WEIGHT GAIN PREVENTION IN YOUNG ADULTS: PREDICTORS OF WEIGHT CHANGE AND BEHAVIORAL TYPOLOGIES

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This dissertation examined the role of four modifiable health behaviors (tobacco and alcohol use, diet, and physical activity) as predictors of weight change over a two-year period and identified distinct behavioral typologies among a population of young adults. This study used baseline and 24-month data from The Choosing Healthy Options in College Environments and Settings study, a randomized controlled trial designed to prevent unhealthy weight gain in young adults (aged 18 – 35) attending 2-year community colleges in the Twin Cities, Minnesota.

**Aim 1.** A multivariate linear regression model was fit to understand the association between 24-month BMI and baseline health behaviors, controlling for covariates (n=365). To aid interpretation of the results, post-hoc analyses applied logistic modeling by dichotomizing the outcome variable to those who maintained/lost less than 3% weight and those who gained 3% weight between baseline and 24-months. Results suggested that binge drinking was significantly predictive of lower 24-month BMI in both models. Linear results suggested those who reported higher amounts of leisure physical activity and current smokers experienced an increased 24-month BMI. The latter associations did not hold in the logistic model. Individual behaviors assessed were generally non-significant, providing some evidence that behaviors may work synergistically, rather than independently, to promote weight change.
**Aim 2.** This aim identified three typologies using Latent Class Analysis (n=441): Class 1: “active, binge-drinkers with healthy dietary intake,” Class 2: “non-active, moderate-smokers, and non-drinkers with poor dietary intake,” and Class 3: “moderately active, non-smokers, non-drinkers with a moderately healthy dietary intake.” Using adjusted multinomial logistic regression models to understand predictors associated with class membership, evidence suggested there were meaningful differences for BMI and age between latent classes. For each additional unit increase in BMI, individuals were more likely to be in Class 2 versus Class 3. For each additional year in age, individuals were more likely to be in Class 1 versus Class 2. Understanding these typologies may help public health professionals create more effective interventions in community colleges by targeting certain behaviors to help reduce the onset and improve management of existing chronic diseases.
Dedicated to my parents, Pam and Joe, for their unconditional love and support.
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<td>AIDS</td>
<td>acquired immune deficiency syndrome</td>
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<tr>
<td>AIC</td>
<td>Akaike’s Information Criterion</td>
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<tr>
<td>BAC</td>
<td>blood alcohol concentration</td>
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<tr>
<td>BIC</td>
<td>Bayesian Information Criterion</td>
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<tr>
<td>BRFSS</td>
<td>Behavioral Risk Factor Surveillance System</td>
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<td>BMI</td>
<td>body mass index</td>
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<td>CHOICES</td>
<td>Choosing Health Options in College Environments and Settings Study</td>
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<tr>
<td>COPD</td>
<td>chronic obstructive pulmonary disease</td>
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<td>CVD</td>
<td>cardiovascular disease</td>
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<tr>
<td>EARLY</td>
<td>Early Adult Reduction of Weight through LifestYle</td>
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<td>HHS</td>
<td>U.S. Department of Health and Human Services</td>
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<td>HIV</td>
<td>human immunodeficiency virus</td>
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<tr>
<td>LCA</td>
<td>latent class analysis</td>
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<tr>
<td>LTPA</td>
<td>leisure-time physical activity</td>
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<tr>
<td>NHANES</td>
<td>National Health Nutrition Examination Survey</td>
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<td>OR</td>
<td>odds ratio</td>
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<tr>
<td>SCT</td>
<td>Social Cognitive Theory</td>
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<tr>
<td>SD</td>
<td>standard deviation</td>
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<tr>
<td>SSB</td>
<td>sugar sweetened beverages</td>
</tr>
<tr>
<td>U.S.</td>
<td>United States</td>
</tr>
<tr>
<td>VIF</td>
<td>variance inflation factor</td>
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<td>WHO</td>
<td>World Health Organization</td>
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CHAPTER 1: INTRODUCTION AND RESEARCH QUESTIONS

Chronic Disease

The World Health Organization (WHO) has identified chronic disease as the major cause of death in almost all nations. While infectious diseases, such as HIV/AIDS, tuberculosis, and malaria, get significant attention in the world’s press, chronic diseases kill more than twice the number of people affected as compared with all infectious diseases combined. Four chronic diseases – cardiovascular disease (heart disease and stroke), cancer, lower respiratory disease, and diabetes have been targeted by WHO for disease prevention and control as a way to reduce premature deaths across the world. These four diseases all have non-modifiable (hereditary, age) and modifiable (behavior) risk factors associated with them. Improving behaviors associated with modifiable risk factors (physical activity, tobacco and alcohol use, diet) has been shown to reduce pre-mature deaths due to preventable chronic disease, and WHO tracks these behaviors and premature deaths associated with them on a country-specific basis.

In the United States, the four modifiable chronic diseases account for over 60% of all deaths nationwide. The calculated probability of dying prematurely (between the ages of 30 and 70) from cardiovascular disease, cancer, lower respiratory disease, and diabetes is 14%. Addressing chronic disease requires a closer look at the major conditions that affect individuals to most effectively mobilize resources towards chronic disease prevention and control.
Cardiovascular Disease

_Heart disease._ There are many forms of heart disease. Coronary heart disease, also known as coronary artery disease or ischemic heart disease, is the leading cause of death globally. It is caused by disease of the blood vessels (atherosclerosis) of the heart, usually as part of the process which affects blood vessels more generally.

_Stroke._ Stroke is a disease of the brain caused by interferences to the blood supply. A stroke occurs when a blood vessel that carries oxygen and nutrients to the brain either bursts (ruptures) or is blocked by a clot. When this occurs, part of the brain cannot get blood and oxygen it needs, so that part of the body will not work at it should.

Cancer

_Cancer._ Cancer describes a range of diseases in which abnormal cells proliferate and spread out of control. There are many types of cancer and all organs of the body can become cancerous. Tobacco use is the main preventable cause of cancer. Lung cancer remains the leading cause of cancer deaths in both men and women. More than 80% of lung cancers are due to smoking or exposure to secondhand smoke.

Diabetes

_Diabetes._ Diabetes is characterized by raised blood glucose (sugar) levels. This results from a lack of hormone insulin, which controls blood glucose levels, and/or an inability of the body’s tissues to respond properly to insulin (a state called insulin resistance). The most common type of diabetes is type 2, which accounts for about 90% of all diabetes and is largely the result of excessive weight and physical inactivity. Until recently, this type of diabetes was seen only in adults but is now occurring in obese children. The usual childhood form of diabetes (type 1 diabetes) is caused by an absolute lack of insulin and not by obesity. Without insulin, type 1 diabetes is rapidly fatal.
Respiratory Disease

Chronic respiratory diseases. Diseases of the lungs take many forms. Smoking is the primary risk factor for chronic respiratory diseases, such as emphysema and chronic bronchitis, both of which are major conditions of chronic obstructive pulmonary disease (COPD).\(^9\) COPD is caused by airflow limitation that is not fully reversible. COPD and lung cancer could become uncommon if smoking rates were substantially reduced.\(^{10}\)

Chronic diseases share common behavioral and intermediate risk factors. Overweight and obesity are intermediate conditions that precede many chronic conditions and have been found to be major contributors to the burden of chronic disease.\(^{11}\) Excess weight-related conditions are a major public health priority\(^{12}\) and will serve as the primary endpoint for this dissertation in regards to chronic disease prevention. The figure below illustrates these relationships:

![Figure 1.1. Chronic Diseases and their Causes](image)

Health-related behaviors such as physical activity, tobacco and alcohol use, and diet are among the major modifiable behavioral risk factors that contribute significantly to preventable weight gain; and chronic disease morbidity and mortality in the United States (U.S.).\(^{13}\)

Four Modifiable Shared Risk Factors that Lead to Obesity and Chronic Disease

Behavioral risk factors are shared across all four main modifiable chronic diseases. The most important modifiable risk factors are: tobacco use, the harmful use of alcohol, physical inactivity, and unhealthy dietary intake. The negative sequela of these behaviors include the intermediate risk factors of high blood pressure, high fasting glucose levels, abnormal blood
lipids, and overweightness (body mass index \( \geq 25\text{kg/m}^2 \)) and obesity (body mass index \( \geq 30\text{kg/m}^2 \)).\(^{14}\)

The major behavioral modifiable risk factors explain the majority of new events of cardiovascular disease,\(^{15}\) respiratory disease, and some cancers. The following health-related behaviors are both modifiable and instrumental to chronic disease and risk of premature death.

**Tobacco Use**

*Tobacco use.* Tobacco use may be defined as any habitual use of the tobacco plant leaf and its products. The predominant use of tobacco is by smoke inhalation of cigarettes, pipes, and cigars. Smoking has been found to harm nearly every organ in the body and diminishes an individual’s overall health. Smoking is the leading cause of cancer and death from cancer; causing cancers of the lung, esophagus, larynx, mouth, throat, kidney, bladder, liver, pancreas, stomach, cervix, colon, and rectum.\(^{16}\) In additional to distal health outcomes, tobacco use affects metabolic risk factors. Tobacco use has often been identified as an unhealthy behavior that is associated with a lower body weight in many cross-sectional studies.\(^{17,18,19}\) Tobacco use may decrease appetite while providing oral stimulation and an inhibitory behavior that reduces eating and drinking.\(^{20}\) In a review article that assessed consequences of smoking for body weight, body fat distribution, and insulin resistance; results for the short-term nicotine use were different from long-term results of use.\(^{21}\) In the short term, nicotine use increases energy expenditure and could reduce appetite. However, heavy smokers tend to have a greater body weight than do light smokers or nonsmokers, which likely reflects a clustering of health-damaging behaviors conducive to weight gain.\(^{22}\) Results also suggested that smoking increases insulin resistance and is associated with central fat accumulation that increases the risk of metabolic syndrome and diabetes, which then, increase the risk of cardiovascular disease.\(^{23}\) In the United States, cigarette
smoking is the leading cause of preventable disease and death, accounting for more than 480,000 deaths every year, or 1 in every 5 deaths.²⁴

**Harmful Use of Alcohol**

*Alcohol use.* Alcohol is the most often used psychoactive substance by young adults and is one of the leading modifiable morbidity and mortality risk factors among young adults.²⁵,²⁶ Most U.S. adult drinkers do not drink every day – which is why it is important to focus on the amount people drink on the days that they do consume alcohol.²⁷ Alcohol consumption significantly contributes to the burden of chronic diseases and conditions worldwide.²⁸ Additionally, alcohol use affects intermediate risk factors; Traversy and Chaput (2015) published a review article on the association between alcohol consumption and obesity. Findings of recent prospective studies suggest that light-to-moderate drinking is not associated with adiposity gain while heavy drinking is more consistently related to weight gain.²⁹ Despite study limitations, evidence across all experimental and observational studies suggest that alcohol may be a risk factor for obesity in some individuals, especially when consumed in large quantities.³⁰ WHO reports there is a causal relationship between harmful use of alcohol and the morbidity and mortality associated with cardiovascular diseases, cancers, and liver diseases.³¹

*Binge drinking.* National Institute on Alcohol Abuse and Alcoholism defines binge drinking as a pattern of drinking that brings blood alcohol concentration (BAC) levels to 0.08% or more. This pattern of drinking usually corresponds to 4 or more drinks for women or 5 or more drinks for men on a single occasion, generally within about 2 hours.³²

**Physical Inactivity**

*Physical inactivity.* Adults who are insufficiently physically active have a 20-30% increased risk of all-cause mortality compared with those who do at least 150 minutes of moderate-intensity physical activity per week, or equivalent.³³ Getting adequate amounts of
physical activity brings about many health benefits independent of body weight. Regular physical activity reduces the risk of heart disease, stroke, diabetes, and breast and colon cancer. Physical activity is protective by way of weight regulation and improving the body’s use of insulin. Being active is beneficial for blood pressure, blood lipid levels, blood glucose levels, blood clotting factors, health of the blood vessels and inflammation, which is a powerful promoter of cardiovascular disease. Decreasing time spent in sedentary behaviors is also important.

**Physical activity.** The 2008 Physical Activity Guidelines for Americans provides science-based guidance to help Americans age six and older to improve their health through appropriate physical activity. The U.S. Department of Health and Human Services (HHS) issues the Physical Activity Guidelines for Americans, a joint effort of HHS and the U.S. Department of Agriculture. The key guidelines for adults include: all adults should avoid inactivity, adults should do at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably, it should be spread throughout the week. Adults should also do muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups two or more days a week, as these activities provide additional health benefits.

**Sedentary behavior.** Accumulating evidence suggests that, independent of physical activity levels, sedentary behaviors are associated with chronic diseases. Evidence shows that more screen time, particularly television viewing or playing video games, is associated with overweight and obese children, adolescents, and adults. Therefore, to maximize health benefits,
approaches to resolve physical inactivity should attempt to both increase intentional physical activity and decrease sedentary behaviors. Substituting time being active for sedentary time can help people manage their weight and provides other health benefits.

**Dietary Intake**

*Unhealthy diet.* Frequent consumption of energy-dense foods, such as processed foods that are high in sugar and fat and sugary drinks, promotes obesity compared to low-energy foods. Obesity increases the likelihood of diabetes, hypertension, heart disease, stroke, and certain types of cancers. Limiting consumption of foods that are high in energy including fast foods and sugary drinks is one of the eight evidence-based recommendations proposed by the World Cancer Research Fund and the American Institute for Cancer Research\(^{37}\) and is included in the 2010 Dietary Guidelines for Americans.\(^{38}\) A healthy eating pattern limits intakes of sodium, solid fats, added sugars, and refined grains and emphasizes nutrient-dense foods and beverages such as vegetables, fruits, whole grains, fat-free or low-fat milk, seafood, lean meats and poultry, eggs, beans, nuts and seeds.\(^{39}\) Empirical evidence is strong for the relationship between the following diet-related behaviors and overweight and obesity.

*Fast-food consumption.* Energy-dense foods and fast foods mainly include processed food items that contain large amounts of fat or sugar such as baked goods (e.g. cookies, cakes, and other grain-based desserts), burgers, and deep fried foods (e.g. french fries, chips, chicken strips).\(^{40}\) Higher frequency of fast food consumption has been associated with diets that are loaded with calories and limited in essential nutrients, which could promote weight gain and obesity.\(^{41}\) In addition to the large amounts of fat and sugar that these foods contain, excessive sodium content is also of concern as it is associated with increased risk of hypertension and cardiovascular disease. With vast availability of processed foods in the U.S., sources of sodium, sugar, and fat are cheap and easy to consume. Evidence suggests that the proportion of daily
calorie intake from foods eaten away from home has increased, and the results demonstrate that children, adolescents, and adults who eat out, particularly at fast food restaurants, are at increased risk of weight gain, overweightness, and obesity.\textsuperscript{42}

**Sugar sweetened beverages (SSB).** The increase in population consumption of SSB has been a major contributor to the obesity epidemic.\textsuperscript{43} SSB mainly include sodas, sugar-sweetened teas, fruit juices, energy and sports drinks and other beverages with added sugar such as sweetened coffee beverages. SSB provide excess calories and few essential nutrients to the diet. A typical 20-ounce soda contains 15 to 18 teaspoons of sugar and upwards of 240 calories. A 64-ounce fountain soda could have up to 700 calories.\textsuperscript{44} People who consume SSB regularly – one to two cans per day or more – have a 26\% greater risk of developing type 2 diabetes than people that rarely drink these sugary beverages.\textsuperscript{45} Studies in adults and children have found that reducing the consumption of SSB can lead to better weight control among those who are initially overweight.\textsuperscript{46}

**Breakfast consumption.** Meal patterns have been linked with obesity prevalence in adults\textsuperscript{47} with habitual meal skipping highlighted as a factor related to weight gain. A recent meta-analysis of cross-sectional studies showed that the risk for overweight or obesity increases by 55\% if breakfast is skipped.\textsuperscript{48} Research suggests that non-breakfast consumers tend to gain weight as a result of overcompensating for energy-intake skipped at breakfast with high-fat, energy-dense foods later in the day. Justification for energy overcompensation can be explained through satiety levels. If breakfast is skipped, one could have lower satiety levels therefore, overeating will ensue later in the day—which over time, leads to weight gain.\textsuperscript{49} Consuming breakfast seems to be an important determinant in counteracting overweight and obesity in the United States.\textsuperscript{50}
Young Adulthood as a Critical Period

Young adulthood (from age 18 to 35) is marked by important transitions, such as increased autonomy in decision-making and behavioral exploration and experimentation, resulting in numerous potential health risk behaviors. A cohort study indicated that weight gain during early college years increases the risk of obesity-related morbidity, even if individuals had a normal weight when entering the higher education institution. Gaining weight can be particularly harmful for young adults, since it can be especially difficult to lose weight and maintain that weight loss once it is gained. Behaviors such as tobacco and alcohol use, high consumption of sugar-sweetened beverages and fast food, and physical inactivity all contribute to a substantial proportion of preventable diseases.

Results from a national study that examined incidence data for obesity among US adults showed the incidences of obesity and extreme obesity were highest among adults aged 18 to 29 years, indicating that young adults are more likely to develop a weight problem over time. The risk for obesity-related chronic disease will be significantly increased among this population once they become obese, which ultimately impacts quality of life.

This period of emerging adulthood may provide important opportunities to prevent long-term risk behaviors that could decrease the risk of chronic diseases later in life. To be most effective, chronic disease prevention must occur across the life course. Young adulthood is an ideal stage to integrate health promotion activities that encourage a consistent pattern of healthy living, prevent intermediate risk factors such as weight gain, and reduce the initial onset of chronic disease.

The four main behavioral risk factors are shared across all four chronic diseases and their associations specifically with young adults are discussed below.
**Tobacco Use**

Approximately 80% of adult smokers begin before age 18 with 99% of first use by 26 years of age,\textsuperscript{57} and those who continue smoking into young adulthood are at greatest risk of being regular smokers in later adulthood.\textsuperscript{58} Cigarette smoking by youth and young adults has immediate adverse health consequences, including addiction, and accelerates the development of chronic disease across the full life course.\textsuperscript{59}

**Harmful Use of Alcohol**

Young adulthood is a period of developmental transition when behavioral patterns related to substance use, especially alcohol consumption, can peak. For example, almost half of U.S. college students report binge drinking in the prior two weeks.\textsuperscript{60} Binge drinking is strongly associated with alcohol-related injuries\textsuperscript{61} and increased risk for the onset of alcohol use disorders.\textsuperscript{62} Between 1993 and 2001, 18 to 20 year old drinkers showed the largest increase (56%) in binge-drinking episodes among American adults. This group of underage drinkers also had the second-highest rate of binge drinking, surpassed only by young adults ages 21 to 25.\textsuperscript{63}

**Physical Inactivity**

In 2010, 23% of adults aged 18 and over were insufficiently physically active, meaning they had less than 150 minutes of moderate-intensity physical activity per week or equivalent.\textsuperscript{64} Women were less active than men and older people were less active than younger people.\textsuperscript{65} Among American adults, approximately one-third report that they participate in leisure-time physical activity on a regular basis, one-third participate in some leisure-time physical activity, and one-third are considered inactive.\textsuperscript{66}
Dietary Intake

Young adults have eating patterns that are associated with weight gain. Among all adult age groups, young adults are the highest consumers of fast food and sugar-sweetened beverages and the lowest consumers of fruits and vegetables. In a study examining associations between restaurant type, dietary intake, and weight status among young adults (n=2,287); results suggested more frequent use of fast-food restaurants that primarily serve hamburgers and french fries is associated with higher risk for overweight/obesity; higher intake of sugar-sweetened beverages, total energy, total fat, and saturated fat; and with lower intake of healthful foods and key nutrients. In a study using NHANES data to assess the impact of breakfast skipping and type of breakfast consumed on energy/nutrient intake and diet quality among young adults (n=2,615); results suggested that 25% of young adults were non-breakfast consumers. Non-breakfast consumers had higher percent energy intake from added sugars than breakfast consumers; and participants who reported eating breakfast had higher healthy eating index scores for intakes of whole fruits, whole grains, and milk.

Of particular interest among young adults is the relationship between living arrangements and health-related behaviors. Greater attention is needed to specify how social conditions place individuals “at risk of risks.” Studies have focused on the health-implications of spatial environments such as neighborhoods or cities on health behaviors, but little research has focused on the most immediate social context in which individuals are embedded: the household. Living arrangements may be particularly salient to health since the household is an important environment for social relations that are encountered on a daily basis. As youth age and become increasingly independent, friend and family influences transform and social roles may evolve from what may have existed in the childhood and adolescent years. Discussed below are ways in which living arrangements influence health-related behaviors in young adults.
**Living with Parents**

Living with parents may have a protective effect on some health-related behaviors. Living with parents could influence access to certain substances due to parental control or availability, which may be an important factor in young adults’ initiation of or increased use of tobacco and alcohol. Individuals who live at home reported consuming fewer alcoholic drinks per week compared to their peers living away from home.\(^7^5\) Wechsler and colleagues (2002) found the lowest rates of binge drinking were among students living in substance-free dorms or off campus with their parents.\(^7^6\) Young adults who live at home also report that their parents are the primary persons responsible for their food purchasing and food was largely prepared by their mothers or both parents.\(^7^7\) Preparing food at home is beneficial to health because foods consumed away from the home are typically more calorically dense, higher in fat, and have been associated with increased BMI and obesity prevalence.\(^7^8\),\(^7^9\),\(^8^0\),\(^8^1\),\(^8^2\)

**Not Living with Parents**

The other category of individuals that are not living with parents include those who are living independently, living with peers, and living with children. The following categories discuss household context on health-related behaviors:

**Living Independently**

Living independently is a natural transition phase for most young adults. This is also a phase where young adults first become in charge of their own food choices,\(^8^3\),\(^8^4\) decide how physically active to be, and how often (if at all) to use tobacco and alcohol. For many young adults, changes in living arrangements result in unfavorable alterations to their food consumption habits in relation to the variety of foods, fruit and vegetable consumption, and the timing of food intake.\(^8^5\) Persons living independently may also be isolated from their social networks, which may have previously supplied economic and supportive ties. These ties may have created a sense
of security, belonging, and direction, and without them, a person may feel lonely and unprotected. To manage poor psychological health, young adults may turn to maladaptive coping strategies such as tobacco and alcohol use. Among students that live independently, literature supports that individuals living alone are more likely to smoke than students living with others and drink more than individuals who are living at home.

**Living with Peers**

The increased autonomy associated with leaving home and living with peers may create a context in which young adults might explore risky or health-damaging behaviors in context of their new relationships with others. Tobacco and alcohol use may increase when young adults choose to or must live with roommates. Influence by peer groups and media become more prominent and influential agents of behavior modeling in comparison to parents, thus, the probability of engaging in deviant behaviors will increase. Other studies suggest that consuming alcohol appeared to be a social activity associated with living among peers.

**Living with Children**

Having a child necessitates the adoption of more adult role responsibilities to ensure that the youth are cared for. A study on family status and health behaviors indicated that marriage and the presence of children in the home is associated with fewer health-damaging behaviors in adults (e.g., tobacco and alcohol use) and being in a family roles promotes social control of health behaviors. However, people with children at home typically do not have higher levels of health than nonparents. In some instances, especially mothers, are more psychologically distressed than nonparents. Two potential reasons for increased stress levels are: (1) children increase economic hardship on families and (2) children decrease the amount of emotional support that spouses receive from each other.
Clustering of Health Behaviors and its Relationship to Chronic Disease Risk

While it can be important to understand the effect of key risk behaviors independently of one another and much is known about the prevalence of single health risk factors and their associations with demographic correlates, they seldom operate in isolation and many of these health-related behaviors are highly connected.

For example, studies have examined the relationship between sedentary behavior and physical activity, and physical activity and dietary intake, and tobacco use and various other behaviors. A number of strong associations between health-related behaviors exist (such as alcohol consumption and tobacco use), however, evidence for associations between multiple health-related behaviors has been mixed, and there is a limited literature addressing the relationships among multiple health-related behaviors or clusters of multiple health-related behaviors and their associations with living arrangements.

There is evidence to support that risk for chronic conditions is reduced when individuals meet public health recommendations for diet, physical activity, alcohol use, and obesity. An increased understanding of the prevalence and clustering patterns of multiple health-related behaviors may help identify typologies of risk and subgroups of the population that are at particularly high risk for disease based on behavioral patterns. Understanding typologies may help public health professionals create more effective and efficient interventions and help reduce the onset and improve management of existing chronic diseases.

A modest number of studies provide evidence that these modifiable health-related risk factors cluster and interact. Among the published work that has assessed multiple health-related behaviors and examined the cluster patterns of various healthy lifestyle factors, a variation of the four modifiable shared risk factors that lead to chronic disease have been included in the analyses. Tobacco use, physical activity, dietary intake (operationalized by consuming a number...
of fruit and vegetables or a healthy diet), and alcohol consumption are all typically considered within the scope of the studies. Among these studies, findings are fairly consistent and suggest that distinct clusters of individuals within a larger population can be identified.\textsuperscript{100, 101, 102}

Among these studies, results suggest that very few American adults met national guidelines related to the four modifiable health behaviors. Reeves and Rafferty (2005) report in a national sample of adults (using BRFSS data), only 3% met all healthy lifestyle characteristics defined as nonsmoking, having a healthy weight (BMI of 18.5-25.0), consuming 5 or more fruits and vegetables a day, and regular physical activity (30 minutes for 5 times per week).\textsuperscript{103} Pronk and colleagues (2004) found that only 10.8% of adults from a large Midwestern Health plan (n=585) met all five lifestyle-related health factor recommendations (physical activity, nonsmoking, high-quality diet, health weight, and alcohol consumption).\textsuperscript{104} Lastly, Ford and colleagues (2001) used data from the National Health Nutrition Examination Survey and determined that only 6.8% of adults engaged in four healthy lifestyle factors (not smoking, adequate fruit and vegetable intake, adequate physical activity, and normal BMI).\textsuperscript{105} Overall, these studies highlight that there are subgroups within a larger population that clustered by multiple health-related behaviors; with few adults adopting all recommended guidelines. These findings indicate and promote further exploration of different patterning of health-related behaviors among young adults.

A method which lends itself to addressing the complexity of health-related behaviors and aids in capturing meaningful patterns in a given population is latent class analysis (LCA),\textsuperscript{106} which refers to a specific type of cluster analysis, called multivariate mixture estimation. LCA can be used to determine the number of subpopulations – or typologies – that are represented by a given set of potential predictors, the probability each individual has for placement in each
typology, and the characteristics that most strongly predict profile membership. The use of LCA allows the consideration of multiple outcomes simultaneously in the identification of typologies. In this dissertation, chronic disease risk behavioral typologies that reflect the four modifiable risk factors (lack of physical activity, dietary intake, tobacco use, and excessive alcohol consumption) will be explored and identified.

A review of the literature suggests that three studies have specifically used LCA to observe clustering effects of multiple health-related behaviors. Héroux and colleagues (2011) used four health-related behaviors (diet, smoking, fitness, and drinking alcohol) as indicators and found the existence of two classes among adults (aged 20 – 84); the results suggested that unhealthy behaviors and healthy behaviors cluster together. The LCA analysis, which controlled for age and gender, established that 38% of the sample were in class 1 and 62% were in class 2. Class 1 membership was characterized by a higher probability of partaking in each of the four unhealthy behaviors, particularly unhealthy diets (51.2% vs. 1.2%). Furthermore, the study assessed whether or not differences in health behavior clustering patterns existed between those with and without chronic disease. In this study, it was found the clustering of unhealthy behaviors did not vary according to chronic disease status. Södergren et al. (2014) used LCA to identify subgroups of older adults (aged 55 – 65) with respect to their lifestyle patterns (including diet, drinking alcohol, smoking, physical activity, and TV viewing) and examined associations between profiles and socio-demographic characteristics. Two classes of lifestyle patterns were identified – healthy and less healthy – with class membership being associated with education, body mass index, and self-rated health. Lastly, Leventhal and colleagues (2014) used LCA to identify the patterns of modifiable biobehavioral risk factors for chronic disease (including alcohol abuse, drug abuse, nicotine dependence, obesity, and physical
inactivity as indicators) among population-based sample of US adults (18 years of age and older) which yielded five latent classes – ‘obese, active non-substance abusers’; ‘nicotine-dependent, active, and non-obese’; ‘active, non-obese alcohol abusers’; ‘inactive, non-substance abusers’; and ‘active, polysubstance abusers’ with each class displaying distinct demographic profiles. No published study to date has examined health-related behaviors among young adults (18 – 35) to assess chronic disease risk behavioral profiles.

The purposes of this dissertation are to: 1) assess if a meaningful LCA model can be identified from nine indicators that represent the four modifiable shared risk factors that lead to chronic disease; 2) assess if the identified classes differ by living arrangements, and evaluate whether there are significant differences in weight-related measures between typologies controlling for demographic characteristics, and 3) examine behavioral predictors of BMI and weight status over time through assessing how baseline health-related behaviors (tobacco use, alcohol use, energy intake, physical activity) among young adults explain change in BMI and categorization of weight status at 24-months.

**Research Questions**

The current research will address gaps in the literature (detailed further in Chapters 3 and 4) by identifying the distinct typologies of young adults on the basis of modifiable risk factors of chronic disease and assess if health-related behaviors (tobacco use, alcohol use, dietary intake, and physical activity) predict change in weight status after 24-months in a sample of young adults (aged 18 – 35) using data from the Choosing Health Options in College Environments and Settings (CHOICES) study. This study was a randomized controlled trial of a weight gain prevention intervention targeting young adults attending 2-year community colleges in the Twin Cities, Minnesota (detailed further in Chapter 2).

This dissertation will answer the following research questions:
Research Question - Aim 1: Do individual health-related behaviors (tobacco use, alcohol use, dietary intake, physical activity) of young adults, holding other behaviors constant, predict change in weight 24-months later?

Aim 1: To understand how baseline health-related behaviors among young adults, holding other behaviors constant, explain change in BMI at 24-months.

Research Questions - Aim 2: Can we identify and describe mutually exclusive typologies of young adults based on their health-related behaviors related to chronic disease risk using latent class analysis? Do the typologies identified differ by the following characteristics: demographics, living arrangements (living with parents versus not living with parents), and mean BMI?

Aim 2: To identify distinct typologies of young adults on the basis of the four modifiable risk factors of chronic disease using LCA and to describe patterns of class membership based on demographics, living arrangements and mean BMI.

Implications for Health Promotion and Disease Prevention

The contribution of the dissertation research is to determine if specific and identifiable typologies of young adults exist based on a set of chronic-disease related health behaviors and if those typologies differ by living arrangement and weight. In addition, this research will examine if baseline health-related behaviors explain change in 24-month BMI. To implement effective prevention interventions for young adults at risk of obesity, it is imperative to understand the health-risk behaviors of this population and longitudinal behavioral effects. Numerous studies examined health-related behaviors of adults, but few focused specifically on young adults.

Literature on the associations between multiple health behaviors is important for two primary reasons. First, successful health promotion and disease prevention efforts hinge upon understanding both the frequency and distribution of multiple health-related behaviors and understanding associations among different behaviors. Second, combinations of health
behaviors may have synergistic effects on the risk of developing chronic disease, such as cancer and other health outcomes.\textsuperscript{113,114}

Identifying chronic disease risk behavioral typologies provides the opportunity to concurrently examine categorizations of multiple health-related behaviors and may aid in the development of typology-specific intervention efforts. These types of intervention efforts can be viewed as audience segmentation, which can be important for effective interventions. Audience segmentation focuses on a specific group of individuals who are most critical to reach and to designs the most effective and efficient strategy for helping each individual adopt new health-promoting behaviors.\textsuperscript{115} Understanding how many audience segments exists and which indicators differentiate them could provide critical information for behavior change campaigns in community colleges. Typologies could be used to help match health promotion programs to particular segments of young adults. This type of audience segmentation can enable the development of salient materials to each household subgroup to develop more refined and potentially more effective health-promoting interventions. University systems could use this information to create campaigns and services to target segments of the student population based on household context to ensure shared risk-behaviors in social contexts are properly addressed. Furthermore, understanding the impact the household context has on contributing to membership in these typologies will provide the basis for interventions to decrease overweight and obesity. Using community college student’s living arrangements (living with parents and not living with parents) as a segmentation tool could provide a way to design and disseminate materials to maximize the resonance between these two subgroups.

This research will add to the growing body of literature about the patterning of the modifiable risk factors of obesity, or distally – chronic disease. The major modifiable risk factors
share causes but also share opportunities for prevention and disease alleviation. Addressing tobacco use, alcohol misuse, physical inactivity, and unhealthy dietary intake could go a long way in mitigating unhealthy weight gain.

Overall, the current research will address gaps in the literature about the multiple health-related chronic disease behavioral typologies in young adults and relationships among living arrangements, mean BMI and classification of weight status. If hypothesized relationships are found, this research will provide beneficial information about the distribution of the four modifiable risk factors of chronic disease, associations among variables, and potentially lend insight into the synergistic effect on the risk unhealthy weight gain. Understanding patterns of modifiable risk factors of overweight and obesity may be useful for holistic insight to disease incidence and intervention.
CHAPTER 2: CONCEPTUAL MODEL, THEORY, AND CHOICES STUDY

Specific Aims and Conceptual Model

Figure 2.1 is an illustration of the key relationships described in this dissertation. The model encompasses personal factors (age, sex, race/ethnicity), behaviors (alcohol and tobacco use, physical activity, dietary intake), and social environment (living arrangements). Personal factors, health-related behaviors, and the social environment are constructs that are believed to be associated with proximal health status (operationalized as body mass index (BMI)) and distally, chronic disease risk. This model posits a possible explanation for health-related chronic disease behavioral typologies and 24-month BMI in young adults. As referenced in Chapter 1 Section 5, the following are the aims and hypotheses of this dissertation:

Specific Aim 1: To examine behavioral predictors of weight over time, aiming to understand how baseline health-related behaviors among young adults explain change in 24-month BMI.

Hypothesis Aim 1: I hypothesize individuals who engage in less health-promoting behaviors (diet, physical activity, and alcohol use) will be more likely to gain weight at 24-months compared to those who do engage in health-promoting behaviors. In contrast, individuals who are cigarette smokers will be more likely to lose weight at 24-months compared to those who do not smoke.

Specific Aim 2: To identify distinct typologies of young adults on the basis of the four modifiable risk factors of chronic disease using LCA and to describe patterns of class membership based on demographics, living arrangements, and mean BMI.
Hypothesis Aim 2: I hypothesize that I will identify typologies of young adults with distinct health-related behavioral characteristics and that group membership will differ by age, living arrangements, and mean BMI.

**Figure 2.1. Conceptual Model**

**Basic Overview: Social Cognitive Theory**

The conceptual model (Figure 2.1) depicts relationships among an individual’s personal factors, behaviors, and environment. A theoretical framework was chosen to guide the aims of this dissertation that considered both the environmental context and individual processes related to multiple health-related behaviors. Bandura’s Social Cognitive Theory (SCT) posits a possible explanation for health-related chronic disease behavioral typologies and 24-month BMI and weight status change in young adults.

Bandura’s (1986)\textsuperscript{116} theoretical perspective suggests that individuals are self-organizing, pro-active, and self-regulating – rather than reactive entities shaped by environmental or biological forces. For example, how a person interprets the results of one’s own behavior informs the environment and alters personal factors which in turn alters future behavior. This example illustrates Bandura’s global hypothesis of reciprocal determinism, or the dynamic interaction between an individual, the individual’s environment and one’s behavior.\textsuperscript{117}
Reciprocal determinism makes it possible for intervention efforts to change health-related behaviors when directed at personal, environmental, or behavioral factors. At the crux of SCT is human agency, which suggests that individuals actively engage in their own development and can individually produce desired outcomes. Individual capabilities within this theoretical perspective include the ability to: (1) plan alternative strategies (anticipate consequences of actions; set goals), (2) symbolize (extract meaning from the environment), (3) learn through vicarious experience (observing others complete a behavior), (4) self-regulate (self-direct changes in one’s behavior), and (5) self-reflect (making sense of an experience; exploring one’s beliefs). Of all the influences on one’s capabilities, the most influential and center to SCT are self-efficacy beliefs, or the confidence in one’s ability to produce a desired action or performance. Self-efficacy beliefs provide the foundation for motivation and personal accomplishment.

**Specific Constructs: Social Cognitive Theory**

As mentioned, SCT emphasizes reciprocal determinism in the interaction between people and their environments, as this theory posits that human behavior is the product of the dynamic interplay of personal factors and environmental influences. In this theoretical model, behavior, personal factors, and environmental influences all operate as interacting determinants that influence each other. Each construct as it relates to the conceptual model (Figure 2.1) is described below:

**Behavior**

What people think, believe, and feel, affects how they behave. Expectations, beliefs, self-efficacy, goals, and intentions give shape and direction to behavior. Behavior is the way in which someone acts or responds in a particular situation – in this case, we are particularly interested in modifiable health-related behaviors which are related to chronic disease risk:
tobacco and alcohol use, physical activity, and dietary intake. According to SCT, engaging in a particular behavior shapes one’s personal factors and environment.

**Personal Factors**

Bandura’s SCT suggests the effect of one’s behavior in turn partially determines a person’s thought patterns and emotional reactions\textsuperscript{124} which can be expressed through knowledge, self-efficacy (the ability to belief in oneself to compete a specific behavior), expectations, and attitudes. Bandura proposes that the beliefs that individuals have about themselves is a critical component of control and personal agency; thus, individuals are viewed as both producers and products of their environment.\textsuperscript{125} Personal factors also encompass the biological properties of the individual.\textsuperscript{126} Individuals elicit different reactions from their environment due to their physical characteristics such as race, age, sex, and physical attractiveness, independent from what a person says or does.\textsuperscript{127}

**Environmental Factors**

SCT highlights the environment as a factor that can influence individual psychosocial processes and subsequent behaviors. Environments refer to the impact of an individual’s external surroundings, such as friends, family, neighborhood characteristics, and food availability on one’s behavior.\textsuperscript{128} The environmental construct is not clearly defined in the SCT.\textsuperscript{129} A review of the literature by Richter and colleagues (2000)\textsuperscript{130} suggested that important environmental variables could be implemented programs, policies, or practices. Another way to depict environment is to focus on the social environment, one of which can be operationalized as “household environment” or “living arrangements.”

**Mechanisms within the household.** Living arrangements represent an element of the social environment and social networks within this environment which have the potential to impact health behaviors in a number of ways. Berkman and Glass (2000)\textsuperscript{131} argue that social
networks have the potential to impact health behaviors through several pathways including: (1) provision of social support; (2) social influence; (3) social engagement; and (4) access to resources and material goods. The social environment may influence behavioral processes, which then influence the most proximate pathways to health including: (1) stress responses; (2) personal factors such as self-efficacy; (3) health-damaging behaviors such as tobacco consumption or alcohol misuse; (4) health promoting behaviors such as health service utilization and physical activity; and finally (5) exposure to infectious disease agents such as sexually transmitted diseases.\textsuperscript{132} Key pathways in the household are discussed below.

\textit{Social support.} The structure of network ties influences health via the provision of many kinds of support. Social support is typically divided up into four subtypes: emotional, instrumental, appraisal, and information support. It should be noted that not all ties are supportive and there is variation in the type, frequency, intensity, and extent of support provided. Heaney and Israel’s social support theory (1997)\textsuperscript{133} posits that an imbalance between environmental demands and an individual’s resources to cope with these demands triggers a cycle of stress and perceived lack of control which contributes to unhealthy behaviors.

\textit{Social influence.} Social influence –or social control –focuses on regulation of behavior directly or indirectly. Influence needs to neither associate with face-to-face contact nor require deliberate or conscious attempts to modify behavior. Emile Durkheim, a sociologist, argued that individuals need some level of regulation by their surrounding society (social environment) to create expectations based in reality and to be attached to society in a meaningful way.\textsuperscript{134} These ideas can be interpreted to mean that social networks – whether through families, educational systems, or workplaces – serve in part to regulate behavior. Social control can happen directly when an individual encourages another individual in a face-to-face situation; or indirectly, when
network interactions create norms for a behavior in addition to social rewards for following those norms or consequences for violating them. Shared norms around health-related behaviors (alcohol, tobacco, diet, physical activity) might be powerful sources of social influence with direct consequences for the behaviors of individuals living in the same household. The social influence that extends from the network’s values and norms constitutes an important pathway through which networks impact health.

Social engagement. A third pathway by which networks may influence health status is by promoting participation and engagement. Participation and engagement result from the enactment of potential ties in activities. Getting together with friends is an example of social engagement. Berkman and Glass hypothesize that part of the reason measures of social integration or “connectedness” have been such powerful predictors of mortality is that these ties give meaning to an individual’s life by enabling the individual to participate fully in society, to be obligated (potentially as a provider of support), and to feel attached to one’s community. Access to resources and material goods. A fourth pathway by which networks could influence health is through access to resources and material goods. For example, participation in a professional organization may provide access to health insurance, without it being provided as a type of support by a specific individual in the group. In turn, this affects health behaviors, particularly those related to seeking primary care, and ultimately health outcomes.

Social Cognitive Theory: Health-Related Behaviors

SCT provides a conceptual framework for understanding the factors that influence behavior and the process through which learning occurs, providing insight into a variety of health-related behaviors. As discussed below, SCT has made significant impacts on various health-related interventions to address multiple public health challenges.
**Tobacco use.** SCT has been used to design intervention approaches related to tobacco use to aid in smoking cessation and smoking initiation.

**Cessation.** Roberts and colleagues (2013) completed a review on behavioral interventions associated with smoking cessation in the treatment of tobacco use in which clinical guidelines suggest that smoking cessation interventions should include both behavioral support and pharmacotherapy (nicotine replacement therapy). The authors stated that smoking cessation interventions are commonly influenced by theories of behavior change including SCT. Key behavioral model constructs used to aid in smoking cessation build interventions using self-efficacy, motivation, subjective norms, attitudes, and cues to action.

**Initiation.** Tobacco use is started and primarily established during adolescence, which makes early experiences in the life-course impactful. In a review paper assessing the evidence for causality between tobacco promotion and initiation of tobacco use by children, results suggested that promotions foster positive attitudes, beliefs, and expectations regarding tobacco use; which fosters intention to use and increases the likelihood of initiation. SCT is mentioned as a theoretical justification as to why children’s attitudes can be changed by vicarious learning (observation of smoking behavior) with this behavior being reinforced by receiving valued rewards such as attention, attractiveness, or popularity. A recent longitudinal study, which tested whether smoking-related perceptions predict smoking initiation among adolescents, found that smoking initiation is directly related to smoking-related perceptions of risks and benefits. Consequently, efforts to reduce adolescent smoking should communicate the health risks of smoking and counteract the perceptions of benefits associated with smoking. This description and cognitive characteristics mentioned are consistent with SCT personal factors, which would link smoking-related perceptions with attitudes, expectations, and knowledge.
Alcohol use. Walters and Neighbors (2005) wrote a review paper using published outcome studies focusing on alcohol interventions for college students that used feedback (an evidence-based strategy) to change normative perceptions of drinking. Results supported the conclusion that feedback can reduce drinking among students when used as a supplement to an individual motivational intervention. Drawing upon Bandura’s work, feedback interventions rely on a component of normative comparisons (for example, beliefs about peers’ drinking or amount consumed compared to peers). Feedback interventions are consistent with SCT personal factors, which link alcohol-related perceptions with attitudes, expectations, and knowledge. SCT has also been proposed to guide future research and intervention efforts among college students in relation to social anxiety and drinking. A better understanding of college students’ reasons for drinking offers the possibility of improving prevention and treatment efforts designed to reduce excessive alcohol consumption.

Physical activity. SCT has been used to design intervention approaches related to physical activity. Self-efficacy has been found to be an important predictor of the adoption and maintenance of physical activity. In a systematic review that was conducted to further understand the best way to change self-efficacy to promote physical activity through interventions, results suggested that interventions that included (1) feedback on performance producing the highest levels of self-efficacy with (2) vicarious experience (seeing another person perform the behavior) associated with higher levels of self-efficacy. These results were similar when applied to a specific priority population. In a systematic review by Plotnikoff and colleagues (2013) that assessed the explanatory power of various social-cognitive theories for describing physical activity behavior among adolescents, self-efficacy was found to be a generally strong predictor of physical activity across various studies. The authors suggested
focusing on self-efficacy could have a positive impact on adolescent physical activity. Parents, teachers, and sport coaches were highlighted to make physical activity opportunities fun and enjoyable, which would possibly build adolescents’ confidence.\textsuperscript{153}

\textbf{Dietary intake.} SCT has been used to design intervention approaches related to dietary intake. For example, a study that focused on nutrition behaviors in an adult population found that important contributors of diet included an individual’s age, gender, socioeconomic status, social support, self-efficacy, negative outcome expectations, and self-regulation – all of which are consistent with SCT constructs.\textsuperscript{154} The authors suggested that interventions which included increasing nutrition related self-efficacy, leveraging familial support, and overcoming negative outcome expectations should help adults enact self-regulatory behaviors essential to buying and eating healthier foods.\textsuperscript{155}

\textbf{Social Cognitive Theory: Personal Factors}

Individual factors included in this model consist of age, sex, and race/ethnicity. These constructs explain health through their complex direct and indirect effects of economic, social, and genetic influence, which justifies their inclusion. Research on each of these factors linked with weight-related health status is presented below.

\textbf{Age and sex.} In a systematic review conducted by Wang and Beydoun (2007) assessing the obesity epidemic in the U.S. by varying individual factors; results suggested that the estimates of the national prevalence of overweight and obesity among adults based on the 1999 – 2004 NHANES data showed that among men and women aged 20 or old, approximately two thirds (66.3\%) were overweight or obese, 32.4\% were obese, and 4.8\% were extremely obese, with the combined prevalence increasing with age.\textsuperscript{156} When assessing the rate of increase for the combined prevalence for overweight and obesity, results suggested among men, the rate of
increase was similar across age groups but among women, the group 20-34 years of age had the fastest increase.\textsuperscript{157}

\textbf{Race/Ethnicity.} Race/ethnicity is included within personal factors because health disparities exist among certain groups of individuals, independent of socioeconomic status, age, or sex. Data from NHANES, BRFSS, and the Add Health study show large racial/ethnic differences in overweight/obesity prevalence, especially for women. Systematic review results minority groups (non-Hispanic Blacks and Mexican Americans) had a higher combined prevalence than non-Hispanic Whites by almost 10%; non-Hispanic Blacks had the highest prevalence compared to all other groups.\textsuperscript{158} These findings are similar to a review paper assessing cardiovascular disease which also found disproportional rates of disease are seen in racial and ethnic minorities.\textsuperscript{159} Racial disparities exist across the life course. Significant racial and ethnic differences are discernible in BMI trajectories among young children, as well, with African-American and Latino children displaying higher mean BMI scores and differing BMI trajectories, compared with white children, adjusting for time-independent and time-dependent predictors.\textsuperscript{160}

\textbf{Social Cognitive Theory: Environment/Living Arrangements}

As described, differing social mechanism explanations can account for the adoption and/or maintenance in multiple health-related behaviors in young adults based upon choice of living arrangements. The two types of living arrangements included in this dissertation are young adults who live (1) with parents and (2) not with parents. These two different living arrangements provide varying degrees of social support, social influence, social engagement, and access to resources. Due to the various mechanisms at play in the household, it would appear that during the period of young adulthood the social environment would influence the adoption or patterning of health-related behaviors. Discussed below are types of living arrangements and
studies that have linked certain types of health-related behaviors in young adults to a specific social environment.

**Living with parents.** Living with parents could influence access to certain substances due to parental control or availability, which may be an important factor in young adults’ initiation of or increased use of tobacco and alcohol. Individuals who live at home reported consuming fewer alcoholic drinks per week compared to their peers living away from home.\(^{161}\) Wechsler and colleagues (2002) found the lowest rates of binge drinking were among students living in substance-free dorms or off campus with their parents.\(^{162}\) Young adults who live at home also report that their parents are the primary person responsible for their food purchasing, and the food was largely prepared by their mothers or both parents.\(^{163}\) Preparing food at home is beneficial to health because foods consumed away from the home are typically more calorically dense, higher in fat, and have been associated with increased body mass index and obesity prevalence.\(^{164,165,166,167,168}\) Living with parents could be seen as having a protective effect on some health-related behaviors.

**Not living with parents.** The other category of individuals that are not living with parents include those who are living alone, living with peers, and living with children. The following categories discuss household context on health-related behaviors:

**Living independently.** Living independently is a natural transition phase for most young adults. This is also a phase where young adults first become in charge of their own food choices,\(^{169,170}\) decide how physically active to be, and how often (if at all) to use tobacco and alcohol. For many young adults, changes in living arrangements result in unfavorable alterations to their food consumption habits in relation to the variety of foods, fruit and vegetable consumption, and the timing of food intake.\(^{171}\) Persons living independently may also be isolated
from their social networks, which may have previously supplied economic and supportive ties. These ties may have created a sense of security, belonging, and direction, and without them, a person may feel lonely and unprotected.\textsuperscript{172} To manage poor psychological health, young adults may turn to maladaptive coping strategies such as tobacco and alcohol use. Among students that live independently, literature supports that individuals living alone are more likely to smoke than students living with others\textsuperscript{173} and drink more than individuals who are living at home.\textsuperscript{174}

\textit{Living with peers}. The increased autonomy associated with leaving home and living with peers may create a context in which young adults might explore risky or health-damaging behaviors.\textsuperscript{175} Tobacco and alcohol use will likely increase if a young adult chooses a peer living environment (e.g., roommates), due to peer groups and media becoming more prominent and influential agents of behavior modeling in comparison to parents, thus, the probability of engaging in deviant behaviors will increase.\textsuperscript{176} In another study, consuming alcohol appeared to be a social activity associated with living among peers in which the authors conclude drinking could be modified by increasing knowledge about the effects of alcohol on health.\textsuperscript{177} Living with peers could change a young adult’s perception of social norms that could potentially increase susceptibility to health-damaging behaviors, such as tobacco and alcohol use.

\textit{Living with children}. Having a child necessitates the adoption of more adult role responsibilities to ensure that the youth are cared for. A study on family status and health behaviors indicated that marriage and the presence of children in the home is associated with fewer health-damaging behaviors in adults (e.g., tobacco and alcohol use) and being in a family role promotes social control of health behaviors.\textsuperscript{178} However, people with children at home typically do not have higher levels of health than nonparents. In some instances, especially mothers, are more psychologically distressed than nonparents.\textsuperscript{179} Two potential reasons for why
stress levels are increased are: (1) children increase economic hardship on families and (2) children decrease the amount of emotional support that spouses receive from each other.\textsuperscript{180}

Overall, we see that living with parents is health promoting as compared to not living with parents. Living with parents provides the opportunity for mechanisms of consistent social support and access to resources and other materials goods that one may not experience if living in alternative arrangements. Examples of resources in this social environment could be perceived as time used to prepare healthy foods or purchasing of foods. Parental control over health-damaging substances can also been seen as protective. Individuals not living with parents may be subjected to social influence from a group of peers or isolated from their social networks that had previously supplied economic and supportive ties. While moving out of the parental home is a natural transition phase for most young adults, this study seeks to further understand the associations between multiple modifiable health-related behaviors, weight-related outcomes, and living arrangements.

Chapter 3 and Chapter 4 provide details on how each variable that is assessed in the conceptual model are operationalized.

**The CHOICES Study: An Overview**

The specific aims proposed are being explored through data collected in 2011-2013 as part of a randomized controlled trial in three community colleges in Twin Cities, Minnesota.

The Choosing Healthy Options in College Environments and Settings (CHOICES) study tested a 24-month intervention which focused on weight gain prevention in young adults aged 18-35 (n=441).\textsuperscript{181} The goal of the CHOICES study was to develop and test innovative strategies to help prevent unhealthy weight gain in students attending 2-year community or technical colleges. The primary outcome for the study was change in BMI.\textsuperscript{182} This study was a part of a larger NIH research consortium called the Early Adult Reduction of Weight through LifestYle
interventions (EARLY) in which seven research sites were funded to conduct interventions that tested similar outcomes and used a set of common measurement tools.\textsuperscript{183}

**Logistics and Recruitment**

The selected colleges were required to agree to (1) allow research staff on campus to recruit students for the study; (2) offer a one-credit course and help with the logistics of making the course available to students; and (3) conduct student measurements on campus.\textsuperscript{184} The administrative offices at the colleges supported recruitment efforts. Students were recruited through a variety of approaches including e-mails sent from the institution, posters, table tents, and information tables hosted by the CHOICES recruitment staff. Students who expressed interest in the study were prescreened for eligibility before being enrolled. Requirements to participate in the study included: being 18-35 years old; BMI = 20-34.9 kg/m\textsuperscript{2}; and planning on being in the geographic area for two or more years.\textsuperscript{185} Prescreening of students occurred by telephone or in person. If prescreening criteria was met, students needed to provide informed consent that included an agreement to (1) comply with the random assignment to intervention or control; (2) participate in the CHOICES intervention if randomized to intervention condition.

**Intervention Description**

The CHOICES intervention consisted of two phases: 1) an academic course and 2) a social network and support website which centered on four health-behaviors - diet, physical activity, screen time, and sleep habits. Intervention development was informed by health behavior ecological theories, SCT, and Social Network Theory; these frameworks suggest that personal and socio-environmental factors influence weight-related behaviors.\textsuperscript{186}

Students were randomized to intervention or control conditions after completing baseline measures. Students randomized to the control condition received basic health promotion information and took part in all outcome evaluation measurements. Students randomized to the
intervention condition enrolled in a one-credit academic course offered at their college. The course focused on nutrition, physical activity, sleep habits, and stress management techniques as ways to help maintain and/or achieve a healthy weight. Three course delivery styles (online, face-to-face, or hybrid) were offered to students to best fit their schedules and learning styles. In addition to registering for the course, students randomized to the intervention condition were invited to participate in a social networking and support website. The website was launched as a component of the academic course and continued the following 20 months after the course had ended, the website was available to intervention students and a limited number of their invited guests. Students were encouraged to interact with the website by tracking their weight and up to ten additional weight-related behaviors (such as fast food or sugary drink consumption). The online platform was intentionally designed to inform, reinforce, and encourage exchange of information and support between participants. Trained research interventionists interacted with students to help problem-solve or offer support through the website, phone, and text messages.

Evaluation

Evaluation measures were collected from the intervention and control participants at baseline, 4-, 12-, and 24-months post intervention implementation. Data collected at each measurement visit included: (1) height, collected using a Shorr height board (Irwin Shorr, Olney, MD); (2) body weight and percent body fat, collected using a Tanita scale with a built-in body fat analyzer (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL); and (3) waist circumference, collected using a Gullick tape measure. Participants also completed a behavioral and psychosocial questionnaire, which included constructs reported to be determinants of obesity among young adults, including eating and activity patterns, sleep, and stress. Finally, each participant provided information on use of medications and any medical
event that had occurred since the previous CHOICES measurement visit. At baseline, the same information was collected, asking respondents to answer based on the previous six months.\textsuperscript{192}

Students received financial compensation ($100 in gift cards) for participating in each evaluation in addition to receiving results from their health assessments. If randomized to the intervention condition – gained access to the CHOICES website and fees were waived for the one-credit class and paid for by the research grant.\textsuperscript{193} The University of Minnesota Institutional Review Board approved all study protocols. Data from the CHOICES study that are used in this dissertation including the following variables, the following measurement periods, and indication of what variables will be used in each of the two studies is found in Table 2.1.

### Table 2.1. Summary of Dissertation Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Aim 1</th>
<th>Aim 2</th>
<th>Measurement Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline BMI</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>24-Month BMI</td>
<td>X</td>
<td></td>
<td>24-Month Post Intervention (2014)</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Breakfast Consumption</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>SSB Consumption</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Fast Food Consumption</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Leisure Time Physical Activity</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Seated TV Watching</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Seated Computer Use for Work</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Seated Computer Use for Non-Work</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Intervention Exposure</td>
<td>X</td>
<td></td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Gender</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Race</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Age</td>
<td>X</td>
<td>X</td>
<td>Baseline (2011/2012)</td>
</tr>
<tr>
<td>Living Arrangements</td>
<td>X</td>
<td></td>
<td>Baseline (2011/2012)</td>
</tr>
</tbody>
</table>
CHAPTER 3: STUDY 1-UNDERSTANDING THE ASSOCIATION BETWEEN BASELINE HEALTH BEHAVIORS AND CHANGE IN 24-MONTH BMI AMONG YOUNG ADULTS

Background

The World Health Organization (WHO) has identified chronic disease as the major cause of death in almost all nations. Four chronic diseases – cardiovascular disease (CVD), cancer, respiratory disease, and diabetes - have been targeted by WHO for prevention and control to reduce premature deaths across the world. These diseases all have non-modifiable (hereditary, age) and modifiable (behavioral) risk factors. Improving health-related behaviors has been shown to reduce pre-mature deaths due to preventable chronic disease.

One of the most prevalent disease precursors for CVD risk is obesity, and trends indicate that obesity develops through gradual weight gain during early adulthood, with most obese individuals becoming so before age 35. Behaviors such as tobacco and alcohol use, high consumption of sugar-sweetened beverages (SSBs) and fast food, and physical inactivity all contribute to a substantial proportion of preventable diseases. The negative sequela of these behaviors include the intermediate risk factors of high blood pressure, high fasting glucose levels, abnormal blood lipids, and overweightness (body mass index ≥ 25kg/m²) and obesity (body mass index ≥ 30kg/m²). Results from a cohort study indicated that weight gain during early college years increases the risk of obesity-related morbidity, even if individuals had a normal weight when entering the higher education institution. Young adulthood (e.g., ages 18-35) is marked by important transitions involving increased autonomy in decision-making and behavioral exploration and experimentation.
the fastest weight gain, averaging 15 kilograms (approximately 33 pounds) over 15 years.\textsuperscript{202} Gaining weight can be particularly harmful for young adults, since it can be especially difficult to lose weight and maintain weight loss.\textsuperscript{203} Nearly one-third of young adults in the United States are obese.\textsuperscript{204} Through the encouragement of consistent healthy living patterns, the transition period of emerging adulthood could provide important opportunities to reduce the initial onset of obesity and related chronic disease.

Health behaviors, including tobacco and alcohol use, eating behaviors and physical activity are both modifiable and related to risk of weight gain. Research suggests that tobacco use and body weight are linked, but the relationship is not well understood. Tobacco use has often been identified as an unhealthy behavior that is associated with a lower body weight in many cross-sectional studies.\textsuperscript{205,206,207} Tobacco use may decrease appetite while providing oral stimulation and an inhibitory behavior that reduces eating and drinking.\textsuperscript{208} However, particularly among individuals with lower socioeconomic status,\textsuperscript{209} tobacco use is associated with weight gain – this may be due to the clustering of other weight-related risk behaviors (e.g., unhealthy diet) that may offset the reduction of body weight. Adding to the complexity of this relationship, smoking cessation can cause excessive weight gain in some individuals which can be associated with the onset of diabetes or obesity.\textsuperscript{210}

Alcohol is the most often used psychoactive substance by young adults and is one of the leading modifiable morbidity and mortality risk factors among young adults.\textsuperscript{211,212} Similar to tobacco use, the relationship between alcohol intake and weight is complex.\textsuperscript{213} Alcohol can be related to unhealthy weight gain since it is a high-calorie beverage that interferes with cognitive and metabolic processes.\textsuperscript{214} Alcohol is a source of energy contributing 7 kcal per gram and is second only to fat in caloric density.\textsuperscript{215} Moderate alcohol consumption results in a greater overall
energy intake from food during a meal than in equivalent no-alcohol conditions,\textsuperscript{216} possibly due to the differential satiating properties of liquids as compared to solids, short-term stimulatory effect on appetite or the disinhibiting influence of alcohol on other behaviors.\textsuperscript{217} Traversy and Chaput (2015) published a review article on the association between alcohol consumption and obesity and found that light-to-moderate drinking is not associated with adiposity gain while heavy drinking is more consistently related to weight gain.\textsuperscript{218} Despite study limitations, evidence across experimental and observational studies suggest that alcohol may be a risk factor for obesity in some individuals, especially when consumed in large quantities.\textsuperscript{219} Alternatively, individuals with alcohol disorders may have high levels alcohol consumption and high frequency of alcohol intake but ingest too few calories from food sources to maintain a normal weight.\textsuperscript{220} Specifically among young adults, heavy drinking can be related to lower weight through disordered eating behaviors.\textsuperscript{221} A phenomenon known as “drunkorexia” represents an example of restricting food calories with binge drinking\textsuperscript{222} as a means to control weight in order to compensate for increased caloric intake from consumption of alcoholic beverages or drink alcohol excessively in order to purge previously consumed food.\textsuperscript{223}

Physical activity is an important factor in healthy weight regulation as a way to expend energy and improve the body’s use of insulin. Being physically active is beneficial for blood pressure, health of the blood vessels and protective against inflammation, which is a powerful promoter of cardiovascular disease.\textsuperscript{224} Decreasing time spent in sedentary behaviors is also important. Accumulating evidence suggests that, independent of physical activity levels, sedentary behaviors are associated with chronic diseases. Evidence shows that more screen time, particularly television viewing or playing video games, is associated with overweight and obese children, adolescents, and adults.\textsuperscript{225} Therefore, to maximize health benefits, approaches to
resolve physical inactivity should attempt to both increase intentional physical activity and
decrease sedentary behaviors.

Eating behaviors, particularly the frequent consumption of energy-dense foods, such as processed foods that are high in sugar and fat and sugar sweetened beverages (SSBs), are risk factors for obesity. Energy-dense foods and fast foods mainly include processed food items that contain large amounts of fat or sugar such as baked goods, burgers, and deep fried food.\textsuperscript{226} Higher frequency of fast food consumption has been associated with diets that are high in calories.\textsuperscript{227} Evidence suggests that the proportion of daily calorie intake from foods eaten away from home has increased, and the results demonstrate that children, adolescents, and adults who eat out, particularly at fast food restaurants, are at increased risk of weight gain and obesity.\textsuperscript{228} The increase in population consumption of SSBs, such as sodas and fruit juices, has been a major contributor to the obesity epidemic.\textsuperscript{229} People who consume SSBs regularly – most often one to two servings per day or more – have a 26\% greater risk of developing type 2 diabetes than people that rarely drink SSBs.\textsuperscript{230}

Meal patterns have also been linked with obesity prevalence in adults\textsuperscript{231} with habitual breakfast skipping highlighted as a factor related to weight gain. A recent meta-analysis of cross-sectional studies showed that the risk for overweight or obesity increases by 55\% if breakfast is skipped.\textsuperscript{232} Research suggests that non-breakfast consumers tend to gain weight as a result of overcompensating for energy-intake skipped at breakfast with high-fat, energy-dense foods later in the day. Justification for energy overcompensation can be explained through satiety levels. If breakfast is skipped, one could have lower satiety levels resulting in overeating later in the day, which over time, leads to weight gain.\textsuperscript{233}
Despite evidence recommending that young adults are at risk for unhealthy weight gain and risk behavior such as drinking, smoking, lack of physical activity and poor eating behaviors, this population has been understudied.\textsuperscript{234} Colleges and universities are ideal settings for weight-gain prevention interventions due to their large young adult populations.\textsuperscript{235} A study examining differences in overweight/obesity prevalence and associate behaviors suggested that students enrolled in 2-year institutions might be at even greater risk for risk factors associated with weight-related behaviors than their 4-year counterparts.\textsuperscript{236} A systematic review conducted by Partridge and colleagues (2015) identified randomized controlled trials that implemented preventive weight gain interventions in healthy individuals between ages 18 and 35. Results suggested that over half the interventions were effective in weight prevention and/or BMI increase in the short term, however, few showed long-term maintenance.\textsuperscript{237} Another systematic review identifying specific characteristics of effective interventions in young adults, the small body of evidence, large heterogeneity across trials, and short duration of studies lead to inconclusive findings on effective strategies for weight gain prevention in this population.\textsuperscript{238} Additional studies are needed to better understand which particular individual health-related behaviors are most important to target to prevent long-term weight gain. There is a need for longitudinal studies to examine relationships over time in order to disentangle the associations and create effective interventions. Understanding which specific health-related behaviors impact weight change in young adults could help identify the most salient behaviors for targeted interventions in community colleges. Identifying key behaviors would allow 2-year institutions to best use their resources and efforts to build programs and services to decrease the onset of weight-gain-initiated chronic diseases.
The purpose of this paper is to investigate how individual health-related behaviors are associated with weight change over a two-year period among community college students. This study’s primary research question is: Do individual health-related behaviors (diet, physical activity, tobacco and alcohol use) of young adults, holding other behaviors constant, predict change in weight 24-months later? Specifically, I hypothesize individuals who engage in less health-promoting behaviors (diet, physical activity, and alcohol use) will be more likely to gain weight at 24-months compared to those who do engage in health-promoting behaviors. In contrast, individuals who are cigarette smokers will be more likely to lose weight at 24-months compared to those who do not smoke. Understanding the predictors of 24-month weight change has important implications for public health. If certain health-related behaviors are found to be significantly associated with 24-month weight gain, targeted interventions could be developed to address them.

**Methods**

**Data Sources**

This study uses baseline and 24-month data from The Choosing Healthy Options in College Environments and Settings (CHOICES) study, a randomized controlled trial designed to prevent unhealthy weight gain in young adults (aged 18 – 35) attending 2-year community colleges. The study was one of seven EARLY (Early Adult Reduction of weight through LifestYle intervention) trials testing the effectiveness of technology-based obesity interventions. During Fall 2011 and Spring 2012, 441 students from three Minnesota community colleges enrolled in the trial. The intervention lasted 24 months and consisted of participation in an academic course and a social networking and support website. Measures were collected at baseline and four, twelve, and 24 months among the treatment and control groups. These included demographics, weight-related behaviors, and other related factors. Participants
received $100 gift cards for participating in each assessment. The CHOICES intervention was not successful in achieving BMI differences between groups but did have an 8% reduction in the prevalence of overweight and obesity among those in the treatment group. The Institutional Review Board of the University of Minnesota approved this study.

**Behavioral Variables**

The CHOICES survey included behavioral questions on tobacco use, binge drinking, dietary intake, and physical activity (Table 3.1). Respondents who reported smoking at least 100 cigarettes in their lifetime and who, at the time of survey, smoked either every day or some days where classified as a current smoker while those who reported never having smoked 100 cigarettes or who smoked at least 100 in the past, but at the time of the survey, did not smoke at all were categorized as not a current smoker. Most adult drinkers do not drink every day – which is why it is important to focus on the amount people drink on the days that they do consume alcohol. Matching the National Institute of Alcohol Abuse and Alcoholism’s binge drinking definition, anyone who indicated drinking 4 (or 5) or more drinks at least one day in the last thirty days was considered a binge drinker.

For the dietary intake questions, fast food consumption was converted to a continuous variable ranging from 0 to 30 signifying how many times in the past 30 days the respondent ate fast food. Likewise, SSBs consumption was converted to a continuous variable ranging from 0 to 30 signifying how many times in the past 30 days the respondent consumed SSBs. Breakfast consumption was recorded as weekly intake, ranging from 0 – 7 times per week. The variable used to measure leisure-time physical activity (LTPA) using the Paffenbarger questionnaire provided estimates of minutes per week of LTPA. Using Healthy People 2010 criteria, adults are sufficiently active if taking part in 150-300 minutes of light to moderate-intensity activity. LTPA was a preferred measure verses moderate- or vigorous-intensity activity measures because
it is suggested to be the largest contributors to discretionary energy expenditure in this population\textsuperscript{247} and could be most modifiable from a multi-level intervention perspective.\textsuperscript{248} Three screen time questions were used as continuous variables to provide estimates of how many hours per week of each activity were performed. These three distinct measures were selected due to differential intervention approaches to address select sedentary behaviors.

Table 3.1. Summary of Health-Related Variables

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Questions from CHOICES Self-Report Survey</th>
<th>Variable Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking Status</td>
<td>“Have you smoked at least 100 cigarettes in your entire life?” and “Do you now smoke cigarettes every day, some days, or not at all?”</td>
<td>Dichotomous (0 = not a smoker; 1 = current smoker)</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td>“Considering all types of alcoholic beverages, how many times during the past 30 days did you have 4 or more drinks (for women) or 5 or more drinks (for men)?”</td>
<td>Dichotomous (0 = no binge drinking; 1 = binge drinking)</td>
</tr>
<tr>
<td>Breakfast Consumption</td>
<td>“In a typical week, how many times do you eat breakfast?”</td>
<td>Continuous (number of days breakfast consumed weekly)</td>
</tr>
<tr>
<td>SSB Consumption</td>
<td>“Over the past 30 days, how many times did you drink: Soda or Pop?; Sports drinks (such as Propel, PowerAde, or Gatorade)?; Energy drinks (such as Red Bull or Jolt)?”</td>
<td>Continuous (number of days SSBs were consumed)</td>
</tr>
<tr>
<td>Fast Food Consumption</td>
<td>Over the past 30 days, how many times did you buy fast food at a fast food restaurant, such as McDonald’s, Burger King, Arby’s, Wendy’s, Hardee’s, Taco Bell, Taco Johns, Chipotle, KFC, Pizza Hut, Panera, Quiznos, Noodles &amp; Company, Bruegger’s Bagels?</td>
<td>Continuous (number of days in a month fast food was consumed)</td>
</tr>
<tr>
<td>Leisure Time Physical Activity</td>
<td>Self-reported weekly leisure time physical activity in minutes was measured using the Paffenbarger Questionnaire\textsuperscript{249}</td>
<td>Continuous (number of weekly minutes of physical activity)</td>
</tr>
<tr>
<td>Seated TV Watching</td>
<td>“On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting while watching television?”</td>
<td>Continuous (number of weekly hours spent watching TV)</td>
</tr>
<tr>
<td>Seated Computer Use for Work</td>
<td>“On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting at work/school doing computer work (email, word or data processing, etc.)?”</td>
<td>Continuous (number of weekly hours using the computer for work)</td>
</tr>
<tr>
<td>Seated Computer Use for Non-Work</td>
<td>“On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting while using the computer for non-work/non-school activities or playing video games?”</td>
<td>Continuous (number of hours using the computer for non-work in a typical week)</td>
</tr>
</tbody>
</table>
Weight-Related Measures

Height and weight were measured by trained staff using Shorr height boards (Irwin Shorr, Olney, MD) and Tanita scales (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL) to assess weight and body mass index (BMI) at baseline and at 24-months.

Demographic Variables

Demographic information including age, gender, and race/ethnicity was collected from participants in a self-report questionnaire. Intervention effects were not of interest but exposure was included in the analysis as a control variable to ensure correct estimation of the relationship between the outcome of interest and predictor variables.

Data Analysis

Diagnostics were performed on the data to assess statistical assumptions before fitting models. Residuals from each model were visually examined for normality before analyses to assess that error terms were normally distributed. A normal probability plot, a kernel density plot, and a histogram provided evidence for normality on all models. To ensure model assumptions were met, tests for multicollinearity and heteroskedasticity were assessed on all models. The variance inflation factor (VIF) was used to evaluate the severity of multicollinearity in the regression analysis. VIF was below 2.0 on all models indicating multicollinearity was not an issue and that each variable was not redundant. A Breusch-Pagan test for heteroskedasticity was performed to check if unequal variances existed. If the test indicated the existence of a problem then the Huber-White sandwich estimator was used to inflate the standard errors in the models to correct heteroskedasticity concerns.

Statistical analyses were conducted using STATA 13.1 (STATACorp, College Station, Texas). Means and frequencies were calculated for demographic, weight, and health-related behavior variables for full and stratified samples. Analyses were performed to examine
interdependencies among variables and their impact on 24-month weight change. A two-tailed test with a $P$ value of $<$0.05 was considered statistically significant. Twenty-four month BMI was used as the dependent variable adjusting for baseline BMI to model weight change. A multivariate linear regression model was fit to understand the association between 24-month BMI and individual baseline health-related behaviors (tobacco and alcohol use, diet, and physical activity) controlling for covariates (baseline BMI, gender, race/ethnicity, age, and intervention exposure).

Post-hoc analyses were then completed using a subsample of those who gained weight between baseline and 24-months. A 3% difference from baseline was considered a change and weight stability of less than a 3% gain or loss was considered maintenance. Three percent was selected because it is an amount of change less than what is clinically relevant, but more than expected from measurement error or fluctuations in fluid balance. A multiple logistic regression model was fit to assess the association of baseline health-related behaviors (tobacco and alcohol use, diet, and physical activity) on 3% weight gain as the dependent variable adjusting for demographic characteristics (gender, race/ethnicity, age) and intervention exposure. There was a seventeen percent attrition rate from baseline to the 24-month assessment period. Demographic differences between those who remained in the study and those who were lost to follow up were examined in the main outcomes paper which found similar results in a dataset using imputed data and the complete cases data. Therefore, only data from complete cases were used in these analyses.
Results

Descriptive Characteristics

Of the 441 students participating in baseline measurements, a total of 365 students continued to the 24-month follow up without missing data on key variables, which is the analytic sample. Table 3.2 shows baseline and 24-month characteristics for the sample. At baseline, the sample was predominately female (67.7%) and white (72.6%), with a mean age of 22.7 years. At the 24-month measurement period the sample lost to follow-up differed by race, with those lost to follow-up more likely to be non-white.\(^{253}\)

<table>
<thead>
<tr>
<th>Variable in Model</th>
<th>Baseline Sample Frequency (%) or Mean (SD)</th>
<th>24-Month Sample Frequency (%) or Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (%) or Mean (SD)</td>
<td>Frequency (%) or Mean (SD)</td>
</tr>
<tr>
<td>N</td>
<td>441</td>
<td>365</td>
</tr>
<tr>
<td>Age, years</td>
<td>22.7 (5)</td>
<td>24.8 (5)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>67.6%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>72.6%</td>
<td>75.4%</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>25.4 (3.8)</td>
<td>26.2 (4.3)</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currently a Cigarette Smoker</td>
<td>16.6%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Alcohol Use in the Past Month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reported Binge Drinking</td>
<td>24.3%</td>
<td>33.9%</td>
</tr>
<tr>
<td>Diet and Energy Intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Fast Food Intake (days/month)</td>
<td>6.6 (6.7)</td>
<td>5.4 (5.9)</td>
</tr>
<tr>
<td>Monthly SSB Intake (days/month)</td>
<td>8.5 (10.6)</td>
<td>6.7 (9.7)</td>
</tr>
<tr>
<td>Weekly Breakfast Intake (days/week)</td>
<td>4.3 (2.4)</td>
<td>4.8 (2.3)</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly Leisure Time Physical Activity (minutes/week)</td>
<td>270.8 (408.6)</td>
<td>216.1 (268.9)</td>
</tr>
<tr>
<td>Weekly Computer Use for Work (hours/week)</td>
<td>15 (11.4)</td>
<td>15.1 (11.8)</td>
</tr>
<tr>
<td>Weekly Computer Use for Non-Work (hours/week)</td>
<td>8.4 (8.9)</td>
<td>9.4 (8.1)</td>
</tr>
<tr>
<td>Weekly Television Watching (hours/week)</td>
<td>10.7 (8.6)</td>
<td>9 (7.5)</td>
</tr>
</tbody>
</table>
Regression Results

Table 3.3 shows adjusted regression coefficients and robust standard errors for baseline health-related behaviors and the association with 24-month BMI change, controlling for demographic characteristics (age, gender, race/ethnicity), intervention exposure and baseline BMI. Being a smoker was a significant predictor of 24-month BMI holding all other behaviors constant (p=0.04). Smokers experienced a 0.79 increase in BMI compared to non-smokers between baseline and 24 months. Binge drinking was significantly predictive of a decrease in BMI at 24-months (β=-0.569, p<0.05) and individuals who reported higher amounts of weekly leisure physical activity experienced an increased BMI at 24-months (β=0.001, p<0.05). Fast food consumption, SSB consumption, breakfast consumption, and sedentary behaviors were not statistically significant independent predictors of 24-month BMI controlling for baseline BMI, age, gender, race/ethnicity, and intervention exposure.

Table 3.3. Health Behaviors Associated with Young Adult’s 24-Month BMI (N=365)

<table>
<thead>
<tr>
<th>Baseline Predictors</th>
<th>BMI at 24-Months</th>
<th>Adjusted β (SE)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Smoker</td>
<td></td>
<td>0.79 (0.381)</td>
<td>0.04</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binge Drinker</td>
<td></td>
<td>-0.57 (0.282)</td>
<td>0.044</td>
</tr>
<tr>
<td>Dietary Intake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Fast Food Intake</td>
<td></td>
<td>0.02</td>
<td>0.39</td>
</tr>
<tr>
<td>Monthly SSB Intake</td>
<td></td>
<td>0.01</td>
<td>0.61</td>
</tr>
<tr>
<td>Weekly Breakfast Intake</td>
<td></td>
<td>0.01</td>
<td>0.81</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly Leisure Time PA</td>
<td></td>
<td>0.001 (0.0003)</td>
<td>0.044</td>
</tr>
<tr>
<td>Weekly Work Computer Use</td>
<td></td>
<td>-0.0004</td>
<td>0.97</td>
</tr>
<tr>
<td>Weekly Non-work Computer Use</td>
<td></td>
<td>0.01</td>
<td>0.72</td>
</tr>
<tr>
<td>Weekly Television Watching</td>
<td></td>
<td>0.001</td>
<td>0.75</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td>-0.008</td>
<td>0.74</td>
</tr>
<tr>
<td>Sex (male)</td>
<td></td>
<td>-0.27</td>
<td>0.31</td>
</tr>
<tr>
<td>Race (white)</td>
<td></td>
<td>0.42</td>
<td>0.20</td>
</tr>
<tr>
<td>Intervention Exposure</td>
<td></td>
<td>0.03</td>
<td>0.91</td>
</tr>
<tr>
<td>Baseline Weight (BMI)</td>
<td></td>
<td>0.99</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note: Model adjusted for listed variables and appropriate baseline weight; robust SE used.
To further understand these multivariate linear regression results, additional post hoc multivariate logistic regression analyses was completed to assess differences of those who gained weight and did not gain weight between baseline and 24-months. Table 3.4 shows descriptive characteristics of the individuals in the full sample, those who maintained/lost weight over 24-months, and those who gained 3% weight over 24-months. Depending on the type of variable, chi-square and t-tests were used to evaluate significant differences between these two groups (Table 3.4). Engaging in binge drinking in the previous month was the only health-related behavior found to be significantly different (p<0.05) between those who maintained/lost less than 3% weight and those who gained 3% weight.

A single multiple logistic regression model was fit to assess the association of baseline health-related behaviors on 3% weight gain as the dependent variable adjusting for demographic characteristics and intervention exposure (Table 3.5). Results of the logistic regression show that engagement in binge drinking in the previous month at baseline was negatively associated with 3% weight gain (OR=0.49; 95% CI: 0.29, 0.83; p<0.01). No significant associations were found regarding tobacco use and odds of 3% weight gain over 24-months.
### Table 3.4. Weight Change Characteristics and Comparisons Among Stratified Samples of Young Adults

<table>
<thead>
<tr>
<th>Variable in Model</th>
<th>Total Sample Frequency (% or Mean (SD))</th>
<th>Maintained/Lost &lt; 3% Weight Frequency (% or Mean (SD))</th>
<th>Gained ≥ 3% Weight Frequency (% or Mean (SD))</th>
<th>Comparison between Maintained/Lost versus Gained (Chi-Square or T-Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>366</td>
<td>170</td>
<td>196</td>
<td>366</td>
</tr>
<tr>
<td><strong>Baseline Age, years</strong></td>
<td>22.8 (5)</td>
<td>22.7 (5)</td>
<td>22.8 (5)</td>
<td>0.95</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>66.7%</td>
<td>65.9%</td>
<td>67.3%</td>
<td>0.09</td>
</tr>
<tr>
<td>White</td>
<td>75.4%</td>
<td>72.3%</td>
<td>78.1%</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Tobacco Use at Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigarette Smoker</td>
<td>15.3%</td>
<td>13.6%</td>
<td>16.8%</td>
<td>0.73</td>
</tr>
<tr>
<td><strong>Alcohol Use in the Past Month at Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reported Binge Drinking</td>
<td>23.5%</td>
<td>28.2%</td>
<td>19.4%</td>
<td><strong>0.046</strong></td>
</tr>
<tr>
<td><strong>Diet and Energy Intake at Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Fast Food Intake</td>
<td>6.4 (6.7)</td>
<td>6.2 (6.8)</td>
<td>6.7 (6.6)</td>
<td>0.47</td>
</tr>
<tr>
<td>Monthly SSB Intake</td>
<td>8.1 (10.2)</td>
<td>7.2 (9.8)</td>
<td>8.8 (10.4)</td>
<td>0.12</td>
</tr>
<tr>
<td>Weekly Breakfast Intake</td>
<td>4.3 (2.4)</td>
<td>4.2 (2.4)</td>
<td>4.4 (2.4)</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Physical Activity at Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LTPA (min/week)</td>
<td>277.5 (419.4)</td>
<td>242.8 (321.9)</td>
<td>307.5 (487.3)</td>
<td>0.27</td>
</tr>
<tr>
<td>Computer Use for Work (hrs/week)</td>
<td>14.9 (11.1)</td>
<td>14.8 (11.3)</td>
<td>14.9 (10.9)</td>
<td>0.98</td>
</tr>
<tr>
<td>Non-Work Computer Use (hrs/week)</td>
<td>8.1 (8.5)</td>
<td>7.8 (8.1)</td>
<td>8.3 (8.8)</td>
<td>0.51</td>
</tr>
<tr>
<td>Television Watching (hrs/week)</td>
<td>10.6 (8.3)</td>
<td>10 (8.4)</td>
<td>11.2 (8.2)</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Table 3.5. Baseline Behaviors Associated with 3% Weight Gain among Young Adults (n=324)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Single Multiple Logistic Regression Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted Odds Ratio</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td></td>
</tr>
<tr>
<td>Not a Smoker (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Smoker</td>
<td>1.54</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td></td>
</tr>
<tr>
<td>Not a Binge Drinker (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Binge Drinker</td>
<td>0.44</td>
</tr>
<tr>
<td>Dietary Intake</td>
<td></td>
</tr>
<tr>
<td>Low Monthly Fast Food Intake (ref)</td>
<td>-</td>
</tr>
<tr>
<td>High Monthly Fast Food Intake (&gt;1/week)</td>
<td>1.26</td>
</tr>
<tr>
<td>Low SSB Consumption (ref)</td>
<td>-</td>
</tr>
<tr>
<td>High SSB Consumption (&gt;1/day)</td>
<td>1.32</td>
</tr>
<tr>
<td>Eats Breakfast 5 or more times per week (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Does Not Eat Breakfast (&lt;4/week)</td>
<td>0.71</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
</tr>
<tr>
<td>Meets Weekly PA Guidelines (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Does Not Meet Weekly PA Guidelines (&lt;149 minutes/week)</td>
<td>0.79</td>
</tr>
<tr>
<td>Low Weekly Work Computer Use (ref)</td>
<td>-</td>
</tr>
<tr>
<td>High Weekly Work Computer Use (&gt;12/week)</td>
<td>1.03</td>
</tr>
<tr>
<td>Low Weekly Non-work Computer Use (ref)</td>
<td>-</td>
</tr>
<tr>
<td>High Weekly Non-work Computer Use (&gt;3 hours/week)</td>
<td>0.80</td>
</tr>
<tr>
<td>Low Weekly Television Watching (ref)</td>
<td>-</td>
</tr>
<tr>
<td>High Weekly Television Watching (&gt;2 hours/day)</td>
<td>1.07</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
</tr>
<tr>
<td>Intervention Exposure</td>
<td></td>
</tr>
<tr>
<td>Unexposed (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Exposed</td>
<td>0.99</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female (ref)</td>
<td>-</td>
</tr>
<tr>
<td>Male</td>
<td>0.93</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>Non-White (ref)</td>
<td>-</td>
</tr>
<tr>
<td>White</td>
<td>1.24</td>
</tr>
<tr>
<td>Age</td>
<td>1.00</td>
</tr>
<tr>
<td>Model (-2 LOG L)</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

To my knowledge, this is one of the first studies to evaluate the longitudinal association between health behaviors and 24-month weight outcomes among 2-year college students. In most cases, the study’s hypothesis was not supported; individuals who engaged in less health-promoting behaviors (e.g., high fast food consumption) generally did not experience a BMI weight increase at 24-months compared to those who did engage in health-promoting behaviors. In particular, despite evidence that suggests poor dietary intake (consumption of fast food\textsuperscript{254} SSBs,\textsuperscript{255} skipping breakfast\textsuperscript{256}) and low physical activity/high sedentary time\textsuperscript{257} are risk factors for weight gain – these predictors did not emerge as significant predictors of 24-month weight gain in this sample. While we expected these weight-related associations to exist, these null findings could be in part due to the composition of this particular sample. Most 2-year college students in our sample reported low participation in adverse weight-related behaviors and had limited 24-month weight gain. For example, on average, participants reported consuming fast food less than two times per week, less than one SSB was consumed per day, and sedentary time spent watching television was less than 2 hours per day with average BMI increasing by 0.94 (approximately 5.5 pounds). Results suggest the need for additional studies to better understand how these health-related behaviors are related to long-term weight gain.

Furthermore, in three cases, we found an association in the opposite direction of what we predicted. First, results from the linear model suggested that increased levels of LTPA predicted a higher 24-month BMI. While this association was significant (p=0.044), the magnitude of this effect was extremely small (β=0.001) and this association did not hold in the logistic model predicting the increased odds of gaining 3% weight at 24-months. Further research is needed to examine leisure time physical activity and its association with weight gain, potentially measuring body fat percentage verses BMI, it might be that individuals are gaining muscle verse fat.
Secondly, we found a negative association between binge drinking and weight, holding all else constant. Both linear and logistic models indicated that individuals reporting binge drinking in the last month had a lower 24-month BMI ($\beta = -0.569$, $p<0.05$) and had lower odds of gaining 3\% body weight 24-months later (OR=0.49, $p<0.01$). These findings suggest that exploring the “drunkorexia” phenomena among this population may be beneficial. Among college students, the drunkorexia trend – defined as the tendency to restrict food intake prior to consuming alcohol and/or participating in excessive exercise in order to compensate for calories consumed from drinking – leads to weight reduction.\textsuperscript{258,259,260} Results from several studies suggest that women engage in drunkorexia more than men as a means of weight control;\textsuperscript{261,262} and food restriction prior to alcohol use was more common among heavier (verses lighter) drinking women.\textsuperscript{263} In future studies, increased sensitive measures would need to be included to gather information on the timing of when young adults are eating, exercising, and binge-drinking. Alternatively, young adults could be exhibiting a pattern of many health-promoting behaviors coupled with infrequent binge drinking. Understanding behavioral patterns among this population should be considered for future studies.

Third, study results suggested that being a baseline cigarette smoker was a significant predictor of increased 24-month BMI, which is counter to the expectation of cigarette smokers having a decreased tendency to gain weight.\textsuperscript{264,265} Therefore, the relationship between smoking cessation and weight gain among this sample was examined to assess if those who were smokers at baseline had quit smoking during the 24-months and due to quitting, had gained weight.\textsuperscript{266} Within this sample, there were twenty smokers that quit from baseline to 24-months. However, post-hoc analyses demonstrated that weight gain between baseline and 24-months was not attributable to baseline smokers quitting smoking (data not shown). While smoking was
associated with incremental weight gain, smoking did not significantly increase the odds that individuals experienced substantial weight gain (OR=1.54; 95% CI: 0.77, 3.06; p=0.21); null results from the logistic regression suggested that smoking was not associated with 3% weight gain. These findings highlight the need for future studies to further understand this complex association\textsuperscript{267} and whether smoking is part of a larger cluster of health-damaging behaviors that are potentially not included in the analyses.

Our result showing that smokers were more likely to have a higher 24-month BMI than non-smokers, coupled with earlier findings from the CHOICES study\textsuperscript{268} suggest that long-term weight change effects might be driven simultaneously by multiple behaviors. In a CHOICES study focusing on the behavioral outcomes, Laska et al. (2016) modeled behavioral outcomes individually in addition to creating a composite of twelve health-related behaviors to create a singular “global complex healthy life-style behaviors” variable. While none of the behaviors were significantly related to weight change in adjusted models, the composite variable that combined multiple behaviors was significantly related to weight loss in the expected direction between treatment and control groups. This suggests that the behaviors assessed worked synergistically to promote weight loss while each individual behavior change was not potent enough to result in weight loss.\textsuperscript{269} This finding, along with other empirical evidence suggests that behavioral patterns may cluster in some manner.\textsuperscript{270,271,272} The global composite variable was not used for the current study as we sought to disentangle the independent association of each behavior with weight change to inform tailored interventions to best utilize community colleges’ resources. The findings from this study do not offer immediate intervention implications with the possible exception of establishing or bolstering on-going efforts to decrease binge-drinking and smoking behaviors on campuses. Future studies should assess the co-occurrence of health
behaviors by using a method – such as latent class analysis – that lends itself to capturing meaningful patterns of co-occurrence in multiple weight-related behaviors in a given population\textsuperscript{273} to better understand the synergy of weight-related behaviors among young adults.

There are limitations to this research. The sample included a large proportion of females (68\%) and is limited in racial/ethnic diversity (73\% white). In addition, external validity is limited since it was focused on one metropolitan area in Minnesota and the results may not be applicable to community colleges across different U.S. regions. This particular sample may also differ from other community college students as evidence by their high frequency of health-protective behaviors. Despite previous research documenting the reliability and validity of measures used,\textsuperscript{274,275,276,277,278} there is a possibility of social desirability in self-reported behaviors which may have captured an over- or under-reporting. Additionally, limited weight gain in the sample might have given rise to a ceiling effect in the possible detectable effect sizes. Finally, we cannot say whether or not the results of our study are causally related.

The strengths of this study include that trained research assistants directly measured height and weight at all evaluation periods therefore we have directly assessed weight related dependent variables rather than self report. There was minimal attrition over the 24 months of observation, minimizing the possibility of selection bias in these results. This study was designed to evaluate the association between four modifiable health-related behaviors and weight change over 24-months. Previous literature has called for a deeper understanding of longitudinal associations in this specific population.\textsuperscript{279} Additionally, given the importance of this phase of life to adult weight change,\textsuperscript{280} this study provides much needed exploratory evidence to better understand weight-related behaviors in this population.
Conclusion

Community college students are in a critical developmental period where health-related behaviors become habits and lifestyles. While binge drinking was associated with weight loss/maintenance, this behavior has been coupled with other negative health consequences such as alcohol dependence and abuse, memory blackouts, sexual violence, and vandalism, and should not be promoted as a positive behavior. As we found smoking status to be associated with weight gain, future studies should seek to understand what other weight-related behaviors cigarette smokers are engaging in and further assess how these behaviors cluster together.
CHAPTER 4: STUDY 2-IDENTIFYING TYPOLOGIES OF YOUNG ADULTS ON THE BASIS OF FOUR MODIFIABLE BEHAVIORAL RISK FACTORS OF CHRONIC DISEASE

Background

Young adulthood (defined as ages 18 to 35) may provide important opportunities to prevent long-term risk behaviors and integrate health promotion activities that encourage a consistent pattern of healthy living. This time period is marked by important transitions, such as increased autonomy in decision-making and behavioral exploration and experimentation; therefore, this life stage may instigate and perpetuate potential health risk behaviors\textsuperscript{283,284} including decreased levels of physical activity,\textsuperscript{285} substance use,\textsuperscript{286} and poor dietary choices.\textsuperscript{287} These transition years represent a period in the life course where individuals may relocate to new environments and create independent lifestyles and habits. Environments such as colleges and universities are ideal settings for weight-gain prevention interventions due to their large young adult populations.\textsuperscript{288} Studies to better understand how health-related behaviors occur in young adults are needed to identify effective intervention strategies to ultimately reduce the burden of chronic disease.

Health-related behaviors such as physical activity, tobacco and alcohol use, and diet are among the major factors that significantly contribute to preventable chronic disease morbidity and mortality in the United States.\textsuperscript{289} Studies have shown that very few American adults meet national guidelines related to these four health behaviors. Reeves and Rafferty (2005) report that in a national sample of adults only 3\% met four healthy lifestyle characteristics, defined as not smoking, having a healthy weight (Body Mass Index (BMI) of 18.5-25.0), consuming five or
more fruits and vegetables a day, and regular physical activity (30 minutes, 5 times per week). Pronk and colleagues (2004) found that only 10.8% of adults from a large Midwestern Health plan (n=585) met five lifestyle-related health factor recommendations (physical activity, non-smoking, high-quality diet, healthy weight, and moderate or no alcohol consumption). Lastly, Ford and colleagues (2001) used data from the National Health and Nutrition Examination Survey and determined that only 6.8% of adults engaged in four healthy lifestyle factors (not smoking, adequate fruit and vegetable intake, adequate physical activity, and normal body weight).

While it can be important to understand the effect of key risk behaviors independently of one another, behaviors seldom operate in isolation, and many of these health-related behaviors are highly related. For example, use of alcohol and tobacco or sedentary behavior and lack of physical activity often co-occur. Thus, in order to holistically address individual chronic disease risk from a behavioral perspective, insights are needed that move beyond single risk-factor assessment to examining the covariance of the four central modifiable behaviors that together contribute to chronic disease burden. A modest number of studies provide evidence that modifiable health-related risk factors cluster. Tobacco and alcohol use, physical activity, and diet are typically considered within the scope of the study. Among these studies, findings are fairly consistent and suggest that distinct clusters of individuals within a larger population can be identified. Identifying modifiable behavioral risk factors that cluster together and are associated with overweight and obesity would inform strategies to address young adult weight gain. Interventions focusing on young adults who pair their newly acquired independence with preventive approaches to obesity could lead to health-promoting behavioral patterns, ultimately decreasing the incidence of obesity and chronic disease.
Latent class analysis (LCA) is a method that lends itself to addressing the complexity of health-related behaviors and aids in capturing meaningful patterns in a given population. LCA can be used to identify the number of subpopulations – or typologies – for a given set of outcomes. A review of the literature revealed several studies using LCA to observe clustering effects of multiple health-related behaviors. Héroux and colleagues (2011) used four health-related behaviors (diet, smoking, fitness, and drinking alcohol) as indicators and found the existence of two classes among adults (aged 20 – 84); the results suggested that unhealthy behaviors and healthy behaviors cluster together. Furthermore, the study found that the clustering of unhealthy behaviors did not vary according to chronic disease status. Leventhal and colleagues (2014) used LCA to identify the patterns of modifiable risk factors for chronic disease (including alcohol abuse, drug abuse, nicotine dependence, obesity, and physical inactivity as indicators) among a population-based sample of US adults (18 years of age and older) and found five latent classes – ‘obese, active non-substance abusers’; ‘nicotine-dependent, active, and non-obese’; ‘active, non-obese alcohol abusers’; ‘inactive, non-substance abusers’; and ‘active, polysubstance abusers’ with each class displaying distinct demographic profiles. No published study to date has examined health-related behaviors among young adults in community colleges (aged 18 – 35) to assess chronic disease risk behavioral typologies. In this study, chronic disease risk behavioral typologies that reflect the four modifiable health-related behaviors (tobacco, alcohol use, physical activity, and diet) will be explored and identified.

Furthermore, we also examined the characterization of behavioral typologies among young adults by living arrangements and weight-related outcomes. Studies have been successful in identifying behavioral causes for disease; however, greater attention is needed to specify how social conditions place individuals “at risk of risks.” Studies have focused on the health
implications of spatial environments such as neighborhoods or cities on health behaviors,\textsuperscript{304,305} but little research has focused on the most immediate social context in which individuals are embedded: the household.\textsuperscript{306} For young adults, living arrangements may be particularly salient to health since the household is an important environment for social relations that are encountered on a daily basis.\textsuperscript{307} Young adults have a variety of living arrangements, including living with their parents, with peers, independently, or with children. Individuals who live with parents report consuming fewer alcoholic drinks per week compared to their peers living away from home.\textsuperscript{308} Living independently or alone, is a natural transition phase for most young adults and is a phase where young adults first take charge of their own food choices,\textsuperscript{309} decide how physically active to be, and choose how often to use tobacco and alcohol. These decisions often result in less healthful behavioral choices.\textsuperscript{310,311,37} Living with peers may create a context in which young adults might explore risky or health-damaging behaviors in context of their new relationships with others as peer group and media influence replaces parental guidance, increasing the probability of risky behavior.\textsuperscript{312,313} Other studies suggest that consuming alcohol is a social activity associated with living among peers.\textsuperscript{314} Marriage and the presence of children in the home are associated with fewer health-damaging behaviors in adults.\textsuperscript{315} However, people with children at home typically do not have higher levels of health than nonparents, possibly due to increased psychological distress.\textsuperscript{316}

This study aims to identify distinct typologies of young adults on the basis of the four modifiable risk factors of chronic disease using LCA and to describe patterns of class membership based on demographic characteristics, living arrangements, and BMI. Identifying subgroups among young adults who share health-related behaviors would provide a deeper understanding into needs of this population and aid in the development of effective interventions.
that can integrate the use of audience segmentation. Specifically, results of this study could inform targeting strategies to prevent chronic disease risk among young adults. Colleges and university systems could use this information to create campaigns and services to target segments of the student population to ensure shared risk behaviors in social contexts are properly addressed.

**Methods**

**Data Sources**

During Fall 2011 and Spring 2012, 441 students from three Minnesota community colleges enrolled in the Choosing Healthy Options in College Environments and Settings (CHOICES) study and completed baseline assessments. The CHOICES study, a randomized controlled trial designed to prevent unhealthy weight gain in young adults (aged 18 – 35) attending 2-year community colleges, was one of seven EARLY (Early Adult Reduction of weight through LifestYle intervention) trials testing the effectiveness of technology-based obesity interventions. The intervention lasted 24 months and consisted of participation in an academic course and a social networking and support website. Evaluation measures were collected at baseline and 4, 12, and 24 months. These included demographics, weight-related behaviors, and other psychosocial factors. Participants received $100 gift cards for participating in each outcome assessment.

**Measures**

Indicators to assess the four modifiable health-related behaviors were developed from item responses from the CHOICES questionnaire recorded at baseline. The questionnaire asked young adults to recall past-month consumption of alcohol, fast food consumption, sugar sweetened beverage (SSB) consumption, past-week breakfast consumption, past-week physical activity, typical weekday and weekend sedentary behavior, and lifetime cigarette smoking. The
CHOICES measures used have been validated and are reliable within this population. LCA uses categorical indicators; therefore, all variables were dichotomized (Table 4.1). Tobacco use included two classifications: current smoker and never smoker. A current smoker included respondents who reported smoking at least 100 cigarettes in their lifetime and who, at the time of survey, smoked either every day or some days. Participants were asked about their binge drinking behavior within the past 30 days. This item was dichotomized as those who did or did not binge drink in the past month according to the definition put forward by the National Institute Alcohol Abuse and Alcoholism.

Three measures were used for diet intake: fast food, breakfast, and SSB consumption. Fast food dichotomization was informed through longitudinal evidence in a young adult population that suggested increased consumption of fast food (one time/week) was associated with a positive increase in BMI change over a three-year period. As for breakfast consumption, a recent meta-analysis of cross-sectional studies showed that the risk for overweight or obesity increased by 55% if breakfast is skipped. Breakfast consumption was dichotomized as eating breakfast (5 or more times a week) or not. Dichotomizing SSB consumption was based on evidence suggesting that individuals who consume sugary drinks regularly – one to two cans per day or more – have a 26% greater risk of developing type 2 diabetes than people that rarely drink these sugary beverages.

Four measures were used to represent physical activity behaviors. Self-reported physical activity was measured using the Paffenbarger Questionnaire to estimate LTPA in minutes per week. Dichotomization was based on the physical activity guidelines and research showing that a total amount of 150 minutes a week of moderate-intensity aerobic activity reduces the risk of chronic disease. Three questions assessing weekday sedentary behavior and three questions
evaluating weekend sedentary behavior were combined to get a weekly total of sedentary time for a particular behavior. Time spent watching television was dichotomized as low amounts of television watched per day (two hours or less) or not. This cut-point was informed through the literature examining weight gain in adults and various amounts of time spent watching television.\textsuperscript{330,331}

Due to a paucity of research focusing specifically on computer use and workplace weekly sitting recommendations, results from other studies evaluating work-related sitting were used as proxies to inform the dichotomous cut point. Three recent studies which examined the association between health behaviors and on time spent sedentary in a car\textsuperscript{332,333} or at work\textsuperscript{334} provided evidence that suggested uninterrupted weekly sitting more than 10 to 14 hours per week in a work-related environment may be health damaging. Therefore, selected cut points included low sitting (12 hours or less per week) or high sitting while working (more than 12).

The categorical cut point for sedentary time spent using the computer for non-work activities or playing video games were informed through a study conducted among adults examining leisure-time Internet and computer use with weight-related outcomes, leisure-time physical activity, and other sedentary behaviors. Participants with high consumption (three or more hours per week) of leisure-time computer use were significantly more likely to be overweight and obese than those who reported no leisure-time computer use.\textsuperscript{335} Therefore, this item was dichotomized as low use sitting while using the computer for non-work activities of playing video games (less than 3 hours per week) or high use (3 hours or more per week).

Self-report demographic information was collected from participants. Age was calculated through reported date of birth. “What is your gender” provided an individual’s gender. Race/ethnicity was documented through, “Which race best describes you?” then recoded as
white/Caucasian or not. Living arrangements were collected with the question “With whom do you live?” Given the aforementioned evidence describing the health-protective effects of living with parents and the small cell sizes of individuals in the remaining categories (e.g., living alone, with peers), responses were dichotomized as living with parents or not. Height and weight were measured by trained research staff using Shorr height boards (Irwin Shorr, Olney, MD) and Tanita scales (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL). Height and weight measurements were used to calculate BMI (kg/m²).

Table 4.1. LCA Indicator Variables

<table>
<thead>
<tr>
<th>LCA Indicator Variables</th>
<th>Questions from CHOICES Survey</th>
</tr>
</thead>
</table>
| Frequency of cigarette use over participant’s lifetime  
1 = Not a Current Smoker  
2 = Current Smoker | “Have you smoked at least 100 cigarettes in your entire life?” and “Do you now smoke cigarettes every day, some days, or not at all?” |
| Binge drank in the previous month  
1 = No  
2 = Yes | “Considering all types of alcoholic beverages, how many times during the past 30 days did you have 4 or more drinks (for women) or 5 or more drinks (for men)?” |
| Frequency of eating breakfast in a week  
1 = 5 or more times per week  
2 = 4 or less times per week | “In a typical week, how many times do you eat breakfast?” |
| Frequency of SSB consumption over the previous month  
1 = Low Consumption (<1/day)  
2 = High Consumption (>1/day) | “Over the past 30 days, how many times did you drink: Soda or Pop?; Sports drinks (such as Propel, PowerAde, or Gatorade)?; Energy drinks (such as Red Bull or Jolt)?” |
| Frequency of fast food consumption over the previous month  
1 = Low Consumption (<1/week)  
2 = High Consumption (>1/week) | Over the past 30 days, how many times did you buy fast food at a fast food restaurant, such as McDonald’s, Burger King, Arby’s, Wendy’s, Hardee’s, Taco Bell, Taco Johns, Chipotle, KFC, Pizza Hut, Panera, Quiznos, Noodles & Company, Bruegger’s Bagels?” |
| Reported minutes of leisure time physical activity over a participant’s typical week  
1 = Meets Guidelines (150 min +/week)  
2 = Does Not Meet Guidelines (149 min or less/week) | Self-reported weekly leisure time physical activity in minutes was measured using the Paffenbarger Questionnaire.336 |
| Frequency of TV watching over a participant’s typical week  
1 = Low (<2 hours per day)  
2 = High (>2 hours per day) | “On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting while watching television?” |
| Frequency of computer use for work over a participant’s typical week  
1 = Low (12 hours or less per week)  
2 = High (More than 12 hours per week) | “On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting at work/school doing computer work (email, word or data processing, etc.)?” |
| Frequency of computer use for non-work or activities over a participant’s typical week  
1 = Low (<3 hours per week)  
2 = High (3 hours or more per week) | “On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) sitting while using the computer for non-work/non-school activities or playing video games?” |
Data Analysis

Data management and analyses were conducted using SAS v. 9.4 (Cary, NC: SAS Institute Inc). A series of LCA models specifying latent class counts from two to six were fit. The nine aforementioned indicator variables were used for the LCA (tobacco and alcohol use, diet, and physical activity) with no covariates included. Model estimation was repeated 1000 times using different starting values to detect any model identification problems. Five factors were considered in model selection including: Akaike’s Information Criterion (AIC), adjusted Bayesian Information Criterion (BIC), the likelihood-ratio value ($G^2$), entropy, and model interpretability or the notion that it should be possible to meaningfully describe each typology. The appropriate number of classes can be determined by comparing the goodness of fit statistics. If the $G^2$ estimates are less than the model’s degrees of freedom, the model is identified as having a reasonably good fit, with lower values of AIC and BIC preferred. Entropy gives an idea of how well the classification applies, with values approaching 1 indicating clear delineation of classes.

Following the estimation of latent classes and selecting the best model to represent the data, latent classes were then tested through measurement invariance to ensure the classes have the same meaning in those living with parents and those not living with parents. Young adults were then assigned to the class in which they had the highest probability of membership. Classes were described by their demographic factors, living arrangements, and BMI, and relationship of these predictors with the probability of class membership were tested through a multinomial logistic regression model, in which the dependent variable was latent class membership. For each variable, statistical significance ($p<0.05$) provides evidence that the independent variable is a significant predictor of class membership.
Results

Descriptive Characteristics

Table 4.2 details the characteristics of the 441 young adults comprising the sample. The sample was primarily female and white with a mean BMI of 25.4 (SD=3.8) Slightly more than half lived with their parents. About 16% of the sample were current cigarette smokers and approximately 25% reported binge drinking in the past month. Half of the sample reported poor diet behaviors - including high fast food intake, high SSB intake, and skipping breakfast. Fifty percent of the sample met the physical activity guidelines. Thirty-five percent of young adults watched more than two hours of TV per day. High sedentary behavior for playing video games or being on the computer for non-work purposes was reported by 70% of young adults. Fifty percent of the sample had high sedentary behavior based on the amount of time they reported spent on the computer for school or work purposes.

Table 4.2. Baseline Characteristics of Young Adults Attending a 2-Year College (N=441)

<table>
<thead>
<tr>
<th>Variable in Model</th>
<th>Frequency (%) or Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>22.7 (5)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>67.6%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>72.6%</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>25.4 (3.8)</td>
</tr>
<tr>
<td>Living Arrangements</td>
<td></td>
</tr>
<tr>
<td>Living with Parents</td>
<td>54.4%</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td></td>
</tr>
<tr>
<td>Current Smoker</td>
<td>16.4%</td>
</tr>
<tr>
<td>Alcohol Use in the Past Month</td>
<td></td>
</tr>
<tr>
<td>Binge Drinking</td>
<td>24.3%</td>
</tr>
<tr>
<td>Diet and Energy Intake</td>
<td></td>
</tr>
<tr>
<td>High Fast Food Intake (&gt;1/week)</td>
<td>50.6%</td>
</tr>
<tr>
<td>High SSB Intake (&gt;1/day)</td>
<td>48.8%</td>
</tr>
<tr>
<td>Skips Breakfast (Eats 0-4 times/week)</td>
<td>48.5%</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
</tr>
<tr>
<td>Meets Guidelines (&gt;150 minutes/week)</td>
<td>50.1%</td>
</tr>
<tr>
<td>High TV Watching (2 hours or more/day)</td>
<td>35.4%</td>
</tr>
<tr>
<td>High Sedentary Time for Work Computer Use (More than 12 hours/week)</td>
<td>49.9%</td>
</tr>
<tr>
<td>High Sedentary Time for Non-work Computer Use (3 hours or more/week)</td>
<td>70.7%</td>
</tr>
</tbody>
</table>
Latent Class Estimation

Based on the model fit indices (Table 4.3), a three-class model represented the optimal balance of model fit and interpretability. The three-class model was favored over the two class model when considering the $G^2$, AIC, entropy, adjusted BIC (which shows improvement for the additional class), and depicting unique health behavior response patterns for the young adult population.

Table 4.3. Model Fit Statistics for Latent Class Models Among Young Adults (N=441)

<table>
<thead>
<tr>
<th>Number of Classes</th>
<th>$G^2$</th>
<th>df</th>
<th>AIC</th>
<th>BIC</th>
<th>Adjusted BIC</th>
<th>Log-Likelihood</th>
<th>Entropy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>454.01</td>
<td>492</td>
<td>492.01</td>
<td>569.70</td>
<td>509.41</td>
<td>-2427.49</td>
<td>0.54</td>
</tr>
<tr>
<td>3</td>
<td><strong>418.41</strong></td>
<td>482</td>
<td>476.41</td>
<td>594.99</td>
<td><strong>502.96</strong></td>
<td>-2409.69</td>
<td>0.73</td>
</tr>
<tr>
<td>4</td>
<td>395.61</td>
<td>472</td>
<td>473.61</td>
<td>633.08</td>
<td>509.31</td>
<td>-2398.29</td>
<td>0.70</td>
</tr>
<tr>
<td>5</td>
<td>371.22</td>
<td>462</td>
<td>469.22</td>
<td>669.58</td>
<td>514.08</td>
<td>-2386.09</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>351.46</td>
<td>452</td>
<td>469.46</td>
<td>710.71</td>
<td>523.47</td>
<td>-2376.21</td>
<td><strong>0.76</strong></td>
</tr>
</tbody>
</table>

Latent Class Typologies

The item-response probabilities for each health-related behavior conditional in the latent classes are in Table 4.4. The descriptive characteristics of each of the classes are presented in Table 4.5. These probabilities and descriptions can be used to characterize the classes. The three distinct classes identified in this sample include:

**Class 1.** (‘active, binge-drinkers with a healthy dietary intake’) accounted for 13.1% of the sample, making this the smallest class among all the classes. Individuals in this class were distinguished by the highest probability of binge drinking in the past month (item-response probability of 0.92) and cigarette smoking (0.32). Individuals in this class did not consume much fast-food (0.24), did not drink a lot of SSBs (0.07), or have a tendency to skip breakfast (0.21). Less than half of young adults in this class failed to meet recommended guidelines for physical activity (0.33). A high proportion of time was spent sedentary doing non-work on the computer.
or playing video games (0.69). This class was mainly female (77%) and most lived without parents (64.2%) and had an average BMI of 25.5 (SD=3.5).

**Class 2.** (‘non-active, moderate-smokers and non-drinkers with poor dietary intake’) included 38.2% of the sample. In this class, young adults were sometimes likely to binge drink in the past month (0.32) and smoke cigarettes (0.26). Individuals were likely to skip breakfast (0.73), drink a high quantity of sugary-beverages (0.89), have a high frequency of fast-food intake (0.82), fail to meet physical activity guidelines (0.63), and have a high proportion of time spent sedentary doing non-work on the computer or playing video games (0.76). Half of the individuals in this class lived with parents (54.8%) and were approximately 61% female.

**Class 3.** (‘moderately active, non-smoking and non-drinkers with moderately healthy dietary intake’) was the largest class and accounted for 48.7% of the sample. Young adults in this class are not cigarette smokers (0.05) and or past-month binge drinkers (0.003). A third of the sample within this class have a high frequency of fast-food intake (0.33), high SSB consumption (0.29), and are likely skip breakfast (0.36). Fewer than half failed to meet recommended guidelines (0.43). This class has a high proportion of young adults spending time doing non-work on the computer/playing video games (0.67) and using the computer for work/school (0.54). Approximately 60% of individuals in this class were normal weight (BMI of 24.9 (SD=3.7)), approximately 70% female, and most lived with parents (58.5%).
Table 4.4. Conditional-Response Probabilities from Latent Three-Class Model of Chronic Disease Risk Behavioral Typologies (N=441)

<table>
<thead>
<tr>
<th>Latent Class</th>
<th>CLASS 1</th>
<th>CLASS 2</th>
<th>CLASS 3</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Smoker</td>
<td>0.321</td>
<td>0.257</td>
<td>0.048</td>
<td>0.164</td>
</tr>
<tr>
<td>Alcohol Use in the Past Month</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binge Drinker</td>
<td>0.917</td>
<td>0.316</td>
<td>0.003</td>
<td>0.243</td>
</tr>
<tr>
<td>Diet and Energy Intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fast Food Intake</td>
<td>0.246</td>
<td>0.822</td>
<td>0.327</td>
<td>0.506</td>
</tr>
<tr>
<td>High Sugary Beverage Intake</td>
<td>0.076</td>
<td>0.898</td>
<td>0.292</td>
<td>0.488</td>
</tr>
<tr>
<td>Does Not Eat Breakfast Regularly</td>
<td>0.209</td>
<td>0.734</td>
<td>0.364</td>
<td>0.485</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fails to Meet Recommended Guidelines</td>
<td>0.332</td>
<td>0.629</td>
<td>0.433</td>
<td>0.499</td>
</tr>
<tr>
<td>High weekly TV watching</td>
<td>0.264</td>
<td>0.487</td>
<td>0.274</td>
<td>0.354</td>
</tr>
<tr>
<td>High non-work computer use</td>
<td>0.691</td>
<td>0.763</td>
<td>0.668</td>
<td>0.707</td>
</tr>
<tr>
<td>High computer use for work</td>
<td>0.455</td>
<td>0.461</td>
<td>0.541</td>
<td>0.499</td>
</tr>
</tbody>
</table>

Note. \( G^2=418.41 \) with 482 df; AIC=476.41; Adjusted BIC=502.96. Bold values indicate the behavior crossed the 50% threshold for participation in the class.

Table 4.5. Chronic Disease Risk Behavioral Typology Characteristics (N=441)

<table>
<thead>
<tr>
<th></th>
<th>CLASS 1 (n=53)</th>
<th>CLASS 2 (n=164)</th>
<th>CLASS 3 (n=224)</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (%) or Mean (SD)</td>
<td>Frequency (%) or Mean (SD)</td>
<td>Frequency (%) or Mean (SD)</td>
<td>Frequency (%) or Mean (SD)</td>
</tr>
<tr>
<td>Age, years</td>
<td>25.2 (5.6)</td>
<td>22.4 (4.8)</td>
<td>22.4 (4.8)</td>
<td>22.7 (5)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>77.3%</td>
<td>61.5%</td>
<td>69.6%</td>
<td>67.6%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>83%</td>
<td>72.6%</td>
<td>70%</td>
<td>72.6%</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>25.5 (3.5)</td>
<td>26 (3.9)</td>
<td>24.9 (3.7)</td>
<td>25.4 (3.8)</td>
</tr>
<tr>
<td>Living Arrangements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with Parents</td>
<td>35.8%</td>
<td>54.8%</td>
<td>58.5%</td>
<td>54.4%</td>
</tr>
</tbody>
</table>

Comparisons of Outcomes by Class

Measurement invariance was used to explore differences across those living with parents and those not living with parents. Results indicated that the latent class membership probabilities were similar for each group (data not shown) therefore living arrangements was used as a covariate. Results from the multinomial logistic regression are presented in Table 4.6, reporting unadjusted and adjusted effects. Unadjusted models only include a single independent variable...
regressed on class membership. Adjusted models include all independent variables to predict class membership. Evidence from the adjusted models suggested there were meaningful differences for BMI and age between latent classes, but not for living arrangements. For each additional unit increase in BMI, individuals are approximately 8% more likely to be in Class 2 versus Class 3 (OR =1.08; p=0.006) controlling for living arrangements, gender, race, and age. For each additional year in age, individuals are approximately 8% more likely to be in Class 1 versus Class 2 (OR=1.10; p=0.039) holding all else constant.

<p>| Table 4.6. Predictors of Class Membership Using Multinomial Logistic Regression |
|---------------------------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Class Effect</th>
<th>OR (95% CI)</th>
<th>aOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class 3 as Comparison Class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1 BMI</td>
<td>1.04 (0.96 - 1.13)</td>
<td>1.04 (0.95 - 1.13)</td>
</tr>
<tr>
<td>Living Arrangements (reference is parents)</td>
<td>2.52 (1.35 - 4.69)**</td>
<td>1.62 (0.72 - 3.63)</td>
</tr>
<tr>
<td>Male (reference is female)</td>
<td>0.67 (0.33 - 1.36)</td>
<td>0.73 (0.35 - 1.52)</td>
</tr>
<tr>
<td>White (reference is non-white)</td>
<td>2.09 (0.96 - 4.51)</td>
<td>2.09 (0.95 - 4.59)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.10 (1.04 - 1.16)***</td>
<td>1.07 (0.99 - 1.14)</td>
</tr>
<tr>
<td><strong>Class 2 as Comparison Class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1 BMI</td>
<td>0.96 (0.89 - 1.05)</td>
<td>0.97 (0.89 - 1.05)</td>
</tr>
<tr>
<td>Living Arrangements (reference is parents)</td>
<td>2.18 (1.15 - 4.13)*</td>
<td>1.25 (0.55 - 2.86)</td>
</tr>
<tr>
<td>Male (reference is female)</td>
<td>0.47 (0.22 - 0.96)*</td>
<td>0.52 (0.25 - 1.10)</td>
</tr>
<tr>
<td>White (reference is non-white)</td>
<td>1.85 (0.83 - 4.09)</td>
<td>1.92 (0.85 - 4.32)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.10 (1.04 - 1.16)***</td>
<td>1.08 (1.00 - 1.16)*</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01 ***p<.001

**Discussion**

The aim of this study was to identify subgroups of young adults with respect to their patterns of tobacco and alcohol use, dietary intake, and physical activity behaviors to further understand behavioral chronic disease risk. Results suggested a meaningful pattern of lifestyle characteristics occur among young adults. This analysis identified three latent classes of modifiable health-related behaviors in young adults in community colleges: “active, binge-
drinkers with healthy dietary intake,” “non-active, moderate-smokers and non-drinkers with poor dietary intake,” and “moderately active, non-smokers, non-drinkers with a moderately healthy dietary intake.” These classes were differentially distributed based on age and weight. Contrary to the literature, the classes did not differ by living arrangement (e.g., living with parents or not).

The classes yield some similarities and differences. All three classes are characterized by high probability of sitting while using the computer for non-work/non-school activities or playing video games, reflecting high prevalence of these behaviors in all young adults in our sample. Class 1 appears to represent community college students who are older, fairly active, and who eat a relatively healthy diet based on their consumption of fast food, SSBs, and breakfast but have the highest probability of being binge drinkers and smokers among the three groups. Those in Class 2 engage in unhealthy behaviors across all four behavioral categories examined. These students are neither active nor eating a healthy diet and have a moderate probability of smoking and binge drinking. This group can be viewed as the high-risk group for weight gain - particularly in regards to traditional lifestyle behaviors (diet and physical activity), and have the highest proportion of males. Class 3 appears to represent the healthiest group of student with probabilities favoring not smoking or binge drinking, healthful diet and physical activity – with the exception of sedentary behavior. The three groups differ significantly in their obesity risk with those students in Class 2 having the highest mean BMI; BMI was similar in Class 1 and 3.

While there was not a significant difference between the groups in living arrangements, Class 1 (active, binge drinkers) descriptively had the fewest group members living with their parents while both Class 2 and 3 had more than half of the group members living with their families. It is difficult to explain why Class 2 and 3 behavioral risks look so different and stands in contrast to the expectation that living with one’s parents may provide an environment where it is easier to
make healthier choices. More information on how engaged students are with their families may be important to understand this finding. Future studies could examine these differences; it may be that the students in Class 2 are living under their parents’ roofs but are otherwise not very engaged in family life or habits that support healthy behaviors while students in Class 3 are more engaged in the healthy behaviors that often accompany family life.

To my knowledge, there has only been one previous study that has assessed clusters of health behaviors in a college population, but this study was conducted among a public university—not a community college. Research among a U.S college sample that examined cancer risk behaviors found that unhealthy diet was high among students universally.\textsuperscript{347} The four clusters in this college sample found evidence for 1) unhealthy diet; 2) unhealthy diet and physical inactivity; 3) unhealthy diet, physical inactivity and overweight/obesity; and 4) tobacco use, binge drinking, unhealthy diet, and physical inactivity.\textsuperscript{348} This research has similar findings as the current study. In particular, Class 2 characterized by high BMI, physical inactivity, and poor diet quality are similar as the patterning of overweight/obesity clustered with those who have unhealthy diet and being physically inactive.\textsuperscript{349} However, there are two distinct findings that add to this literature: sedentary behavior (differing from low diet quality) and Class 1—those who engage in mostly healthy behaviors but had a high proportion of binge drinking. Current findings might diverge from the other study due to measurement differences or by behaviors studied. Results from LCA are constrained by the indicators that are included in the model.

There are limitations to this research. The sample included a large proportion of females (68%) and is primarily white (73%) which limits generalizability of our findings. This study is also cross-sectional so it is difficult to know whether individuals will potentially transition to lower or higher risk profiles over time. This is especially important for the individuals in class
one who have a high endorsement of binge drinking, which may be commonly observed in the young adulthood years. Though dichotomizing variables is an approach that is commonly used in LCA and may aid in the interpretability and communications of findings, there may be some loss of sensitivity that results from categorizing the data in this way. This study also has several strengths, such as the use of data from community colleges, application of a current analytic methodology, and the use of valid measurements.

The results of this study leads to three different intervention implications. First, each class is characterized by the presence of high amounts of sedentary behavior spent on the computer. In fact, more than 70% of the sample reported more than 2 hours of non-work time with a computer. This underscores the potential utility of a community college-wide intervention that replaces time spent on the computer playing video games or other non-work with non-sedentary behavior. Young adults often play online/video games for immersion experiences, achievement, and social engagement purposes. Non-sedentary lifestyles could be facilitated through the creation of physical activity opportunities such as group intramurals, walking/running clubs, fitness classes, or the use of activity trackers that have built in competitions with friends and achievement features. Future research should understand key determinants of this behavior and find ways to motivate young adults to attend and participate in non-sedentary activities.

Secondly and specifically for those individuals who are engaging in physically active lifestyles but also binge drinking and smoking, intervention strategies should focus on substance use behaviors. Differential social mechanisms might be asserting influence on this group such as affiliations with key organizations or social networks, outside of living arrangements, if, for example, students in this class participate in sports leagues or community social groups that
organize around fitness followed by alcohol consumption. Future research should examine this premise, and if confirmed, alcohol-specific strategies and information could be tailored to these social groups. Educational programs could also provide salient information about the dangers of excessive alcohol consumption or changing social norms among networks regarding binge drinking. Intervention implications could be geared towards creating social media platforms and social environments conducive to participating in alcohol-free events, encouraging alcohol use in moderation, and integrating campaigns that change the current perception of binge drinking and cigarette use.

Lastly, providing targeted interventions that integrate multiple health behaviors would be useful for identified students with multiple health risk behaviors. Approximately 40 percent of the sample was in Class 2, which is characterized by the high likelihood of multiple health-damaging behaviors. More than half of the students in this group did not meet the recommendations for weekly physical activity and consistently reported poor dietary behaviors. Accordingly, students in this group may benefit most from obesity interventions that do not focus just on decreasing physical inactivity to reduce their obesity risk. Instead, the coupling of diet and physical activity programming might be most effective for this group. Intervention implications for this group include finding ways to best motivate these students to become healthier. A participatory health course that teaches students how they can cook nutritious food, experience various forms of physical activity, and explore fun non-sedentary activities while building connections with others could be beneficial for this group. Anti-smoking and anti-binge drinking campaigns would also be advantageous for the identified individuals.

These findings highlight important future research. Qualitative research needs to be completed to properly target each of the classes to increase health-promoting behaviors.
Suggestions can be put forth to address each of the health-related behaviors that have been found to be particularly risky for a specific group, however for effective intervention development, formative research is recommended to uncover determinants of these co-occurring behaviors which may warrant different strategies. Formative research is particularly important for Class 1 and Class 2 to identify the salient messages, interpersonal influences, and channels to disseminate programs.

Conclusions

The increased understanding of the prevalence and clustering patterns of multiple health-related behaviors is helpful in identifying subgroups of the population that are at particularly high risk for weight gain based on behavioral patterns. Understanding these typologies may help public health professionals create more effective and efficient interventions in community colleges by targeting certain behaviors or certain contexts to help reduce the onset and improve management of existing chronic diseases.
CHAPTER 5: SYNTHESIS AND DISCUSSION

The purpose of this dissertation was to examine the role of four modifiable health-related behaviors (tobacco and alcohol use, diet, and physical activity) as predictors of weight change over a two-year period and to identify distinct behavioral typologies among a population of young adults. This study used baseline and 24-month data from The Choosing Healthy Options in College Environments and Settings (CHOICES) study, a randomized controlled trial designed to prevent unhealthy weight gain in young adults (aged 18 – 35) attending 2-year community colleges in the Twin Cities, Minnesota. The results of the dissertation contribute important understanding of the modifiable health-related behaviors in this population, and provide insights and implications for the development of future weight gain prevention interventions in this and in similar populations.

Summary of Findings

Aim 1

In this first aim, a multivariate linear regression model was fit to understand the association between 24-month BMI and baseline health-related behaviors (tobacco and alcohol use, diet, and physical activity) controlling for covariates (baseline BMI, gender, race/ethnicity, age, and intervention exposure). Post-hoc analyses were then completed using a subsample of those who gained weight between baseline and 24-months, dichotomizing the outcome variable to those who maintained/lost less than 3% weight and those who gained 3% weight. Results showed that being a smoker was a significant predictor of 24-month BMI, holding all other behaviors constant (p=0.04). Smokers experienced a 0.79 increase in BMI compared to non-
smokers between baseline and 24 months. Binge drinking was significantly predictive of a decrease in BMI at 24-months ($\beta = -0.569$, $p<0.05$) and individuals who reported higher amounts of weekly leisure physical activity experienced an increased BMI at 24-months ($\beta=0.001$, $p<0.05$). Fast food consumption, SSB consumption, breakfast consumption, and sedentary behaviors were not statistically significant independent predictors of 24-month BMI controlling for baseline BMI, age, gender, race/ethnicity, and intervention exposure. Additionally, results of the logistic regression show that engagement in binge drinking in the previous month was negatively associated with 3% weight gain (OR=0.49; 95% CI: 0.29, 0.83; $p<0.01$). No significant associations were found regarding tobacco use and odds of 3% weight gain over 24-months. These findings provide evidence of an association between binge drinking and weight, where those who engaged in binge drinking in the previous month had a lower likelihood of gaining weight 24 months later. Additionally, study results suggested that being a cigarette smoker was a significant predictor of increased 24-month BMI, which is counter to the expectation of cigarette smokers having a decreased tendency to gain weight. These findings provide some evidence that behaviors assessed may work synergistically to promote weight change even though each individual behavior change was not potent enough to result in weight change. Future research should investigate if behavioral patterns may cluster in some manner, a goal addressed in part by Aim 2.

**Aim 2**

This study aimed to identify distinct typologies of young adults on the basis of the four modifiable health-related behaviors using latent class analysis (LCA) and to describe patterns of class membership based on demographic characteristics, living arrangements (living with parents or not), and mean BMI. Indicators for the LCA included past-month binge drinking, fast food consumption, sugar sweetened beverage (SSB) consumption, past-week breakfast consumption,
past-week physical activity, typical weekday and weekend sedentary behavior, and cigarette smoking. The analysis identified three latent classes of modifiable health-related behaviors in young adults in community colleges: Class 1: “active, binge-drinkers with healthy dietary intake,” Class 2: “non-active, moderate-smokers, and non-drinkers with poor dietary intake,” and Class 3: “moderately active, non-smokers, non-drinkers with a moderately healthy dietary intake.” All three classes are characterized by high probability of sitting while using the computer for non-work/non-school activities or playing video games, reflecting high prevalence of these behaviors in all young adults in our sample. Class 1 appears to represent community college students who are older, fairly active, and who eat a relatively healthy diet based on their consumption of fast food, SSBs, and breakfast but have the highest probability of being binge drinkers and smokers among the three groups. Those in Class 2 engage in unhealthy behaviors across all four behavioral categories examined. These students are neither active nor eating a healthy diet and have a moderate probability of smoking and binge drinking. This group can be viewed as the high-risk group for weight gain - particularly in regards to traditional lifestyle behaviors (diet and physical activity), and have the highest proportion of males. Class 3 appears to represent the healthiest group of student with probabilities favoring not smoking or binge drinking, healthful diet and physical activity – with the exception of sedentary behavior.

Adjusted multinomial logistic regression models were fit to assess a predictor variable’s association to class membership. Evidence suggested there were meaningful differences for BMI and age between latent classes, but not for living arrangements. For each additional unit increase in BMI, individuals were approximately 8% more likely to be in Class 2 versus Class 3 (OR =1.08; p=0.006) controlling for living arrangements, gender, race, and age. For each additional year in age, individuals were approximately 8% more likely to be in Class 1 versus Class 2
(OR=1.10; p=0.039) holding all else constant. Results suggest patterns of behaviors do not vary by those who are living with parents and those who are not living with parents. These findings highlight important future qualitative research that needs to be completed to properly target each of the classes to increase health-promoting behaviors. Conclusions and suggestions can be put forth to address each of the health-related behaviors that have been found to be particularly risky for a specific group, however for effective and sustainable intervention development, formative research is recommended to uncover determinants of these behaviors and behaviors found to be coupled.

**Strengths and Weaknesses**

**Sample**

There were both strengths and limitations of the sample. Some limitations include the demographic composition of the sample, which included a large proportion of females (68%) and is limited in racial/ethnic diversity (73% white). This particular sample may also differ from other community college students as evidence by their high frequency of health-protective behaviors and the majority having a healthy weight; these factors combined made finding predictors of weight change difficult. Additionally, external validity is limited since it was focused on one metropolitan area in Minnesota and the results may not be applicable to community colleges across different U.S. regions.

Strengths of the sample data included retention and studying the 2-year college population. There was very little attrition over the 24-months of observation, minimizing the possibility of selection bias in Aim 1 results. Furthermore, community college students are an understudied population and young adulthood is a critical developmental timeframe where health-related behaviors become habits and lifestyles.
Measurement

There were both strengths and weaknesses of the measures chosen to capture key variables. The use of trained research assistants measuring height and weight using Shorr height boards (Irwin Shorr, Olney, MD) and Tanita scales (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL) to calculate BMI is a strength of this study. Behaviors (tobacco use, alcohol use, breakfast consumption, SSB consumption, fast food consumption, leisure time physical activity, seated TV watching, seated computer use for work, seated computer use for non-work) were self-report. Although these key behaviors were assessed using previously validated measures, social desirability bias is possible but could not be assessed. Social desirability for self-reported behaviors has the potential for non-random systematic measurement error that can lead to incorrect inferences about behaviors and bias study results. Specifically, this could include an over-reporting of health-promoting behaviors which would inflate results or an under-reporting of health-damaging behaviors which potentially would minimize study results. In particular, assessment of leisure time physical activity (LTPA) the indicator could have been strengthened by using an accelerometer instead of self-report. Despite each of these variables being associated with weight in the general literature, being modifiable, and providing tangible opportunities for impact, these individual measures do not capture entire dimensions of tobacco use and alcohol use, diet, and physical activity. For example, more information about dietary intake including fruits and vegetables, grain-based desserts, junk food, and snacks would be helpful to include in models used.

Modeling

Aim 1. Strengths of the multivariate linear and logistic regression models employed in this research included using longitudinal data to capture weight change in individuals over time. Longitudinal data is beneficial because it demonstrates how baseline health-related behaviors can
affect BMI 24-months later, moving beyond cross-sectional associations to capture changes in individuals over a two year time period. With respect to modeling, unequal variances were found (indicating heteroskedasticity) which violated an assumption of ordinary least squares regression. Therefore, a Huber-White sandwich estimator was used to inflate the standard errors in the models to correct heteroskedasticity concerns. Limitations to this modeling approach are centered on casual inference. Temporality can be established with the use of this data by observing the change in the 24-month weight after baseline health behaviors are measured. However, it is not possible to establish if the behaviors are the actual cause in the change in 24-month weight. There may be shared confounders among the independent variables and the dependent variable. For example, an unmeasured confounder not included in the regression model could be mental health status – causing both 24-month weight gain and tobacco use. Similarly, there are potential shared risk factors that are not included as control variables in the model which may have resulted in spurious relationships between the health behaviors and 24-month weight.

**Aim 2.** Latent class analysis (LCA) was used as a method to investigate clusters of modifiable health behaviors, which is a powerful model-based method for conducting cluster analysis modeling. Various numbers of models were fit until the simplest model that provided an adequate fit that accurately described the data was found. To avoid multiple solutions in LCA parameter estimates, each model was run 1000 times to search for a global solution. Use of LCA represents a person-centered approach, which allows for examination of the role of mean BMI, living arrangements, and demographic characteristics as predictors of complex behavioral typologies – rather than independent predictors on a single behavior, or a variable-centered approach.
With this modeling technique, there were some limitations. The cross-sectional nature of this method is a limitation, as temporality cannot be established for identified relationships. True class membership is unknown but is referred from the responses of a set of observed variables. The classify-analyze approach that was used relies on posterior probabilities with each individual having a probability of membership in each latent class. This can be challenging if there are very similar probabilities for a single individual. Another potential limitation of using LCA is the dichotomization of indicator variables. Critics of mixture modeling question whether true clustering of people along behavioral and psychological phenomena exists or whether the identification of such clusters is a statistical artifact using arbitrary cut points.\textsuperscript{351} The cut-points used for most LCA indicators were not truly binary but were literature informed. The classes that emerged from the data are based on probability and membership in each is subject to error; however, uncovering these patterns of behaviors has both theoretical and practical utility to understanding weight-related disease. Inclusion of indicators and the identified classes that emerged represents a contribution to the literature, but the classes cannot be said to fully represent what is happening with modifiable health behaviors in community college students universally. Additional work is needed to validate whether the 3-class solution that emerged from the current data can be generalized to other similar samples of community college students.

**Future Directions**

Results of both Aim 1 and Aim 2 present avenues for future research to better understand the relationships between key modifiable health-related behaviors and weight gain among young adults.
Aim 1

There is a need for additional longitudinal studies to examine relationships over time in order to disentangle the associations and create effective interventions. Aim 1 measured effects of baseline behaviors on 24-month weight; but it would be advantageous to have future studies focus on baseline health-related behaviors on 24-month weight change and beyond. Future studies should also consider using additional dimensions of health behaviors to assess 24-month weight change. Addition of other behaviors linked with weight change, such as the aforementioned diet variables, would potentially aid in uncovering other modifiable behaviors that are contributing to weight gain. The analyses should be repeated among a different sample of community college students that experienced a higher variability of weight change to examine if the current study’s findings hold or throughout a longer time period. Limited weight gain in the sample might have given rise to a ceiling effect in the possible detectable effect sizes.

Aim 2

Results from Latent Class Analysis (LCA) are constrained by the indicators that are included in the model. Therefore, inclusion of other modifiable health behaviors that are not captured in this study may lead to the identification of even more complex chronic disease typologies. Due to the low proportion of individuals in some of the categories for living arrangements (such as individuals living by themselves or with peers) – this variable was collapsed into a dichotomous variable (living with parents or not) to observe influence of living arrangements on clusters of health behaviors. A larger sample that includes individuals living with others (e.g., peers only, parents only, spouse with child,) or by themselves would be ideal and should be explored in subsequent studies. Future research would benefit from a longitudinal design to see if baseline classes predict weight change over time (24-months and beyond). It would also be of interest to follow a cohort of students through the beginning of their program of
study to the end to assess how community college or university environments impact their health behaviors over a period of time. To answer this particular question, data would need to be collected on the nearby food and beverage environment (convenience stores, fast food restaurants, vending machines, proximity to bars, etc.), campus policies, and physical activity opportunities. Future research would also benefit from gathering information about the home environment and level of engagement from the families with whom the students are living. Are these students actually disengaged/engaged with their families or are their families encouraging a healthy/unhealthy home environment? Furthermore, living arrangements were not found to be a predictor of class membership. If this is the case, what are the other social or environmental mechanisms by which networks are asserting influence in community colleges? Perhaps there are key informal or formal organizations or social networks that individuals are a part of that are influencing the cluster of behaviors since social networks tend to organize around common psychological and socio-demographic characteristics. Weight-related disease prevention interventions might be more effective if designed to target multiple behaviors and tailored to subgroups of individuals with similar risk behavior patterns. Future research should understand the needs of this particular population and design effective interventions to address multiple behaviors as seen in Class 2 (‘non-active, non-smokers and non-drinkers with poor dietary intake’). Additional formative research is needed on the specific clusters identified which should inform public health practitioners how to best raise awareness, inform students about the significance of multiple risk behaviors, and create environments that are conducive to health-promoting behavior change.

Overall, this dissertation makes important contributions to the literature. Young adulthood, particularly in the community college setting, is a critical time period for developing
health-promoting behaviors. However, students continue to engage in a variety of health-damaging behaviors at a high rate despite the known health consequences. First, it was shown that there is an association between binge drinking and weight, where those who engaged in binge drinking in the previous month had a lower likelihood of gaining weight 24-months later (Aim 1). This sheds light on alternative health-damaging social implications and risk-behaviors associated with binge-drinking excluding weight gain leading to chronic disease risk. Additionally, results suggested that being a baseline cigarette smoker was a significant predictor of increased 24-month BMI, which is counter to the expectation of cigarette smokers having a decreased tendency to gain weight (Aim 1). Coupling the latter Aim 1 findings with Aim 2, evidence suggests that behaviors do work synergistically to promote weight change with those who are smokers to be clustered with additional health-damaging behaviors (binge-drinking, poor diet quality, high sedentary behavior). The increased understanding of the prevalence and clustering patterns of multiple health-related behaviors is helpful in identifying subgroups of the population that are at particularly high risk for weight gain based on behavioral patterns. Understanding these typologies may help public health professionals create more effective and efficient interventions in community colleges by targeting certain behaviors or certain contexts to help reduce the onset and improve management of existing chronic diseases.
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