AN EXAMINATION OF THE BEHAVIORAL CONTEXTS AFFECTING OBESITY DEVELOPMENT FROM ADOLESCENCE TO YOUNG ADULTHOOD USING LATENT CLASS ANALYSIS

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Chapter I: Literature Review

Abstract

Most research suggests that there are many physical, social, and economic costs to children and adults with high levels of body weight (often labeled as obese). This review of the literature on the development of obesity from adolescence to adulthood identifies key contributing behavioral contexts, including nutrition, physical activity, sleep, and social/emotional climate. The review examines the relative importance of these behaviors together over time, including the developmental time periods during which some behaviors and contexts have greater influence on an individual. Also examined is the issue of whether specific factors are more dominant for some individuals (based on sex, race/ethnicity, SES, baseline BMI) compared to other factors.
Chapter I: Literature Review

Prevalence of Obesity

Childhood obesity has been named “one of the most serious public health challenges of the 21st century” by the World Health Organization (World Health Organization, 2016a). Obesity is prevalent among adults and children alike: in 2014, more than 600 million adults worldwide were obese (World Health Organization, 2016b) and, as of 2012, approximately 17% of youth and over one-third of adults in the United States were obese (Ogden, Carroll, Kit, and Flegal, 2014). Most researchers agree that this high rate of prevalence in the United States is the result of a trend – over the past 30 years, rates of obesity have doubled for children and quadrupled for adults (Ogden et al., 2014). While there has been some encouraging research suggesting that these patterns are slowing (Campos, Saguy, Ernsberger, Oliver, & Gaesser, 2006; Ogden, et al., 2014) and even that the obesity epidemic has been overstated (Campos et al., 2006; Kwan & Graves, 2013; Lyons, 2009; Rich & Evans, 2005), the consensus seems to be a trend toward a high prevalence of obesity both in the United States and worldwide. These issues are concerning because the costs of obesity are important.

Costs of Obesity

Most research suggests that obesity has many physical, social, and economic costs. Physically, children who are obese are more vulnerable to a variety of nutrition deficiencies and a worsening of certain health conditions such as asthma, insulin resistance, hypertension, and broken bones (World Health Organization, 2016b). Furthermore, children who are obese are more likely to be obese during adulthood (Biro & Wien, 2010; Deshmukh-Taskar et al., 2006; Guo, & Chumlea, 1999; Whitaker,
Wright, Pepe, Seidel, Dietz, 1997). Adult obesity poses a major risk for development of type 2 diabetes, heart disease and stroke, fatty liver disease, and certain cancers, among other conditions often leading to premature death (Inge et al., 2013; U.S. Department of Health and Human Services, 2004). However, Campos et al. (2006) assert that premature death, thought to be associated with obesity, is in fact a risk associated only with very extreme levels of overweight.

In addition to the physical costs of obesity, numerous social costs exist for obese individuals. Weight bias, or discrimination targeted toward those at higher weight statuses, is prevalent both within and outside of the United States (Puhl et al., 2015), resulting in children with obesity being at greater risk for poor social adjustment related to negative interactions with peers, such as name-calling, appearance-related teasing, and bullying (Janssen, Craig, Boyce, & Pickett, 2004; Neumark-Sztainer, Story, & Faiibisch, 1998; Pierce & Wardle, 1997; Storch et al., 2006; Thompson et al., 2007). There are also financial implications: adults who are obese spend on average $5,560 per year on healthcare, while individuals who are morbidly obese spend on average $7,010 dollars per year, compared to $4,030 for non-obese individuals (Congressional Budget Office, 2010). All of these costs have made preventing obesity a policy goal.

**Prevention of Obesity**

While the prevalence and consequences of obesity make it a desirable issue for policymakers to address, obesity eludes easy preventative solutions. Weight gain prevention programs have been met with little success (Haynos & O’Donohue, 2012; Stice, Shaw, & Marti, 2006). For example, one meta-analysis examined changes in body mass index (BMI), a common weight measurement statistic calculated by dividing weight
by height squared, across 61 randomized controlled obesity prevention programs (Stice et al., 2006). Only 21% of the studies resulted in changes in BMI, and the average effect size was small (Stice et al., 2006). Of course, BMI reveals only part of a person’s weight profile, and as such does not include fat-to-muscle-mass ratios, or levels of physical fitness, which may be better indicators of overall health (Sweeting, 2007). It is important to keep this in mind when reviewing literature that uses BMI as the principal indicator of obesity and health. Furthermore, prevention effects are difficult to sustain over time: only 5% of the programs reviewed had lasting preventive weight gain effects during follow-up (Stice et al., 2006). In other words, obesity is a common and increasing occurrence in society with obvious consequences and few preventive solutions. Obesity is a condition that often persists from childhood to adulthood, though it can also develop in adults who were not obese as children. Thus, this report examines the behavioral contexts associated with childhood/adolescent obesity and the factors that cause obesity to develop from childhood/adolescence to adulthood.

**Purpose and Gaps in the Literature**

Much effort has been directed toward understanding the mechanisms of weight gain that lead to obesity and identifying the behavioral risk contexts that might be modified. While obesity development from childhood/adolescence to adulthood is complex, with many interrelated factors, four main categories of modifiable behavioral contexts related to obesity development have been identified: (1) nutritional intake/diet, (2) physical activity, (3) sleep, and (4) social/emotional climate (Brown, Halvorson, Cohen, Lazorick, & Skelton, 2015; De Vriendt et al., 2011; Dev, McBride, Fiese, Jones, & Cho, 2013; Hart, Cairns, & Jelalian, 2011; Jelalian & Steele, 2008; Koch, Sepa &
Ludvigsson, 2008; Reilly et al., 2005; Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011).

The purpose of this literature review is to examine in detail these four factors related to the development of obesity from childhood/adolescence to adulthood. Because it is useful to examine each of these factors individually, we will focus on each of these in turn, progressing from nutrition (defined as consumption amounts, consumption of processed foods, and consumption of fruits and vegetables), to physical activity (time spent actively, neighborhood facilities and safety, and sedentary behavior). We will then discuss sleep (the longitudinal effects of lack of sleep on obesity), and social/emotional climate (family cohesion - family meals, and depression) (See Figure 1 for the conceptual model for this review). After we have reviewed each factor separately, we will examine how each of these factors interact with individual and environmental factors to contribute to weight gain.

In order to accomplish this, this report examined several behavioral contexts simultaneously in order to compare their relative importance, compared the influence of these factors on individuals with different demographic characteristics, focused on the influence of these factors at different stages of development, and considered how environmental factors such as access to nutritious foods influence these behaviors and contexts. Each approach is discussed in detail below.

Evaluating several behavioral contexts simultaneously can reveal an understanding of which of these categories is most influential in the development of obesity across the highest number of individuals, thus clarifying the factors most worthy of targeting in intervention. However, this is difficult to accomplish because past
longitudinal research has focused only on a few factors simultaneously, ignoring others. A failure to integrate the many behavioral and contextual factors involved in obesity provides only a partial picture of how obesity develops over an individual’s life. Thus, this research is unable to compare the levels of relative influence of particular behavioral and contextual factors on weight status. For example, studies that address only physical activity and nutrition cannot compare the importance of physical activity and nutrition to factors like sleep and social/emotional climate. Therefore, such studies cannot provide greater clarity about which of these factors or combinations of factors might have the most importance on the development of obesity from childhood/adolescence to adulthood. Furthermore, if included and excluded factors are correlated (e.g., depression limits physical activity), then the effect of the included factors may be overstated. As a result, this research has aimed to examine within a cohesive framework each of these behavioral and contextual factors in order to evaluate their relative influences on individuals as they grow and develop.

This framework differs among individuals based on their demographics [i.e., sex, race/ethnicity, socioeconomic status (SES), and BMI at the first time point in longitudinal studies (baseline BMI)]. For example, perhaps social/emotional climates are more influential in the development of obesity in females, while perhaps physical activity and nutrition are more influential for males.

Changes in the influences of each behavioral context on individuals over time, during certain developmental time periods have also been examined. For example, perhaps social/emotional climates are more influential in the development of obesity in women during their teenage years but have less influence in their young- and middle-
adult years. These individual factors and their changes over time are only one aspect of the review; environmental impacts of behavioral and contextual factors on the development of obesity have been examined as well.

This review has taken an ecological approach, examining not only factors directly connected to the individual but how those factors are influenced by the individual’s environment. For example, the nutrition-related factors considered in this review include direct factors such as an individual’s diet of fruits, vegetables, and processed foods, but also environmental influences such as how an individual’s diet is influenced by the surrounding food availability and accessibility, whether local grocery stores carry affordable fruits, vegetables, and processed foods, and the cost of fruits and vegetables compared to processed or fast foods. These external environmental influences might particularly impact children or adolescents, who tend to have less choice in their environmental surroundings than adults.

Using each of these approaches: examining behavioral contexts in a cohesive framework in combination with individual characteristics across developmental time periods, and taking into account environmental influences, the main goal is to present a more comprehensive review of the behavioral and contextual factors related to obesity from childhood/adolescence to adulthood.

Behavioral Contexts Related to Obesity

The consequences of obesity are far-reaching, and a variety of behavioral contexts have emerged in the literature. Before discussion of these factors, it is helpful to review the literature search methods for this paper.
Methods for literature search. Scholar OneSearch was used to identify quantitative studies that investigated the development of obesity both cross-sectionally and longitudinally with regard to the behavioral contexts selected: nutrition, physical activity, sleep, and social/emotional climate. Initial searches included different combinations of the search terms “obesity,” “weight gain,” “BMI,” “child,” “adolescent,” “longitudinal,” and the specific terms for each of the behavioral and contextual factors (“nutrition,” “physical activity,” “sleep,” “stress,” “family emotional climate,” and “depression”). In addition, once research areas within these behavioral contexts were identified, search terms expanded to include “portion size,” “fruit and vegetable consumption,” “fitness centers,” “recreation centers,” “family meals,” in combination with “meta,” or “meta-analysis.” Meta analyses, when available, were used to organize information for each section of the review and were chosen based on their inclusion of longitudinal studies examining the transition from adolescence to adulthood. Meta-analyses were also selected to represent the most recent data possible. Additionally, literature was explored through reading the “Handbook of Childhood and Adolescent Obesity” (Jelalian & Steele, 2008) and by searching authors listed across several of the handbook’s chapters for current and past research. This text was chosen because the author, Elissa Jelalian, is an associate professor of psychiatry and human behavior and pediatrics at Brown University and a leading researcher in the field of childhood obesity. “The Handbook of Childhood and Adolescent Obesity” considers multiple environmental dimensions of obesity and is a key text in the field. These methods for finding literature were also supplemented with other relevant, hand-picked studies that were not brought up under the search terms above. Literature was eliminated that tested various weight
management interventions, as well as works that studied individuals with eating disorders, including binge-eating disorder. This review begins by focusing on the literature related to nutrition.

**Nutrition.** Nutritional intake and diet are thought to be major contributors to obesity rates, and perhaps one reason for a rise in obesity rates over the past 30 years. A number of behavioral contexts included in the literature focus on this area, including the amount of food consumed, consumption of processed foods, consumption of fruits and vegetables, and the influence of the availability and accessibility of foods in one’s family and neighborhood (Cerin et al., 2011; Faith, Dennison, Edmunds, & Stratton, 2006; Jetter & Cassady, 2006; Fisher, Rolls, & Birch, 2003; Nielsen & Popkin, 2003; Pala et al., 2013; Piernas & Popkin, 2011; Sturm & Datar, 2005). Each behavioral context has been described here.

**Amount of food consumed.** Both children’s and adolescents’ portion sizes of processed foods and overall daily calories consumed have increased over the years (Duffey & Popkin, 2011; Ebbeling et al., 2012; Piernas & Popkin, 2011). Between 1977 and 1996, portion sizes at home have increased from approximately 50 to 150 calories for foods such as hamburgers, salty snacks, French fries, and sweets for those ages 2 years and older (Nielsen & Popkin, 2003). This is concerning because children who are presented with larger portions tend to eat more. For example, one study compared preschoolers’ consumption of self-served lunches with consumption of adult-served, age-appropriate-sized lunches, and with adult-served, double-sized lunches. When the lunch size was doubled, preschoolers consumed 25% more food and obtained 15% more
calories than when preschoolers either served themselves or were served age-appropriate portions (Fisher et al., 2003).

Even when children serve themselves, environmental factors such as the availability of food and the sizes of plates and serving spoons also may influence their intake. For example, preschoolers were observed in four different dinner conditions spaced one week apart: entrée availability totaling 275 grams, entrée availability totaling 550 grams (double the previous entrée size), serving spoon size equal to a teaspoon, and serving spoon size equal to a tablespoon (triple the previous serving spoon size). Preschoolers served themselves 40% more food when the amount of available food was doubled (550 grams), and 13% more food when the serving spoon size was tripled (tablespoon) (Fisher, Birch, Zhang, Grusak, & Hughes, 2013).

Plate size may also increase the amount of food children serve themselves and consume. In one study, first-graders were placed in two different lunch conditions: eating off of child-sized plates or eating off larger adult-sized plates. When eating from the adult-sized plates, children served themselves an average of 90 calories more food and consumed 0.43 calories for each additional calorie they served themselves (DiSantis et al., 2013).

Taken together, this literature suggests that portion size has increased over the years, and that it may also be possible that among children there has been increase over time in the amount of food served by parents, plate size, serving spoon size, and amount of food available to them. If this is the case, research has shown that these factors lead to greater overall food consumption among children, which may also lead to weight gain and eventual obesity development in adulthood. There is also evidence that not only food
amounts but types of foods consumed, such as processed foods, may increase weight status in children.

*Consumption of processed foods.* Between the 1970s and 2000s, children ages 2-18 (n=31,337) consumed significantly more – an average of 60 calories per portion – of what researchers labeled “unhealthy foods,” including soft drinks, fruit drinks, pizza, burgers, processed Mexican food, desserts, and salty snacks, according to a study utilizing secondary data from four nationally representative samples [from the United States Department of Agriculture (USDA) and National Health and Nutrition Examination Survey (NHANES)] (Piernas & Popkin, 2011). In a similar way, the amount of fruit juice and sugar-sweetened beverages consumed has been a recent topic of investigation into children’s nutritional health and weight (Ebbeling et al., 2012). Specifically, sugar-sweetened beverages have been identified as being related to obesity at least among those who are already obese. In particular, in an intervention study, obese children who reduced their sugar-sweetened beverage consumption had less weight gain over time than obese youth whose sugar-sweetened beverage consumption was not altered (Ebbeling et al., 2012). The availability of processed foods and sweetened drinks and the choice to consume them may be a driver of further weight gain in those already obese. But other research has also looked at the consumption of foods thought to protect against weight gain and obesity.

*Consumption of fruits and vegetables.* While consumption of processed foods has increased, obese youth are at the same time failing to consume the recommended daily amounts of nutrients (Gillis & Gillis, 2005). Increasing daily fruit and vegetable intake during early childhood seems to be a protective behavior (Faith et al., 2006; Pala et
al., 2013). In particular, increasing parental offering of whole fruits and decreasing fruit juice intake among children at risk for weight gain was associated with slower rates of weight gain and lower likelihood of becoming overweight or obese (Faith et al., 2006; Pala et al., 2013).

In one multinational study that evaluated the effects of dietary choices on risk of obesity in children ages 2-9 years, four dietary patterns or groups were identified using the Children’s Eating Habits Questionnaire (Pala et al., 2013). These included a vegetable and whole wheat group (high in consumption of vegetables, grains, unsweetened milk, and fruit), a snacking group (high in consumption of street foods such as sandwiches, pastries, and chocolate), a sweet and fat group (high in consumption of candy, sweets, biscuits, fried meat, and sugar-sweetened beverages), and a protein and water group (high in consumption of fish, meat, eggs, and water). Controlling for the child’s sex, age, SES, physical activity, and initial BMI, the vegetable and whole wheat group was associated with less risk of becoming overweight or obese after two years. This demonstrates the positive and protective impact that vegetable, and possibly whole grain consumption, has on development of childhood obesity over time.

Even the mere presence of fresh vegetables in one’s home environment has been associated with weight status in children: preschoolers who were obese were less likely to have fresh vegetables available at home regardless of family SES (Boles, Scharf, Filigno, Saelens, & Stark, 2013). The children in these families also had less access to these vegetables within their homes (that is, vegetables were not kept within reach). Although this research is correlational, it does suggest that children who have higher weight statuses may, when selecting from the foods in their homes, choose processed choices
because they are more available (and may be less likely to choose fruits or vegetables because they are less available). This research highlights the importance of environment and its relationship to individual differences – children in these families are less likely to be obese when “healthy” foods are available and accessible and more likely to be obese when “healthy” foods are less available and less accessible. But do environmental factors beyond the home, for example in neighborhoods, also matter?

**Neighborhoods: Availability and accessibility of “healthy” foods.** Food consumed in one’s home is often obtained from neighborhood stores. But neighborhoods can differ in their access to fruits, vegetables, and processed foods and the quality and price of those foods, which this may influence diet and obesity among individuals living in those neighborhoods (Cerin et al., 2011; Jetter & Cassady, 2006; Sturm & Datar, 2005). For example, in middle- to high-income neighborhoods, the number of grocery stores within one kilometer of one’s home was cross-sectionally predictive of a lower risk of obesity (Cerin et al., 2011), and across low, middle, and high-income neighborhoods, greater availability of fresh vegetables within 100 meters of one’s home was cross-sectionally predictive of greater vegetable consumption (Bodor, Rose, Farley, Swalm, & Scott, 2008).

In low-income neighborhoods, not just the mere presence of grocery stores, but also store quality can influence the health of surrounding residents. In one study, the smaller grocery stores more prevalent in low-income neighborhoods provided less access to foods such as whole grain breads, and low-fat meats and cheeses than did larger grocery stores (Jetter & Cassady, 2006). The price of what researchers deemed “healthier foods” was higher ($230 compared to $194 for a two-week market basket). Further, if
options deemed “healthy and unhealthy” were similarly priced, the quantities were different: unhealthy foods were more likely to be sold in bigger quantities while healthier foods were sold in smaller quantities, making the less healthy options the more economical choice (Jetter & Cassady, 2006).

Indeed, fruit and vegetable prices in individual neighborhoods have been shown to relate to resident children’s weight gain, though not necessarily obesity. In a longitudinal study examining changes in BMI from Kindergarten through third grade (controlling for SES, baseline BMI, and age), as the price for fruits and vegetables increased in a neighborhood, there was an incremental but significant increase in children’s BMI over time, compared to the neighborhoods that were not subject to increased prices for their fruits and vegetables (Sturm & Datar, 2005). Because this study did not have data on the children’s actual food consumption, it is unclear whether children in these neighborhoods consumed less of these healthy foods because their families could no longer afford to purchase as many fruits and vegetables.

Another question also arises: if the presence and accessibility of fruits and vegetables in homes and neighborhoods have been linked to a lower risk of weight gain and obesity, is the reverse also true? That is, is the presence and accessibility of processed foods associated with higher risk of weight gain and obesity?

**Neighborhoods: Availability and accessibility of processed and fast foods.** Many studies measuring the presence of processed foods have focused on proximity to fast food restaurants near the home or school. Links between obesity and proximity to fast food restaurants have been mixed. In general, studies, including those controlling for SES, have found no links between obesity and proximity to fast food restaurants (Burdette &
Whitaker, 2004; Fraser & Edwards, 2010); that is children who are obese live no closer to fast food restaurants than children who are not obese. Three possibilities exist for this lack of relationship: either residents are not dining at these restaurants frequently; or if they frequently dine at these locations, they are making healthier choices at those restaurants; or fast food does not cause obesity. Evidence points toward at least two possibilities. Studies have found that fast-food availability was not linked to consumption of fast food (Richardson, Boone-Heinonen, Popkin, & Gordon-Larsen, 2011).

Furthermore, in comparison to sit-down restaurants, fast food restaurants were shown to have a higher percentage of healthy food choices such as salads, giving people who eat at fast food establishments a wider array of healthy choices (Cerin et al., 2011).

On the other hand, studies that have measured the density of fast food restaurants per person in neighborhoods, rather than individuals’ mere proximity to these establishments, have found associations with a greater presence of overweight and obese individuals, even after controlling for SES (Fraser & Edwards, 2010; Maddock, 2004). Thus, it seems that the presence of a single fast food restaurant nearby may not be related to residents’ obesity, but the presence of many fast food establishments may increase residents’ likelihood of dining at such restaurants – and therefore increase their likelihood of being obese.

These studies did not record the density of other restaurant choices in these areas, including restaurants offering entrees that may be as unhealthy as fast food restaurants’ entrees. As a result, it remains unclear whether the obesity in these neighborhoods is related to the density of fast food restaurants or simply to overall restaurant density. The density of fast food restaurants is also related to SES; that is, those in the lowest income
brackets live in areas with the highest density of fast food restaurants (Reidpath, Burns, Garrard, Mahoney, & Townsend, 2002). Studies have indeed shown that fast food consumption is higher among those from low SES backgrounds (French, Harnack, & Jeffery, 2000). Given that only approximately half of the above studies controlled for SES, it is unclear whether correlations with fast food and obesity are an artifact of SES or whether this relationship is independent of SES. This body of research indicates the classic interplay between environmental and individual factors – living in an area dense with fast food is associated with obesity, and low SES individuals are more likely to live in these areas. Although SES can further describe the relationship between obesity and fast food, more research is needed to examine the effects of neighborhood fast food density on the development of obesity, especially longitudinally.

**Summary.** A large body of evidence points to the association of nutrition with obesity. Amount of fruits, vegetables, and processed foods consumed has strong associations with childhood obesity, and this is seen in early childhood. While the consumption of processed foods, such as fast food and sugar-sweetened beverages, is related to higher obesity status among children, consumption of vegetables, fruits, and grains may be a protective factor. Additionally, the types of foods consumed in the home are influenced by the availability and accessibility of healthy and unhealthy food in a child’s neighborhood, particularly grocery store availability of healthy foods and pricing, which is closely related to individual factors like SES. Consumption is, in turn, influenced by environmental factors ranging from portion sizes to whether fruits and vegetables are available and accessible at home or in one’s neighborhood.
However, what remains unknown is how the presence of fast food restaurants influence obesity, given that one’s proximity to such restaurants were not associated with obesity but the density of those restaurants was related (but may also be an indicator simply of the density of all types of restaurants). Neighborhood fast food density is related to SES, and fast food consumption is related to SES. Clearly, there are many relationships to explore further, including which developmental periods when an individual’s nutrition appears to have a stronger relative influence on whether they become obese.

Like nutrition, physical activity is related to environmental context, including the presence of places where individuals can engage in physical activity in the neighborhood. The literature on physical activity and its impact on development of obesity has been reviewed below.

**Physical activity.** Physical activity is another behavioral context related to obesity. Physical activity can include physical activity performed by a child within the home or within their neighborhood (influenced by environmental factors like neighborhood safety), as well as a child’s sedentary pursuits, including screen time, especially TV viewing.

Outside of school hours, 61.5% of children ages nine to thirteen are not involved in any organized physical activity, and 22.6% of children do not participate in any free-time physical activity (Centers for Disease Control and Prevention, 2003). However, these levels of physical activity outside of school hours will not be true of all children. This section explores how the availability of physical activity at home and in neighborhoods interacts with individual characteristics to influence obesity.
**Homes and physical activity.** In examining factors correlated with obesity, obese preschoolers’ homes had fewer physical activity devices (children’s items such as “non-powered seated toy cars” and adult items such as treadmills) compared with healthy weight preschoolers (Boles et al., 2013). The presence of such devices is also correlated with self-reported and accelerometer-measured physical activity (Atkinson et al., 2005), which may help regulate weight over time.

**Neighborhood safety.** Neighborhood safety has also been related to the amount of physical activity performed outdoors, particularly for children (Carver, Timperio, Hesketh, & Crawford, 2012). Associations between the prevalence of obesity and neighborhood crime have been investigated. Children ages 3 to 5 from low SES neighborhoods experienced a 22% higher prevalence of obesity in neighborhoods with higher homicide rates (in the 75th percentile) (Lovasi et al., 2013). This relationship continued among slightly older children: at age 7, children were at higher risk of developing obesity if their neighborhood was less safe (in the bottom 25% in terms of Neighborhood Safety Ratings), even after controlling for SES (Lumeng et al., 2007).

In an adolescent population (8th-10th graders), neighborhood safety was also associated with obesity. Children in less safe neighborhoods had higher BMIs and higher levels of obesity, especially girls, who faced more constraints surrounding their outdoor physical activity behavior in unsafe neighborhoods (Carver et al., 2012; Slater, 2010).

Despite the above findings, some studies have not found a relationship between neighborhood safety and childhood obesity. Among 3-4 year olds, although researchers found a relationship between number of 911 calls made in the neighborhood and child obesity, there was not a relationship between overall neighborhood safety (measured
through crime statistics) and child obesity rates (Burdette & Whitaker, 2004). Both cross-sectionally and longitudinally (from Kindergarten through 8th grade), parent-perceived levels of neighborhood safety and their children’s BMI were not significantly associated (Datar, Nicosia, & Shier, 2013). However, this study did find that children in less safe neighborhoods watched more TV and were less physically active. Thus, it is possible that over a longer span of time (if measures were collected into adulthood), these behaviors could contribute to weight gain and eventual obesity development.

From this body of research, two points may be derived. First, environment is important: safe neighborhoods have a trend toward less obesity, although the result is not entirely consistent across studies due to varying measures. Second, the effects of the environment may not present immediately, as in the study above, but if unsafe neighborhoods are associated with more TV watching and less activity, children who are not obese may develop obesity later. Of course, another reason neighborhoods and neighborhood safety are important is likely to be their relationship to sedentary pursuits.

**Physical activity versus time spent on sedentary pursuits.** While time spent engaging in physical activity is related to a child’s weight status, time spent in sedentary pursuits, especially screen time has also been shown to relate to weight outcomes for children (Tremblay et al., 2011). Hours of TV viewing, in particular, have been associated with higher BMI and overweight/obesity (Kimbro, Brooks-Gunn, & McLanahan, 2011; Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005; Tremblay et al, 2011). In terms of individual differences, Black and Hispanic children watched more TV and had higher BMI (Kimbro et al., 2011). A meta-analysis of longitudinal studies comparing sedentary behaviors and obesity reported that children
who watched more TV also were more likely to be obese, even into adulthood (Tremblay et al., 2011).

One potential reason that screen time, including TV viewing is associated with later development of obesity is that children who spend more time watching TV spend less time engaged in physical activity (Brown, Nicholson, Broom, & Bittman, 2011). However, this does not explain the difference in obesity between children who spend time watching TV and children who spend time engaging in other sedentary activities like reading or studying. Metabolic effects, that is, the amount of energy expended, did not differ in children engaged in watching TV versus children resting quietly or listening to a story (Cooper, Klesges, DeBon, Klesges, & Shelton, 2006). Given this finding, it appears that a unique relationship between TV viewing and obesity exists that is not found with other sedentary activities.

It is possible that among sedentary activities, the time children spend on average watching TV may be greater than, for example, the time children spend on average reading. It may also be that TV viewing has qualities beyond decreased physical activity that are unique to TV-watching, such as exposure to commercials advertising unhealthy, nutrient-poor, energy-dense foods. Indeed, studies have linked TV viewing and a number of unhealthy advertisements with higher BMI, which, over long spans of time, may lead to obesity. In particular, viewing more ads for unhealthy foods is associated with higher BMI in children (Lobstein & Dibb, 2005). It is estimated that eliminating fast food commercials for children would result in approximately a 10% reduction in overweight children and adolescents (Chou, Rashad, & Grossman, 2005). In fact, several countries (the United Kingdom, Sweden, Norway, Greece, and parts of Canada) have already
banned unhealthy food advertising during children’s programming, and the U.S. Federal Trade Commission has recommended restricting children’s food advertising to healthier foods (Dhar & Baylis, 2011). Although this study does not control for children who watch adult programming, its evaluation of these policies so far has been positive: the effect of the ban in Quebec, Canada, for example, is estimated to have reduced household consumption of fast food per week by 13% (Dhar & Baylis, 2011).

In addition to influencing children’s food choices outside of TV viewing, the combination of viewing unhealthy food commercials and the passive nature of TV may encourage snacking during TV viewing. TV viewing is associated with snacking during programming (Brown et al., 2011), and an estimated 20% to 25% of children’s total daily energy intake is consumed while they are watching TV (Matheson, Killen, Wang, Varady, & Robinson, 2004). The longer the duration of viewing, the more opportunities there are to increase the total time spent snacking during the day. Clearly, engagement in TV viewing affects obesity, but does this effect persist into adulthood?

**Longitudinal effects of sedentary behavior from childhood to adulthood.** Studies that measure longitudinal effects of sedentary behavior on obesity and BMI have had mixed effects. A meta-analysis examining the relationships between childhood and adolescent TV viewing and adult weight status found that while early TV viewing was related to later obesity and increases in BMI (Thorp, Owen, Neuhaus, & Dunstan, 2011; Tremblay et al., 2011), the results were more mixed for other types of sedentary behaviors (Tremblay et al., 2011). Adjusting for SES, sex, physical activity, and TV-watching frequency in early adulthood, time spent watching TV in childhood was related to overweight and obesity status in early adulthood (Hancox, Milne, & Poulton, 2004;
Landhuis, Poulton, Welch, & Hancox, 2008b; Parsons, Manor, & Power, 2008; Viner & Cole, 2005; Viner & Cole, 2006). The fact that a longitudinal effect exists when controlling for individual characteristics indicates that the results described above are not likely to simply be due to other, perhaps more central relationships but may be due to the activities themselves.

**Summary.** Physical activity and sedentary behavior have many connections with child, adolescent, and adult weight. In particular, opportunities for physical activity in the home environment as well as neighborhood safety influence the amount of physical activity engaged in by children. The findings regarding the relationship between the safety of a neighborhood and the risk of childhood obesity have been divergent. Sedentary activity and screen time, particularly TV viewing, appears to have a powerful effect on obesity development through a variety of avenues, including advertisements for unhealthy foods and snacking while watching TV. This literature suggests that physical activity and sedentary behavior, in particular TV viewing, are important correlates of obesity. Furthermore, the literature suggests that physical activity and TV viewing may be an especially important influence on obesity in the developmental period from childhood or adolescence to adulthood (Glenmark et al., 1994; Hancox et al., 2004; Huotari et al., 2011; Landhuis et al. 2008b; Parsons et al., 2008; Tammelin et al., 2004; Telama et al., 2005; Viner & Cole, 2005; Viner & Cole, 2006). While much research has focused on the activity levels during waking hours, other researchers have focused on issues related to sleep.

**Sleep.** Adolescents need nine and one-quarter hours of sleep per night on average (National Sleep Foundation, 2016). However, only 15% of adolescents report sleeping
even eight and a half hours on school nights (National Sleep Foundation, 2016). Many cross-sectional studies (most of which measure sleep through questions about bedtimes and rise times but often do not measure the time it takes to fall asleep or repeated awakenings during the night) have found evidence that children and adolescents who are obese spend even less time sleeping than their non-obese peers (Hart et al., 2011). Evidence also suggests that the relationship between sleep and obesity is stronger for younger children and for boys (Ievers-Landis, Storfer-Isser, Rosen, Johnson, & Redline, 2008; Thind et al., 2014). However, the literature examining longitudinal relationships between sleep and obesity has mixed findings, most likely due in part to the vastly different methodologies employed in these studies.

**Longitudinal effects of sleep duration on obesity.** According to the findings of a recent meta-analysis on the longitudinal effects of insufficient sleep on adolescent obesity, differences in study design, including the length in time between baseline and follow-up measures, have led to mixed findings (Thind et al., 2014). A major difference in study design is that some studies examine the relationship between baseline sleep duration and later adolescent BMI or overweight/obesity, while others examine the relationship between changes over time in sleep and in BMI or overweight/obesity. The differences described above in study design are important, because they might yield vastly different findings given that sleep might fluctuate throughout an individual’s developmental cycle. Baseline sleep duration, depending on when this baseline is measured, may not reflect sleep over the entire course of the study. Studies that measure changes over time in sleep and BMI or overweight/obesity can better capture potential
variances in sleep patterns across the course of the study, making such studies more sensitive to relationships between sleep and BMI or overweight/obesity.

Two separate four-year studies of participants during early to late adolescence found a consistent relationship between BMI and sleep duration: greater reductions in the amounts of sleep from early to late adolescence were associated with greater increases in BMI (Mitchell, Rodriguez, Schmitz, & Audrain-McGovern, 2013; Rutters, Gerver, Nieuwenhuizen, Verhoef, & Westerterp-Plantenga, 2010). For example, Mitchell et al. (2013) found that between ages 14 and 18, each one-hour reduction in sleep was associated with an increase of .27 kg/m² BMI points for those in the 90th BMI percentile, even after controlling for gender, race, maternal education, physical activity, and sedentary/screen time. Rutters et al. (2010) also found that decreasing sleep time between the ages of 12-16 was related to BMI increases, even after controlling for baseline BMI and other potential confounders (parent BMI, etc.). It is important to mention that these changes in BMI are incremental and are not related to obesity but only to weight gain.

Five different studies did not measure changes in sleep between baseline and follow-up and instead examined the relationship simply between sleep duration at baseline and later BMI or obesity, and revealed more mixed findings. Of these studies, one study found significant relationships between lower levels of sleep and greater risk of adolescent obesity after five years, after adjusting for factors such as baseline BMI/obesity, age, and ethnicity – that relationship was stronger among boys but significant across both sexes (Silva et al., 2011). Three of the five studies found that associations disappeared after controlling for factors such as baseline BMI/obesity, gender, age, race, and parental income (Araújo, Severo, & Ramos, 2012; Calamaro et al.,
One study did not find a significant association (Lytle et al., 2013). For the studies that found relationships that disappeared once obesity at baseline was controlled for, it is possible that obesity may in some cases be contributing to sleep difficulties.

**Summary.** The findings are mixed in studies exploring the relationship between sleep and obesity from early to late adolescence. There appears to be evidence that changes in sleep duration across a four-year time period are associated with changes in BMI, with those who receive fewer hours of sleep most likely to have higher BMI, though not necessarily obesity. However, studies using measurements of baseline sleep duration as a predictor of follow-up BMI or obesity status are less cohesive and reveal sex differences. Often, if relationships are significant, they are not significant independent of baseline BMI/obesity. This suggests that the relationship between baseline sleep duration and follow-up obesity may not be robust.

While the above studies measured the effects of sleep on weight in early to late adolescence, few studies have measured child or adolescent sleep and its impact on adult obesity. To our knowledge, two such studies exist (Landhuis, Poulton, Welch, & Hancox, 2008a; Al Mamun et al., 2007). The first study found a 35% decrease in obesity risk of at age 32 for every hour slept on average at age 3, controlling for early BMI, childhood SES, and other factors (Landhuis et al., 2008a). The second study found that obesity at age 21 was related to “irregular or troubled sleeping” during ages 2-4, controlling for sex, baseline BMI, and other factors (Al Mamun et al., 2007).

While these studies measured the impact of childhood sleep on adult obesity (through measuring variables at *childhood* and comparing them to adult outcomes), there
have been no studies measuring the longitudinal impact of adolescent sleep on adult obesity (though measuring variables at adolescence and comparing them to adult outcomes). More information is needed on the impact of sleep duration in adolescence and its effect on the weight and health of adults. It is also difficult to know whether sleep alone influences weight status, or whether other behavioral and contextual factors that influence sleep (mood, for example) are more strongly related to weight status.

**Social/emotional climate.** Social/emotional climate is an additional behavioral context that may be related to obesity (Blaine, 2008; Kattelmann et al., 2014; Wardle et al., 2011). Kattelmann et al. (2014) suggest that stress and a family’s emotional climate might interact with nutrition, physical activity, and sleep to impact weight. For example, during times of high perceived levels of stress or negative family emotional dynamics, individuals may engage in less healthy behaviors, including eating processed or fast foods, not being as physically active, and getting less sleep, each of which relate to weight status (Kattelmann et al., 2014). Emotional climate, in particular, depression may also interact with nutrition, physical activity, and sleep to impact weight. For example, a person with depression may eat more or less than usual, be less physically active, or sleep more or less than usual, which might impact their weight, and over time, lead to obesity.

The next section has included a discussion of a child’s stress at home, with a review of the research on family stress, including how it is measured and which components of family stress seem to most impact the development of overweight and obesity in children and adolescents. This has been followed by a discussion of depression – which, in contrast to family stress is an internal individual state – and the impact that depression may have on the development of obesity from adolescence to adulthood.
Family stress/family emotional climate. Family typically has a strong influence on a child’s life and development, and there is some evidence that family stress in particular influences weight status in children (Koch et al., 2008). An important dimension of this is the family’s emotional climate, including whether family interactions are more positive or negative, supportive, cohesive, controlling, or conflictual. Family emotional climate has typically been assessed in three main ways: through parent self-reports of emotional climate, child self-reports of emotional climate, and observation and/or self-report of family mealtimes as a measure of general family emotional climate.

Family emotional climate includes components such as parental support (parents help children and are supportive), conflict (family members frequently fight), cohesion (family members frequently spend time with, and feel connected to, one another), and parental control (parents frequently constrain children’s behaviors). Evidence on the influences of these components of family emotional climate on weight status has been mixed. Studies that measure parental perceptions of family climate have either found no differences between the family climates of overweight/obese and non-overweight/non-obese youth (Brown, Ogden, Vögele, & Gibson, 2008; Stradmeijer, Bosch, Koops, & Seidell, 2000) or have found significant differences between some dimensions of emotional climates in families with overweight/obese children, compared to families with non-overweight/non-obese children (Wilkins, Kendrick, Stitt, Stinett, & Hammarlund, 1998; Zeller et al., 2007). In a study focusing only on clinically obese adolescents seeking treatment, in terms of and based on mothers’ perceptions of family cohesion and conflict, families of the children who were obese reported less cohesion and more conflict (but no differences in control and support) than the families of a non-treatment-seeking
control group with BMIs below the 85\textsuperscript{th} percentile matched for race and age (Zeller et al., 2007).

In contrast, mothers of overweight and obese 5th graders (compared to mothers of non-overweight/non-obese 5th graders) perceived higher levels of parental control; however, this study had a few limitations (Wilkins et al., 1998). In particular, a low response rate (35\%) resulted in few families with overweight or obese children being included in the study. Had all families in the original sample been included, the results of the study may have been different. As such, the strength of the evidence linking parental control with overweight and obese youth should be interpreted with caution.

Research on family emotional climate using parental self-report data has produced mixed findings. The two components of family emotional climate that might differ between families with obese and families with non-obese youth are family cohesion and conflict. However, studies measuring family emotional climate and child obesity using children’s perceptions should be examined to see whether children in these families also perceive the same components perceived by parents. Such studies are summarized below.

**Children’s perceptions of family emotional climate.** The findings in studies measuring children’s perceptions of family climate have also been mixed (Jelalian & Steele, 2008). In addition, these studies have reported sex differences in the relationship between family emotional climate and overweight and obesity and in the relationship between family climate and physical-activity correlates (Mendelson & White, 1995; Mellin, Neumark-Sztainer, Story, Ireland, & Resnick, 2002).

One aspect of family emotional climate – family cohesion – that was significant across parent-reported studies is perceived differently by youth of both sexes (Mendelson
& White, 1995). In a study of 9-year-old girls and boys, only the girls (but not boys) who perceived lower levels of family cohesion had a higher overweight and obesity status.

In summary, across studies of family emotional climate, low cohesion (child- and parental-reported) and high conflict (parental-reported) emerged as the strongest correlates with pediatric obesity. There is little evidence in self-report studies of the existence of a relationship between parental control or support and pediatric obesity. Also, the findings from these studies may be limited to only the self-selected populations measured (those who enrolled in the studies versus those who did not). Specifically overweight and obese female adolescents reported lower levels of family cohesion compared to overweight and obese male adolescents. Observations of family mealtimes are an alternative way to measure family emotional climate features.

**Family meals.** Family meals may be a measure of the emotional climate, particularly family cohesion. Higher frequency of family meals has been associated with lower rates of overweight and obesity (Anderson & Whitaker, 2010; Hammons & Fiese, 2011) and with greater consumption of fruits and vegetables (Hammons & Fiese, 2011; Verzeletti, Maes, Santinello, Baldassari, & Vereecken, 2010).

The quality of family meal interactions has also been compared between families with children who are obese and children who are not obese. Direct observation and coding of family mealtimes with an eye towards family interactions and climate have revealed that obese children’s parents were more controlling and less supportive (Moens, Braet, Soetens, 2007), compared to the parents of children who were not obese. It appears that accounting for all methodologies (child self-report, parent self-report, self-report and
observation of family meals), there is some cross-sectional evidence to support the relationship between family climate and overweight/obesity status in children.

The relationship between the frequency of family meals during one’s childhood and later obesity is unclear, again in part due to variations in methodologies and also a shortage of relevant longitudinal studies (Fulkerson, Neumark-Sztainer, Hannan & Story, 2008; Gable, Chang, & Krull, 2007; Hammons & Fiese, 2011; Sen, 2006; Taveras et al., 2005). Overall, results from a meta-analysis revealed significant relationships between the frequency of family meals and later overweight or obesity status: participants reporting fewer family meals were more likely to be overweight or obese by late childhood (Hammons & Fiese, 2011). Two central studies included in this meta-analysis revealed significant relationships between frequency of family meals and obesity (Gable et al., 2007; Sen, 2006). The first examined Kindergartners and first graders who ate fewer family breakfasts and dinners, and found that they were more likely to be obese in third grade, controlling for sex, race, and family SES (Gable et al., 2007).

The second study revealed racial differences: among 12 to 15 year olds, only non-Hispanic white individuals (compared to African American and Hispanic individuals) had higher odds within one year of becoming obese if they ate less than three meals with their family, controlling for sex, age, height, family structure, poverty status, and maternal education (Sen, 2006). Additionally, individuals who were obese at baseline, and reported eating at least seven family meals per week had increased odds of ceasing to be obese two years later, compared to those who never ate with family (Sen, 2006).

While the above two studies showed an association between family meal frequency and later obesity, two other studies failed to find such effects (Fulkerson et al.,
2008; Taveras et al., 2005). Furthermore, few longitudinal studies have examined relationships between child and adolescent family meal frequency and later weight status, and there is currently only one longitudinal study we know of focusing on family meal frequency in adolescence and weight status in adulthood (Berge et al., 2015). This longitudinal study, which controlled for sex, age, race, SES, and baseline weight status, reported that a lack of family meals during middle and high school predicted overweight and obesity in young adulthood (10 years later). Specifically, 60% of adolescents who reported never eating family meals were later overweight, and 29% were later obese compared to all groups (those that ate family meals of varying weekly frequencies).

Adolescent family meals may contribute to a lower risk of developing obesity in young adulthood, though more research is needed.

A number of factors often described as theoretically related to family meals were not included in the above studies. For example, frequent family meals might signal greater family organization, which could equate to less stress and lower risk of obesity. Family meals and sleep might also interact. Adolescents might sleep less if they are in families who are more stressed, have fewer family meals and have more negative family emotional climates. Family meal frequency has also been related to fruit and vegetable consumption, which could mediate the relationship with greater risk of obesity (Hammons & Fiese, 2011; Verzeletti et al., 2010). Inclusion of stress/family emotional climate, sleep, physical activity, and fruit and vegetable consumption, along with family meal frequency, in a longitudinal analysis from adolescence to adulthood would shed more light onto the factors leading to obesity.
Summary. One strong point emerges from these studies: family stress, measured through family emotional climate, is related to many aspects of a child’s life, including obesity. Family emotional climate, particularly family cohesion, is related to family meal frequency. However, while there are advantages to using frequency of family meals as a measure – and higher frequency suggests higher levels of overall family cohesion – the quality of these family meals often remains unknown. While family is an important behavioral context in children’s lives, internal stress and emotions, particularly depression, have also been shown to have strong relationships to many childhood behavioral and contextual factors and to weight status.

Depression. Depression is related to many correlates of pediatric obesity (e.g., sleep, physical activity), but the research is mixed on whether depression during childhood or adolescence is correlated with developing obesity during adulthood (Blaine, 2008; Franko, Striegel-Moore, Thompson, Schreiber, & Daniels, 2005; Gaysina et al., 2011; Hasler et al., 2005; Mustillo et al., 2003; Stice, Presnell, Shaw, & Rohde, 2005). A meta-analysis examining the impact of adolescent depression on weight gain and obesity revealed that depressed adolescents were approximately 2.5 times more likely than their peers to have gained weight or developed obesity at follow-up (these studies averaging 6.8 years in length) (Blaine, 2008). However, after baseline BMI and other variables were considered, adolescent depression predicted later obesity only among young women. For young men, depression predicted later weight gain but not obesity.

Depression in adolescent girls has been shown to contribute to obesity into early and middle adulthood (Franko et al., 2005; Gaysina et al., 2011; Hasler et al., 2005; Stice et al., 2005). Specifically, teenage girls who had depressive symptoms experienced more
rapid rates of increases in BMI during early adulthood and middle adulthood, and a higher prevalence of obesity than teenage girls who did not experience depressive symptoms (Gaysina et al., 2011; Hasler et al., 2005). In particular, one study found that females with depressive symptoms had a higher rate of increase in BMI and higher BMI by age 53 than women who did not have depressive symptoms (Gaysina et al., 2011), though they did not necessarily have higher rates of obesity. Another study controlling for physical activity, baseline BMI, SES, and a “family history of weight problems” reported that teenage girls with depression were also more likely to be obese in adulthood (Hasler et al., 2005).

These studies strongly suggest that symptoms of depression in girls can impact the development of obesity over decades and can influence weight status into middle adulthood. However, other studies have suggested that feelings of adolescent depression may affect weight status even earlier: at the beginning of adulthood and even late adolescence (Franko et al., 2005; Stice et al., 2005). Significant effects of depressive symptoms in adolescent girls on obesity in young adulthood have been documented when controlling for baseline BMI and parental education (Franko et al., 2005). The rate of development of BMI between ages 16 and 21 increased linearly with depressive symptoms, and adolescent depressive symptoms predicted adult obesity.

Another study with younger adolescents (11-15 years old at baseline and 15-19 years old at follow-up) determined that an increase in endorsement of every additional depressive symptom among girls led to a four times greater risk of onset of obesity (Stice et al., 2005). However, this effect disappeared once other factors, such as dieting, were
included in the model, and the authors suggested that these other factors might also contribute to obesity development.

The longitudinal findings for males have been more mixed. Some studies have suggested that males who experienced depressive symptoms had lower weights throughout adolescence (Gaysina et al., 2011) and adulthood (Gaysina et al., 2011; Pine, Cohen, Brook, & Coplan, 1997), compared to their counterparts who experienced no symptoms of depression. In contrast to this literature, one study uniquely examined male developmental trajectories of weight gain and then looked back at their likelihood of having had earlier depression. Only males who were chronically obese throughout childhood and adolescence were more likely to be depressed compared to males who either were never obese, were obese but lost weight, or were not obese in adolescence but became obese (Mustillo et al., 2003).

Methodological differences prevent definitive conclusions about the relationship between depression and obesity (different baselines, follow-up ages, and study durations). The relationship between depression and obesity may also be difficult to measure, because a common symptom of depression is a change in appetite, whether either eating too much or too little or having a general disinterest in food variety or quality. Although the relationship between overeating and pediatric obesity is not clear-cut, patterns of consistent overeating or under-eating may influence the development of obesity over long spans of time, depending on how long the depression lasts. As such, studies of depression that do not take into account symptoms related to food consumption may make depression too vague a factor to discern its relationship to obesity.
Loss of interest in activities, another common symptom of depression, may also lead to less physical activity. A reduction in physical activity over time, without changes to other aspects such as food intake, might also lead to obesity. Therefore, it is unknown whether depression or the reduction in physical activity is driving weight gain. Again, depression’s relation to alterations in sleep patterns (either sleeping much more or much less than usual) might also impact weight gain.

Although research on childhood depression’s association with weight has yielded mixed results, depression early in life does seem to have a consistent longitudinal relationship with overweight and obesity status. In terms of sex differences, some research suggests that depression tends to affect women’s weight as they transition from adolescence to adulthood (Blaine, 2008; Franko et al., 2005; Gaysina et al., 2011; Hasler et al., 2005; Stice et al., 2005). How depression may affect men over the course of their development is less well understood, in part due to varying methodologies and limitations in measuring depression (Blaine, 2008; Gaysina et al., 2011; Hasler et al., 2005; Mustillo et al., 2003; Pine et al., 1997). More information is needed to further examine the relationship between depression and obesity, given various independent characteristics (such as sex) over the course of time.

**Summary.** In general, more longitudinal data focusing on relationships between obesity and stress, family emotional climate, and depression are needed. While family emotional climate and depression appear to affect weight, the precise relationships between these factors are still unclear. Family cohesion and family meals appear associated with a lower prevalence of obesity, though these studies are mixed in part because of differences in methodology. Depression also appears related to obesity in that
individuals who are more depressed, or are depressed for a longer period of time are more likely to either be obese, gain weight, or develop overweight/obesity. Again, differences due to varied methodologies, as well as sex differences, are in need of clarification. Further investigation is needed to more thoroughly examine each factor and its relationship with adolescent and adult weight status.

**Integrative Theories of Obesity**

As mentioned above, few studies have simultaneously examined the role of all four behavioral and contextual factors – nutrition, physical activity, sleep, social/emotional climate – in the development of obesity (Dev et al., 2013; Huh et al., 2011; Ottevaere et al., 2011; Reilly et al., 2005; Scharoun-Lee et al., 2011). There are a few exceptions. One study that included three of these four factors found that sleep and restrictive parental feeding practices were significantly related to overweight and obesity in preschoolers ages 2-5 (Dev et al., 2013). Specifically, children who attained eight or fewer hours of sleep and whose parents controlled their intake of food were more likely to be either overweight or obese. Other factors that were not significant included ethnicity, sex, time spent watching TV, physical activity opportunities, fruit and vegetable consumption, and fast food consumption. However, this study measured outcomes only for preschoolers and did not measure the development of obesity into later childhood, adolescence, or adulthood. Effects of behavioral contexts such as time spent watching TV on the development of obesity may take longer to emerge.

Indeed, a different study investigating the longitudinal effects of several variables among children ages 3 to 7 revealed strong effects of TV viewing on weight gain (Reilly et al., 2005). Overall, this study compared 25 different factors for 3 year olds and these
factors’ levels of influence on the weight status of the children when they reached 7 years of age. These factors spanned three of the four factors described above: nutrition, physical activity/sedentary behavior, and sleep (as well as others). Of the 25 variables measured, eight were significantly associated with weight status, including TV viewing time, sleep, birth weight, and parental weight status; dietary patterns approached significance. It is likely that across a longer span of time, dietary patterns might also have influenced weight gain, but it is unknown the age at which this effect might emerge.

By combining many behavioral and contextual factors, these two studies addressed several limitations of prior studies that focused on only a few factors simultaneously but still have limitations. First, the two studies measured the effects of behavioral contexts over short spans of time that typically excluded adolescence and young adulthood, which is the period of interest of the current review since adolescence constitutes a risk period for the development of obesity among some groups (Huh, Stice, Shaw & Boutelle, 2012). Second, neither study examined individual differences as covariates (sex, race/ethnicity, SES). Past research has shown that weight gain occurs differently across individuals (Huh et al., 2011; Ottevaere et al., 2011; Scharoun-Lee et al., 2011). For example, an individual’s sex, SES, race/ethnicity, and age may yield differences in obesity development in terms of the influence of various behavioral or contextual factors (nutrition, physical activity, sleep, social/emotional climate).

In a study illustrating the role of individual differences in the influence of behavioral and contextual factors related to weight gain, Ottevaere et al. (2011) found that male adolescents were more likely to be part of a group characterized by high levels of physical activity and “low” quality diets, while female adolescents were more likely to
be part of a group characterized by low levels of physical activity and “high” quality diets. Thus, targeting nutrition would be more important to teenage boys than targeting physical activity, while the reverse would be true for girls. This finding illustrates why understanding the relationship between individual characteristics and the factors (nutrition, physical activity, sleep, social/emotional climate) are important – this knowledge can aid researchers in targeting intervention or prevention efforts.

As a final example of individual differences in the influence of behavioral and contextual factors on obesity, Hispanic and African-American teens who were obese were more likely to also engage in the following: high sedentary behavior and high-fat, high-sugar snack consumption compared to white teens (Huh et al., 2011). Again, the implications of this study might mean targeting a modifiable behavior (e.g., physical activity and nutrition) for a vulnerable group (e.g., Hispanics and African-Americans). In sum, these studies suggest that more thought should be given to various pathways in the development of obesity for people of differing ages, sexes, racial/ethnic backgrounds, and SES groups.

The research outlined above is an excellent example of literature that is in the spirit of this paper, in that they consider how different behavioral and contextual factors may impact obesity differently for individuals with different characteristics. However, none of the above studies mention the effects of social/emotional climate on the development of obesity, despite the fact that early social/emotional climates have been shown to influence later adult obesity (Wardle et al., 2011). A discussion of the role of sleep is also absent. And none of these studies measured whether various pathways to obesity that combine several behavioral contexts (nutrition, physical activity, sleep,
social/emotional climate) were consistent over developmental time periods (from adolescence to adulthood, for example). For this reason, the developmental time period from adolescence to adulthood would be important to explore. This review attempts to build on the existing literature by summarizing the longitudinal research that separately examines behavioral contexts influencing weight gain from adolescence to adulthood with research that integrates two or more factors simultaneously.

Summary and Implications

In conclusion, the behavioral contexts: nutrition, physical activity, sleep, and social/emotional climate appear to be associated with weight gain and/or the development of obesity, but many of their intricacies and interrelationships remain unclear. In terms of nutrition, the amount of food consumed, including processed foods, has increased over the years. Consumption of fruits and vegetables seem to serve as a protective factor. However, their consumption is influenced by neighborhood availability and accessibility (which is related to SES), particularly pricing and the availability of healthy foods at neighborhood grocery stores, while the influence of fast food restaurant density on obesity remains unclear.

Physical activity opportunities in the home appear to influence the amount of physical activity in which children are engaged. However, outside of the home, it is unclear whether neighborhood safety influences neighborhood physical activity and, consequently, weight status. There is some evidence that for teenage girls in unsafe neighborhoods, parents may restrain physical activity, which could influence obesity. There is, however, other evidence that points to either no influence of neighborhood safety on weight or to an influence of neighborhood safety on physical activity and
sedentary behavior absent of weight. Throughout the literature, it is unclear whether effects on weight and obesity would emerge if it were studied over a longer span of time.

Sleep also appeared to be related to weight, but the findings were again mixed. Integrative studies focused on early and middle childhood revealed a strong relationship between sleep and weight gain, suggesting that sleep may be very important during this developmental period. In adolescence, studies measuring changes in sleep over time have shown that decreased sleep was related to increased BMI, but not necessarily to the development of obesity. Among studies assessing sleep at baseline and tracking changes in BMI/obesity from baseline to follow-up, findings varied according to the methodologies used, were often not significant independent of baseline BMI/obesity, or found an association between sleep and BMI/obesity for males only. Studies examining sleep irregularities and hours of sleep attained during the preschool years reported relationships to obesity in young adults. However, since each study differs in the length of time between baseline and follow-up and in the methodologies used, much remains unknown about the association between sleep and the development of obesity.

The last behavioral and contextual factor – social/emotional climate – also appears to have a relationship with obesity development. However, here again, the variety of methodologies used renders the findings difficult to interpret and summarize. Family stress/family emotional climate, measured by the number and quality of family meals, appear to affect a child’s weight. Parents who are more controlling and provide less support are more likely to have overweight or obese youth. Depression has shown an association with obesity development, but the strength of this association varies because of differing methodologies. Across all of this research, however, depression early in life
has consistent longitudinal relationships with weight. In terms of sex differences, some research suggested that depression tends to affect women’s weight as they transition from adolescence to adulthood. It is less understood whether or how depression affects men over the course of their development.

Research that examines differences in the pathways to obesity has found varying levels of influence of physical activity, sedentary behavior, and nutrition among groups with different sexes, races/ethnicities, and SES statuses. However, these studies neither account for sleep or for social/emotional climate, nor do they measure whether these influences are consistent from adolescence to adulthood. Future research needs to continue to integrate behavioral contexts over time in order to contribute to our growing knowledge of how obesity develops during adolescence and into adulthood.

Obesity is a challenging condition to treat and prevent. If researchers can identify which adolescent characteristics tend to result in later obesity, their work can better inform prevention. Given the numerous health, social, and financial costs to obesity, it is essential that researchers continue to explore the development of obesity across multiple populations and developmental time periods.
References


Chapter II: Empirical Research

Abstract

Previous research suggests that nutrition, physical activity, sleep, and social/emotional climate influence weight gain, but few empirical studies have examined their effects jointly. Using individuals who were obese during the 4th wave of the National Longitudinal Study of Adolescent to Adult Health (Add Health) (N=1,889, ages 24-32), this study applied latent class analysis (LCA) to identify subgroups of adolescents (wave 1, ages 14-17), and separately, subgroups of young adults (wave 2, ages 18-26), who exhibit unique, co-occurring behavioral risk contexts for obesity. We found 6 distinct classes during both adolescence and young adulthood, but although the number of classes was similar, the classes themselves differed. Specifically, classes during adolescence were comprised of fewer risk factors compared to adulthood suggesting behavioral factors build over time. Covariates (sex, SES, race, health, and individual education level) differentiated between class membership (i.e., females and minorities were more likely to be in groups characterized by depression). This information can help researchers study weight gain and maintenance longitudinally and identify individuals with co-occurring risk factors for obesity.
Chapter II: Empirical Research Proposal

In 2014, more than 600 million adults were obese worldwide (World Health Organization, 2016b) and, as of 2012, approximately 17% of youth and over one-third of adults were obese in the United States (Ogden, Carroll, Kit, & Flegal, 2014). Children and adults who are obese are more vulnerable to asthma, type 2 diabetes, heart disease, stroke, and certain cancers (Inge et al., 2013; U.S. Department of Health and Human Services, 2004; World Health Organization, 2016a). For those affected, obesity often originates in childhood/adolescence and persists into adulthood (Biro & Wien, 2010; Deshmukh-Taskar et al., 2006; Guo, & Chumlea, 1999; Whitaker, Wright, Pepe, Seidel, Dietz, 1997). For the purpose of prevention and intervention, it is important to capture risk factors leading to obesity to avoid a life-long journey with extra weight and associated health conditions.

Previous research has identified four categories of behavioral and contextual risk factors associated with weight gain. They include: 1) nutrition, 2) physical activity, 3) sleep, and 4) social/emotional climate (Brown, Halvorson, Cohen, Lazorick, & Skelton, 2015; De Vriendt et al., 2011; Dev, McBride, Fiese, Jones, & Cho, 2013; Hart, Cairns, & Jelalian, 2011; Jelalian & Steele, 2008; Michels et al., 2012; Reilly et al., 2005). For the most part, however, studies have looked at these factors individually, rather than considering them synergistically. Further, there is no comprehensive understanding of whether the factors are more prevalent during a specific developmental stage versus another. In combination, these gaps result in a somewhat vague understanding of how the factors work together and their prevalence across the developmental life span. The current study aims to fill these gaps by examining all four behavioral and contextual risk
factors as they are present in adolescence (ages 14-17) and potentially carry over in adulthood (ages 18-26) in a nationally represented sample. By applying the latent class analysis approach (McCutcheon, 1987), we identify clusters of individuals that share common risk factors, and describe their prevalence and demographic characteristics. We also evaluate similarity in clustering between adolescence and adulthood to highlight possible changes. In the sections that follow, we first review relevant findings pertaining to each individual group of risk factors outlined above, followed by a synergistic summary linking the factors together. Then, we present the research questions and methodological framework, share results, and place current findings in the context of existing literature.

**Individual Risk Factors**

Much important work has been done to investigate each of the behavioral and contextual factors. First, in the area of nutrition, it has been found that high consumption of processed foods is linked to higher weight status, whereas consumption of fruit and vegetables is a protective factor (Faith et al., 2006; Pala et al., 2013; Piernas & Popkin, 2011). For example, in children ages 2-9 years, controlling for the child’s sex, age, SES, physical activity, and initial BMI, those that consumed more vegetables had less risk of becoming overweight or obese after two years (Pala et al., 2013).

Second, in the area of physical activity, literature indicates that high levels of sedentary behavior, including screen time and TV viewing are associated with obesity (Boles et al., 2013; Brown et al., 2011; Carver, Timperio, Hesketh, & Crawford, 2012; Chou, Rashad, & Grossman, 2005). At the same time, neighborhood characteristics of physical activity opportunities (presence of fitness centers, for example) are conducive to
lower weight (Atkinson, Sallis, Saelens, Cain, & Black, 2005; Boles et al., 2013; Slater et al., 2010). Additionally, within neighborhoods, safety appears to influence amount of physical activity, although “safe” and “unsafe” neighborhoods have inconsistent relationships with children’s obesity status in the literature (Burdette & Whitaker, 2004; Carver et al., 2012; Lovasi et al., 2013; Lumeng et al., 2007; Slater et al., 2010).

Third, there is strong evidence that changes in sleep duration yield changes in adolescent weight, with those that began sleeping less being most likely to transition to higher BMI (Mitchell, Rodriguez, Schmitz, & Audrain-McGovern, 2013; Rutters, Gerver, Nieuwenhuizen, Verhoef, and Westerterp-Plantenga, 2010). However, findings on the relationship between initial sleep level and initial BMI are mixed (Araújo, Severo, & Ramos, 2012; Calamaro et al., 2010; Lytle et al., 2013; Silva et al., 2011; Storfer-Isser, Patel, Babineau, & Redline, 2012). Longitudinally, children who slept less during their preschool years were more likely to be obese during young adulthood (Landhuis et al., 2008a; Al Mamun et al., 2007).

Fourth, social/emotional climate – which includes factors related to frequency of family meals, family cohesion, peer approval and mental health – has also been shown to be associated with obesity. In particular, longitudinal studies that controlled for sex, age, race, SES, and baseline weight status, found family meal frequency during middle school and high school predicted overweight and obesity status 10 years later (Anderson & Whitaker, 2010; Berge et al., 2015; Hammons & Fiese, 2011). In terms of peer relations, overweight or obese teens are likely to experience weight-related bullying, name-calling, teasing, and physical aggression by peers (Janssen, Craig, Boyce, & Pickett, 2004; Neumark-Sztainer, Story, & Faibisch, 1998; Puhl et al., 2015). These types of
interactions can cause feelings of isolation, as well as anxiety, depression, and lower physical activity (Storch et al., 2007), which could ultimately lead to obesity. Adolescents that are depressed are more likely to have gained weight at follow-up than non-depressed peers (these studies average 6.8 years in length) (Blaine, 2008). However, only for girls did depression in adolescence predict later obesity. Longitudinally, from childhood into adulthood, depression was a predictor of the magnitude of increase in adult BMI, with a longer duration of depression associated with higher BMI (Pine, Goldstein, Wolk, & Weissman, 2001).

**Ecological Perspective**

The path to obesity is multifactorial and no single factor can fully capture the risk. In recent years, a number of studies examined how risk factors cluster together to impact weight gain (Huh et al., 2011; Ottevaere et al., 2011; Scharoun-Lee et al., 2011). Other studies have noted that not all of the above risk factors are equally present among different demographic groups. Specifically, adolescent boys are more likely to exhibit high physical activity and low quality diet, while girls are the opposite – lower on PA and higher on consumption of quality foods. (Ottevaere et al., 2011). Another important factor that differentiates between individuals is race and ethnicity, especially since Hispanic and African-Americans generally exhibit higher levels of obesity, 43% and 48% respectively, than non-Hispanic whites at 35% (CDC, 2016). Behaviorally, Hispanic and African American teens generally spend a lot of time on sedentary activities and consume high-fat and high-sugar snacks (Huh et al., 2011). Understanding cultural and ethnic differences is essential for designing sensitive and customized interventions.
Yet, even studies that look at co-occurring risk have not examined the whole picture, at most examining two of the four relevant factors. Examining the full-range of co-occurring risk factors among groups of individuals – referred to in some studies as an “ecological” or “holistic” approach – can contribute to the understanding of how these factors interact to lead to the development of obesity (Lanza, Rhoades, Nix, & Greenberg, 2010).

The second shortcoming of the literature is that existing studies tend to focus on risk factors at one point in time instead of over time. Evidence exists that as individuals pass through childhood and adolescence, they collect risk factors that exacerbate the risk of obesity (Mayo Clinic, 2016). Thus, this study will examine how the groups change over time, with one possibility being they become more complex in terms of the number of risk factors involved.

**Research Questions**

Our research questions are centered on the number and character of latent classes that exist in adolescence and adulthood, as well as the prevalence and characteristics of individuals in each class. These questions also include a comparison of classes across time points and an investigation into how individuals transition across time. For details on these queries and their corresponding hypotheses, please see below.

**Research Question 1**: How many latent classes of individuals, who exhibit distinct risk behavioral contexts that are likely to contribute to weight gain, exist within these data? Specifically, we are interested in evaluating the number of latent classes that exist, the characteristics of each class based on the likelihood of behavioral contexts, and the prevalence of individuals in each class.
Hypothesis 1: We expect to find several latent classes of individuals who exhibit distinct risk behavioral contexts within these data. Latent classes can be characterized and prevalence of individuals in each class can be identified.

Research Question 2: Do background characteristics (e.g., sex, race/ethnicity, SES, baseline BMI) help to describe individuals in each latent class? For example, are females more prevalent within the emotional eating class?

Hypothesis 2: Covariates will help to distinguish among latent class memberships (e.g., sex, race/ethnicity, SES, baseline BMI).

Research Question 3: Does the same number and type of latent classes persist from adolescence through young adulthood, or does the nature of the classes change across time?

Hypothesis 3: Latent classes will not significantly vary in number and configuration between adolescence and young adulthood.

Methods

Participants

This study was a secondary data analysis using publicly available data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health was directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill (for more detailed information, see Harris et al., 2009).

Add Health collected information on psychosocial and physical health for individuals from adolescence to young adulthood over four survey waves spanning a total of 15 years (See Table 1). For the purposes of this study, we will use data from student
in-home questionnaires because these data include the variables of interest (described below). Only those participants who were obese during the fourth wave of the study (N=1,889) will be included in this study, as we aim to identify early habits and behaviors that may have contributed to the development of obesity. We examined co-occurring behavioral contexts among groups during wave 1 (adolescence: ages 14-17) and wave 3 (young adulthood: ages 18-26) for these participants. We have omitted wave 2 (adolescence: ages 15-18) because it occurs only one year after wave 1, during which fewer changes are likely to occur across variables (i.e., sleep) than a four-year time lapse (wave 1-wave 3).

**Measures**

**Body mass index (BMI).** The Body Mass Index (BMI) of participants in the fourth wave of the survey was used to determine which participants developed obesity. It is worth keeping in mind that BMI reveals only part of a person’s weight profile and does not convey information regarding fat-to-muscle mass ratios, or levels of physical fitness, which may be good indicators of overall health (Sweeting, 2007). However, BMI is a commonly used measure of obesity and is used here because of its availability in the data.

Participants were asked to self-report their height (in feet and in inches) and weight (in pounds). BMI was calculated through converting height and weight into metric measurements and then dividing weight (in kilograms) by height (in meters squared) (Ajilore, Amialchuk, Xiong, & Ye, 2014). Z-scores were then derived from these values through comparison with norms that take into account age and sex via a nationally representative sample: the 2000 Centers for Disease Control Growth Charts (Centers for Disease Control and Prevention, 2002). Data were then classified into categories that
include “normal” (below the 85th percentile of BMI), “overweight” (the 85th-95th percentiles), and “obese” (the 95th percentile and above) groups (Harris et al., 2009). At the final time point in the study (young adulthood), every category except the obese group was excluded from analysis.

**Indicator variables.** The indicator variables/indicators that were included in this model span four behavioral and contextual categories – nutrition, physical activity, sleep, and social/emotional climate– and take into account both individual and environmental behavioral contexts that can influence levels of obesity (See Table 2). For nutrition, the categorical variables included fruit and vegetable consumption, processed food consumption, and fast food visits. For physical activity, the categorical variables included hours spent engaging in physical activity, use of fitness centers in one’s neighborhood, neighborhood safety (a factor of outdoor physical outlet usage), screen time, and time spent viewing TV. For sleep, the average amount of sleep per night was used. For social/emotional climate, feelings of closeness to one’s parent, the number of weekly family meals, level of perceived social acceptance, and levels of depression were used. It is worth noting that, while not all of these variables are available in each wave of the study being used, at least one from each category was available. For a list of all the questions included in each variable, see Appendix A.

For analysis purposes, we dichotomized all responses, informed by theoretical justifications for high and low risk behavioral contexts. For instance, for fruit and vegetable consumption, low risk included adolescents that reported three or more occasions of daily fruit and vegetable consumption, which is consistent with current
guidelines for youth (CDC, 2015a). Table 2 presents dichotomization information on all indicators.

**Daily fruit and vegetable consumption.** In wave 1, participants were asked how often they had eaten fruit or vegetables or had drunk fruit juice during the previous day. Answers included “didn’t eat,” “ate once,” and “ate twice or more.” For analysis, the sum of participants’ numerical answers to these questions were combined within wave 1 and split into high and low risk fruit/vegetable consumption scores. Low risk included adolescents that reported three or more occasions of daily fruit and vegetable consumption, which is consistent with current guidelines for youth (CDC, 2015a). Wave 3 did not contain questions about fruit and vegetables, or particular food varieties, so this time point will be excluded from fruit-vegetable analysis (See Appendix A).

**Daily processed food consumption.** In wave 1, participants were asked how often they ate sweets, including “cookies, doughnuts, pie, or cake” during the previous day. Participants’ numerical answers were dichotomously split simply into either yes (participants did eat sweets on the previous day) or no (participants did not eat sweets on the previous day). No questions about processed foods in particular were administered during wave 3 (See Appendix A).

**Weekly fast food visits.** Because the other categories of nutrition were not asked in wave 3, nutrition data from wave 3 is derived from how many days in the last week adults dined at fast food restaurants. These data were included in the analysis and converted into dichotomous categorical variables split into low risk (less than 1 day per week) and high risk values. These values are based upon dietary recommendations that suggested that individuals who ate at fast food restaurants more than once per week were
at risk for developing obesity (CDC, 2015a). Wave 1 data was not entered in the analysis because it did not include questions about fast food visits (See Appendix A).

**Weekly physical activity occasions.** Across all waves, participants were asked how many times in the past week they had performed certain activities, for example: “During the past week, how many times did you go roller-blading, roller-skating, skateboarding, or bicycling?" (See Appendix A for a full list of physical activity questions). In wave 3, when participants were asked, “Were the last seven days typical in terms of your physical activity?” approximately 80% replied that the past seven days had been typical, so measurement of the past week’s physical activities appeared to be a valid representation of one’s typical activity level for this sample.

Across different activities, participants’ frequency of specific activity-related pursuits was combined to form a total sum of their weekly physical activity occasions, and then split into dichotomous categorical variables: low risk (an average/high physical activity occasion group) and high risk (a low physical activity occasion group). Current guidelines suggest that individuals should aim for at least 60 minutes of physical activity across each of the seven days of the week (CDC, 2015b; WHO, 2016). Assuming an individual’s typical activity lasts approximately an hour, we calculated that individuals should aim for at least seven physical activity occasions per week. Thus, the low risk group contained those that reported seven or greater physical activity occasions per week. Wave 1 included three questions focusing on physical activity occasions, while wave 3 included seven questions about physical activity occasions, expanded to represent the greater diversity of physical activity available to young adults (e.g., golf or weight lifting/strength training). Consistent with the methodology in McPhie & Rawana (2015),
we weighted the wave 3 data by dividing the total sum of weekly physical activity occasions by 7 (the number of items in wave 3), then multiplying by 3 (the number of items in wave 1) in order to have a comparable variable across waves 1 and 3.

**Use of a neighborhood fitness center.** Across all waves, participants were asked whether they used a physical fitness center in their neighborhood. In wave 1, participants were simply asked whether they used that fitness center (dichotomous). In wave 3, participants were asked how many times they had used the fitness center in the last seven days (See Appendix A). Within wave 3, any participant response equal to or greater than 1 was converted into an answer that reflects usage of a fitness center, while a response of 0 reflects non-usage.

**Neighborhood safety.** In terms of neighborhood safety, participants in wave 1 were asked, “Do you usually feel safe in your neighborhood? (yes/no).” This is a categorical dichotomous variable that was used to measure the child’s perceptions of neighborhood safety. No questions about neighborhood safety were administered during wave 3.

**Weekly hours of screen time/TV viewing.** Across waves 1 and 3, participants were asked how many hours a week, on average, they spent engaging in screen time (including computer, TV, and video game usage) and separately how many hours they watched TV (See Appendix A). Current recommendations include that children should spend no more than two hours per day either engaged in screen time or watching TV (American Academy of Pediatrics, 2011, American College of Pediatricians, 2014). Thus, we calculated two hours over seven days of the week and labeled high risk values as greater than or equal to 14 hours per week.
Sleep. During wave 1, participants were asked: “How many hours of sleep do you usually get?” In wave 3, participants were asked what time they go to sleep the night before either a day with a planned activity or a day they will not need to be up at a particular time and what time they wake up the following morning. Thus, for wave 3, the time between going to sleep and waking up was calculated to obtain a continuous variable representing daily hours of sleep. For wave 3, hours of sleep was averaged between planned and unplanned activity/work/school days. Across both waves, daily hours of sleep were divided into dichotomous variables representing high and low risk. The high risk sleep group included those who reported obtaining less than eight average hours per night based on recommendations that individuals should obtain at least eight hours of sleep per night (National Sleep Foundation, 2016).

Family cohesion. Across waves 1 and 3, family cohesion was measured as self-reported closeness to one’s mother. Participants were asked, “How close do you feel to your (mother/adoptive mother/stepmother/foster mother/etc.)?” This variable was dichotomized into “close” (ranging from quite close to extremely close) and “average/not close” (ranging from somewhat to not close at all).

Weekly family meals. Weekly family meals were measured in wave 1 with the question: “On how many of the past 7 days was at least one of your parents in the room with you while you ate your evening meal?” Using the criteria established by Hammons and Fiese (2011), weekly family meals will be split into an average/high frequency per week (greater than or equal to three days per week of family meals) and low frequency. Frequency of family meals was not measured during wave 3 (See Appendix A).

Feelings of social acceptance. During wave 1, participants were asked whether
they agreed or disagreed with the statement: “You feel socially accepted.” Low risk/high social acceptance ranged from agree to strongly agree, while high risk/low social acceptance ranged from neither agree nor disagree to strongly disagree. Also during wave 1, participants were asked: “How much do you feel that your friends care about you?” Again, low risk/high social acceptance ranged from quite a bit to very much, while high risk/low social acceptance ranged from somewhat to not at all. During wave 3, participants were not asked either of the previous questions; we used a similar question (“You felt that people disliked you, during the past seven days.”). Because this item was worded as the inverse of the questions at wave 1, we reverse coded items such that low risk/high social acceptance ranged from never/rarely, while high risk/low social acceptance ranged from a lot of the time/most of the time.

Depression. Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (CES-D) (CES-D Revised, 2015). The CES-D is a reliable and valid instrument that measures the symptoms of depression according to the American Psychiatric Association’s Diagnostic and Statistical Manual, fourth edition (CES-D Revised, 2015; Radloff, 1977; Roberts, Lewinsohn, & Seeley, 1991). In wave 1, 19 of the 20 total items were slightly modified for this sample (Goodman & Whitaker, 2002). In wave 3, nine of these modified items were selected and administered as representative of the overall depression scale. In order to make the scores from waves 1 and 3 consistent, only the nine items used in wave 3 were used in wave 1 (McPhie & Rawana, 2015). Shortened scales of the CES-D have been shown to have high concurrent validity with longer versions (Roberts et al., 1991). Participants’ numerical responses were summed into one continuous score that reflects a participant’s total level of
depressive symptoms.

Across both waves, the range of the scores were 0 (for those who reported having symptoms “not at all of less than one day” to all nine questions) to 27 (for those who reported having symptoms “5-7 days or nearly every day for two weeks” to all nine questions) (CES-D Revised, 2015). The total scores were split into dichotomous categories: depression (a score of ten or above) and no depression (a score of nine or below) (Roberts et al., 1991).

**Covariates.** The covariates used in this study consist of various background characteristics. During wave 1, covariates included sex (male/female), race/ethnicity (Caucasian/minority race or ethnicity), SES/Mother’s Education (high school or less/some college), baseline BMI (not obese/obese at baseline), whether one or more of the individual’s parents were obese at baseline, which we will call “parental obesity” (not obese/obese), and self-reported health, which we will call “health” (good to excellent/fair to poor). During wave 3, covariates included all of the above plus marriage status (married/not married) and participant’s education level (high school or less/some college).

**Data Source, Analysis Software, and Overview of the Data**

LCA was conducted using SAS software, Version 9.4 (SAS Institute, 2014). SAS PROC LCA will be used (The Methodology Center at Pennsylvania State University, 2015). Latent Class Analysis (LCA) is a multivariate latent variable analytical approach that describes relationships between two or more observed categorical variables in terms of their association to a third, discrete latent variable (McCutcheon, 1987). In LCA, latent variables are categorical (i.e., latent groups) and are unobserved and statistically inferred
from the data. Conceptually, latent variables represent groups of individuals with similar characteristics. Unlike observed variables (e.g., sex), which allow direct comparisons, latent variables must be inferred from observed responses. Individuals are classified into mutually exclusive groups and described based on shared behavioral characteristics (Lanza & Collins, 2008; McCutcheon, 1987). Since the number of latent groups is not known a priori, a process of model-fitting is carried out iteratively: the number of classes is progressively increased, and models are compared to arrive at the best solution. LCA can be uniquely used to discern common behavioral patterns when the group membership is not known. LCA is a part of a broader framework of mixture modeling (McLachlan & Peel, 2000), which is increasingly used for analysis of multivariate data.

**Imputation of Missing Data**

LCA utilizes maximum likelihood estimation for missing data on outcome variables, but uses a list-wise deletion approach when there are missing cases for indicator variables and covariates. In this case, we had three covariates for which missing data was 18 percent, 14 percent, and 5 percent of the sample and list-wise deletion would have resulted in 44 percent missing data for across the sample. For details on missing data for each of our indicator variables and covariates, see Table 3. In order to account for missing data, we employed the Multiple Imputation (MI) procedure in SAS 9.2, imputing five datasets, a recommended amount for many MI applications (Lanza, Coffman, & Xu, 2013; Lai-Rose et al., unpublished manuscript; Shiyko & Pappas, 2009). The MI generates 5 sets of data, where missing values are imputed based on the regression procedure accounting for uncertainty. This estimation is based on a different subsample of complete data utilizing auxiliary variables (See Table 3). This approach is
preferable to other traditional methods of handling missing data (e.g., mean replacement or list-wise deletion), because MI preserves data variability and relationships between variables (Enders, 2010; Shiyko & Pappas, 2009).

Following MI, LCA analyses were conducted on each of the five imputed data sets. To arrive at a final solution, we interpreted each model for each imputed data set separately, qualitatively matched each class based on the configuration of item response probabilities, and averaged across 5 sets of parameter estimates (e.g., item-response probabilities, latent class prevalence, fit indices), an approach previously used by researchers utilizing MI with LCA (Lai-Rose et al., unpublished manuscript).

**Comparison of Classes Across Time and Transitions of Individuals Between Classes**

In order to compare whether latent classes changed from adolescence to adulthood, we descriptively compared latent classes at both points in time, including number of classes, their prevalence, and characteristics (co-occurring behavioral and contextual factors) among those classes. This included determining individual class membership, based on class membership probabilities, and examining patterns and frequencies of transitions between the two developmental stages. Traditionally, latent transition analysis (LTA) is used to evaluate changes in an individual’s latent class membership over time statistically (Lanza et al., 2010). In the current dataset, LTA is not feasible, because variables are measured inconsistently between adolescence and young adulthood (e.g., for nutrition, the measurement variable at adolescence is daily processed food consumption, while at young adulthood, it is weekly fast food visits). Thus, we compared and contrasted transitions across time descriptively by using graphs and frequencies.
Results

Sample Descriptives

The sample was comprised of 42% males and 58% females, 68% Caucasian and 32% minority. In addition, 58% of the sample had low SES/education while 42% had high SES/education. Although, by design, the entire sample was obese in wave 4, the baseline BMI in wave 1 included only 25% of obese adolescents (See Table 2).

LCA for Wave 1 (Adolescence): A Six-Class Model with a Diversity of Risk

Behavioral Contexts and Two Depression Classes

Fit statistics and interpretability suggested that a six-class model was the best fit for this data. In terms of model selection, specifically, fit statistics from models with two through six classes were compared (See Table 4). The AIC suggested that the best fit was a six-class model while the BIC suggested that the best fit was a four-class model. Thus, as is common in LCA model fitting, there was some disagreement between the BIC and AIC regarding the optimal number of classes (Dziak, Coffman, Lanza, & Li, 2012; Dziak, Lanza, & Tan, 2014), however, interpretations of the six-class model significantly contributed to an understanding of this population beyond the interpretation of the three-, four- and five-class models. Taken together, the AIC and model interpretability indicated that the six-class model was the best fit for these data (described in more detail below).

For ease of interpretation and because the composition of classes changed slightly between the baseline (without covariates) and covariate models, the results represent the final model with covariates.

Overall, each of the six classes was unique and was comprised of approximately only one or two risk behavioral contexts (See Table 5). The first class, “high screen time
snacking.” was comprised of 24.4% of the individuals in our sample and was characterized by adolescents who reported high screen time/TV viewing and high processed food (snack) consumption (See Table 5). The second class, “low fruit/veg,” was comprised of 21.1% of the sample and characterized by low fruit and vegetable consumption. The third class, “processed food” was comprised of 12.8% of the sample and was characterized by high processed food consumption. The fourth class, “food + screen time,” was comprised of 19.7% of the sample and characterized by risky food consumption (low fruit and vegetable and high processed food consumption) and high screen time and TV viewing. The fifth category, “depression with behavioral factors,” was comprised of 10.2% of the sample and characterized by depression, sedentary behaviors (high screen time/TV viewing, low physical activity), low sleep, and low family meal frequency. The sixth category, “depression,” was comprised of 11.9% of adolescents and characterized by depression without any additional risk factors (See Table 5).

Fitness center usage (individuals did not use fitness centers across all classes), neighborhood safety, and social/relational variables (individuals were close to mothers, and felt socially accepted across all classes) did not discriminate between latent classes.

**Distinguishing Membership Between Classes: Differences in Race/Ethnicity, Gender, SES, and Health**

Sex, race/ethnicity, SES/mother’s education level, and health distinguished class membership during adolescence. We used the largest latent class, “high screen time snacking” as a reference group (McLachlan & Peel, 2000). Individuals from a minority race/ethnicity were more likely than those from a majority race/ethnicity to be members
of classes with additional food-related risk factors such as low fruit and vegetable consumption. Specifically, minority race individuals were more likely to be in the “food + screen time” class (OR = 11.63, p < 0.001) compared to their membership in the “high screen time snacking” class. Minority race individuals were also more likely to be in both depression classes (OR = 3.25, p < 0.001, OR = 2.78, p < 0.001) than in the “high screen time snacking” class (See Table 7).

Similarly, those in fair-poor health compared to those in good-excellent health were also more likely to be both of the depression classes and the higher food-related risk class (“food + screen time”) compared to membership in the “high screen time snacking” class (OR = 14.95, p < 0.001, OR = 9.09, p < 0.001, OR = 4.80, p < 0.001, respectively) (See Table 7).

Females generally were less likely than males to be members of classes that consumed processed food in the absence of screen time (OR = 0.07, p < 0.001), but were more likely than males to belong to the “low fruit/veg” group (OR = 2.08, p < 0.001) over membership in the “high screen time snacking” group.

Those who had higher SES backgrounds or whose mothers attained at least some college education were more likely to be part of the “low fruit/veg” group, compared to membership in the “high screen time snacking” class (OR = 2.08, p = 0.01) (See Table 7).

Interestingly, covariates that did not predict class membership included both whether one was obese at baseline or had one or more parent with obesity at baseline (See Table 7).
LCA for Wave 3 (Adulthood): A Six-Class Model with Classes Containing Many
Multiple Risk Behavioral Contexts

Consideration of fit statistics model interpretability indicated that a six-class model was the best fit for these data. In terms of model selection, specifically, fit statistics from models with two through six classes were compared (See Table 4). The AIC suggested that the best fit was a six-class model while the BIC suggested that the best fit was a three-class model. Interpretations of the six-class model significantly contributed to an understanding of this population beyond the interpretation of the three-, four- and five-class models. Taken together, the AIC and model interpretability indicated that the six-class model was the best fit for these data (described in more detail below).

For ease of interpretation and because the composition of classes changed slightly between the baseline (without covariates) and covariate models, the results represent the final model with covariates.

Overall, each of the six classes was unique and was comprised of multiple risk behavioral contexts. The first class, “depression with behavioral factors,” included 6.5% of the young adults in our sample and was characterized by risky food behaviors, low physical activity, and low sleep (See Table 6). The second class, “food + sedentary (use fit ctr) + low sleep,” included 15.3% of the sample and was characterized by risky food consumption, sedentary behaviors (high screen time/TV viewing, low physical activity), and low sleep. However, members of this group generally reported using a fitness center. The third and most prevalent class, “food + sedentary (no fit ctr use) + low sleep,” included 30.6% of the sample and was similar to the second class, except members generally reported no fitness center usage. The fourth class, “food + sedentary,” included
14.7% of the sample and, like the second and third classes, were characterized by risky food behaviors and sedentary behavior, but not low sleep. The fifth category, “food + low PA,” included 23.2% of the sample and was characterized by risky food consumption and low physical activity. The sixth category “food + low PA + low sleep,” included 9.7% of adolescents and was characterized by risky food behaviors, low physical activity, and low sleep (See Table 6). Social/relational variables did not discriminate between classes.

**Distinguishing Membership between Classes: Differences in Gender, SES, and Education Level**

Sex, SES/mother’s education level, and participant’s education level significantly distinguished class membership. The comparison group was the most prevalent class: “food + sedentary + low sleep.” Females were more likely than males to be in the “depression” class at adulthood (OR= 2.95, \( p < 0.001 \)) than members of the comparison group (See Table 8).

Although SES/mother’s education level was significant in distinguishing between class membership overall (\( p < 0.05 \)), specific comparisons between classes were not significant. There were differences however, for individual education level: those who attained at least some college education were more likely than those who had high school education or less to be in a class that used a fitness center (“food + sedentary (use fitctr) + low sleep”) and less likely to be in the depression class (OR=2.32, \( p < 0.001 \), OR=0.53, \( p < 0.001 \)) (See Table 8).

In adulthood, baseline obesity status and having at least one parent with obesity was not a significant predictor of group membership, as in wave 1. Being married was also not a predictor of group membership. Although race and health were significant
predictors of group membership in adolescence, they were no longer significant predictors of group membership in adulthood (See Table 8).

**Descriptive Comparison across Classes for Waves 1 and 3**

**Transitions in Class Membership from Adolescence to Adulthood**

Figure 3 presents a graphical summary of transitions from wave 1 (adolescence) to wave 3 (adulthood). A majority of individuals from most classes in wave 1 transitioned to class 3 (“food + sedentary + low sleep”) in wave 3. A majority of individuals from five out of the six classes from wave 1 (“high screen time,” “processed food,” “food + high screen time,” “depression,” and “depression with behavioral factors”) transitioned to class 3 (“food + sedentary + low sleep”) in adulthood.

Figure 3 depicts the high prevalence of those with depression from wave 1 that transitioned primarily into two groups in wave 3 (“food + sedentary + low sleep” and “depression with behavioral factors”) (25.9% and 21.9%, respectively) compared to the rest of wave 1 groups combined that transitioned into these two wave 3 groups (21.3% and 17.6% respectively). Transitions into wave 3 classes were roughly equal across other wave 1 classes.

**Discussion**

Using previously identified, modifiable risk behavioral contexts for weight gain (nutrition, physical activity, sleep, and social/emotional climate) (Brown et al., 2015; De Vriendt et al., 2011; Dev et al., 2013; Hart et al., 2011; Jelalian & Steele, 2008; Michels et al., 2012; Reilly et al., 2005), we examined the co-occurring effects of these behavioral contexts across time, an approach which has been utilized in only a few studies and even
then without focusing on the full range of factors (Huh et al., 2011; Ottevaere et al., 2011; Scharoun-Lee et al., 2011).

Our first goal included identification, characterization, and measurement of the prevalence of latent classes of individuals who exhibit distinct risk behavioral contexts likely to contribute to weight gain. Our second goal included identifying background characteristics/covariates that describe individuals in each latent class. Our third goal included a comparison of the number and configuration of latent classes from adolescence to adulthood. In order to accomplish our goals, we analyzed longitudinal data measured at adolescence and adulthood, identified latent classes of individuals who exhibited co-occurring risk behavioral contexts for obesity, explored the characteristics of individuals in each latent class, and examined transitions from one class to another over time. At the beginning of this study, several hypotheses were laid out. Below, we provide a discussion of how these hypotheses were supported (or not) by the data.

**Hypothesis 1: Latent Classes with Varying Behavioral Factors Can be Identified**

Hypothesis 1 stated that several latent classes of risk behavioral factors existed and could be characterized within these data. Furthermore, prevalence of individuals in each class could be identified. Overall, discrete latent classes (six in number) of behavioral contexts were identified during adolescence and six during young adulthood among our sample of individuals who were obese in middle adulthood. The identification of unique groups in this study lends support to our first hypothesis and suggests vast differences in the factors that led those in middle adulthood to develop obesity (or maintain it from youth). Consistent with prior research, significant risk behavioral contexts among these classes in both adolescence and adulthood included nutrition (fruit
and vegetable consumption, processed food consumption), physical activity (physical activity occasions, use of a fitness center, neighborhood safety, screen time/TV viewing), sleep, and some social/emotional climate variables (family meal frequency, depression) (Brown et al., 2015; De Vriendt et al., 2011; Dev et al., 2013; Hart, Cairns, & Jelalian, 2011; Jelalian & Steele, 2008; Michels et al., 2012; Reilly et al., 2005).

The various classes identified provide valuable insight into how risk factors interact to lead to obesity and how those risks change over time. Approximately half of adolescents (54.3%) were in at least one class characterized by high-risk screen time/TV viewing (over 14 hours per week), and this number was higher (60.6%) for young adults. Furthermore, in adolescence, latent classes characterized by high-risk screen time/TV viewing were separate from classes characterized by high-risk (low) physical activity (except for the depression class) (See Table 5).

This result is consistent with prior research that suggests the effect of screen time goes beyond simply taking the place of time spent on physical activity. In particular, in adolescence, the “high screen time snacking” class suggests that both snacking and screen time may occur together, which is consistent with prior research findings that screen time/TV viewing exposes individuals to processed food advertisements resulting in food cravings and is also a type of sedentary behavior that encourages snacking (Lobstein & Dibb, 2005; Brown et al., 2011; Matheson Killen, Wang, Varady, & Robinson, 2004). These results also suggest that screen time may be different in quality from other sedentary activities such as reading, which is again consistent with prior research (Cooper, Klesges, DeBon, Klesges, & Shelton, 2006).
Another area for future research is on the role of screen time and results from the timing of the data collection used here. Wave 1 of the Add Health study was collected in 1994. Since then, screen time has expanded to include more portable devices such as cell phones, tablets, and laptops, for example. As a result, children may be spending more time on screens and may even be engaging with two or more screens at once. Thus, the high prevalence of screen time in our study during both adolescence and adulthood may be more pronounced if data were collected at our current point in time.

The nature of the identified classes also has implications for how clinicians view depression and obesity development in adolescence. There were two depression classes in adolescence (depression only and depression with behavioral factors) and together these comprised 22.1% of the sample. This rate is disproportionate to the prevalence of teenage depression in the overall population (approximately 11%), suggesting those who are obese in adolescence or become obese in adulthood are disproportionately depressed as teens (Center for Behavioral Health Statistics and Quality, 2015). For the portion of the adolescent sample who were depressed but not obese (and thus became obese later) (17%), this finding also supports prior research on the link between depression in adolescence and obesity development in early and middle adulthood (Franko, Striegel-Moore, Thompson, Schreiber, & Daniels, 2005; Gaysina et al., 2011; Hasler et al., 2005; Stice et al., 2005). Thus, for these adolescents, depression may have led to the development of obesity over a longer course of time and thus should be viewed in this context.

Perhaps more importantly, the identification of two separate classes of individuals with depression (one with behavioral aspects and one with depression by itself) suggests
the condition cannot be viewed uniformly with respect to obesity. Membership in the two depression classes in adolescence was almost equally divided between depression with behavioral factors (low physical activity, high screen time/TV viewing, fewer family meals, and low sleep) and depression alone (See Table 5). Of course, the discussion of depression would be incomplete without mention that the diagnosis of Major Depressive Disorder (MDD) is dependent on presence of depressed mood as well as a variety of criteria, some of which was measured in this study. For instance, criteria for depression include presence of either insomnia or hypersomnia, and increase or decrease in appetite/significant weight gain or loss. Our depression with behavioral factors class includes some of these behaviors (e.g., insomnia) and it is important to mention that our “depression only” category may contain some of these factors as well at the opposite end, including hypersomnia and weight loss/decreased appetite. We were unable to observe these behavioral factors in the “depression only” group due to the split points used in this study. Future research should investigate these relationships further.

The results related to Hypothesis 1, that six discrete latent classes of behavioral contexts were identified during adolescence and young adulthood, also has implications for clinicians targeting prevention of “unhealthy” habits developing in adulthood. It is worth noting that almost all adults with obesity displayed some kind of food related risky behavior combined with low physical activity, which was not the case for these same individuals when they were adolescents. This finding suggests targeting food behavior and physical activity in adolescence would be a useful avenue for clinicians regardless of whatever other behaviors the individual may be displaying. In this way, the development of risky food and physical activity behaviors and habits can be prevented.
It is also worth noting that the results suggest depression in young adulthood occurred at a much lower rate (6.5%) than in adolescence for our sample. Again, the characteristics of the depression with behavioral factors class (depression, low sleep, low physical activity, high fast food consumption) may help to describe how depression manifests in this group of individuals. Over half of those who were members of the depressed class as young adults were also members of one of the depressed classes in adolescence. Reoccurrence or cycling of depression is common in those that have experienced an episode of depression (American Psychiatric Association, 2013), thus it is not surprising that even if adolescents sought treatment for their depression, some may still suffer from persistent chronic depression and others may re-experience bouts of depression at certain points in their lives. Because this study only collected data at specific points in time, it may miss these patterns in the development and course of depression over time. Thus, future studies may benefit from more continuous data collection, or data collection that is collected more often throughout the life course, such as studies utilizing ecological momentary methods, for example.

In this way, identification and description of unique latent groups in adolescence and young adulthood of those that are obese in middle adulthood is a useful endeavor that contributes to our general knowledge of the development and maintenance of obesity, and is also useful for clinicians working to prevent obesity development. Another way in which clinicians can address prevention is through knowing which prevention efforts are best targeted at which groups. Hypothesis two sheds light onto which demographic groups are more vulnerable to certain group memberships, information that contributes
both to our general knowledge and to guidance for clinicians' prevention efforts given the demographics of the individuals they serve.

**Hypothesis 2: Covariates Distinguished Among Latent Class Membership**

Our second goal, to identify background characteristics/covariates that describe individuals in each latent class was supported. Significant demographic predictors of class membership included sex, SES/mother’s education, race/ethnicity, health, and individual education. These findings can be useful because they can offer clues at intake as to the underlying risks a person may have with respect to obesity.

For example, female adolescents were less likely than males to be members of classes displaying high processed food consumption. In turn, females were more likely to be a member of the group characterized by low screen time and low fruit and vegetable consumption. While the finding of low screen time for females may seem encouraging, research also indicates that females have lower levels of physical activity compared to males (Ottevaera et al., 2011), suggesting that females may not be replacing low screen time hours with time spent on physical activity. The joint findings that females are less likely to consume processed food, less likely to consume fruit and vegetables, and less likely to have high screen time suggests clinicians working with adolescent girls may consider focusing less on reducing risky behaviors like eating processed food and watching too much TV and more on increasing protective activities, like eating fruits and vegetables and engaging in physical activity.

In terms of race/ethnicity, those from a minority race were more likely to be members of both depression classes in adolescence. At least in adolescence, it is possible that part of this relationship can be explained by discrimination, as this has shown to be
positively correlated with symptoms of depression (Huynh, 2012). In any case, those working with adolescent minorities should be aware that depression may be a frequent risk factor for developing obesity among this population. Yet, depression is not the most striking finding for minorities, who were even more disproportionately likely to be in the group comprised of high processed food and high screen time. Clinicians working with minority adolescents may want to focus on these dual behaviors as an obvious way to reduce the risk of obesity for this group.

In young adulthood, no demographic differences emerged across groups in terms of food or physical activity, however, females were more likely to be a part of the depressed group compared to membership in the most prevalent class (“food + sedentary + low sleep”). This finding is consistent with research that depression is more prevalent overall in women (Essau, Lewinsohn, Seeley, & Sasagawa, 2010). This finding may be especially useful for clinicians working with females presenting as obese, since it suggests depression may be a cause worth investigating early.

Finally, in young adulthood, individual education distinguished between class membership; those with at least some college education were more likely to be members of the depressed class and the “food + sedentary (use fitness center) + low sleep” class compared to the most prevalent class [“food + sedentary (no fitness center use) + low sleep”]. It seems individuals in this study with more education are more likely to have access to a fitness center than those without education (perhaps due to higher overall financial resources), but are still likely to exhibit other risky behaviors. Fitness center use may give clinicians for these individuals a tool to offset sedentary behavior not available
for those with less education. Although there is no existing literature on these relationships, they may be worthy of further inquiry.

Interestingly, both obesity in adolescence and whether one’s parents were obese during the child’s adolescence were not significant predictors of class membership at either time point. In other words, knowledge of whether an adolescent is obese does not provide insight into his or her underlying risky behaviors. This suggests that other contexts such as gender, race, SES, and education were predictors of group membership in this sample, and not physical weight-related factors of oneself and one’s parents.

Knowledge about which demographic and contextual factors guide group membership (and which do not) provides researchers and clinicians with further information that can be adapted towards future research and prevention efforts. Lastly, the descriptive comparisons of classes over time and transitions of individuals from adolescence to adulthood may also serve useful for researchers and clinicians with longitudinal aims.

**Hypothesis 3: Differences in Quality But Not Quantity of Latent Classes between Adolescence and Young Adulthood**

Partial support was found for our third hypothesis: although the number of classes did not differ between adolescence and young adulthood, the character of the classes did. Practically, two findings emerged that are especially relevant for researchers and clinicians and that suggest directions for future work: 1) classes tended to become more complex with age, consistent with an increase in risky behaviors as individuals became obese as adults; and 2) an individual’s class as an adolescent was not necessarily predictive of the risk class as an adult.
On the first point, in adolescence, half of the classes were comprised of only one or two risk behavioral contexts. In young adulthood, the lowest number of risk behaviors exhibited by a class was three. This finding is intuitive; many adolescents in the study were not yet obese and so may have only been exhibiting a few of the risk behaviors associated with obesity. But, as they approach the stage of their life when, by inclusion in the sample they have become obese, they accumulated the risky behaviors that ultimately led them there. While intuitive, this finding highlights the importance of dealing with risky behaviors when individuals are young and when there may only be a few, versus waiting until obesity presents itself and many behaviors are in play. In other words, working with adolescents who may not yet be obese but are displaying a few risky behaviors may be a more efficient way to deal with adult obesity than the treatment of adults themselves. This line of reasoning also suggests directions for future research. Because the present study only examined individuals who ultimately develop obesity, determining which latent classes are more likely to actually develop obesity was not possible. Yet, this information would help clinicians identify which groups of behaviors are most important to address.

The total result of having more risk factors for young adults was that classes during young adulthood were also more similar to one another than classes during adolescence. Risky food consumption, sedentary behavior, and low sleep were more prevalent during young adulthood than during adolescence. Indeed, research shows that the transition to young adulthood is a unique developmental period wherein risky food consumption increases while sedentary behaviors also increase, making young adults vulnerable to weight gain (Ferrara, 2009; Gorden-Larsen, Nelson, & Popkin, 2004;
Kwan, Cairney, Faulkner, & Pullenayegum, 2012) reinforcing the notion that intervening while young is important.

In terms of transitions, a majority of individuals who had just a single risk factor of processed food, lack of activity, or depression in adolescence transitioned to a class with three risk factors, “Food + Sedentary + Low Sleep,” in young adulthood. This finding suggests that eating larger amounts of processed food, having high screen time/TV viewing, or having symptoms of depression in adolescence might put one at risk for developing additional factors surrounding these risks in young adulthood. Another interesting pattern was that those who exhibited depression (with or without behavior factors) in adolescence were much more likely to transition to one of two classes in young adulthood: 1) the single depression class with behavioral factors or 2) the sedentary class with processed food choices. Depression is persistent and if present when young, for this sample, it was either more likely to present when older or was replaced with more risk factors.

But, perhaps more interesting than the patterns identified above, is the general lack of a clear pattern in transitions between classes. Figure 3 shows that all of the classes in adulthood are comprised of individuals from all of the adolescent classes. This shows that regardless of the risk factors present when individuals were young, they are likely to display many more risk factors once older, although the mix of factors is not predictable. It seems that the findings under hypothesis 3 support the notion of intervening while individuals are young, before the variety of risk factors associated with obesity in adulthood have developed.
Despite these interesting results, little current research exists about the transitions of risk behavioral contexts of weight gain from adolescence to adulthood. More investigation is needed in this area, including identifying the developmental mechanisms that may lead to weight gain over time and investigating the timing of risk factors that apparently develop between adolescence and young adulthood. One thing is clear: possible efforts at preventing obesity from developing should start early.

**Strengths & Limitations of this Study**

This is one of few studies to examine multiple risk behavioral contexts of obesity simultaneously and across time using latent class analysis. Through this methodology, we explored the number of discrete classes of co-occurring behavioral contexts in adolescence and adulthood, characteristics of individuals in each latent class, predictors of class membership, and transitions across time. This enabled us to gather information about classes of risk behavioral contexts that existed amongst those who either maintained obesity or became obese during middle adulthood.

The dataset used, Add Health, is a rich national data set containing information on many dimensions of individuals’ lives, is nationally representative, and spans approximately a decade and a half. This study also included examination of a wide array of behavioral and contextual factors spanning the areas of nutrition, physical activity, sleep, and social/emotional climate. Through evaluation of behavioral contexts, we were able to identify the most prevalent latent classes during adolescence and adulthood, and were able to track transitions of individuals longitudinally from adolescence to adulthood. We were also able to identify screen time/TV viewing as a highly prevalent factor across groups for both time periods, and describe unusually high levels of depression (and the
behavioral characteristics present in these depression groups) amongst two groups in adolescence and one group in adulthood for our sample of individuals. We were able to ascertain which covariates (gender, race/ethnicity, SES, etc.) predicted class membership and which did not (baseline obesity, parental obesity).

Limitations of this study also exist. Because this is a secondary analysis, we were limited in the variables included in the study, which sometimes resulted in different measurements across time periods. While many of the variables we used were consistent (fitness center usage, physical activity, screen time/TV viewing, for example) others were not (fruit and vegetable consumption was not measured in adulthood, family meal frequency was also not measured in adulthood). In this way, we did not have an exact comparison of behaviors from adolescence to adulthood. However, we were able to descriptively compare categories and glean information from that analysis.

Because we selected from a sample of those that were obese in middle adulthood, we cannot conclude that the latent groups of risk behavioral contexts cause individuals to develop obesity. Our conclusions are limited to describing the risk behavioral contexts in latent groups of those that either maintain obesity or become obese in middle adulthood. We also do not identify groups of individuals who are obese in adolescence but are not obese in middle adulthood. In the future, it would be interesting to compare such groups.

**Conclusions**

This study suggests that during adolescence and young adulthood, there are heterogeneous, discrete classes (totaling six in number) of individuals with differing risk behavioral contexts for obesity amongst those obese in middle adulthood. In adolescence, these classes generally contain one or two risk behavioral contexts, while in adulthood,
classes are comprised of multiple risk behavioral contexts, almost all of which include nutrition and physical activity risk factors. Additionally, a majority of adolescents transition to a class with three risk factors, “Food + Sedentary (no fitness center use) + Low Sleep,” in adulthood.

These findings indicate that the time between adolescence and young adulthood is a crucial time period in which to intervene to create healthy nutrition, physical activity, and sleep habits. In this study, it appears that as individuals aged, they developed additional risk factors for obesity, so intervening early may aid this population of those that are obese in middle adulthood in developing fewer risk behavioral factors over the life course.

Much remains unknown about those who maintain or develop obesity in middle adulthood. While we compared similar categories from adolescence to middle adulthood, future research should pursue latent transition analysis using the same measurements across time periods. Future research is also needed to compare latent classes amongst varying groups, including those that are obese as adolescents but are not obese in middle adulthood. In this way, more information could be gathered to help explain the development and maintenance of behavioral contexts associated with obesity development across time.
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Table 1

Descriptors of Waves of Data from the National Longitudinal Study of Adolescent to Adult Health (Add Health) Questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave 3</th>
<th>Wave 4*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ages</td>
<td>14-17 years</td>
<td>15-18 years</td>
<td>18-26 years</td>
<td>24-32 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,889 obese adults</td>
</tr>
</tbody>
</table>

Note. *Wave 4 used only to determine number of participants who are obese in middle adulthood. Data collected from waves 1 and 3 were analyzed only for the 1,889 participants who were obese during wave 4 (middle adulthood).
Table 2

Percent of Participants in Each Latent Class Indicator Variable

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator Variables</th>
<th>Wave 1 (Ages 14-17)</th>
<th>Wave 3 (Ages 18-26)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nutrition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Fruit/Vegetable</td>
<td>Low Risk (3 or greater)</td>
<td>59.1</td>
<td>--</td>
</tr>
<tr>
<td>Consumption</td>
<td>High Risk (Less than 3)</td>
<td>40.9</td>
<td>--</td>
</tr>
<tr>
<td>Daily Processed Food</td>
<td>Low Risk (Less than 1)</td>
<td>50.5</td>
<td>--</td>
</tr>
<tr>
<td>Consumption</td>
<td>High Risk (1 or more)</td>
<td>49.5</td>
<td>--</td>
</tr>
<tr>
<td>Weekly Fast Food Visits</td>
<td>Low Risk (1 day or less)</td>
<td>--</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>High Risk (2 or more days)</td>
<td>--</td>
<td>82.9</td>
</tr>
<tr>
<td><strong>Physical Activity</strong></td>
<td>Weekly Physical Activity Occasions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Risk (7 or greater)</td>
<td>64.8</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>High Risk (Less than 7)</td>
<td>35.2</td>
<td>86.4</td>
</tr>
<tr>
<td>Fitness Center Usage</td>
<td>Low Risk (Usage)</td>
<td>18.9</td>
<td>32.4</td>
</tr>
<tr>
<td></td>
<td>High Risk (No usage)</td>
<td>81.1</td>
<td>67.6</td>
</tr>
<tr>
<td>Weekly Screen Time (TV, videos, &amp; computer/video games)</td>
<td>Low Risk (Less than 14 hours)</td>
<td>38.7</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>High Risk (14 hours or more)</td>
<td>61.3</td>
<td>66.0</td>
</tr>
<tr>
<td>Weekly TV Viewing</td>
<td>Low Risk (Less than 14 hours)</td>
<td>51.3</td>
<td>61.1</td>
</tr>
<tr>
<td></td>
<td>High Risk (14 hours or more)</td>
<td>48.7</td>
<td>38.9</td>
</tr>
<tr>
<td><strong>Neighborhood Safety</strong></td>
<td>Low Risk (Safe)</td>
<td>88.3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>High Risk (Unsafe)</td>
<td>11.7</td>
<td>--</td>
</tr>
<tr>
<td><strong>Sleep</strong></td>
<td>Daily Sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Risk (8 hours or more)</td>
<td>61.2</td>
<td>48.4</td>
</tr>
<tr>
<td></td>
<td>High Risk (Less than 8 hours)</td>
<td>38.8</td>
<td>51.6</td>
</tr>
<tr>
<td><strong>Emotional/ Relational</strong></td>
<td>Weekly Family Meals</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Risk (5 days or more)</td>
<td>75.2</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>High Risk (Less than 5 days)</td>
<td>24.8</td>
<td>--</td>
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<tr>
<td>Depression Score (CES-D)</td>
<td>Low Risk (Not clinically depressed)</td>
<td>84.2</td>
<td>87.0</td>
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<td></td>
<td>High Risk (Clinically depressed)</td>
<td>15.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Closeness to Mother</td>
<td>Low Risk (Quite a bit to very much)</td>
<td>85.8</td>
<td>94.7</td>
</tr>
<tr>
<td>Behavioral Context</td>
<td>High Risk (Not at all to somewhat)</td>
<td>Low Risk (Agree to strongly agree)</td>
<td>High Risk (Neutral to disagree)</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Feeling Socially Accepted</td>
<td>14.2</td>
<td>84.6</td>
<td>15.4</td>
</tr>
<tr>
<td>Feeling Friends Care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling People Dislike You</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. N varies slightly among each behavioral context based on missing data. Amount of missing data did not exceed more than 29 participants out of 1586 total participants.
Table 3

*Missing Data for Indicators and Covariates*

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator Variables</th>
<th>Wave 1 (Ages 14-17)</th>
<th>Wave 3 (Ages 18-26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td><em>Daily Fruit/Vegetable Consumption</em></td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><em>Daily Processed Food Consumption</em></td>
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<td>--</td>
</tr>
<tr>
<td></td>
<td><em>Weekly Fast Food Visits</em></td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Physical Activity</td>
<td><em>Weekly Physical Activity Occasions</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Fitness Center Usage</em></td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Weekly Screen Time (TV, videos, &amp; computer/video games)</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Weekly TV Viewing</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Neighborhood Safety</em></td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Sleep</td>
<td><em>Daily Sleep</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Emotional/ Relational</td>
<td><em>Weekly Family Meals</em></td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><em>Depression Score (CES-D)</em></td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><em>Closeness to Mother</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Feeling Socially Accepted</em></td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><em>Feeling Friends Care</em></td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><em>Feeling People Dislike You</em></td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Covariates</td>
<td><em>Sex</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Race/Ethnicity</em></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><em>SES/Mother’s Education Level</em></td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td><em>Baseline BMI</em></td>
<td>217</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td><em>Parent Obesity</em></td>
<td>278</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td><em>Health</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Married</em></td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><em>Individual Education Level</em></td>
<td>--</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note. N= 1586. Auxiliary variables included whether one’s parents were immigrants, whether one was from a single parent household or not, and whether one has asthma.*
Table 4

*Fit Statistics and Model Fit Information*

<table>
<thead>
<tr>
<th>Number of Classes</th>
<th>Likelihood Ratio $G^2$</th>
<th>Degrees of Freedom</th>
<th>AIC</th>
<th>BIC</th>
<th>CAIC</th>
<th>ABIC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wave 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2717.0</td>
<td>8164</td>
<td>2771.0</td>
<td>2915.9</td>
<td>2942.9</td>
<td>2830.2</td>
</tr>
<tr>
<td>3</td>
<td>2433.5</td>
<td>8150</td>
<td>2515.5</td>
<td>2735.7</td>
<td>2776.7</td>
<td>2605.4</td>
</tr>
<tr>
<td>4</td>
<td>2284.9</td>
<td>8136</td>
<td>2394.9</td>
<td>2690.2</td>
<td>2745.2</td>
<td><strong>2515.5</strong></td>
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<tr>
<td>5</td>
<td>2226.6</td>
<td>8122</td>
<td>2364.6</td>
<td>2735.1</td>
<td>2804.1</td>
<td>2515.9</td>
</tr>
<tr>
<td>6</td>
<td>2181.6</td>
<td>8108</td>
<td><strong>2347.6</strong></td>
<td>2793.2</td>
<td>2876.2</td>
<td>2529.6</td>
</tr>
<tr>
<td><strong>Wave 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>436.9</td>
<td>492</td>
<td>474.9</td>
<td>576.9</td>
<td>595.9</td>
<td>516.5</td>
</tr>
<tr>
<td>3</td>
<td>333.1</td>
<td>482</td>
<td>391.1</td>
<td><strong>546.8</strong></td>
<td><strong>575.8</strong></td>
<td>454.7</td>
</tr>
<tr>
<td>4</td>
<td>284.5</td>
<td>472</td>
<td>362.5</td>
<td>571.9</td>
<td>610.9</td>
<td><strong>448.0</strong></td>
</tr>
<tr>
<td>5</td>
<td>249.8</td>
<td>462</td>
<td>347.8</td>
<td>610.8</td>
<td>659.8</td>
<td>455.2</td>
</tr>
<tr>
<td>6</td>
<td>228.8</td>
<td>452</td>
<td><strong>346.8</strong></td>
<td>663.6</td>
<td>722.6</td>
<td>476.1</td>
</tr>
</tbody>
</table>

*Note.* AIC = Akaike Information Criteria, BIC = Bayesian Information Criteria, CAIC = Corrected Akaike Information Criteria, ABIC = Adjusted Bayesian Information Criteria.
Table 5

Wave 1 (Adolescence) Latent Class Prevalence and Item-Response Probabilities for High Engagement in Behavioral Contexts

<table>
<thead>
<tr>
<th>Wave 1</th>
<th>Class 1:</th>
<th>Class 2:</th>
<th>Class 3:</th>
<th>Class 4:</th>
<th>Class 5:</th>
<th>Class 6:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Screen Time</td>
<td>Low Fruit/Veg Snacking</td>
<td>Processed Food</td>
<td>Food + Screen Time</td>
<td>Depression with Behavioral Factors</td>
<td>Depression</td>
</tr>
<tr>
<td>Latent class prevalence</td>
<td>24.4%</td>
<td>21.1%</td>
<td>12.8%</td>
<td>19.7%</td>
<td>10.2%</td>
<td>11.9%</td>
</tr>
<tr>
<td>Item-response probabilities</td>
<td><strong>Bolded item-response probabilities indicate values greater than 0.50.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low fruit/veg consumption</td>
<td>.311</td>
<td>.560</td>
<td>.326</td>
<td>.571</td>
<td>.234</td>
<td>.294</td>
</tr>
<tr>
<td>High processed food</td>
<td>.501</td>
<td>.444</td>
<td>.520</td>
<td>.631</td>
<td>.449</td>
<td>.349</td>
</tr>
<tr>
<td>Low phys. activity occasions</td>
<td>.477</td>
<td>.388</td>
<td>.470</td>
<td>.320</td>
<td>.590</td>
<td>.461</td>
</tr>
<tr>
<td>No fitness center attendance</td>
<td><strong>.870</strong></td>
<td><strong>.817</strong></td>
<td><strong>.746</strong></td>
<td><strong>.686</strong></td>
<td><strong>.948</strong></td>
<td><strong>.835</strong></td>
</tr>
<tr>
<td>High screen time</td>
<td><strong>.999</strong></td>
<td>.195</td>
<td>.152</td>
<td><strong>1.00</strong></td>
<td><strong>.999</strong></td>
<td>.086</td>
</tr>
<tr>
<td>High TV viewing</td>
<td><strong>.948</strong></td>
<td><strong>.000</strong></td>
<td>.005</td>
<td><strong>.852</strong></td>
<td><strong>.878</strong></td>
<td>.006</td>
</tr>
<tr>
<td>Low safety</td>
<td>.083</td>
<td>.026</td>
<td>.071</td>
<td>.134</td>
<td>.280</td>
<td>.219</td>
</tr>
<tr>
<td>Low sleep</td>
<td>.244</td>
<td>.391</td>
<td>.442</td>
<td>.405</td>
<td><strong>.537</strong></td>
<td>.465</td>
</tr>
<tr>
<td>Low family meal frequency</td>
<td>.094</td>
<td>.185</td>
<td>.276</td>
<td>.222</td>
<td><strong>.550</strong></td>
<td>.456</td>
</tr>
<tr>
<td>Depression</td>
<td>.059</td>
<td>.037</td>
<td>.039</td>
<td>.069</td>
<td><strong>.541</strong></td>
<td><strong>.518</strong></td>
</tr>
<tr>
<td>Not close to mom</td>
<td>.060</td>
<td>.090</td>
<td>.050</td>
<td>.051</td>
<td>.466</td>
<td>.381</td>
</tr>
<tr>
<td>Not feel socially accepted</td>
<td>.088</td>
<td>.034</td>
<td>.065</td>
<td>.088</td>
<td>.458</td>
<td>.441</td>
</tr>
<tr>
<td>Friends care</td>
<td>.060</td>
<td>.001</td>
<td>.319</td>
<td>.224</td>
<td>.324</td>
<td>.328</td>
</tr>
</tbody>
</table>

*Note. N= 1586.*
Table 6

*Wave 3 (Adulthood) Latent Class Prevalence and Item-Response Probabilities for High Engagement in Behavioral Context*

<table>
<thead>
<tr>
<th>Class</th>
<th>Indicators</th>
<th>Wave 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1: Depression with Behavior Factors</td>
<td>Latent class prevalence</td>
<td>6.5%</td>
</tr>
<tr>
<td>Class 2: Food + Sedentariness (Use FitCtr) + Low Sleep</td>
<td>High fast food consumption</td>
<td>.799</td>
</tr>
<tr>
<td>Class 3: Food + Sedentariness + Low Sleep</td>
<td>Low phys. activity occasions</td>
<td>1.00</td>
</tr>
<tr>
<td>Class 4: Food + Sedentariness</td>
<td>No fitness center attendance</td>
<td>.795</td>
</tr>
<tr>
<td>Class 5: Food + Low PA</td>
<td>High screen time</td>
<td>.320</td>
</tr>
<tr>
<td>Class 6: Food + Low PA + Low Sleep</td>
<td>High TV viewing</td>
<td>.001</td>
</tr>
<tr>
<td>Class 6: Food + Low PA + Low Sleep</td>
<td>Low sleep</td>
<td>.508</td>
</tr>
<tr>
<td>Class 5: Food + Low PA</td>
<td>Depression</td>
<td>.850</td>
</tr>
<tr>
<td>Class 6: Food + Low PA + Low Sleep</td>
<td>Not close to mom</td>
<td>.135</td>
</tr>
<tr>
<td>Class 6: Food + Low PA + Low Sleep</td>
<td>People dislike</td>
<td>.312</td>
</tr>
</tbody>
</table>

*Note. N= 1586. Bolded item-response probabilities indicate values greater than 0.50.*
Table 7

Odds Ratios - LCA With Covariates (Sex, Baseline BMI, Race/Ethnicity, SES/Mother’s Education Level, Parent Obesity, Health) for Wave 1

<table>
<thead>
<tr>
<th>Class:</th>
<th>Class 1: High Screen Time Snacking</th>
<th>Class 2: Low Fruit/Veg</th>
<th>Class 3: Processed Food</th>
<th>Class 4: Food + Screen Time</th>
<th>Class 5: Depression with Behavioral Factors</th>
<th>Class 6: Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>Reference</td>
<td>0.458</td>
<td>0.741</td>
<td>0.628</td>
<td>0.195</td>
<td>0.313</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>0.213</td>
<td>0.370</td>
<td>0.222</td>
<td>0.082</td>
<td>0.146</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>0.989</td>
<td>1.501</td>
<td>1.785</td>
<td>0.463</td>
<td>0.670</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>2.084</td>
<td>0.065</td>
<td>0.148</td>
<td>1.422</td>
<td>1.322</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>1.044</td>
<td>0.022</td>
<td>0.065</td>
<td>0.691</td>
<td>0.663</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>4.164</td>
<td>0.201</td>
<td>0.335</td>
<td>2.941</td>
<td>2.645</td>
</tr>
<tr>
<td>Obese at baseline</td>
<td></td>
<td>0.680</td>
<td>1.280</td>
<td>1.158</td>
<td>0.742</td>
<td>0.540</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>0.410</td>
<td>0.641</td>
<td>0.543</td>
<td>0.385</td>
<td>0.290</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>1.129</td>
<td>2.564</td>
<td>2.476</td>
<td>1.432</td>
<td>1.007</td>
</tr>
<tr>
<td>High SES/Mother some college</td>
<td></td>
<td>2.078</td>
<td>0.746</td>
<td>1.285</td>
<td>1.216</td>
<td>1.045</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>1.357</td>
<td>0.359</td>
<td>0.582</td>
<td>0.664</td>
<td>0.619</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>3.185</td>
<td>1.562</td>
<td>2.839</td>
<td>2.232</td>
<td>1.769</td>
</tr>
<tr>
<td>Minority race/ethnicity</td>
<td></td>
<td>0.735</td>
<td>8.225</td>
<td>11.633</td>
<td>3.252</td>
<td>2.781</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>0.338</td>
<td>2.694</td>
<td>3.790</td>
<td>1.436</td>
<td>1.250</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>1.607</td>
<td>25.716</td>
<td>35.728</td>
<td>7.441</td>
<td>6.257</td>
</tr>
<tr>
<td>One or more parents obese</td>
<td></td>
<td>1.098</td>
<td>1.553</td>
<td>1.912</td>
<td>0.807</td>
<td>0.947</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>0.712</td>
<td>0.759</td>
<td>0.949</td>
<td>0.4219</td>
<td>0.551</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>1.694</td>
<td>3.184</td>
<td>3.864</td>
<td>1.523</td>
<td>1.629</td>
</tr>
<tr>
<td>Fair to poor health</td>
<td></td>
<td>2.541</td>
<td>3.917</td>
<td>4.802</td>
<td>14.948</td>
<td>9.090</td>
</tr>
<tr>
<td>Lower bound</td>
<td></td>
<td>0.731</td>
<td>0.839</td>
<td>1.047</td>
<td>4.048</td>
<td>2.562</td>
</tr>
<tr>
<td>Upper bound</td>
<td></td>
<td>9.200</td>
<td>18.653</td>
<td>22.209</td>
<td>57.407</td>
<td>33.696</td>
</tr>
</tbody>
</table>

Note. Bolded items indicate significance at the .05 level.
### Table 8

Odds Ratios - LCA With Covariates (Sex, Baseline BMI, Race/Ethnicity, SES/Mother’s Education Level, Parent Obesity, Health, Martial Status, Education Level) for Wave 3

<table>
<thead>
<tr>
<th>Class:</th>
<th>Class 1: Depression with Behavioral Factors</th>
<th>Class 2: Food + Sedentary (Use FitCtr) + Low Sleep</th>
<th>Class 3: Food + Sedentary + Low Sleep</th>
<th>Class 4: Food + Sedentary</th>
<th>Class 5: Food + Low PA</th>
<th>Class 6: Food + Low PA + Low Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.041</td>
<td>0.230</td>
<td>Reference</td>
<td>0.269</td>
<td>0.533</td>
<td>0.170</td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.202</td>
<td>0.105</td>
<td>0.133</td>
<td>0.334</td>
<td>0.083</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>2.747</td>
<td>0.509</td>
<td>0.554</td>
<td>0.852</td>
<td>0.373</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>2.747</td>
<td>0.526</td>
<td>3.358</td>
<td>2.235</td>
<td>0.603</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>1.546</td>
<td>0.318</td>
<td>1.756</td>
<td>1.509</td>
<td>0.340</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>4.892</td>
<td>0.872</td>
<td>6.603</td>
<td>3.321</td>
<td>1.100</td>
<td></td>
</tr>
<tr>
<td>Obese at baseline</td>
<td>0.577</td>
<td>0.787</td>
<td>1.314</td>
<td>1.211</td>
<td>1.173</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.306</td>
<td>0.474</td>
<td>0.777</td>
<td>0.841</td>
<td>0.477</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>1.201</td>
<td>1.310</td>
<td>2.236</td>
<td>1.744</td>
<td>3.161</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES/Mother some college</td>
<td>1.647</td>
<td>1.533</td>
<td>1.124</td>
<td>1.120</td>
<td>1.806</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.964</td>
<td>0.960</td>
<td>0.694</td>
<td>0.790</td>
<td>0.998</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>2.823</td>
<td>2.452</td>
<td>1.837</td>
<td>1.589</td>
<td>3.509</td>
<td></td>
</tr>
<tr>
<td>Minority race/ethnicity</td>
<td>1.210</td>
<td>1.401</td>
<td>1.546</td>
<td>1.099</td>
<td>4.223</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.704</td>
<td>0.857</td>
<td>0.934</td>
<td>0.769</td>
<td>0.938</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>2.087</td>
<td>2.293</td>
<td>2.573</td>
<td>1.573</td>
<td>27.759</td>
<td></td>
</tr>
<tr>
<td>One or more parents obese</td>
<td>0.823</td>
<td>1.088</td>
<td>1.020</td>
<td>0.954</td>
<td>0.736</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.463</td>
<td>0.686</td>
<td>0.634</td>
<td>0.682</td>
<td>0.404</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>1.469</td>
<td>1.729</td>
<td>1.652</td>
<td>1.336</td>
<td>1.573</td>
<td></td>
</tr>
<tr>
<td>Fair to poor health</td>
<td>0.938</td>
<td>0.575</td>
<td>1.028</td>
<td>0.698</td>
<td>0.286</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.456</td>
<td>0.284</td>
<td>0.561</td>
<td>0.446</td>
<td>0.100</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>1.944</td>
<td>1.182</td>
<td>1.894</td>
<td>1.094</td>
<td>1.364</td>
<td></td>
</tr>
<tr>
<td>Not married</td>
<td>1.956</td>
<td>2.080</td>
<td>1.077</td>
<td>0.946</td>
<td>1.540</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>1.009</td>
<td>1.114</td>
<td>0.652</td>
<td>0.660</td>
<td>0.780</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>3.813</td>
<td>3.912</td>
<td>1.787</td>
<td>1.356</td>
<td>3.235</td>
<td></td>
</tr>
<tr>
<td>At least some college</td>
<td>0.525</td>
<td>2.315</td>
<td>0.895</td>
<td>1.279</td>
<td>1.655</td>
<td></td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.282</td>
<td>1.399</td>
<td>0.574</td>
<td>0.903</td>
<td>0.710</td>
<td></td>
</tr>
<tr>
<td>Upper bound</td>
<td>0.987</td>
<td>3.839</td>
<td>1.409</td>
<td>1.812</td>
<td>4.355</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Bolded items indicate significance at the .05 level.
Figure 1

_Literature Review Design_

- Amount of food consumed
- Consumption of processed foods
- Consumption of fruits & vegetables
- Neighborhoods: Availability & accessibility of “healthy” foods
- Neighborhoods: availability & accessibility of processed & fast foods
- Neighborhoods & physical activity
- Neighborhood safety
- Physical activity versus time spent on sedentary pursuits
- Effects of physical activity & sedentary behavior from childhood to adulthood
- Family cohesion—family meals
- Depression

**Nutrition**

- Effects of sleep duration on adolescent & adult weight

**Physical Activity**

**Sleep**
Figure 2

Chapter II: Study Design

**Nutrition**
- Fruit & vegetable consumption
- Processed food consumption
- Fast food visits

**Physical Activity**
- Weekly PA occasions
- Use of neighborhood fitness center
- Neighborhood safety
- Sedentary behavior: Screen time/TV viewing

**Sleep**
- Average hours of sleep

**Stress/Family Emotional Climate and Depression**
- Family cohesion
- Weekly family meals
- Social acceptance
- Depression
Figure 3

*Transitions in Latent Classes from Wave 1 to Wave 3*

Transitions Wave 1 to Wave 3

- C1: Depression with Behavioral Factors
- C2: Food + Sedentary (use fitctr) + Low Sleep
- C3: Food + Sedentary + Low Sleep
- C4: Food + Sedentary
- C5: Food + Low PA
- C6: Food + Low PA + Low Sleep

Legend:
- Orange: Food + Screen Time
- Blue: Processed Food
- Purple: Low Fruit/Veg
- Green: Screen Time Snacking
- Red: Depression Alone
- Blue: Depression with Behavioral Factors
Appendix A

*Questions from the National Longitudinal Study of Adolescent to Adult Health (Add Health) Questionnaire*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Variables</th>
<th>Waves Available</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition - Fruits</td>
<td>How often did you eat fruit or drink fruit juice yesterday?</td>
<td>w1</td>
<td>0=didn't eat, 1=ate once, 2=ate twice or more, 6=refused, 8=d/k</td>
</tr>
<tr>
<td>and Vegetables</td>
<td>How often did you eat vegetables yesterday?</td>
<td>w1</td>
<td>0=didn't eat, 1=ate once, 2=ate twice or more, 6=refused, 8=d/k</td>
</tr>
<tr>
<td>Nutrition - Processed Foods</td>
<td>How often did you eat cookies, doughnuts, pie, or cake yesterday?</td>
<td>w1</td>
<td>0=didn't eat, 1=ate once, 2=ate twice or more, 6=refused, 8=d/k</td>
</tr>
<tr>
<td>Nutrition - Fast Food</td>
<td>On how many of the past seven days did you eat food from a fast food place McDonalds, Kentucky Fried Chicken, Pizza Hut, Taco Bell, or local fast food restaurant?</td>
<td>w3</td>
<td>0=didn't eat, 1=ate once, 2=ate twice or more, 6=refused, 8=d/k</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>During the past week, how many times did you go roller-blading, roller-skating, skate-boarding, or bicycling?</td>
<td>w1</td>
<td>0=not at all, 1=1 or 2 times, 3=3 or 4 times, 3=5 or more times, 6=refused, 8=d/k</td>
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<tr>
<td></td>
<td>Play an active sport such as baseball, softball, basketball, soccer, swimming, or football?</td>
<td>w1</td>
<td>0=not at all, 1=1 or 2 times, 3=3 or 4 times, 3=5 or more times, 6=refused, 8=d/k</td>
</tr>
<tr>
<td></td>
<td>How many times did you do exercise, such as jogging, walking, karate, jumping rope, gymnastics, or dancing?</td>
<td>w1</td>
<td>0=not at all, 1=1 or 2 times, 3=3 or 4 times, 3=5 or more times, 6=refused, 8=d/k</td>
</tr>
<tr>
<td></td>
<td>In the past seven days, how many times did you bicycle, skateboard, dance, hike, hunt, or do yard work?</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
</tr>
<tr>
<td></td>
<td>How many times did you roller blade, roller skate, downhill ski, snowboard, play racquet sports, or do aerobics?</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
</tr>
<tr>
<td>Question</td>
<td>Code</td>
<td>Options</td>
<td></td>
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<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>How many times did you participate in strenuous team sports such as...</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
<td></td>
</tr>
<tr>
<td>How many times did you participate in individual sports such as...</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
<td></td>
</tr>
<tr>
<td>How many times did you participate in gymnastics, weight lifting, or...</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
<td></td>
</tr>
<tr>
<td>How many times did you play golf, go fishing or bowling, or...</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
<td></td>
</tr>
<tr>
<td>How many times did you walk for exercise?</td>
<td>w3</td>
<td>0=not at all, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
<td></td>
</tr>
<tr>
<td>Physical Activity-Sedentary Activities</td>
<td>How many hours a week do you watch television?</td>
<td>w1</td>
<td>5=5 times, 6=6 times, 7=7 or more times, 96=refused, 98=d/k</td>
</tr>
<tr>
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<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Physical Activity-Fitness Center</td>
<td>Do you use a physical fitness or recreation center in your neighborhood</td>
<td>w1</td>
<td>0=no, 1=yes, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td></td>
<td>In the past seven days, how many times did you go to an exercise or fitness center to exercise or work out?</td>
<td>w3</td>
<td>(numerical response), 98=d/k</td>
</tr>
<tr>
<td>Physical Activity-Neighborhood Safety</td>
<td>Do you usually feel safe in your neighborhood?</td>
<td>w1</td>
<td>0=no, 1=yes, 6=refused, 8=don't know, 9=not applicable</td>
</tr>
<tr>
<td>Sleep</td>
<td>How many hours of sleep do you usually get?</td>
<td>w1</td>
<td>(numerical response), 96=refused, 98=d/k</td>
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</tr>
<tr>
<td></td>
<td>What time do you usually go to sleep the night (or day before?)</td>
<td>w3</td>
<td>Indicate hour, minute, and AM or PM</td>
</tr>
<tr>
<td></td>
<td>On days when you go to work, school, or similar activities, what time do you usually wake up?</td>
<td>w3</td>
<td>Indicate hour, minute, and AM or PM</td>
</tr>
<tr>
<td></td>
<td>On days you don't have to get up at a certain time, what time do you usually get up?</td>
<td>w3, w4</td>
<td>Indicate hour, minute, and AM or PM</td>
</tr>
<tr>
<td></td>
<td>On those days, what time do you usually go to sleep the night or day before?</td>
<td>w3</td>
<td>Indicate hour, minute, and AM or PM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social/Emotional Climate-Family Meals</th>
<th>On how many of the past 7 days was at least one of your parents in the room with you while you ate your evening meal?</th>
<th>w1</th>
<th>0=1 day, 2=2 days, 3=days, 4=4 days, 5=5 days, 6=6 days, 7=7 days, 96=refused, 97=legitimate skip (no mom/dad), 98=d/k</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social/Emotional Climate-Depression</td>
<td>You were bothered by things that usually don’t bother you</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>You felt that you could not shake off the blues, even with help from your family and your friends</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td></td>
<td>You felt that you were just as good as other people</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td></td>
<td>You had trouble keeping your mind on what you were doing</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k</td>
</tr>
<tr>
<td></td>
<td>You felt depressed</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td></td>
<td>You felt that you were too tired to do things</td>
<td>ALL</td>
<td>0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most/all of the time, 6=refused, 8=d/k, 9=n/a</td>
</tr>
<tr>
<td>Social/Emotional Climate</td>
<td>Question</td>
<td>Scale</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Social/Emotional Family Cohesion-Closeness to Mother</td>
<td>How close do you feel to your mother/adoptive mother/stepmother/foster mother/etc.</td>
<td>ALL</td>
<td>1=not at all, 2=very little, 3=somewhat, 4=quite a bit, 5=very much, 6=refused, 7=legitimate skip, 8=d/k</td>
</tr>
<tr>
<td>Social/Emotional Social Acceptance</td>
<td>You feel socially accepted</td>
<td>w1</td>
<td>1=strongly agree, 2=agree, 3=neither agree nor disagree, 4=disagree, 5=strongly disagree, 6=refused, 8=d/k</td>
</tr>
<tr>
<td></td>
<td>How much do you feel that your friends care about you?</td>
<td>w1</td>
<td>1=not at all, 2=very little, 3=somewhat, 4=quite a bit, 5=very much, 6=does not</td>
</tr>
<tr>
<td>Question</td>
<td>Scale</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>You felt that people disliked you, during the past seven days</td>
<td>w3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 0=never/rarely, 1=sometimes, 2=a lot of the time, 3=most of the time/all of the time, 6=refused, 8=don’t know, 9=n/a
- apply, 96=refused, 98=d/k