($\chi^2(1) = 6.206$, $p = .013$) with a small effect size (.230). Chi Square Tests of Independence also determined that there is no statistically significant relationship between the remaining independent and control variables and obesity.

Binary logistic regression was used to address research question 1: What is the association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity? The analysis indicated that there is no statistically significant association between current alcohol use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity. Therefore, the null hypothesis for this research question is retained.

Binary logistic regression was used to address research question 2: What is the association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity? The analysis indicated that there is no statistically significant association between current marijuana use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity. Therefore, the null hypothesis for this research question is retained.

Binary logistic regression was used to address research question 3: What is the association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity? The analysis indicated that there is no statistically significant association between current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity. Therefore, the null hypothesis for this research question is retained.

Binary logistic regression was used to address research question 4: What is the association between current alcohol, marijuana, and tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity? The analysis indicated that there is no statistically significant association between current alcohol use, current marijuana use, and current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity. Therefore, the null hypothesis for this research question is retained.

Obesity and substance use, including alcohol, marijuana, and tobacco product use, are common among Native American adolescents. This study was designed to evaluate relationships between these variables to better understand the complex public health issue of obesity among Native American adolescents. The fourth section of this study synthesizes the study results, identify relevant limitations and recommendations, and explore opportunities for professional practice and social change.

Section 4: Application to Professional Practice and Implications for Social Change

Introduction

Obesity and substance use are two significant public health issues among Native American adolescents. Native American adolescents are 30% more likely to be obese than non-Hispanic white high school students (Office of Minority Health, 2020) while rates of substance use, including alcohol and tobacco products, are significantly higher among Native American adolescents that their non-Hispanic white peers (Zhao et al., 2022). The purpose of this quantitative study was to examine associations between current substance use and obesity among Native American high school students, when adjusted for sex and two specific health behaviors: soda consumption and physical activity.

To address the research questions developed for this study, a cross-sectional study design was used to investigate associations between self-reported past 30-day use of alcohol, marijuana, and tobacco and obesity among Native American high school students using an analysis of secondary data from CDCs Youth Risk Behavior Surveillance System (YRBSS) 2019 dataset. The 2019 YRBSS dataset contains all the variables needed to conduct this study including:

- Dependent variable: obesity (had obesity; students who were ≥ 95th percentile for body mass index, based on sex- and age-specific reference data from the 2000 CDC growth charts)
- Independent variables: current alcohol use, and current marijuana use, and current tobacco product use (self-reported past 30-day use)

- Control variables: sex, current soda consumption (self-reported past 7-day consumption), and current physical activity (self-reported past 7-day performance).

This section of the study synthesizes the study results, identifies relevant limitations and recommendations, and explores opportunities to improve professional practice and elicit positive social change.

Summarization of Key Findings

From the 13,677 valid survey responses included in the 2019 YRBS dataset, filtering was used to identify responses from individuals who identified exclusively as American Indian/Alaska Native. In total, 202 survey responses were identified (1.5% of all valid surveys). Data for at least one of the study variables was missing from 85 respondents, resulting in a final study sample of 117 valid responses (0.86% of all valid surveys).

Frequency distributions were derived for all variables and crosstabs were completed to identify significant associations between key variables. Of the 117 valid responses included in this analysis, 53.8% of respondents identified as female and 46.2% identified as male, 13.7% of respondents were categorized as obese, 26.5% of respondents reported current (past 30-day) alcohol use, 19.7% of respondents reported current (past 30-day) marijuana use, 31.6% of respondents reported current (past 30-day) tobacco product use, 25.6% of respondents reported current (past 7-day) soda consumption, 35.0% of respondents reported being physically active (past 7-day).

Bivariate analyses using Chi Square Tests of Independence were completed to evaluate associations between sex and each study variable. These analyses determined that there is a significant relationship between obesity and sex ($\chi^2(1) = 6.206$, $p = .013$) with a small effect size (.230) and a significant relationship between current physical activity and sex ($\chi^2(1) = 7.567$, $p = .006$) with a small effect size (.254). There was no significant association between the remaining study variables and sex.

Bivariate analyses using Chi Square Tests of Independence were also completed to evaluate associations between the dependent variable obesity and each independent and control variable. These analyses determined that there is a trend toward a significant relationship between current marijuana use and obesity ($\chi^2(1) = 3.736$, $p = .053$) with a small effect size (.179). There was no significant association between the remaining study variables and obesity.

After testing all relevant assumptions, a two-step hierarchical binary logistic regression was used to analyze the relationship between each independent variable (current alcohol use, current marijuana use, and current tobacco product use) and the dependent variable (obesity) to address research questions 1, 2, and 3. These analyses demonstrated no statistically significant association between current alcohol use, current marijuana use, and current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity. Therefore, the null hypotheses for research questions 1 -3 were retained.

Binary logistic regression was also used to address research question 4: What is the association between current alcohol, marijuana, and tobacco product use and obesity

among Native American adolescents when controlling for sex, current soda consumption, and current physical activity? Again, the analysis demonstrated no statistically significant association between current alcohol use, current marijuana use, and current tobacco product use and obesity among Native American adolescents when controlling for sex, current soda consumption, and current physical activity, thereby retaining the null hypothesis.

Interpretation of the Findings

While many researchers have reported the prevalence of obesity and substance use among adolescents as well as their negative health consequences (Twig et al., 2020, Zamora-Kapoor et al., 2021, Kohut et al., 2019, Karaağaç et al., 2019, Gohil, 2018, Kessler et al., 2018, Whitaker et al., 2018, Chu et al., 2019, Wang et al., 2019, Çolpan et al., 2018), the relationship between obesity as a health condition and current substance use as a collection of health behaviors is not well documented – especially among Native American adolescents. Using data from the 2019 Youth Risk Behavior Survey, this study reported the prevalence of obesity, current alcohol, marijuana, and tobacco product use among adolescents who identified as American Indian/Alaska Native as well associations between these variables.

Prevalence Rates of Obesity and Substance Use

Although data describing obesity prevalence specific to Native American adolescents is limited, Bullock et al. (2017) used data from the Indian Health Service National Data Warehouse and found that the prevalence rate of obesity was 29.7% among Native Americans aged 2 to 19 years in 2015. Interestingly, Bullock et al. noted that

Native American boys had markedly higher rates of obesity than Native American girls (31.5% vs. 27.9%). Results from this study demonstrated a prevalence rate of obesity of 13.7% among respondents who identified exclusively as Native American – markedly lower than previously reported estimates.

Considering prevalence rates of substance use among Native American high school students, the National Institute on Alcohol Abuse and Alcoholism (2021) reported prevalence rates of past 30-day alcohol use of 32.6%, past 30-day marijuana use of 33.8%, and past 30-day tobacco product use of 52.4%. Results from this study demonstrated prevalence rates of current alcohol use of 26.5%, current marijuana use of 19.7%, current tobacco product use of 31.6% among respondents who identified exclusively as Native American – all of which are lower than previously reported estimates.

Relevant Associations Between Variables

In this study, Chi Square Tests of Independence were used to evaluate associations between all study variables and obesity among Native American survey respondents, with a significant relationship identified between sex and obesity ($\chi^2(1) = 6.206$, $p = .013$). Additionally, binary logistic regression found that Native American males were up to 5.5 times more likely to be obese than their female counterparts. While obesity rates in 2018 were reported as 19.9% among all adolescent females and 22.5% among all adolescent males (NCHS, 2021), little to no research has been conducted to determine if associations exist between sex and obesity among adolescent populations based on race – including Native Americans.

Similarly, this study used a Chi Square Test of Independence to identify a trend toward a significant relationship between current marijuana use and obesity ($\chi^2(1) = 3.736$, $p = .053$) among Native American survey respondents, though binary logistic regression found that current marijuana use was not predictive of obesity when controlling for sex, current soda consumption, and current physical activity. While Yu et al. (2021) reported a past 30-day marijuana use prevalence rate of 12% in 2016 among adolescent females and nearly 18% in 2016 among adolescent males and the National Institute on Alcohol Abuse and Alcoholism (2021) reported that a 33.8% prevalence of past 30-day marijuana use among Native American adolescents in 2019, little to no research has been conducted to determine if associations exist between current marijuana use and obesity among adolescent populations based on race (including Native Americans).

Limitations

Several limitations should be considered when interpreting the results of this study. First, the data utilized for this investigation was collected specifically for the 2019 YRBS and not as primary data for this specific study. Supporting the limitations associated with the use of secondary data, Cheng and Phillips (2014) reported that access to specific variables is an inherent limitation of secondary data analyses. Second, the 2019 YRBS collected data from children who attend public or private schools, resulting in a dataset that may not be representative of all high school-aged individuals in the United States. It is also important to consider that high school students from several types of schools, including alternative schools, vocational schools, and schools operated by the

Bureau of Indian Education, were excluded from the 2019 Youth Risk Behavior Survey (Underwood et al., 2020). Because of these exclusions, the sample population utilized for this study may not be representative of all Native American adolescents. Despite exceeding the number of responses required to adequately power the analysis for this study (98), a final study sample of 117 valid responses (0.86% of all valid surveys) was obtained after filtering was used to identify responses from individuals who identified exclusively as American Indian/Alaska Native and incomplete responses were removed from the dataset. Third, the accuracy of data reported by survey participants cannot be determined. Despite reports that the test-retest reliability of the YRBS survey questions has been determined to be good (Brener et al., 2002; Brener et al., 2003), other researchers have demonstrated that self-reported weight are commonly underestimated by both female and male adolescents (Sherry, et al., 2007, Bowring et al., 2012, Lipsky et al., 2019). Since self-reported measures of height and weight were used to calculate BMI and thereby determine weight status, underestimations of body weight by survey respondents can contribute to underestimations of obesity. Fourth, the YRBS is a cross-sectional cohort survey that collected data during a relatively short period of time. While this data can be used to identify associations between variables, it is susceptible to recall and nonresponse bias and cannot be used to explain reasons for trends or to determine a causal relationship between variables (Wang & Cheng, 2020).

Recommendations

The results of this study provide multiple opportunities for future research. First, the analyses completed in this study can be repeated using previous datasets as well as

new datasets since the YRBS is conducted every two years. Additional secondary analyses using previous and/or future datasets can be used to identify trends and differences in associations between obesity and current substance use among Native American adolescents. Second, data from the 2019 YRBS can be used to investigate associations between obesity and current substance use among respondents who identified as a race other than American Indian/Alaska Native. For the 2019 YRBS, a total of 13,677 valid surveys were included for analysis (Underwood et al., 2020). Among the valid responses, Underwood et al. (2020) reported that 51.2% of the respondents identified as non-Hispanic white, 26.1% identified as Hispanic, 12.2% identified as black. These larger populations present an opportunity to determine if associations exist between current substance use and obesity among adolescents who identify as a race other than American Indian/Alaska Native. Third, associations between long-term substance use and obesity could reveal results that differ from those reported in this study relevant to short-term (past 30-day) substance use. While the YRBS does not collect long-term substance use data, future studies can investigate associations between long-term substance use behaviors and weight status among Native American adolescents.

Implications for Professional Practice and Social Change

Despite ample evidence demonstrating high rates of both substance use and obesity among Native American adolescents, few researchers have explored the relationship between substance use and obesity within this population. As one of the first

to explore these relationships, this study presents multiple opportunities to improve professional practice and elicit positive social change.

Implications for Professional Practice

This study is significant in that it describes the association between substance use and obesity among Native American adolescents, which is limited or absent in the current literature. Considering the call to action from Eitle and Eitle (2018) to explore differences in the relationship between substance use and obesity among various racial/ethnic populations, this study may provide a better understanding of the impact of specific adolescent behaviors on health among the well-defined and underserved population of Native American adolescents.

Implications for Positive Social Change

This study presents multiple opportunities to elicit meaningful social change. First, the findings from this investigation can be used to foster collaboration among healthcare providers and school district personnel that prioritize obesity prevention interventions among Native American adolescents. For example, Redmond et al. (2019) described a multilevel, multicomponent (MLMC) obesity prevention program termed OPREVENT (Obesity PRevention and Evaluation of InterVention Effectiveness in NaTive North Americans) that was developed by the Department of International Health and Human Nutrition at Johns Hopkins University and implemented by in community food stores, worksites, schools, and media in five rural Native American communities over the course of one year. The authors reported that the school-based component of the program was designed to educate elementary school children in the classroom and

motivate them to act as change agents within their household (Redmond et al., 2019). Data from this study may help to inform the design of similar MLMC obesity prevention programs in the future by providing insights on health behaviors associated with obesity among Native American adolescents.

Additionally, public health practitioners may also use findings from this study to develop new or enhance existing programs designed to discourage substance use among Native American adolescents. The Tribal Law and Order Act (TLOA), signed into law by President Barack Obama in 2010, helps to "ensure that justice, safety, education, youth, and alcohol and substance misuse prevention and treatment issues relevant to Indian Country remain the subject of consistent focus for the federal government." (About the Tribal Law and Order Act, n.d.). As a requirement of this act, the Secretary of the Department of Health and Human Services, the Secretary of the Interior, and the United States Attorney General, in coordination with the Substance Abuse and Mental Health Services Administration (SAMHSA), are required to determine the scope of substance misuse among the Native American population, identify resources and programs that could be used to address substance misuse, and coordinate existing substance misuse programs with those established under the TLOA (About the Tribal Law and Order Act, n.d.). Data from this study may help to support the development of new or to enhance existing TLOA substance misuse prevention programs for Native American adolescents by providing information about associations between substance use and adverse health conditions such as obesity.

Conclusion

Obesity, as a health condition, and substance use, as a collection of health behaviors including alcohol use, marijuana use, and tobacco product use, are highly prevalent among U.S. adolescents. When comparing racial subgroups, prevalence rates for both obesity and substance use are highest among Native American adolescents. Due to the negative health outcomes associated with obesity and substance use among adolescents, many population-based preventive initiatives to have been developed over the past several decades. Unfortunately, there is little to no evidence that describes associations between obesity and substance use, especially among Native American adolescents. This study was the first to examine associations between self-reported current (past 30-day) substance use (alcohol, marijuana, and tobacco products) and obesity among Native American adolescents. While results from this study indicated that male Native American adolescents were up to 5.5 times more likely to be obese than their female counterparts, no significant associations were found between current alcohol, marijuana, and tobacco product use and obesity when controlling for sex, current soda consumption, and current physical activity. The results of this study can be used as a framework to explore associations between other measures of substance use and obesity in the future. Additionally, public health practitioners and other key stakeholders charged with preventing obesity and substance use among adolescents can use the findings of this study to inform the development of evidence-based interventions and policies.

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