THE RELATIONSHIP BETWEEN DIET AND AGGRESSION IN ADOLESCENTS

By

Lauren E. Healey

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ABSTRACT

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Based on the biosocial theoretical perspective, this study seeks to incorporate the biological sciences in explaining maladaptive behaviors that predict criminal activity. More specifically, this study examines how dietary intake can influence the externalizing problem behaviors of adolescents. While the relationship between nutrition and physiological functioning has been well established, research examining diet modification as a preventative strategy for decreasing aggression and, thus, potentially mitigating subsequent crime is still relatively new. This study finds that the consumption of soda/juice drinks and fast food significantly increases the probability of externalizing problem behaviors within adolescents. Meanwhile, the consumption of green salads significantly decreases this likelihood. This work supports the provision of nutritional and supplemental aid to children in need, and suggests that early nutrition-based intervention can be an effective and low-cost solution to treating children exhibiting those behaviors shown to predict criminal activity. This work also provides evidence supporting a biological approach to understanding crime causation and validates the presence and usefulness of the biosocial theories within criminology.

DEDICATION

For my mother, whose unwavering love and support strengthens me, and my dearest friend, Natalie Nuno, for being a constant source of positivity and laughter in my life.

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INTRODUCTION

Discovering the roots of violent behavior is a central concern in the study of crime prevention. While the relationship between aggression and the propensity to commit crime has been routinely explored throughout the criminological literature, the role of nutrition in producing aggressive, violent behavior has only been explored in recent years. It has been suggested that such a biological approach to the study of crime has been historically ignored due to its more complex scientific nature which incorporates advanced methodologies, precise measurements, and sophisticated medical technology (Wright & Boisvert, 2009). Fortunately, researchers have begun to utilize modern technology to improve criminological studies by incorporating biological, neurological, and genetic discoveries into contemporary research. In a summary of new theoretical perspectives within criminology, Wright and Boisvert (2009) note that the inclusion of biological influences points to an important "paradigm shift" within the field that has the potential to ignite new questions and methodologies that will result in better research.

In including biological influences to the study of crime, biochemical and physiological workings of the body are considered. Studies in nutrition and diet have increased in popularity as a means to examine these internal workings. Previous studies regarding the behavioral effects of nutrition have primarily focused on adults, such as prison inmates, who already display problem behaviors (Fishbein & Pease, 1995). Unfortunately, the use of incarcerated populations limits the generalizability of findings (Fishbein, 1990). Additionally, due to certain anatomical and physiological differences, behavioral responses may be more easily observable in children. Still-developing blood-brain barriers and greater Central Nervous System (CNS) receptivity and respiratory rates make children more vulnerable to chemical agents absorbed within the body

(Columbia University, 2005). As a result, children may be more symptomatic than adults. It is also plausible that adolescents may be more susceptible to dietary adjustments given that they are still developing (The American Dietetic Association, 1999). To address these concerns, the proposed work focuses solely on adolescents.

Using data from the Early Childhood Longitudinal Study (ECLS), the current work focuses specifically on examining nutrition as a possible root cause of violence and aggression, as a way to reduce individual proclivity to criminal activity at an early age. The specific research question asked is whether or not poor diet affects maladaptive behaviors in children. Based on a biosocial theoretical foundation, the interactions that occur between environmental forces and biology in influencing criminal activity are considered. Such research is significant, as it examines the importance of human physiology in the individual's response to environmental events. If findings demonstrate that diet significantly affects behavior, the implications of this work would suggest that a more proactive nutritional-based intervention be incorporated when treating early childhood behaviors that predict future criminality. Additionally, this research could offer support for federal programs such as Women, Infants, and Children (WIC) and Head Start that offer preventative nutritional and supplemental aid to low income, at-risk children.

In exploring this topic, the existing literature on aggression and crime is reviewed in order to provide a background on how aggressive behaviors have been shown to predict criminal activity. Following this is a discussion of how nutrition and diet can influence that relationship by either reducing or increasing individual aggression. As biological approaches to criminal study can become complex, brief explanations are included on how exactly vitamins, minerals, and other compounds alter the biochemistry of the body. A description of the data,

methodologies, and findings then follow. Lastly, policy implications of the findings on crime prevention strategies and treatment of aggressive behaviors are discussed.

CHAPTER 1: THEORETICAL PERSPECTIVE

Sociological and political perspectives have historically dominated the criminological field (Fishbein, 2001). Although insightful, these theories alone do not offer complete explanations for the occurrence of criminal activity as they neglect the biological underpinnings of human action. Early biological studies of criminal behavior, such as Lombroso's atavistic man, were quickly discredited as being unscientific and methodologically unsound (Fishbein, 1990). Criminologists, being for the most part sociologically trained, were resistant to accept biological perspectives in the study of crime (Walsh & Ellis, 2004). However, the explosive growth of scientific technology, such as those in the forensic sciences, makes it difficult to further ignore the usefulness and necessity of integrating these advanced tools into crime analysis.

For the first time in criminological study, science and technology can now provide criminologists a more complete understanding into the potential biological factors of criminality (Ellis, 2005). In just the past decade, biosocial theory has been introduced into the literature as an integrative approach that examines the complex interactions between biology and sociology in crime causation. By introducing "relevant data, concepts, and methods from the biological sciences into traditional criminological approaches", biosocial theory offers criminologists more quality control over research with the use of these advanced tools (Walsh & Beaver, 2009, p. 7). Walsh and Beaver (2009) go as far to assert that the insights gained from the biological sciences will only strengthen criminology's claim for "preventative environmental intervention" (p. 3).

Theoretical Assumptions

The main tenet of the biosocial perspective is that criminal behavior is rooted in both nature (biology) and nurture (the environment). Thus, this theoretical perspective is inherently

integrative (Walsh & Beaver, 2009). According to the theory, it is the interactions of these different forces that determine the individual's susceptibility to antisocial, violent, and criminal behavior (Ellis, 2005, Walsh & Beaver, 2009). By including biological variables in the study of crime, data has been introduced from many behavioral sciences previously ignored, including behavioral genetics, physiology, psychopharmacology, and neuroscience; all of which indicate the significance of biology in the development of antisocial and violent behaviors (Fishbein, 1990). While biosocial theory still recognizes the importance of the environment in influencing human behavior, it asserts that the same environment will have varying affects due to individual differences.

The biosocial approach is also developmental, suggesting that biology will affect individual responses to meaningful events throughout life (Walsh & Beaver, 2009). Importantly, Walsh and Beaver (2009) point out that the term developmental is not suggestive of "preformationism", meaning that this theory does not assume any sort of predetermined development. Instead, the biosocial approach is useful in indentifying maladaptive behaviors, such as antisocial personality disorders, that are not necessarily criminal, but are indicative of subsequent criminal activity (Fishbein, 1990). One assumption of biosocial theory is that individuals are not inherently criminal, but precursors to criminal activity do exist. Fishbein (1990) describes these precursors as "manifestations of a problem frequently observed in childhood [that] are compounded by suboptimal environmental and social conditions" (p. 33). Therefore, the biosocial perspective also suggests targeting individuals early in the developmental process in order to mitigate subsequent criminal activity.

Additionally, it is important to remember that biosocial theory assumes that there is no single biological approach better suited for criminological study than another. As stated above,

this theoretical perspective incorporates principles from many different genetic, evolutionary, and neuroscience studies. Furthermore, despite concern from academics that the introduction of varying methods may not result in compatible analyses, the principles between these different approaches appear conceptually consistent (Fishbein, 1990). Walsh and Beaver (2009) confirm this finding, stating that, "not only are they consistent across approaches, they are all so environment friendly that we may well call them 'biologically informed environmental approaches" (p. 9).

Most importantly, the biosocial theoretical approach takes into account a multitude of factors in explaining criminal behavior, from the social environment to the biological background of the individual. As Rowe (1994) expressed, "biosocial research controls for the effects of genes while estimating environmental effects" (p. 10). For example, popular studies examining twins and adoption have found that genetics and heritability can influence the individual's social response to environmental stimuli (Walsh & Beaver 2009; Walters & White, 1989). Additional studies within biosocial criminology include how brain structure is related to the etiology of aggression and crime; the role of genotypes in selecting certain environments; and the connection between social class, cognition, and crime (Walsh & Beaver, 2009; Wright, Tibbetts, & Daigle, 2008).

As a multidisciplinary perspective, biosocial theory allows for an integrated, more informed approach to identifying the causes of criminal behavior and determining the best methods for prevention and management. Additionally, the use of advanced technological tools enables researchers to conduct more specific studies of specialized topics. For example, the current work on the nutritional affects on aggression is made possible only when utilizing recent scientific discoveries that incorporate biobehavioral data previously unavailable.

CHAPTER 2: LITERATURE REVIEW

Beginning in the mid-1900s, researchers began to take a more multidisciplinary approach to studying crime by combining traditional sociological theories with new biological perspectives. While some early biosocial research, like those on phrenology and morphology, began with a poor understanding of human biology, technological advancement over time has lead to more precise, methodological sound research (Fishbein, 2000). In one of the first studies looking at the biological factors in crime, Glueck and Glueck's (1934) examination of female delinquency suggested that changes in biology could explain changes in antisocial behavior. They also proposed that future works examine genetics. Unfortunately, the technology for genetic screening was not available at the time. The Gluecks' (1950) continued the exploration of biosocial theory with their seminal work "Unraveling Juvenile Delinquency", which rejected traditional conceptions of preventing crime and instead focused on how to prevent criminals. Through a matched comparison of 500 delinquent and non-delinquent Boston youths, Glueck and Glueck (1950) sought to identify all plausible causes of crime by investigating family backgrounds, physique, health, intelligence, and personality traits. Unfortunately, later reanalysis found that while the research design was strong, the study was lacking in methodological rigor (Laub & Sampson, 1988). Other works that occurred during the initial exploration of a biosocial theory of crime include Pollak's (1950) work on female emotionality and Sheldon's (1942) study of body type.

With the advancement of scientific tools, such as genetic therapies and neurological testing, more recent biological theories were introduced that utilized new measuring techniques (Fishbein, 2000). Such work includes studies on testosterone and criminal behavior (Archer, 1991; Willie & Beier, 1989), explorations of how neurotransmitters affect aggression (Scerbo &

Raine, 1993), and the genetic factors of criminal tendencies (Mednick & Hutchings, 1978). By the 1990s, the growing presence of biosocial theory in criminology was clearly evident, as research continually demonstrated the role of biological conditions in the development of maladaptive behavior (Fishbein, 2000). Perhaps most significant was Moffit's (1993) work on antisocial behavior that suggested an interplay between neuropsychological problems and criminogenic environments. This research offered a more advanced, clinical examination of the neuroscience behind the development of antisocial personality disorders.

Current studies in biosocial criminology aim to identify specific biological markers influencing aggression and crime, and how these factors interact with differing social forces. In a meta-analysis reviewing biosocial research, Raine (2002) highlights the importance of multiple biological conditions in the development of antisocial behavior. Thus, the trend in contemporary research is to focus on the interaction affects of both the social and biological sciences (Fishbein, 2000). The current study adds to this work by exploring the connection between nutrition, maladaptive behaviors, and crime.

Predicting Criminal Activity

Certain childhood behaviors, such as aggression, have been empirically found to predict subsequent criminal activity (Pepper & Rubin, 1991). While not necessarily criminal in nature, identification of these behaviors at an early age can be used as an early crime prevention strategy. It is common to find statements within existing research indicating that most adult antisocial behaviors are developed from childhood aggression and behavioral problems (Lynam, 1996; Moffitt, 1993; Moffitt, Caspi, Dickson, Silva, & Stanton, 1996; Thornberry, Huizinga, & Loeber, 1995).

Additional childhood behaviors that have also been shown to predict criminal involvement during young adulthood include impulsivity and hyperactivity (Babinski, Hartsough, & Lambert, 1999; Farrington, Loeber, & Van Kammen, 1990; Pratt, Cullen, Blevins, & Daigle, 2002). Babinski and colleagues (1999) found that impulsivity is generally expressed by adolescents through externalized aggressive actions, such as defiance, participation in fights, and destruction of materials (p. 349). Using official arrest records and self-reports, researchers found that impulsivity significantly increased the risk of subsequent criminal behavior of males (Babinski, Hartsough, & Lambert, 1999). Such findings are especially important to the current work, as measures of impulsivity are included in the construction of the dependent variable measuring externalized problem behaviors.

Impulsivity is often studied through research involving children exhibiting Attention-Deficit Hyperactivity Disorder (ADHD). Diagnostically, ADHD actually overlaps with Aggressive Behavioral Syndrome within the DSM-IV (Werbach, 1995). Research has indicated that childhood attention-deficit disorders can better predict later criminal activity than simple conduct problems (Farrington et al., 1990). In fact, identification of children suffering from ADHD is especially useful in predicting chronic offenders (Farrington et al., 1990; Lynam, 1998). Early treatment of this disorder could, therefore, lead to a significant reduction in future crime.

In addition to an increased risk of aggressive behavior, children with ADHD also display low cognitive performance (Hinshaw, 1987; Krain & Castellianos, 2006). For this reason, it is reasonable to suspect that impulsivity, aggression, and hyperactivity are all closely related to neurological development and functioning. Interestingly, low cognitive functioning and learning disabilities among adolescents have also been shown to predict antisocial and

delinquent behaviors (Farrington, 2005; Moffit, 1993). In fact, empirical research has strongly supported the notion that IQ is related to behavior (Fergusson & Horwood, 1995; Koenan et al., 2006). However, it is argued that there are several factors that mediate the relationship between intelligence and crime. For example, while research has consistently found a negative correlation between IQ and delinquent behavior, this relationship is mediated by factors such as a lack of social bonds, low self-control, poor academic performance, and delinquent peer groups (Hirschi and Hindelang, 1977; McGloin, Pratt, & Maahs, 2004; Moffitt et al., 1981).

Another factor affecting the regulation of attention and behavior is negative emotionality. In trying to predict childhood problem behaviors, Eisenberg and colleagues (2000) found that "the prediction of problem behavior from attentional control was significant only for children prone to negative emotionality" (p. 1367). Other studies have found associations between negative emotionality and weak constraint, impulsivity, and poor social functioning; all of which predict criminal behavior (Agnew, Brezina, Wright, & Cullen, 2002; Caspi et al., 1994; Eisenberg et al., 1995; Krueger et al., 1994). Overall, the importance between adolescent cognition and physiology in the expression of externalized problem behaviors has been found consistently throughout research (Farrington et al., 1990; Hinshaw, 1992; Lynam & Moffit, 1995; Steinberg, 2005).

The Biology of Maladaptive Behavior

The neurobiology behind aggression, negative emotionality, impulsivity, and hyperactivity is influenced by interactions between various physiological factors, including neurotransmitter functioning and limbic responsiveness (Davidson, Putnam, & Larson, 2000; Kavoussi, Armstead, & Coccaro, 1997; Siever, 2008). Specifically, those exhibiting aggressive tendencies and hyperactivity experience lower levels of serotonin and the amino acid GABA, as

well as increased levels of dopamine, epinephrine, glutamate, and acetylochline (Fishbein, 2001; Siever, 2008). Imbalances of these important neuromodulators can potentially inhibit chemical receptivity, brain development, emotion, and impulse control (Fishbein, 2001). Interestingly, the biological pathways affecting aggressive behaviors are similar to those influencing criminal activity, as criminals also often exhibit lower levels of serotonin, which can lead to the impairment of the dopamine system (Bernhardt, 1997; De Simoni, Dal Toso, Fodritto, Sokola, & Algeri, 1987; Seo, Patrick, & Kennealy, 2008). Essentially, consistent findings have shown that "serotonin, norepinephrine, dopamine, GABA (gamma amino buteric acid), [and] acetylcholine… are considered related to aggressive or violent behavior" (Tupin, 2000, p. 3).

In a meta-analysis on the childhood origins of antisocial behavior, Farrington (2005) concludes that,

> Impulsiveness, attention problems, low IQ, and low school achievement could all be linked to deficits in the executive functions of the brain, located in the frontal lobes. These executive functions include sustaining attention and concentration, abstract reasoning, concept formation, goal formulation, anticipation and planning, programming and initiation of purposive sequences of motor behavior, and inhibition of inappropriate or impulsive behaviors (p. 180).

Research has shown that these types of maladaptive behaviors displayed in childhood stem from neurological malfunctions within the human brain, similar to what has been found for criminals. Due to the high incidence of "neuropsychiatric abnormalities" found among violent offenders, it has been suggested that criminals also suffer from deficits in executive functioning within the prefrontal cortex of the brain (Bergvall, Wessely, Forsman, & Hansen, 2001; Brower & Price, 2001). Such findings provide strong support for a biological approach to altering criminal

behavior, which will hopefully enable researchers to better predict criminal activity at an earlier period in time.

Overall, existing research has clearly demonstrated that the behaviors predicting criminal activity are significantly related to human physiology. Importantly, the neurological functions that affect these behaviors can be influenced by a number of internal and external factors, including genetics, trauma, substance abuse, and nutrition (Kolb, Gibb, & Robinson, 2003). For the purpose of this research, the next section focuses on the processes through which diet and nutrition can affect individual cognition and behavior.

Nutritional Affects on Development and Behavior

Proper dietary intake has been consistently linked to an individual's overall health, cognition, and functioning (Fishbein & Pease, 1995; Morgane et al., 1993). Simply put, nutrition affects individual behavior by "providing energy and nutrients needed for development of cellular structures and various essential metabolic systems" (Morgane et al., 1993, p. 92). The severity of nutritional deficiencies experienced, as well as the stage of development in which malnutrition occurs, influences the level of impact that diet has on individual functioning (McGregor, Walker, & Chang, 2000).

These mechanisms are established early in life as prenatal care of the mother can significantly affect proper development of the fetus (Hingson et al., 1982; Hofhuis, Jongste, & Merkus, 2003; McGregor et al., 2000; Morgane et al., 1993). Glover (1997) found that "organ function, anatomy, cognitive ability, intelligence level, psychiatric status, and behavioral patterns" are all directly affected by conditions within the mother's womb (p. 105). Importantly, nutritional intake can also directly affect fetal development (Fishbein, 2001). For example, studies show that low iodine levels during pregnancy resulted in thyroid deficiencies and poorer

development within the child (Cao et al., 1994; McGregor et al., 2000). Additionally, it has been found that babies born at low birth weights demonstrate poorer cognitive functioning between the ages of 9 and 17 years of age than their normal birth weight counterparts (Hack et al., 1994). In essence, prenatal nutrition is a significant determinant of neural and functional development (Morgane et al., 1993). As previously discussed, the developments of these pathways play an important role in the expression of antisocial, impulsive, and aggressive behaviors.

Following birth, adequate nutrition is a main contributor to maintaining proper health and functioning (Fishbein, 2001). Certain dietary features, such as sugar levels and food additives, have been found to alter behavior by affecting individual physiology. For example, glucose, a type of sugar that enables cerebral functioning, has been proven to influence self-control, attention deficits, emotionality, and aggressive behaviors (Benton & Owens, 1993; Fairclough & Houston, 2004; Gailliot & Baumeister, 2007). In a study by Benton (1987), children receiving a glucose drink concoction were able to sustain attention longer and respond faster than the control group. In another study, children with glucose deficiencies experienced more emotional mood swings and aggressive tendencies than their counterparts (Meijer, 1984). In a study testing 129 juvenile delinquents immediately after arrest, 90% had lower than normal glucose levels (Rojas & Sanchi, 1941). The evidence overwhelmingly suggests that glucose plays an important role in proper physiological functioning and behavior.

Regulation of glucose levels can be accomplished through proper diet and nutrition. Fishbein and Pease (1994) note that research indicates that individuals suffering from hypoglycemia should make sure to eat often so that blood sugar does not drop too low. They also suggest that these individuals follow healthy diets of low-glycemic indexed carbohydrates,

fruits, and vegetables that release sugar slowly into the body for longer periods of time (Fishbein & Pease, 1994).

For the purpose of this study, the next section will discuss how nutrition can further be used to modify the internal physiological workings of the human body as a means to decrease the incidence of violence. More specifically, past research is discussed in an effort to discover how to decrease levels of aggression through diet and nutrition. This includes a review of the important vitamins and minerals that are essential to proper cognitive and behavioral functioning.

Altering the Biochemistry of Violence With Nutrition

Clinical studies have found that poor diet may be "associated with, or exacerbate, such conditions as learning disability, poor impulse control, intellectual deficits, tendency toward violence, hyperactivity, and alcoholism and or drug abuse" (Fishbein & Pease, 1995). As stated earlier in this work, many of these maladaptive behaviors are indicative of later criminal activity. Therefore, maintaining a well-balanced healthy diet may reduce the occurrence of behavioral problems, which will aid in later reducing crime.

Based on research findings that neurological chemicals, such as serotonin and dopamine, affect levels of aggression and externalizing behaviors (Fishbein, 2001), this work postulates that malnutrition and poor diet work in the same physiological fashion by negatively affecting proper development. The biochemistry, or chemical processes occurring within the body, can be significantly affected by a number of internal and external elements. Important to this particular research are the dietary and nutritional habits of the individual that may affect aggression.

One of the most researched nutritional effects on the aggressive behavior of children is that of sugar and food-additive intake. Interest in this specific topic is perhaps due to the United

States Department of Agriculture's finding that "refined sugar (sucrose and other nutritive sweeteners) accounts for a significant proportion of the calories consumed by children" (Household Food Consumption Survey, 1972). In one of the first methodologically sound experiments on the topic, Swanson and Kinsbourne (1980) found that food additives significantly and negatively affected hyperactive children's problem behaviors. Additionally, Pinz, Roberts, and Hantman (1980) found that the consumption of sucrose affects the behaviors of children four to seven years of age. Interestingly, only the hyperactive children group displayed significantly greater "destructive-aggressive" behavior following the administration of sucrose, while non-hyperactive children only displayed greater movement action. This indicates that poor diet may aggravate a child's preexisting behavioral issues. Therefore, proper dietary intake may be especially important to those children already displaying behaviors that have been shown to predict later criminal activity, such as hyperactivity and impulsivity.

The intake of refined carbohydrates (i.e. candy, soda, chips, and white flours) has also been linked to behavioral disorders (Fishbein, 1992; Fishbein & Pease, 1994; Prinz, Roberts, & Hantman, 1980). Studies found that aggression, hyperactivity, and irritability decreased to normal rates after individuals had refined carbohydrates removed from their diets (Hudspeth, Peterson, Soli, & Trimble, 1981; Langseth & Dowd, 1977; Powers, 1974; Schauss, 1980). Additionally, in a study investigating the diets of children, Lester and colleagues (1982) found that higher intake of refined carbohydrates was significantly related to lower cognitive functioning.

Despite the unfortunate aggressive-induced effects of food additives, sugars, and refined carbohydrates in the diets of children, emerging research is demonstrating promising insight into the utilization of vitamins and minerals in modifying the individual's experience of aggression.

Benton (2007) found that the supplementation of certain nutrients through the use of vitamins significantly decreased the incidence of antisocial behavior in children. The next section discusses these essential nutrients that can affect aggressive behaviors, separating them into vitamins, minerals, and fatty acids. Additionally, food sensitivities and exposure to external elements that may also produce behavioral affects are briefly addressed (Clarke, 1950; Moyer, 1975; Werbach, 1995).

Vitamins, Minerals, and Fatty Acids

Vitamins are important chemical compounds that deliver nutrients to the body that are required for proper functioning (Lieberman & Bruning, 1990). The body itself cannot synthesize vitamins, and, therefore, diet is essential to the absorption of these important chemicals (Fishbein & Pease, 1994). Dietary supplements containing vitamins are often used when the body may not be consuming enough of these nutrients through regular eating habits.

There are two types of vitamins, fat-soluble and water-soluble. Fat-soluble vitamins, such as A, D, E, and K are stored within the body and play an important role in bone formation and blood clotting, among other things (Lieberman & Bruning, 1990). Conversely, water-soluble vitamins are not stored within the body and serve to aid enzymes in readying the body for catalytic activity (Lieberman & Bruning, 1990). These types include vitamin C and all B vitamins; the functions of which include oxidation-reduction and electron transfer (U.S. Department of Health and Human Services, 2012). Deficiencies in these particular essential nutrients can cause severe degeneration of the body, such as nerve damage and muscle fatigue (Centers for Disease Control and Prevention, 2011a). The consistent daily intake of water-soluble vitamins through dietary means is especially important as they are easily dissolved and excreted from the body.

Interestingly, there is compounding evidence that several specific vitamins may be associated with aggressive behavior (Werbach, 1995). For example, vitamins such as niacin (B3), thiamine (B1), and vitamins B6 and C have all been shown to decrease irritability (Gelenberg, 1988; Lonsdale, 1980; Werbach, 1995; Wilmont, 1983). In a double-blind study of 231 young adult prisoners, capsules containing the aforementioned vitamins, as well as vitamins A, B12, and D reduced the incidence of violent offenses by 26% in the experimental group (Gesch, 2002, p. 22). When compared to initial base rates, prisoners taking the capsules had an average 35% reduction in offenses while those in the control group experienced no significant change (p. 26). Findings such as these implicate that those individuals who do not gain essential nutritive elements through diet or supplementation are more prone to display aggressive behaviors.

Deficiencies of the nutrients integral to proper bodily performance are caused by either a restrictive diet or poor absorption within the body. Importantly though, although deficiencies of vitamins are a serious concern and have been empirically linked with poor functioning, problems may also occur when there is an overabundance of vitamins present within the body (Bitsas, 2004; Centers for Disease Control and Prevention, 2011a). Therefore, the emphasis for proper development and functioning is to achieve a balance of the necessary nutrients within the body.

The most significant elements lost as a result of poor food choice and nutrition are inorganic compounds identified as minerals (Gesch, 2002). Most notably, "lead, mercury, iodine, cobalt, iron, copper, manganese, and zinc have all been found to influence brain development and function" (Bitsas, 2004). In a comparative study of trace-metal concentrations in males ages 3 to 20, those with prior assaultive behavior were found to have significantly higher levels of copper/zinc ratios than the control group (Walsh, Isaacson, Rehman, & Hall,

1996). Research at the Pfeiffer Medical Center, an outpatient facility specializing in the treatment of biochemical imbalances through nutrient therapy, has repeatedly found that violent individuals exhibit "trace-metal imbalances" that are not present in normal-functioning persons (Bitsas, 2004; Schoenthaler & Bier, 2000; Sever, Ashkenazi, Tyano, & Weizman, 1997). As humans are not able to excrete these toxins, high amounts can accumulate over time, leading to alterations in brain functioning and neurotransmitter activity (Fishbein & Pease, 1994).

Lead, in particular, has received most of the scholarly attention regarding the relationship between minerals and subsequent behavioral problems. Exposure to environmental toxins, like lead, is one way in which external elements may affect the body's proper functioning and increases aggression. Empirical studies have demonstrated links between exposure to lead and serious mental deficiencies such as low IQ and learning disabilities, as well as behavioral problems such as hyperactivity, impulsivity and aggression (Bitsas, 2004; Center for Disease Control and Prevention, 1997; Fishbein & Pease, 1994; Narag, Pizarro, & Gibbs, 2009). In a study measuring blood levels of 201 children aged 2 to 5, those exposed to higher concentrations of lead exhibited higher levels of internalizing and externalizing problem behaviors (Sciarillo, Alexander, & Farrell, 1992).

Similar to the manner in which mineral imbalances within the body contribute to maladaptive aggressive behavior, imbalances of fatty acids have also been found to produce aggressive behavioral responses. In a study of boys 6 to 12 years of age, deficiencies of omega-3 fatty acids were significantly related to problems in conduct, anxiety, and impulsivity (Stevens, Abate, Kuczek, & Burgess, 1996). There is also preliminary evidence that changes in fatty acids increases physical aggression in girls as well (Itomura et al., 2005). Hibbeln and colleagues

(2006) assert that, “ensuring optimal intakes of omega-3 fatty acids during early development and adulthood shows considerable promise in preventing aggression and hostility” (p. 107).

The relationship between food sensitivities and aggression has also been investigated. In a meta-analysis, Fishbein and Pease (1994) reported that clinical studies had shown that food sensitivities influence neurotransmitter activity, with serotonin levels being significantly lower among individuals experiencing allergy-type reactions. As previously discussed, low serotonin has been found to trigger aggressive behavior. In a series of case studies, Rapp (1981) found that young boys who had previously displayed maladaptive and aggressive problem behaviors normalized when put on milk-free or egg-free diets. Interestingly, when these food sensitive items were reintroduced, the behavioral symptoms returned.

All of the studies discussed within this review lead investigators to believe that there is a significant connection between diet and subsequent aggressive behavior. Beginning with the fetus, diet and nutrition plays a critical role in neurological and physiological development. The intake of essential nutrients appears to be especially critical during the adolescent development stages, as well as among those populations already exhibiting behavioral issues. Research clearly demonstrates how poor diet is associated with impulsivity, hyperactivity, and low cognition.

Importantly, research has also found that cognition, IQ, negative emotionality, impulsivity, hyperactivity, and aggression are all predictors of criminal activity. The significance of this work is examining how nutrition can alter the relationship between these maladaptive behaviors and crime. As this review has demonstrated, certain nutritional deficiencies have been found to negatively affect development and behavior in a way that increases the risk of individual criminality. It is postulated in this work that poor diet can

influence early problem behaviors, thereby increasing subsequent crime (See Figure 1). Empirical research supports the idea of using nutrition as a means to managing behavior. The next section will introduce the current study and describe how it aims to add to the existing literature.

CHAPTER 3: THE CURRENT STUDY

Research Questions and Hypotheses

Overall, existing research supports the hypothesis that the biochemistry of the body heavily influences levels of aggression and impulsivity. It also suggests that aggression may be directly influenced by poor diet and nutrition through which the body does not gain the proper balance of nutrients. While genetics or preexisting medical conditions can also cause similar imbalances within the body (Werbach, 1995), this work focuses specifically on the role that poor diet plays in creating imbalances that negatively affect behavior in what should otherwise be normal, healthy children. Therefore, it is the interaction of biological processes and the social environment that drive the theoretical foundation for this research. Despite, the recent growth of studies that utilize a biosocial perspective in investigating how biology, and more specifically nutrition, influences behavior, many of these studies will often only include populations who already exhibit maladaptive behaviors. In doing so, researchers limit their ability to investigate the causal processes occurring. Conversely, this study analyzes existing data without first separating participants based on past behavioral history.

As the research discussed within this work has indicated, nutritional care appears to be most important during critical developmental points. This is especially true for children as proper nutrition heavily influences proper growth and development (Steinberg, 2005). Unfortunately, the number of overweight and obese children has doubled in the past thirty years (National Institute of Health, 2011). According to the U.S. Department of Health and Human Services, 17 percent of children ages 2-19 are currently overweight (National Institute of Health, 2011). The purpose of this research is to further investigate the relationship between adolescent nutrition and behavior. The primary research question is: *Are poor dietary habits of children*

related to externalizing problem behaviors? Based on past research, *it is hypothesized that children not receiving proper dietary care will exhibit the most problematic behaviors, such as aggression, irritability, hyperactivity, impulsiveness, and low cognitive functioning*. As all of these behaviors have been empirically shown to predict criminal activity, it is believed that this research could be helpful in mitigating an individual's later involvement in crime by establishing proper nutritional intake early in life.

If the hypothesis is supported, this research could have significant implications for public policy in terms of the nutritional and dietary resources made available to children. Most importantly, the inclusion of diet modification and nutritional therapy could be considered as treatment options for children exhibiting problem behaviors. Such research could be especially significant for those children living within low socioeconomic communities who may already be "at-risk" of developing problem behaviors due to experiences within the social world, such as low educational attainment and exposure to violence (Eitle & Turner, 2002). If nutrition could be used to insulate individuals from the risk of developing maladaptive behaviors in childhood, it may reduce future crime levels. These implications extend into the criminal justice system, as it will force agencies to reevaluate the most effective methods for dealing with offenders. Some examples of potential policy changes include making nutritional assessment a part of psychological screenings, offering healthier food services in correction facilities, or offering nutritional therapy to more aggressive offenders.

Data Collection

The data from this study were originally collected as a part of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 (ECLS-K) sponsored by the U.S. Department of Education. Collected by the National Center for Education Statistics (NCES), the

study focused on children's early school experiences by utilizing a "multisource, multimethod" approach that gathered information from student records, interviews with parents and teachers, and direct child assessments. Beginning in the Fall and Spring of the 1998-99 school year, a nationally representative cohort of children were followed through five waves of data collection, ending in the Spring of 2007 during the students' eighth-grade year. For the purposes of this work, data is used exclusively from the fifth-grade wave of data collection, which occurred in the Spring of 2004.

The fifth-grade collection period gathered a wealth of information that includes school experiences, activities, perceptions of self, as well as weight, diet, and level of exercise. Computer-assisted interviewing and hard-copy questionnaire forms were also used to gain additional information from parents and teachers regarding student behavior. In total, the fifth-grade collection instruments included eight questionnaires, three achievement tests, and one physical measurement form (Tourangeau, Nord, Sorongon, & Najarian, 2009). Consent was received from the parent or guardian of each child prior to participation within the study. To ensure the confidentiality of participants without compromising the overall quality of the data, the NCES suppressed certain sensitive information before the release of the K-8 full sample public-use data file. For the purposes of this work, only the fifth-grade sample is discussed in further detail as information regarding the dietary habits of students was only collected during the fifth and eighth-grade data collection period.[i]

This study uses information gathered from two separate questionnaires administered during the student's fifth-grade year. The first self-administered survey gathered information on student's dietary habits in the seven days prior to the study. Information collected in this questionnaire included: "How many times did you eat a meal or snack from a fast food

restaurant?", "How many times did you drink milk?" and "Where in the school did you buy soda or juice drinks?" (See Appendix A for questionnaire). The student's reading teacher completed the second questionnaire, which was used to collect information on externalizing behavior. Items measured included the frequency with which a child "argues, fights, gets angry, acts impulsively, and disturbs ongoing activities" (Tourangeau et al., 2006, p. 2-23). This measurement was gathered using a five-item Social Rating Scale (SRS) that was adapted from the "Social Skills Rating Scale Elementary Scale" instrument by Gresham and Elliott (1990)[ii].

To ensure the reliability and integrity of the data, all field staff and interviewers underwent standardized field training. However, as with most longitudinal designs, some amount of attrition was expected to occur over the course of the study due to ineligibility or nonresponse. Additional quality control processes included procedures to maximize cooperation and decrease the threat of nonresponse bias. All base-year sampled children were included within the fifth-grade wave of data collection, with the exception of those who had moved or were deceased. The total number of children eligible to participate in the survey during the Spring of 2004 was 12,029. Additionally, children with disabilities that could not be accommodated were excluded from participating in direct assessments.

The Sample

The ECLS-K is a multistage probability sampling study that selected a nationally representative sample of children enrolled in kindergarten in the 1998-99 school year. Four stages of probability sampling were conducted. The first sampled by county, the second sampled schools, and the final two stages randomly selected children within these schools. Through the first two rounds of probability sampling, 1,413 schools were selected. However, 136 of these schools were subsequently excluded from the study since they did not offer kindergarten

programs. A complete list of all children enrolled in kindergarten was obtained at each sampled school. After two rounds of random probability sampling, a total of 22,666 children were selected for the study. Following attrition and ineligibility, the total number of students participating in the fifth-grade wave of collection was 12,029. However, this study only includes students for whom externalizing behavior was recorded. Therefore, the total number of participants in the current study is 10,722. The ages of students during fifth grade were 10 or 11, and, therefore, defined as "adolescents" by World Health Organization (WHO) standards (Canadian Pediatric Society, 2003).

The majority of those sampled attended public schools (80%), with the rest attending either religious (18%) or private institutions (2%). Additionally, the majority of participants were White (57%). As minority populations were not oversampled, this study only contains 11% Blacks, 19% Hispanics, and very few other minority ethnicities. Conversely, the gender ratio of respondents was almost equal, with 51% male and 49% female. Table 1 lists selected characteristics and demographics of the sample.

Methodology

Using the kindergarten-eighth grade full sample public-use file to isolate data collected from only the fifth-grade wave period, a within-year (cross-sectional) analysis is performed. To answer the research questions, the variables of interest were first extracted from the ECLS electronic codebook into IBM SPSS Statistic Version 17 in order to perform the appropriate statistical tests. In order to calculate the relationship between behavior and diet, the dependent variable must be the amount of externalizing behavior for each student. Therefore, the unit of analysis is the individual. The means of externalizing behavior across various levels of dietary intake are then calculated. Lastly, these comparisons are placed into tables and examined to

determine if there are significant differences between an individual's diet and their expression of problem behaviors within the classroom. Control variables are included to identify potential forces that may affect the hypothesized relationship.

Measures

Dependent variable. The dependent variable is the child's externalizing behavior, as reported by his or her reading teacher in Part C of the teacher questionnaire. Externalizing behavior was recorded for each individual student's "acting out" behavior, and included how often the child: 1) fights, 2) argues, 3) acts impulsively, 4) causes disruptions, or 5) speaks out of turn during class. Following previous research (Babinski, Hartsough, & Lambert, 1999), display of these types of impulsive and aggressive behaviors during adolescence are related to criminal activity later in life. The frequency of these five behaviors was originally measured on a Likert-type scale of 1 (never) to 4 (very often). Next, a composite score of the mean ratings of these items combined was recorded for each student[iii]. For the current study's analysis, individual mean scores were placed into ranked categories of 1) Low/Rarely, 2) Medium/Sometimes, and 3) High/Often. (See Table 2 for coding schema and Table 3 for descriptive statistics).

Independent variables. The models for this study include several multi-level independent variables (See Table 2 for coding schema and Table 3 for descriptive statistics). Based on the Food Consumption Questionnaire given to students, information regarding their dietary intake in the seven days prior to data collection was gathered. Participants were asked to include any and all foods they had consumed at home, school, or elsewhere.

Indicators of poor diet. An important objective of the survey was to examine childhood consumption of foods that are "high in fat, sodium, and/or sugars (e.g., candy, salty snacks, soft drinks)" (Tourangeau et al., 2009, p. 56). For the purposes of the current study, four food items

were identified as “indicators of poor health” that may affect problem behavior. These items are: 1) sweets, 2) salty snacks, 3) soda/juice drinks, and 4) fast food. These foods were chosen as indicators of poor diet due to their high fat, sodium, sugar, and caloric contents, while offering very little to no nutritional value in the form of vitamins or minerals. The level of consumption for each of these items was measured at three levels: 1) Never, 2) Sometimes, and 3) A lot (See Table 2 for coding schema).

Indicators of healthy diet. While the correlation between poor diet and externalizing behavior is of most interest within this study, it is important to compare this to the relationship that occurs between a healthy diet and these same behaviors. Therefore, three food items within the questionnaire were indentified as “indicators of healthy diet” and included within this analysis. The items measured were: 1) fruits, 2) vegetables, and 3) green salads. Unlike the indicators of poor diet, these food items have very little fats and carbohydrates and provide an abundance of vitamins and minerals. Important nutritional components such as vitamins A, B, and C, as well as calcium, iron, and potassium, can be gained by eating these healthy foods (Lieberman & Bruning, 1990). Again, level of consumption was measured as either 1) Never, 2) Sometimes, or 3) A lot (See Table 2 for coding schema).

Control variables. Several control variables were included to identify potential effects on externalizing behavior that are independent of diet. This information was gathered from two additional surveys. The first survey collected students’ general demographic information, such as gender and race. Additionally, the weight and height of each respondent was recorded in order to calculate Body Mass Index (BMI). Other control variables were extracted from a survey completed by the student’s parent or guardian, and included information on income and living area.

In total, five variables were controlled for in this study (gender, race, socioeconomic status, living area, and BMI. See Table 2 for coding schema and Table 3 for descriptive statistics). Gender and race were included as controls since the criminological literature has traditionally explored their relationship to crime. For example, research has found consistent differences between male and female rates in delinquency, with males committing more offenses (Gottfredson & Hirschi, 1993). Additionally, racial minorities, particularly blacks, have disproportionally higher arrest and incarceration rates (Sampson & Wilson, 2005). For these reasons, Males and Nonwhites are used as reference categories in the analysis.

Socioeconomic status (SES) and living area are included to determine how community-level factors affect the individual's problem behavior. Research finds that low SES is linked to social disorganization and delinquency, while urban locales are more likely to become high-crime areas (Fergusson, Swain-Campbell, & Horwood, 2004; Sampson & Groves, 1989; Schuerman & Korbin, 1986). Based on previous research, including these particular variables serves to control for mediating factors that may affect the true relationship between diet and maladaptive behaviors. Meanwhile, controlling for BMI allows us to see how physical health status may affect dietary choices. For example, a study on snack consumption found that increased BMI was related to lower self-control (Lawrence, Hinton, Parkinson, & Lawrence, 2012).

In this study, children identified themselves as either male or female in the measurement of gender, and white or nonwhite in the measurement of race. BMI, a reliable index of body fat, was also recorded based on the height and weight of each student. Unlike adult BMI scores, BMI for children takes into account gender and age within a single sample. Those children with BMI scores in the bottom 5^{th} percentile are considered underweight, while those in the 95^{th}

percentile are classified as overweight (Center for Disease Control and Prevention, 2011b). However, in order to maintain an equal distribution across BMI categories, adult classifications are used in this analysis. Unfortunately, this presents a conceptual limitation when controlling for BMI. According to the U.S. Department of Health and Human Services, individuals with a BMI under 18.5 are considered underweight, those between 18.5-24.9 are normal, 25-29.9 are overweight, and any number above 30 is considered obese. In this study, the students were separated into the first three categories, with overweight and obese levels collapsed into one (See Table 2 for coding schema). Due to the unequal distribution of cases across the three levels, the underweight category is used as the reference. Socioeconomic status was determined by the parent's report of household income (in the thousands) for the previous year. This was measured on a four-level ordinal scale (35k or less, 35-50k, 50-100k, or 100k or more). The final control included is the child's living area. This was measured nominally as either 1) City, 2) Suburb, or 3) Rural.

Analysis Strategy

The current study utilizes an ordinal logit regression model to identify if there is a relationship between externalizing behavior and dietary intake, while also controlling for gender, race, BMI, socioeconomic status, and living area. The utilization of this particular statistical test is due to the nature of the categorical dependent variable that measures externalizing behavior on a three-tiered, ordered scale from low to high. As an extension of traditional linear models, regression models estimate how changes in the independent variables will affect the dependent variable (Bachman & Paternoster, 2009). The estimated coefficients reflect these changes. However, logit coefficients are in log-odds units and, therefore, cannot be used to interpret per unit change. More generally, ordinal regression is used in this study to predict the probability of

externalizing problem behaviors, while controlling for other variables, such as socioeconomic status, that have been shown to be criminogenic. Controlling for these other variables makes research findings regarding the relationship between the independent and dependent variables more powerful.

The ordinal logit regression model simultaneously estimates equations for each category of the dependent variable, with one set of coefficients for each independent variable (Bachman & Paternoster, 2009). The goal of running this particular test is to account for as much variance in the dependent variable as possible. The pseudo-R^2 value assesses the predictive strength of the regression model. Due to the extremely high percentage of unknown values in the sweet and salty snacks independent variables (See Table 3 for descriptive statistics), the analysis and results presented in the next chapter omits these particular predictors[iv].

CHAPTER 4: FINDINGS

Prior to conducting the ordinal logit regression model, bivariate correlation tests were used to determine how each independent and control measure was individually related to the dependent variable (See Table 4 for correlation matrix). Results show that consumption of sweets, soda/juice drinks, fast food, vegetables, and salads were all statistically significantly related to externalizing problem behavior. Many of the control variables were also statistically significant (gender, race, location, over/underweight, and SES). Importantly, these preliminary results supported the hypothesized directionality of relationships between variables. For example, poor diet foods that were statistically significant had positive values, indicating a positive linear correlation with the dependent variable (i.e. the more a student consumed a poor diet food, the greater their level of externalized behavior). Conversely, statistically significant healthy diet foods (vegetables and salads) had negative values. Therefore, the less a child ate these healthy items, the greater their level of externalizing behavior (i.e. negative correlation). Similarly, SES and underweight categories were negatively related to the dependent variable.

Correlation tests also reveal how the independent and control variables are related to one another. To improve the accuracy of any analysis, it is important to ensure that the constructed measures are not highly correlated (i.e. measuring the same thing). Table 5 presents a test for collinearity between the independent and control variables included in the current work. The tolerance indicates variance in the predictor that is not accounted for by other variables. The high (.8+) tolerance levels show that there are no redundant measurements in this analysis. Furthermore, any variation inflation factor (VIF) score over 10 would need further investigation. VIF scores do not exceed 1 in the current study. Therefore, there are no issues of multicollinearity.

Results from the regression model are shown in Table 6. Overall, the model is statistically significant ($\chi^2 = 508.578$, $p < .01$), and explains a significant amount of variance in the dependent variable ($R^2 = .058$). Three of the independent variables remained significant when externalizing behavior was measured ordinally. In particular, greater consumption of soda/juice drinks and fast food were related to greater amounts of externalized behavior. Meanwhile, students consuming less green salads were more likely to exhibit such problem behaviors. Like the bivariate findings, results of the regression model support the hypothesized directionality of relationships between poor and healthy diet foods with externalizing behavior.

Four of the control variables were also found to be significant. Males were much more likely than females to externalize problem behaviors, as were those students from a lower socioeconomic status. This is theoretical consistent with existing research regarding the relationship between gender and SES with crime and aggression. Also theoretically consistent with existing literature was the finding that those students living in suburban areas were significantly less likely to exhibit externalizing behaviors than those residing in a city. Lastly, students whose BMI fell into the "normal" range were less likely to exhibit these problem behaviors when compared those who were categorized as underweight.

The overall goal of the current study was to incorporate nutrition into a crime-predicting model by asking the specific research question: do poor diet foods affect externalizing behavior? Results from the regression model clearly demonstrate that the consumption of certain unhealthy and healthy food items influences the expression of maladaptive behavior. This is in addition to the control variables, such as SES, gender, and location, which are theoretically expected to affect these behaviors in the first place. Results, therefore, support an interactionary theory in

which both biological and environmental forces have been found to affect externalizing behavior.

CHAPTER 5: DISCUSSION AND CONCLUSION

This study sought to explore the potential relationship between diet and behavior in adolescents. More specifically, it was hypothesized that the level of consumption of certain foods would affect the amount of externalizing problem behaviors exhibited by students. Ordinal logit regression models were used to determine if there were significant differences in the probability of externalizing behaviors across varying dietary habits. The foods examined include those indicating poor diet (e.g., consumption of sweets, salty snacks, soda/juice drinks, and fast food) and those indicating healthy diet (e.g., consumption of fruits, vegetables, and green salads). It was hypothesized that a specific directional relationship would exist between these different indicators and the dependent variable. In other words, the more a student consumed a poor diet food, the greater their level of externalizing behavior would be (i.e., positive linear correlation). Conversely, it was hypothesized that the more a student consumed a healthy diet food, the lower their externalizing behavior (i.e., negative linear correlation).

Overall, the findings support the hypothesis that diet affects externalizing behavior. The consumption of soda/juice drinks and fast food significantly increases the likelihood of externalizing behavior within adolescents. On the other hand, consumption of green salads significantly decreases this likelihood. Interestingly, fruits and vegetables did not appear to significantly affect maladaptive behavior. Perhaps there is a certain nutrient gained from green salad that affects the body in a way that mitigates externalizing behavior, which cannot be gained from fruits and vegetables. Also, certain fruits, such as apples and bananas, have particular high levels of sugar (U.S. Food and Drug Administration, 2009). An alternative explanation is that confounding variables, such as strong family bonds, could influence consumption of certain

foods. Future work on nutrition could explore the benefits and factors influencing consumption of these various food items.

Unfortunately, the consumption of sweets and salty snacks could not be included in the analysis due the high percentage of missing data. It is suggested that future work on this topic include the consumption of sweets and salty foods when complete data are available. Building on the findings of the current work, research could further explore the specific dietary contents of the foods found to be significant. For example, soda/juice drinks such as Mountain Dew and Kool-Aid were identified in the Food Consumption Survey. One eight ounce serving of Mountain Dew contains 40 milligrams of sodium, 31 grams of sugar, and 36 milligrams of caffeine (PESPSICO, 2012). Future work could examine which of these nutritional components affects adolescent behavior the most, or determine if they work in combination to create negative behavioral outcomes. Additionally, the significance of the gender, SES, and living area control variables should also be explored in future work. The effects that being male, low-income, or residing in an urban location have on the level of consumption of certain foods is a relevant topic that constitutes further investigation.

By demonstrating the important role of nutrition in influencing behavior, this study suggests that the availability of healthy nutritional resources is important, especially among developing children. These results could hold significant implications for policies regarding the delivery of nutritional services. Equitable access to dietary and nutritional information and products is advocated throughout this work as an essential right and requirement to health development. These findings support the continuation of federal programs, such as WIC, that provide nutritional and supplemental aid to those children in need. Additionally, this work stresses the inclusion of nutrition services in health care programs. Unfortunately, obtaining the

proper diet is not a guarantee in today's society. The diet and nutritional information an individual receives are greatly affected by one's environment. This is especially true for children, as they are often not responsible for ensuring the nutritional quality of the foods that they consume. It has been suggested in previous research that an adverse consequence to living in poverty includes the "lack of affordable nutritious food and facilities for physical activities in a neighborhood" (Macintyre, 2007). Indeed, the current findings suggest that there is a relationship between income and food consumption. Perhaps increased access to federal programs that provide nutritional assistance will aid in reducing this problem. Findings suggest that a disadvantaged social environment and poor diet could interact to have a compounding affect on maladaptive behaviors. Thus, it may be useful for biosocial theory to expand its scope and explore environmental-nutrition interactions within contemporary research.

Although promising, this study is not without its limitations. First, the data originally collected did not oversample low-income or minority children, and, therefore, may not be representative of all fifth-grade students at the time (Tourangeau et al., 2009). Additionally, it was not a simple random sample, so not all schools and children had an equal probability of being chosen. The attrition level should also be considered as a limitation to the findings. By the time the fifth-grade data was collected, almost half of the original sample had been lost due to nonresponse or ineligibility. Other collection limitations include the use of self-reported data, as children may not accurately recount their eating behavior.

Limitations of the analytical approach include the absence of two theoretically relevant independent variables, sweets and salty snacks. Many of these food items are often marketed specifically towards children and it would be valuable to determine how they are affecting adolescent behavior. Unfortunately, due to the constraints of missing data, they were precluded

from the current study. Additionally, the distribution of the dependent variable was highly skewed, with only 4% included within the highest level. However, due to the large sample size and high raw number of participants (450) it was determined that there was enough variance across individual cases to interpret these results meaningfully.

Nevertheless, this study has important theoretical and practical implications. First, it identifies nutrition as an important issue that should be incorporated into already popular areas of the biosocial perspective, such as behavioral genetics, evolutionary psychology, and the neurosciences. The bulk of contemporary biosocial research currently lies within these three areas (McMurtry & Curling, 2008). However, results from this work, along with others on vitamins and supplements (Liu & Wuerker, 2005; Neisser et al., 1996), indicate that nutrition may also be useful in explaining individual propensity to crime by demonstrating the links between particular dietary items and subsequent maladaptive behaviors, such as aggression, impulsivity, and hyperactivity.

A strength of biosocial theory is its ability to integrate several biological factors in one study. Thus, the scope of this perspective is extensive, as it does not discount any potential influencer of crime, whether sociological or biological. Research on nutrition falls under this theory since it not only involves several different aspects of biology, such as neurological functioning and transmitters, system receptivity, and vitamin and mineral levels in the body, but also includes sociological aspects. The controls used within the current study show that, in addition to nutrition, environmental factors, such as SES, could be related to externalizing behavior. Interestingly, social factors may also influence an individual's dietary intake (Macintyre, 2007). For example, future studies could examine how income affects children's access to or consumption of certain foods. Within biosocial theory, sociological and biological

processes can interact in multiple, varying sequences in an effort to best explain criminal behavior. Based on the concept model of the current research, Figure 2 offers an expanded example of potential interactions that *may* occur between sociological and biological processes that could affect diet and aggression. Unfortunately, this study was unable to control for all biological pathways potentially affecting aggression and additional research is thus needed.

Biological approaches to crime have been critiqued in the past for assuming that anti-social or criminal traits are predetermined, especially in regards to genetics and heritability studies (McMurtry & Curling, 2008). Conversely, studies in diet and nutrition demonstrate how maladaptive behaviors are not predetermined in biosocial theory, but instead delayed developmental consequences to previous events, such as poor diet. Results within the current study suggest how biological conditions can be influenced by, and interact with, the social environment.

This research suggests that behavior can be affected by diet, which is, in turn, influenced by the social environment. It also provides some support for the biosocial perspective as a sound, non-deterministic theory by exploring non-fixed dietary factors in an effort to explain crime causation. While critics have stated that a "deterministic" biosocial theory cannot account for rapid changes in crime (Walsh & Beaver, 2008), this research argues that alterations to diet can be easily made that may affect behavior. Therefore, the current work strengthens the validity of biosocial theory by potentially explaining certain criminological phenomena that it was previously considered not to be applicable to. By exploring the role of nutrition in affecting behavior, the statistically significant findings presented here further aid in validating the inclusion of the biosocial perspective as a criminological theory.

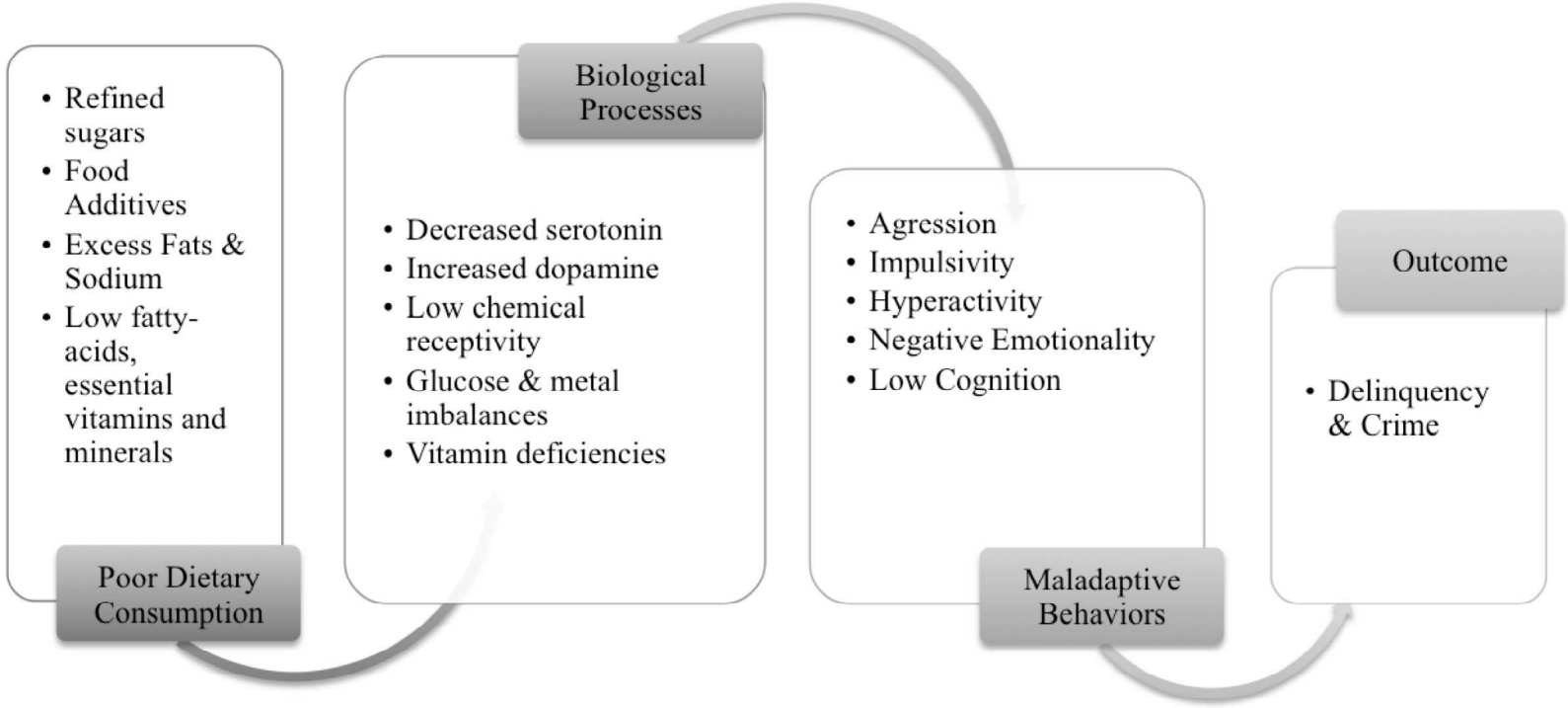
This study also has important implications on how to treat children exhibiting behaviors that predict future criminal activity, such as impulsivity and aggression. The most basic policy implication of this work is to improve the nutrition status of foods children consume. This can be accomplished at the individual level by more closely monitoring eating habits of the child or at a broader level by evaluating and regulating the foods made available within schools. However, before either of these actions can occur, there needs to be a coordinated effort between government, local communities, teachers, and parents to provide improved education of dietary choices; not just to children, but to each other as well. Fortunately, initiatives such as the Healthy, Hunger-Free Kids Act of 2010 have recently sought to improve the state of child nutrition programs. Initiatives include expanding after-school meals to at-risk children, establishing national nutrition standards, and ensuring program compliance (U.S Department of Agriculture, 2012). Although many of these provisions will not take effect until the 2012-2013 school year and results cannot be assessed at the moment, empirical findings like those in the current study provide critical support to such important initiatives that require funding from the government. This marks a historic attempt to improve the quality of meals served to children and, if successfully, could affect approximately 32 million kids nationwide.

Clearly, recent research has demonstrated that human physiology, nutrition, and behavior are related. This study hopes to expand the current literature by highlighting a more progressive, early-intervention response to criminal activity through altering the dietary habits of adolescents. Historically, the United States has taken a very punitive approach when responding to crime. This is especially true concerning juvenile justice policy and its movement towards the "adultification of youth" (Benekos & Merlo, 2008; Dove, 2001). The country is unique in its use of extremely stringent penalties and building of the largest prison system, while still maintaining

some of the highest reoffending rates (Currie, 1998). In a global comparison of differing approaches to crime, it was found that the United States remains "far and away the most violent advanced industrial society on earth" (Currie, 1998, p. 4). Despite research indicating that more stringent and punitive approaches to sentencing may not be working, criminal justice policies remain the same (Benekos & Merlo, 2008; Finley & Schindler, 1999). Perhaps, as new theories create the so-called "paradigm shift" in criminological study that Wright and Boisvert (2009) suggested, the time is ripe to look at alternatives to reducing violence and crime that are more progressive than reactionary. The current research, founded on a biosocial theoretical perspective, tries to reinterpret the occurrence of violence and crime in a preventative manner by targeting children susceptible to developing aggressive behavior due to individual and environmental factors influencing physiological development.

APPENDIX

Figure 1: Concept Model



Appendix A: Food Consumption Questionnaire

The next questions ask about food you ate or drank during the past 7 days. Think about all the meals and snacks you had from the time you got up until you went to bed. Be sure to include food you ate at home, at school, at restaurants, or anywhere else.

1. In your school, can kids buy candy, ice cream, cookies, cakes, brownies or other sweets in the school?

2. During the last week that you were in school, how many times did you buy candy, ice cream, cookies, cakes, brownies or other sweets at school?

3. During the last week that you were in school, where in the school did you usually buy candy, ice cream, cookies, cakes, brownies or other sweets?

4. In your school, can kids buy potato chips, corn chips (Fritos, Doritos), Cheetos, pretzels, popcorn, crackers or other salty snack foods at school?

5. During the last week that you were in school, how many times did you buy salty snack foods at school?

6. During the last week that you were in school, where in the school did you usually buy salty snack foods?

7. In your school, can kids buy Soda pop (EXAMPLES Coke, Pepsi, Mountain Dew), sports drinks (EXAMPLE Gatorade), or fruit drinks that are not 100% fruit juice (EXAMPLES Kool-Aid, Hi-C, Fruitopia, Fruitworks) in the school? During the last week that you were in school, how many times did you buy soda pop, sports drinks, or fruit drinks at school?

8. During the last week that you were in school, where in the school did you usually buy soda pop, sports drinks, or fruit drinks?

9. During the past 7 days, how many glasses of milk did you drink?

10. What kind of milk did you drink during the past 7 days?

11. During the past 7 days, how many times did you drink 100% fruit juices such as orange juice, apple juice, or grape juice? (Do not count punch, Kool-Aid, sports drinks, or other fruit-flavored drinks.)

12. During the past 7 days, how many times did you drink Soda pop (EXAMPLES Coke, Pepsi, Mountain Dew), sports drinks (EXAMPLE Gatorade), or fruit drinks that are not 100% fruit juice (EXAMPLES Kool-Aid, Hi-C, Fruitopia, Fruitworks)?

13. During the past 7 days, how many times did you eat green salad?

Appendix A: Food Consumption Questionnaire – Continued.

14. During the past 7 days, how many times did you eat potatoes? (Do not count french fries, fried potatoes, or potato chips.)

15. During the past 7 days, how many times did you eat carrots?

16. During the past 7 days, how many times did you eat other vegetables? (Do not count green salad, potatoes, or carrots.)

17. During the past 7 days, how many times did you eat fruit, such as apples, bananas, oranges, berries or other fruit? (Do not count fruit juice.)

18. During the past 7 days, about how many times did you eat a meal or snack from a fast food restaurant such as McDonald's, Pizza Hut, Burger King, KFC (Kentucky Fried Chicken), Taco Bell, Wendy's and so on?

SOURCE: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), spring 2004.

Table 1: Children in Spring 2004 fifth-grade sample, by selected characteristics

Characteristic	Total	Public Sector	Private Sector
Total	12,029	9,567	2,462
Region			
Northwest	2,254	1,705	549
Midwest	3,124	2,354	770
South	3,849	3,237	612
West	2,802	2,271	531
Type of locale			
City	4,578	3,329	1,249
Suburb	4,625	3,798	827
Rural	2,826	2,440	386
School Affiliation			
Public	9,567	9,567	--
Religious	2,177	--	2,177
Private	285	--	285
Race/Ethnicity			
White	6,846	5,075	1,771
Black	1,365	1,229	136
Hispanic	2,264	1,961	303
Other	1,526	1,278	248

Table 2: Variable Coding Schema

Variable	Definition/Coding
Dependent	*How frequently did student exhibit problem behaviors?*
Externalizing Problem Behavior	1 = Low/Rarely; 2 = Medium/Sometimes; 3 = High/Often
Independent	*How frequently was item consumed in the past 7 days?*
Sweets	1 = Never; 2 = Sometimes; 3 = A lot
Salty Snacks	1 = Never; 2 = Sometimes; 3 = A lot
Soda/Juice Drinks	1 = Never; 2 = Sometimes; 3 = A lot
Fast Food	1 = Never; 2 = Sometimes; 3 = A lot
Fruits	1 = Never; 2 = Sometimes; 3 = A lot
Vegetables	1 = Never; 2 = Sometimes; 3 = A lot
Salads	1 = Never; 2 = Sometimes; 3 = A lot
Control	
Gender	1 = Male; 0 = Female
Race	1 = Nonwhite*; 0 = White
Body Mass Index (BMI)**	*Categorization of BMI score****
Underweight+	1 = Underweight; 0 = Else
Overweight	1= Overweight; 0 = Else
Normal	1 = Normal; 0 = Else
SES	*Total household income last year in the thousands* 1 = 35k or less; 2 = 35–50k; 3 = 50–100k; 4 = 100k or more
Living Area	
City+	1 = City; 0 = Else
Suburb	1 = Suburb; 0 = Else
Rural	1 = Rural; 0 = Else

+ Reference variable
*Nonwhite races include Blacks, Hispanics, Asians, and Native Americans
**Calculated by formula: Weight in pounds / (height in inches2) x 703
***As defined by the U.S. Department of Health and Human Services

Table 3: Variable Descriptive Statistics, N = 10,722

	Count	Percentage
Dependent Variable		
Externalizing Problem Behavior		
Low/Rarely	7820	73%
Medium/Sometimes	2450	23%
High/Often	450	4%
Independent Variables		
Indicators of Poor Diet		
Sweets		
Never	3024	28%
Sometimes	2485	23%
A lot	60	1%
Unknown	5153	48%
Salty Snacks		
Never	3445	32%
Sometimes	1710	16%
A lot	39	.4%
Unknown	5528	51.6%
Soda/Juice Drinks		
Never	1671	16%
Sometimes	7839	73%
A lot	1107	10%
Unknown	105	1%
Fast Food		
Never	3018	28%
Sometimes	7275	68%
A lot	324	3%
Unknown	105	1%
Indicators of Healthy Diet		
Fruits		
Never	956	9%
Sometimes	8090	75%
A lot	1570	15%
Unknown	106	1%
Vegetables		
Never	1913	18%
Sometimes	7979	74%
A lot	722	7%
Unknown	108	1%
Salads		
Never	5154	48%
Sometimes	5259	49%

Table 3: Variable Descriptive Statistics, N = 10,722 (Cont'd)

A lot	203	2%
Unknown	106	1%
Control Variables		
Gender		
Male	5405	50.4%
Female	5317	49.6%
Race		
White	6227	58.1%
Nonwhite	4482	41.8%
Unknown	13	.1%
Living Area		
City	3812	36%
Suburb	3978	37%
Rural	2511	23%
Unknown	421	4%
BMI		
Underweight	4389	41%
Normal	4309	40%
Overweight	1734	16%
Unknown	290	3%
SES		
35k or less	3029	28%
35 – 50k	1478	14%
50 – 100k	3085	29%
100k or more	1558	14%
Unknown	1572	15%

Table 4: Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Externalizing	--																
2. Sweets	.05[a]	--															
3. Salty	.02	.29[a]	--														
4. Soda/Juice	.04[a]	.09[a]	.10[a]	--													
5. Fast food	.04[a]	.12[a]	.14[a]	.21[a]	--												
6. Fruits	.01	.02	.05[a]	.05[a]	.05[a]	--											
7. Vegetables	-.02[b]	.03[b]	.03[b]	.01	-.05	.23[a]	--										
8. Salad	-.05[a]	.03	.06[a]	-.04[a]	-.04[a]	.15[a]	.21[a]	--									
9. Gender	.19[a]	-.02	-.02	.05[a]	.01	-.03[a]	-.06[a]	-.11[a]	--								
10. Race	.06[a]	.04[a]	.07[a]	-.03[a]	.09[a]	.09[a]	-.02[b]	-.02[b]	-.01	--							
Living Area																	
11.City	.03[a]	-.03[b]	.00	-.01	.05[a]	.04[a]	.00	.02	-.02	.23[a]	--						
12.Suburb	-.05[a]	.01	-.01	-.01	-.02	-.02	.01	.03[a]	.01	-.09[a]	-.61[a]	--					
13.Rural	.02[b]	.03[b]	.02	.02[b]	-.04	-.02[b]	- .01	-.05[a]	.01	-.15[a]	-.44[a]	-.45[a]	--				
BMI																	
14.Overweight	.04[a]	-.02	.02	-.01	-.01	.00	.00	.03[a]	-.02[b]	.02[b]	.01	-.03[a]	.03	--			
15.Normal	.01	.00	.00	.01	-.01	-.01	-.01	.01	-.02	.01	.02	.01	.02[b]	-.38[a]	--		
16.Underweight	-.04[a]	.01	-.01	-.01	.01	.01	.01	-.03[a]	.00	-.08[a]	-.04[a]	.02[b]	-.04[a]	-.38[a]	-.71[a]	--	
17. SES	-.13[a]	-.05[a]	.00	-.04[a]	-.06[a]	-.02[b]	.05[a]	.10[a]	.00	-.35	-.13[a]	.17[a]	-.13[a]	-.13[a]	-.02	.12	--

[a]. Significant at the $p < .05$ level.

[b]. Significant at the $p < .01$ level.

Table 5: Test of Collinearity

Variable	Tolerance	VIF
Sweets	.902	1.108
Salty Snacks	.904	1.106
Soda/Juice Drinks	.927	1.078
Fast food	.922	1.085
Fruits	.910	1.099
Vegetables	.901	1.109
Salads	.915	1.093
Gender	.980	1.020
Race	.811	1.233
BMI	.967	1.034
Living Area	.930	1.076
SES	.828	1.208

Table 6: Ordered Logit Regression (N = 10,722)

Variable	Coeff.	S.E.	Sig.
Independent			
Soda/Juice Drinks	.111	.051	.030*
Fast Food	.104	.052	.045*
Fruits	.028	.053	.595
Vegetables	-.022	.053	.681
Salads	-.112	.049	.022*
Control			
Gender	.903	.052	.000**
Race	.062	.057	.279
SES	-.250	.026	.000**
Living Area			
Suburb	-.148	.060	.013*
Rural	.053	.067	.431
BMI			
Overweight	.143	.073	.051
Normal	-.122	.056	.029*

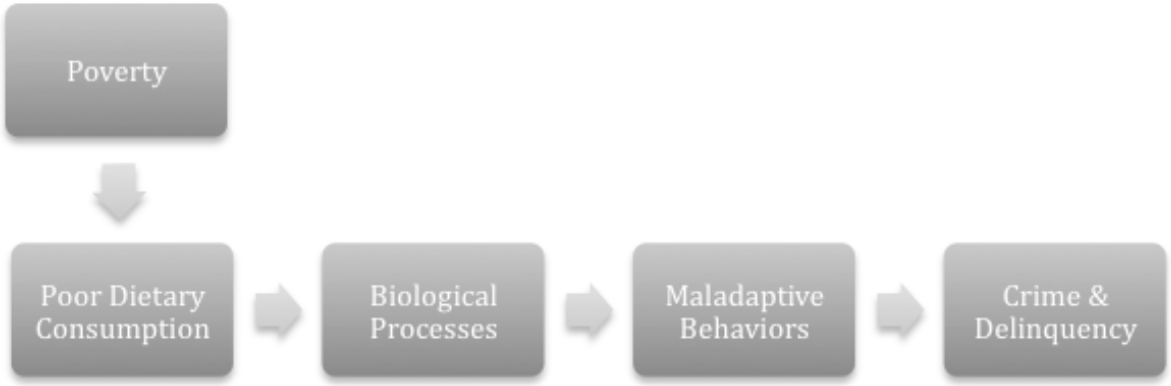
Intercept = 7479.477
-2 Log likelihood = 6970.900
Model Chi-Square (p) = 508.578 (.000)
Cox and Snell *R*-Square = .058

* p < .05, ** p <.01
S.E. = standard error

Figure 2: Expansion of Concept Model for Future Research

Step 1: Current Model

Step 2: Addition of Sociological Factor



Step 3: Addition of Biological Factor

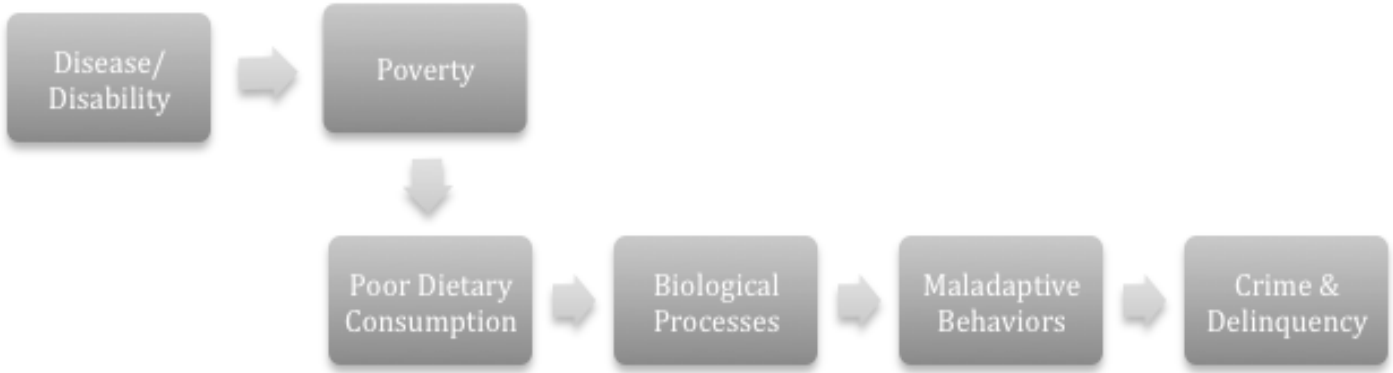


Table 7: Ordered Logit Regression (Including Sweets and Salty Snacks) (N = 10,722)

Variable	Coeff.	S.E.	Sig.
Independent			
Sweets	.159	.084	.060
Salty Snacks	.004	.090	.961
Soda/Juice Drinks	.149	.090	.098
Fast Food	.215	.090	.017*
Fruits	-.100	.091	.269
Vegetables	.079	.093	.394
Salads	-.085	.082	.302
Control			
Gender	.928	.088	.000**
Race	.146	.096	.128
SES	-.249	.043	.000**
Living Area			
Suburb	-.027	.099	.784
Rural	.088	.122	.467
BMI			
Overweight	.027	.120	.821
Normal	-.012	.094	.902

Intercept = 3737.461
-2 Log likelihood = 3540.655
Model Chi-Square (p) = 196.807 (.000)
Cox and Snell *R*-Square = .060

* p < .05, ** p <.01
S.E. = Standard error

NOTES

NOTES

i. The eighth-grade data is not included here as many of these variables were suppressed. The information collected in this wave also contained formal medical diagnoses related to weight and diet that the NCES determined should be excluded in order to best protect participants (Tourangeau et al., 2009). As a result, several important variables regarding student diet and health were omitted from the eight-grade publicly released data. For this reason, only the fifth-grade collection data is utilized.

ii. The actual questionnaire is not available due to copyright restrictions (Tourangeau et al., 2006).

iii. The actual scales are not available in the dataset. Only the mean score for all of the scales was reported.

iv. Although conceptually important to the research question of the current study, sweet and salty snacks independent variables were precluded due to the high percentage of unknown data (48% and 51.6%, respectively). In doing so, the remaining model becomes more stable and the results more powerful. For informational purposes, Table 7 shows the regression with these variables still included.

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