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# Do Early Childhood Body Mass Index Trajectories Affect School Readiness, Socioemotional Development, or Cognition? Findings From the CANDLE Study.

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# DO EARLY CHILDHOOD BODY MASS INDEX TRAJECTORIES AFFECT SCHOOL READINESS, SOCIOEMOTIONAL DEVELOPMENT, OR COGNITION? FINDINGS FROM THE CANDLE STUDY.

By

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## Preface

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## Abstract

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Childhood obesity is associated with negative health and social outcomes in school-age children. These effects range from absenteeism and poor self-esteem to worse test scores, and fewer completed grades. Although previous studies have found these associations in school-age children and adolescents, less is known about this association in young children, who are just beginning school. Additionally, many studies of the outcomes of obesity are limited by cross-sectional study designs. These projects attempted to examine three distinct effects of obesity in early childhood by using a novel strategy: trajectory analysis. Using yearly data from the Conditions Affecting Neurocognitive Development and Learning in Early childhood (CANDLE) study, a prospective birth cohort study in Memphis, TN, we categorized child participants into one of four BMI percentile group trajectories. Linear regression was used to examine the association between these trajectories and school readiness, socioemotional development, and cognition. Crude analysis in all three studies yielded no significant associations. Once potential confounders were included in the models, there was still no association between trajectory group and the outcomes. Maternal education, insurance type, and child's race were significant predictors of school readiness, with insurance type having the largest effect. Children with private insurance, compared to children with public insurance, had higher average scores by 1.64 and 1.73 points for girls and boys, respectively. Maternal education was a significant predictor of score on all eight outcome scales that measured socioemotional development, with children of mothers without a college degree having higher average scores on the total problems scales by 3.60 points, compared to children of mothers with a college degree or more education. Child's

race was a significant predictor of the score on two outcome scales. Maternal education, maternal marital status, insurance type, and child race were all significant predictors of IQ in girls. Maternal education, insurance type, and child race were significant predictors of IQ in boys. Girls and boys who have private insurance, compared to girls who have public insurance, have higher average IQs by 4.58 and 4.67 points, respectively.

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# Chapter 1

## Introduction

The prevalence of overweight and obesity in children has increased dramatically since the 1980s. Data, from 2009-2010, estimates that 9.7% of infants and toddlers and 16.9% of children and adolescents are overweight or obese.[1] Obesity in children and adolescents is defined by percentile of body mass index (BMI). First, BMI is calculated by dividing children's weight in kilograms by their height in meters squared. Then the BMI is compared to a reference population that includes children of the same age and gender. Comparing BMI to those in this reference population accounts for the substantial growth and differing body compositions that occur during childhood and adolescence. Children with a BMI between the 85th and 95th percentile are considered overweight, and children with a BMI above the 95th percentile are considered obese.[2]

Many studies have attempted to sort out the repercussions of this alarming upward trend by investigating the effects of childhood overweight and obesity throughout the lifespan. Researchers have shown the future effects of childhood overweight and obesity include a persistence into adult overweight and obesity,[3] that contributes to many deleterious health effects including: higher systolic and diastolic blood pressure, and triglycerides, as well as lower HDL cholesterol.[4] These health effects each contribute to the increasing morbidity and health care spending related to cardiovascular disease in adults.

Other studies have found additional consequences of obesity that are not related to health outcomes in adulthood. A study by Gortmaker et al. examined some of the social outcomes of overweight during adolescence and found that women who were overweight at age 16-24 completed fewer years of school, earned less income, were less likely to be married, and were more likely to live in poverty at follow-up seven years later. In this same study, men who were

overweight were also less likely to be married at follow-up.[5] These social outcomes of obesity illustrate the other reasons for the increasing economic toll of this disease in the United States.

While the aforementioned health and social outcomes were seen as overweight children and teenagers grew into adults, recent research has shown that some negative consequences of overweight and obesity begin to emerge in adolescence. One study found that obese 15 to 17 year-olds were significantly more likely to be diagnosed with type II diabetes. This association has been well established in adult populations, but this new evidence suggests that the mechanism causing diabetes may begin earlier than previously expected. Additionally, this study explored a multitude of other health and psychosocial factors and found that obese adolescents, ages 10-17, were more likely to have overall worse health than their normal weight peers. Other outcomes more common in obese adolescents include physical health problems, developmental conditions, mental health problems, and psychosocial issues. Interestingly, the reported psychosocial issues include both school related problems and absenteeism,[6] which could explain why obese female students tend to complete less years of school.

A study that included mostly Latino and Asian American students found that BMI was inversely related to self-reported grades, but not measured grades. This discovery may indicate possible self-esteem issues in children who are overweight.[7] Indeed, another study found that obese adolescents ages 8-16 were more likely to have unfavorable peer perceptions than their normal weight peers. Peers indicated that their obese classmates were less likable, more apt to cause disruptions in class, and also less healthy.[8] These negative peer perceptions could affect both self-esteem and school performance among obese adolescents.[9] [10] Could these early problems with peers, self-esteem, and absenteeism be keeping overweight teens and young adults

from finishing school? To understand these complex relationships, we first need to have a clear understanding of when these school problems begin.

Studies about the potential effects of overweight and obesity during early childhood and adolescence have been inconclusive. For example, a study by Schwimmer et al. found that obese children and adolescents report lower health-related quality of life than their normal weight counterparts, but its small sample size and large age range are limitations in generalizing these results to our population of interest.[11] A larger cross-sectional study of children ages 5-17 studied health risk factors including: total cholesterol, blood pressure, fasting insulin, triglycerides, and LDL cholesterol and found that 58% of overweight children and adolescents had elevated levels of at least one risk factor but, again, it is unclear if these effects remain true when only examining the youngest subjects in this study.[12] A study of children in fifth grade found that obese students were more likely to have lower self-esteem than their normal weight peers; however, this study also found that weight did not significantly affect children's school performance.[9] Similarly, a study of third graders found that overweight children scored worse on standardized tests, but the association was not significant once the researchers controlled for socioeconomic factors. In this same study, however, girls who were overweight had more problematic internalizing and externalizing behaviors, as well as problems with self-control. These associations remained significant even after controlling for socioeconomic characteristics.[13] A study of data collected as part of the Early Childhood Longitudinal Study assessed the effect of weight status at kindergarten on reading and math test scores at kindergarten and at first grade. Similar to other studies' findings, significant differences in test scores among overweight children and their normal weight counterparts mostly disappeared once the researchers controlled for socioeconomic variables. However, this study did find that

overweight boys had significantly lower math scores in kindergarten, even after controlling for socioeconomic variables, indicating that there may be a relationship between overweight and cognition that is not explained by socioeconomic factors.[14]

These inconsistent findings and limited study designs lead us to the need for more research in the area of early childhood overweight and obesity outcomes. The proposed projects will attempt to disentangle both psychosocial and cognitive outcomes in young children, using first a cross-sectional then a longitudinal design with data from the Conditions Affecting Neurocognitive Development and Learning in Early childhood (CANDLE) study.

The CANDLE study is a birth cohort study that began in 2006 in Memphis, Tennessee and the surrounding Shelby County. Private funds were awarded to the University of Tennessee Health Science Center, with the goal of recruiting a sample of pregnant women to ascertain which factors affect cognitive development in the first three years of life. Recruitment for the study began at Regional One hospital, the area's safety net hospital, in an attempt to capture the area's most disadvantaged expectant mothers. In this phase of recruitment, expectant mothers were approached during their prenatal appointments and asked if they would be interested in participating in the study. After successfully recruiting 344 pregnant women, recruitment expanded to include four other community hospitals, to capture a sample that accurately represented Memphis and Shelby County. The community recruitment required expectant mothers to come to a research clinic for their enrollment and prenatal appointments, instead of being seen at their obstetrician's office. Overall, the study was successful in its goal by recruiting a sample of 1,503 pregnant women, who closely matched the demographic characteristics of Memphis and Shelby County, with 64.7% African American, 43.6% single mothers, and 50.7% living with an income <$25,000 per year.[15]

Expectant mothers were eligible for the study if they were Shelby County residents planning to deliver at one of the five aforementioned hospitals, were between the ages of 16 to 40, were in their second trimester of pregnancy, were receiving regular prenatal care, had a singleton uncomplicated pregnancy, and provided consent. At the time of enrollment, participants agreed to follow-up for 3 years after the baby's birth via yearly appointments in which the children and mothers were given a battery of psychological tests and surveys. Other data collected during these yearly visits included health, nutrition, and demographic information, as well as physical measurements and hair samples.[15] In 2011, the study was awarded funding to continue to follow the cohort via another study visit at age 4-6, in order to assess asthma and allergy outcomes among the children. With additional private funding, the investigators were able to bring the children and mothers back for another full cognitive exam. The study is ongoing, with current follow-up funded by the National Institutes of Health and the Environmental influences on Child Health Outcomes (ECHO) program, to assess the impact of maternal and child stressors on asthma, allergies, and cognitive development at ages 8-9 and 10-11.

Retention of the original study cohort has been good, with 1,136, 1,103, 1,049, and 1,157 participants seen at the one, two, three, and four to six-year follow-up visits, respectively. The first three follow-up visits were scheduled within a six-month window of the child's birthday and the final visit was scheduled from the child's fourth birthday up to the day before his or her eighth birthday. These follow-up clinic visits took place at two sites in Memphis, for the convenience of the participants. Each year, study participants provided informed consent, and research assistants administered a plethora of surveys collecting health, demographic, nutrition and psychosocial information. Research assistants also collected anthropometric data including

height and weight at each time point, head circumference at years one through three, and waist circumference at year four. Biological specimens collected include: hair, buccal swabs, and blood samples. During the study visits, the participants would also meet with a cognitive examiner, who administered the cognitive assessments and additional psychosocial surveys. The cognitive examiners were psychologists and trainees from the Boling Center for Developmental Disabilities at the University of Tennessee Health Science Center. Participants were provided with immediate feedback about their children's development and referrals for more extensive assessments were given when warranted.

While we planned to initially look at the data cross-sectionally, using both predictor and outcome variables from the four to six-year visit, we realize that this design is limited, especially when it is used in weight-related research. A study by Ziyab et al. introduced the idea of creating group-based weight trajectories as being a way to capture the "age-of-onset, duration, and intensity" of overweight and obesity.[16] While there have been a limited number of studies that used group-based trajectory modeling in childhood, none have examined its association with school or social outcomes. The CANDLE study's prospective design makes it a good option for continuing this group-based trajectory work. Therefore, we used data from all four CANDLE study visits in our final analyses: height and weight to create our trajectories, and outcomes including socio-emotional health as measured by the Child Behavior Checklist, school readiness as measured by the Bracken Basic Concept Scale, and cognitive ability as measured by the Stanford Binet Intelligence Scales.

The goal of these projects is to assess the association between weight and these three outcomes in young children, who are just entering school. These projects will add to our knowledge about when weight status affects school and social outcomes. This work will be

important in determining the most advantageous time to begin weight control interventions, in order to avoid deleterious effects.

## Chapter 2

**The association between early childhood BMI trajectory and school readiness, as measured by the Bracken Basic Concept Scale - 3rd Edition: Receptive (Bracken).**

### Background

The increasing prevalence of overweight and obesity in childhood described by Hales et al., which is currently at 18.5%, has spurned much research into not only the health effects of early overweight and obesity, but also the potential social effects.[17] Investigators have assessed some of the social effects of obesity in adolescents including mental health problems and school-related problems. One study found that obese girls completed fewer years of school, earned less income, and were more likely to live in poverty,[5] while another found a significant increase in health problems, as well as school-related problems and absenteeism among obese adolescents.[6]

On the other hand, a study in younger children found that BMI was inversely associated to student-reported grades, but not measured grades.[7] This study illustrates one current conundrum that researchers have yet to tease apart: whether possible bullying or self-esteem issues are causing these school problems[10] or whether these obese children are not as cognitively ready for school as their normal weight peers.[14]

None of the previously mentioned studies include data from very young children, who are just entering school. This gap in the literature leaves a valuable opportunity to assess whether weight directly effects school performance (or readiness) or has some effect via the bullying and social ostracism that come with being overweight as a child. Another major limitation of many of the aforementioned studies is that weight is measured at only one time point, concurrent with the outcome measurements. This study design limits an investigator's ability to make any causal assumptions about the outcomes of the research.

This project was designed to address both of these gaps in the literature by creating a trajectory of BMI percentiles over a child's first four to six years of life and examining the association between that trajectory and school readiness, as measured by the Bracken Basic Concept Scale- 3rd Edition: Receptive (Bracken).

Trajectory analysis of weight status has been used successfully in a few studies.[16,18] Creating a group-based trajectory of weight status over the first four to six years of life gives additional benefits not available by examining these data cross-sectionally. First, trajectory analysis gives information about the onset of obesity, which could be important in determining specific risk profiles. Additionally, trajectory analysis gives information about the duration of obesity, as well as the intensity of obesity. All three of these pieces of information are important when examining obesity as an exposure. Additionally, one study found that early-life trajectories were set by the age of four, meaning that whichever trajectory a person belongs to at age four, they are likely to stay in until age eighteen.[16]

**Methods**

Data for this project were collected from participants enrolled in the CANDLE study, a prospective birth cohort study in Memphis, Tennessee. A detailed description of the CANDLE study participants and timeline was included previously. This project used data collected at the CANDLE study one, two, three, and four to six-year clinic visits. At these visits, participants provided informed consent then trained research staff measured the children's height and weight twice for accuracy. For the one-year clinic visit only, research assistants measured recumbent length instead of height. Length was measured in centimeters using a measuring board, height was measured in centimeters using a wall-mounted stadiometer, and weight was measured in kilograms using a digital scale. The average of the two height (or length) measurements and

weight measurements was used to calculate BMI percentiles. BMI percentiles were calculated using the SAS macros provided for the WHO growth charts for children up to two years of age and the CDC growth charts for children two and older.[19] [20]

Other data collected at the four to six-year visit for this project includes the Bracken Basic Concept Scale. This achievement test was designed to be appropriate for children just starting school. In fact, the first five subtests of the Bracken assess school readiness by measuring the fundamental knowledge that children need to be successful in the first few years of school including: colors, letters, numbers, sizes, and shapes. When these subtest scores are combined, they become the school readiness composite (SRC), which has been shown to predict school success.[21] Additionally, all five subtests require only receptive language, so a child can be successful, even if his or her expressive communication is lagging. The entire SRC takes about 10-15 minutes to complete with a child, and it was administered by a psychologist or trainee from the Boling Center for Developmental Disabilities during the CANDLE study visit.

A test-retest reliability study of the Bracken SRC show some differences among age groups, but was good overall, reporting *r*s of .84 and internal consistency measures reporting *r*s of .95 among all age groups. A validity study comparing the third edition to an earlier edition also reported *r*s of .84.[22] An additional study of validity has shown that the Bracken successfully predicts children's performance on a standardized reading test as well as teacher-reported readiness. This study reports that the Bracken was also successful in identifying children who needed referrals for developmental services or repetition of kindergarten.[21] The SRC gives a scaled score from 1-19, with a mean of 10. Children who score between 4 and 7 are considered delayed, while children who score lower than 4 are considered very delayed.

For this study, the scaled score on the SRC is the outcome variable. While the SRC is recommended for children up to age six years eleven months, this study is focused on school readiness as children are beginning school; therefore, children who were six and older at the time of data collection were excluded from the analysis. This measure's ability to predict school success was instrumental in showing whether overweight children were already behind before they began formal schooling.

This study was designed to examine the association between BMI percentile trajectory group to the SRC scaled score. Potential confounders included in the models were race, type of insurance coverage, mother's level of education, and mother's marital status. Each of these variables were collected via self-administered survey at the four to six-year study visit. Child's sex, which was abstracted from medical records at delivery, was also included in the analysis. Low birth weight status (low birthweight, normal birthweight), which was also abstracted from medical records at the time of delivery, was considered a potential confounder, however very few children were below the cutoff (2500g) for low birthweight; therefore, these children were excluded from the analyses. Type of insurance coverage was used as a proxy for household income, because there is less missingness in the insurance data. All potential confounders included in this project were chosen because of known associations with childhood obesity, as well as academic performance.

**Statistical Analysis**

The first step in these analyses was to model the BMI trajectories over the first four CANDLE study visits. Participants who had BMI percentile data for at least two study visits within the first four study visits were eligible to be included in the trajectory analysis. We used the procedure outlined by Bobby L. Jones, PhD, as well as the PROC TRAJ macro in SAS,

which uses semi-parametric mixture modeling, to identify the trajectory groups.[23] The procedure includes some exploratory analyses to identify how many trajectory groups are appropriate for the data, as well as the shape of the groups' trajectories. Steps and documentation are outlined on Dr. Jones's website.[24] Briefly, models were created with one to four trajectory groups, then tested for the shape of each group's trajectory, using the Bayesian Information Criterion. Both boys and girls were included in the trajectory models, since sex is already accounted for in the BMI percentile determination. After finding the most appropriate model, participants were categorized based on their estimated trajectory membership probabilities. This identifier became the predictor variable for subsequent analyses.

After creating the trajectories, the analytical sample was compared to the original study cohort sample to check for selection bias, using Chi-square tests of two stable descriptive variables (mother's race and child's sex). The mean and standard deviation of the SRC scaled score were reported by trajectory group. Additionally, the mean and standard deviation for each continuous independent variable, and the frequency and percentage of each categorical independent variable were reported by trajectory group.

Finally, the newly created trajectory group identifier was used as the predictor variable in the models. PROC GLM in SAS was used to first run a crude linear regression model using only the trajectory group and the SRC scaled score as the outcome. Then, all potential confounders were added to the model, as well as the potential effect modifier. These covariates were then systematically removed one by one from the model in order from the smallest to largest effect size, ensuring that the estimate for the trajectory groups did not change by more than 10%.

**Results**

There were 1,157 participants who completed the CANDLE four to six-year clinic visit. Of those, 996 had BMI percentile measurements for at least two time points and could be included in the trajectory modeling. SRC outcome data were available for 904 of those participants. Those who were older than six years of age at the time of the visit (n=13) were excluded since this project was focused on children who are just entering school, as well as those who had low birthweight (n=62), resulting in 829 participants available for these analyses (Figure 1).

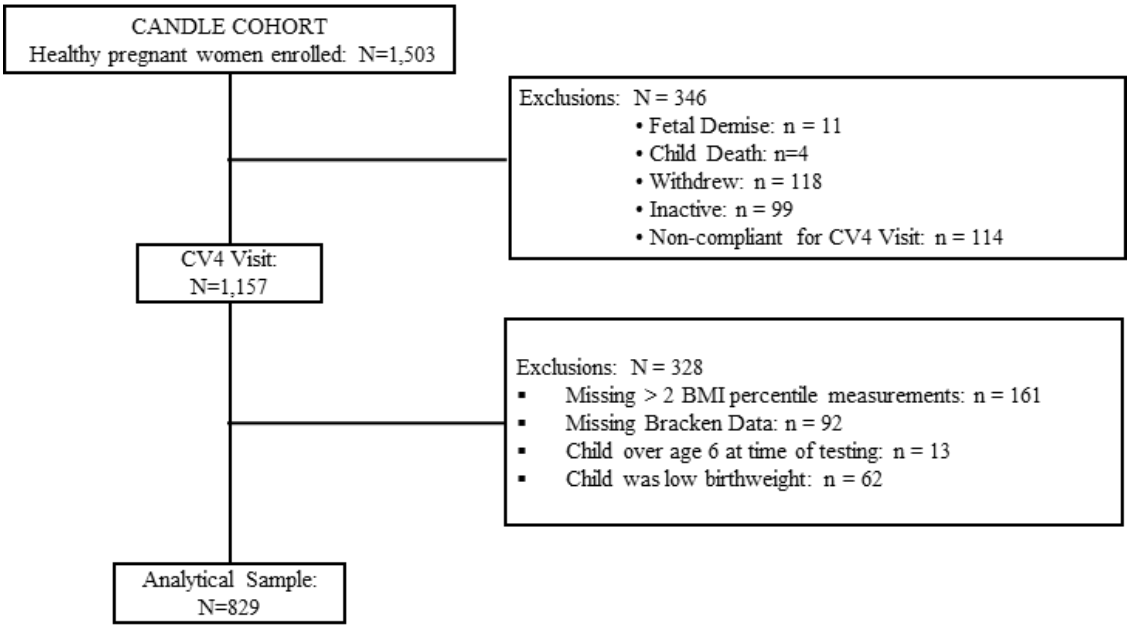


Figure 1 – Exclusion Criteria for Study 1

Exploratory trajectory analyses using PROC TRAJ yielded four distinct trajectory groups: one low stable BMI percentile group (group 1, n=154), one decreasing then stable BMI percentile group (group 2, n=220), one increasing BMI percentile group (group 3, n=69), and one high stable BMI percentile group (group 4, n=386) (Figure 2). The average BMI percentile

at the four to six-year visit was calculated for each trajectory group, to ensure they fit within the trajectory curves. Those means were 29.3, 52.4, 71.0, and 85.0, respectively.

The mean overall score for the school readiness composite (SRC) was 9.88 (SD= 3.52). The children were 50% male, 62% African American, and 49% reported using publicly funded insurance. Of the children, 69% were normal weight, 14% were overweight, and 17% were obese at the time of the four-year visit. Of the mothers in the final sample, 55% had less than a college degree at the time of the four to six-year study visit. Chi-square tests found no differences between our analytical sample and the original CANDLE study sample (Tables 1 and 2).

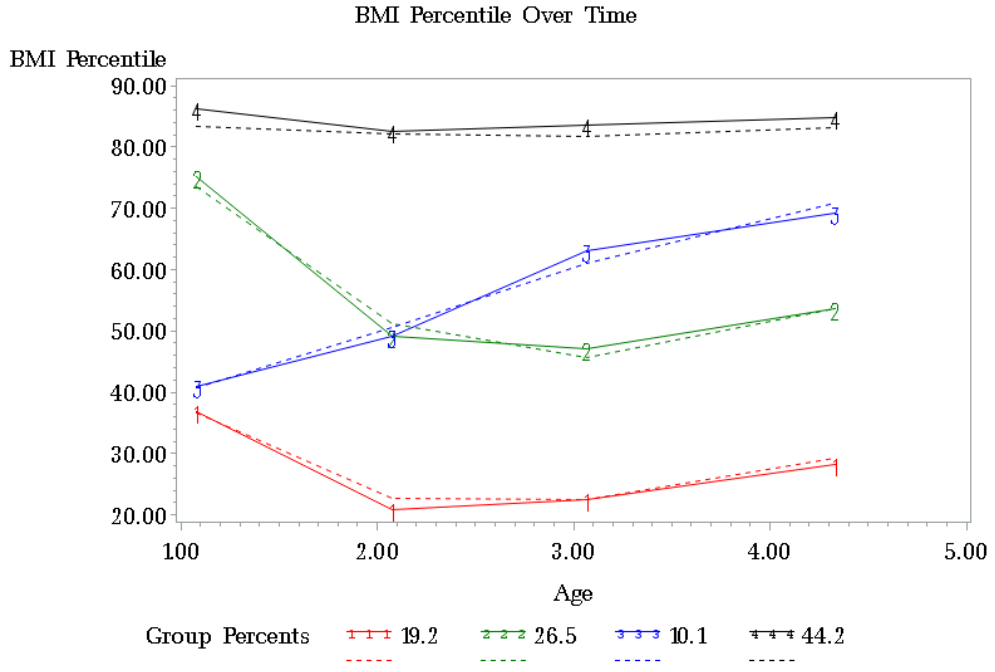


Figure 2 - Four Distinct BMI Trajectories over the first 4-6 years of Life

Table 1 - Comparison of Original Cohort Sample and Analytical Sample for Study 1

| | Study Sample (N=1503) | Analytical Sample (N=829) | Chi-Square (p-value) |
|---|---|---|---|
| Sex, n (%) | | | 0.11 (0.7380) |
| Male | 715 (50.4) | 413 (49.8) | |
| Female | 705 (49.6) | 416 (50.2) | |
| Missing | 83 | 0 | |
| Mother's Race, n (%) | | | 1.12 (0.5708) |
| African American | 936 (62.4) | 510 (61.5) | |
| Caucasian | 467 (31.1) | 270 (32.6) | |
| Other | 98 (6.5) | 49 (5.9) | |
| Missing | 2 | 0 | |

Table 2 - Subject Characteristics by Early Childhood BMI Trajectory for Study 1

| | Total | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| SRC Score, mean | 9.88 | 9.57 (3.7) | 10.28 (3.2) | 10.02 (3.3) | 9.75 (3.6) |
| BMI percentile, mean | 64.8 | 29.3 | 52.4 | 71.0 | 85.0 |
| Child's Sex, n (%) | 829 | | | | |
| Male | 413 (49.8) | 65 (42.2) | 116 (52.7) | 27 (39.1) | 205 (53.1) |
| Female | 416 (50.2) | 89 (57.8) | 104 (47.3) | 42 (60.9) | 181 (46.9) |
| Child's Race, n (%) | 772 | | | | |
| African American | 483 (62.6) | 100 (68.0) | 125 (60.7) | 40 (65.5) | 218 (61.4) |
| Caucasian | 233 (30.2) | 34 (23.1) | 64 (31.1) | 19 (29.7) | 116 (32.7) |
| Other | 56 (7.3) | 13 (8.8) | 17 (8.3) | 5 (7.8) | 21 (5.9) |
| Marital Status, n (%) | 826 | | | | |
| Single Parent | 327 (39.6) | 64 (41.8) | 82 (37.3) | 28 (40.6) | 153 (39.8) |
| Married/ Cohabitating | 499 (60.4) | 89 (58.2) | 138 (62.7) | 41 (59.4) | 231 (60.2) |
| Insurance type, n (%) | 823 | | | | |
| Public | 382 (46.4) | 75 (49.0) | 89 (40.6) | 31 (44.9) | 187 (49.0) |
| Private | 441 (53.6) | 78 (51.0) | 130 (59.4) | 38 (55.1) | 195 (51.0) |
| Mother's education, n (%) | 829 | | | | |
| < College Degree | 455 (54.9) | 91 (59.1) | 111(50.5) | 35 (50.7) | 218 (56.5) |
| ≥ College Degree | 374 (45.1) | 63 (40.9) | 109 (49.5) | 34 (49.3) | 168 (43.5) |

Crude analysis using only group assignment as the predictor and the SRC as the outcome found no significant association between group assignment and SRC (Table 3). Multivariable analysis found evidence of effect modification of sex on the association between group and SRC score, therefore, the analysis was stratified by child sex. Mother's marital status was not a confounder of the association between group and SRC, but all other potential confounders remained in the final model. However, trajectory group was not significantly associated with the SRC score in the final models (Tables 4 and 5). Compared to boys with public insurance, boys with private insurance had a higher average SRC score by 1.64 points, and compared to boys of mothers with more education, boys of mothers with less than a college degree had a lower average SRC score by 1.72 points. Similarly, girls with private insurance, compared to girls with public insurance, had a higher average SRC score by 1.73 points, and girls of mothers with less than a college degree had a lower average SRC score by 1.50 points, when compared to girls of mothers with more education. For both boys and girls, African American race, compared with Caucasian race, was associated with a lower average SRC score by 1.62 and 0.77 points, respectively.

Table 3 – Crude Linear Regression Analysis of Early Childhood BMI Trajectory Group and SRC

| | Estimate (SE) | t Value | p Value |
|---|---|---|---|
| Trajectory | | | |
| Group 1 | -0.17 (0.34) | -0.52 | 0.6051 |
| Group 2 | 0.53 (0.29) | 1.79 | 0.0745 |
| Group 3 | 0.28 (0.46) | 0.60 | 0.5459 |
| Group 4 | reference | | |

Table 4 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and SRC for Boys

| | Estimate (SE) | t Value | p Value |
|---|---|---|---|
| Trajectory 1 | 0.14 (0.44) | 0.32 | 0.7468 |
| Trajectory 2 | 0.63 (0.36) | 1.76 | 0.0788 |
| Trajectory 3 | 0.60 (0.61) | 0.98 | 0.3256 |
| Trajectory 4 | Reference | | |
| Child's Race, n (%) | | | |
| African American | -1.62 (0.35) | 4.70 | <.0001 |
| Other | -0.59 (0.61) | -0.96 | 0.3380 |
| Caucasian | Reference | | |
| Insurance Type, n (%) | | | |
| Private | 1.64 (0.35) | 4.70 | <.0001 |
| Public | Reference | | |
| Mother's education, n (%) | | | |
| < College Degree | -1.72 (0.33) | -5.21 | <.0001 |
| >= College Degree | Reference | | |

Table 5 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and SRC for Girls

| | Estimate (SE) | t Value | p Value |
|---|---|---|---|
| Trajectory | | | |
| Group 1 | -0.34 (0.41) | -0.82 | 0.4102 |
| Group 2 | -0.02 (0.39) | -0.05 | 0.9599 |
| Group 3 | -0.38 (0.56) | -0.68 | 0.4973 |
| Group 4 | Reference | | |
| Child's Race, n (%) | | | |
| African American | -0.77 (0.40) | -1.90 | 0.0588 |
| Other | 1.47 (0.67) | 2.18 | 0.0297 |
| Caucasian | Reference | | |
| Insurance Type, n (%) | | | |
| Private | 1.73 (0.39) | 4.37 | <.0001 |
| Public | Reference | | |
| Mother's education, n (%) | | | |
| < College Degree | -1.50 (0.37) | -4.07 | <.0001 |
| ≥ College Degree | Reference | | |

**Discussion**

This project consisted of first using trajectory analysis to determine how BMI percentiles in this study population changed over the first four to six years of life. These trajectory groups were then used as the predictor variable in crude and then multivariable linear regression models. Trajectory analysis successfully produced four distinct trajectory groups, that were assigned to

all participants, based on their highest group assignment probabilities. These trajectories include one high-stable, one low-stable, and two groups that change course from year one to year two. While these studies focused on exploring effects of weight early in life, only having data from the first four to six years of life is a limitation because these trajectories may not remain consistent into the school years. However, another study found that most of the changes in weight-based trajectories occur by age four, giving evidence that participants' trajectories were well established by the four to six-year visit in this study.[16]

The trajectory analysis itself can be a source of misclassification bias, since group assignments are based on the highest group membership probability. However, calculating the average BMI percentiles of each of the four groups in this study produced results consistent with what would be expected based on the groups' trajectory curves.

When group assignments were used as a predictor variable, no significant associations were found between group assignment and SRC score in the crude analysis. The confounders included in the multivariable models (race, maternal education, and insurance) were significant predictors of school success, which is similar to two studies that we found, which reported differences in school performance among overweight children and their normal-weight peers that disappeared once socioeconomic variables and maternal education were included in the models.[13,14]

It is possible that, once stratified, we lacked power to detect an association between BMI percentile and SRC. Additionally, there was not much variability within the SRC scores, further hindering our ability to detect associations. Future studies should expect to analyze data separately for boys and girls, so that an adequate sample size may be obtained.

These findings may support the idea that children who are just entering school are the ideal population in which to begin weight control interventions, since some deleterious school effects were not yet seen in the young children in this study. Some researchers are looking into the social effects of obesity in childhood to see if they may be causing or exacerbating negative school outcomes. In fact, a study by Krukowski et al. found that when weight-based teasing was included in a model with overweight status to predict school performance, the weight-based teasing became more important, reducing the effect of overweight status in the final model.[10] This study further supports the idea that these children are the ideal age for intervention, since they would not yet be subjected to this weight-based teasing.

## Chapter 3

**The association between early childhood weight trajectory and psychosocial development as measured by the Child Behavior Checklist (CBCL).**

### Background

The steadily increasing trend of childhood obesity, with current rates at 18.5 %, has brought this condition to the forefront of public health research over the past twenty years.[17] Indeed, researchers have moved past examining the causes of overweight and obesity alone and are currently investigating the many deleterious effects of overweight and obesity in childhood.

While some studies have focused on the health-related effects of childhood overweight and obesity such as high blood pressure, type II diabetes, and atherosclerosis, other studies have focused on social outcomes such as school success and psychological health. In fact, one study by Halfon et al. examined both these areas of interest in a group of adolescents aged 10-17. The researchers found that the obese participants were more likely to have worse health than their normal weight peers. Interestingly, the researchers also found that the obese participants were more likely to have developmental conditions, mental health problems, and psychosocial issues that include school related problems and absenteeism.[6]

Another study examined peer perceptions of obese children and found that normal weight children describe their obese classmates as less likable, more apt to cause class disruptions, and less healthy.[8] Indeed, these negative perceptions are not exclusive to their peers. Another study found that child weight is inversely associated with their teacher's assessment of their academic performance.[25] With all of these negative perceptions, it is not surprising that researchers have found that self-esteem issues are associated with poor academic performance in children with obesity.[10]

The question that remains is whether these self-esteem issues translate into other problems as the children grow up, or whether the mental health issues seen in some of these studies of older adolescents are another direct potential of obesity. Missing from the literature are studies on very young children, who are just entering school. Additionally, a limitation of much of the literature on obesity is its cross-sectional design, which measures weight and outcomes at the same point in time. This design fails to establish temporality and to account for the duration of obesity. If there is a process that is making obese children depressed, for example, it makes sense that greater duration of obesity would put the child at greater risk of depression.

This study attempted to address these gaps in the literature by examining psychosocial effects of obesity in early childhood. This study used the previously created trajectory of weight status over the first four to six years of life to assess the association between early childhood weight status and psychosocial development as measured by the Child Behavior Checklist (CBCL 1.5-5).

**Methods**

Data for this project were collected from participants enrolled in the CANDLE study. The CANDLE study is a prospective birth cohort study in Memphis, Tennessee and the surrounding Shelby County. Details of the collection instruments and timeline used in the CANDLE study were described previously. Data for this project were collected at the CANDLE one, two, three, and four to six-year clinic visits. At each of these study visits, participants provided informed consent then trained research staff measured the children's height and weight twice for accuracy. For the one-year clinic visit only, research staff measured recumbent length instead of height. Length was measured in centimeters using a measuring board, height was measured in centimeters using a wall-mounted stadiometer, and weight was measured in kilograms using a

digital scale. The average of the two height (or length) and weight measurements was used to calculate BMI percentiles. BMI percentiles were calculated using the SAS macros provided for the WHO growth charts for children up to two years of age and the CDC growth charts for children, two and older.[19] These BMI percentiles were used to identify trajectories of weight status over the first four to six-years of life.

Our main outcomes for this project included problem behaviors as captured by the CBCL. The CBCL is part of the Achenbach System of Empirically Based Assessment (ASEBA) and consists of 100 items such as "Acts too young for age." Mothers or caregivers completed this survey at the CANDLE study four to six-year visit based on their child's behavior during the previous six months. Three possible responses include 0 (not true), 1 (somewhat or sometimes true), or 2 (very true or often true). Standard scores from this survey were calculated according to the guidelines created by ASEBA, where higher scores indicate more problems, with scores from 65-70 indicating borderline clinical and above 70 indicating clinical problems. The ASEBA scoring protocol produces scores for both syndrome scales and Diagnostic and Statistical Manual of Mental Disorders (DSM) oriented scales. The syndrome scales include emotional reactivity, somatic complaints, anxiety/depression, withdrawn, sleep problems, attention problems, and aggression. The DSM-oriented scales include only items that are considered consistent with DSM-5 diagnostic categories and include depressive, anxiety, autism spectrum, attention deficit/hyperactivity, and oppositional defiant problems.

Reliability for the CBCL has been good, with an overall mean *r* (for all scales) of .85 and a total problems scale *r* of .90. Validity was measured by comparing scores of children who were referred for mental health or special education services to those of demographically similar children who were not referred for these services. In each scale, children who were referred

scored significantly higher than those who were not referred. Additionally, there were no significant differences seen in scores based on age, gender, or socioeconomic status.[26] The version of the CBCL used at the CANDLE four to six-year visit was created for children up to six years of age; therefore, we limited our analyses to those children who completed study procedures before their sixth birthday. For this project, we used each DSM-oriented scale, as well as the somatic complaints, sleep problems, and total problems scales as outcomes; the calculated t-score for each scale was our dependent variable.

Potential confounders included in the models were race, type of insurance coverage, mother's level of education, and mother's marital status. Each of these variables were collected via self-administered survey at the four to six-year study visit. Additionally, child's gender, which was abstracted from medical records at delivery, was included in the analyses. Low birth weight status, which was also abstracted from medical records at delivery, was considered a potential confounder, but very few children in this sample were below the cutoff (2500g) for low birthweight; therefore, those children were excluded from the analyses. Type of insurance coverage was used as a proxy for income, due to the missingness in those data. Family structure, included as a sociodemographic variable in a previous study, was found to be significantly associated with childhood overweight and mental health outcome.[6] Therefore, mother's marital status was included in this study to capture family structure. The other potential confounders included in this study were chosen similarly, because they have been significantly associated with both the predictor and outcome in previous studies.[27-30]

**Statistical Analysis**

The trajectory groups determined in the first study are the primary exposure in this study as well. The methods for determining these groups are described in detail in study 1. Participants

who had BMI percentile data for at least two timepoints between the one-year visit and the four to six-year visit, were included in the trajectory analysis. Chi-square tests were used to compare the study sample to the original CANDLE cohort to assess possible selection bias, since only a portion of the original study population was eligible for this analysis. Descriptive analyses were run to calculate means and standard deviations for each scale of interest by the four trajectory groups. Means and standard deviations for each continuous independent variable are also reported, as well as the frequency and percentages of each categorical independent variable by trajectory group.

The crude association between BMI trajectory and each of the eight scales of interest was assessed using simple linear regression, then multivariable linear regression was run, which included all potential confounders. The final model was determined by including all potential confounders in the model, as well as the potential effect modifier of child. First the interaction term was tested and results were stratified, if warranted. Then the final models were formed by systematically deleting covariates by effect size, while ensuring that the effect estimates of the trajectory groups did not change by more than 10%.

**Results**

Of the original 1,503 women who enrolled in the CANDLE study, 1,157 completed a four to six-year study visit. Of those, 996 had BMI percentile measurements for at least two time points and could be included in the trajectory modeling. Ninety of those participants were missing outcome data from the CBCL. Children who were older than six years of age at the time of the visit were excluded (n=13) since this version of the CBCL was designed for children under six years of age. Those who were low birthweight (n=62) were also excluded due to low numbers (Figure 3).

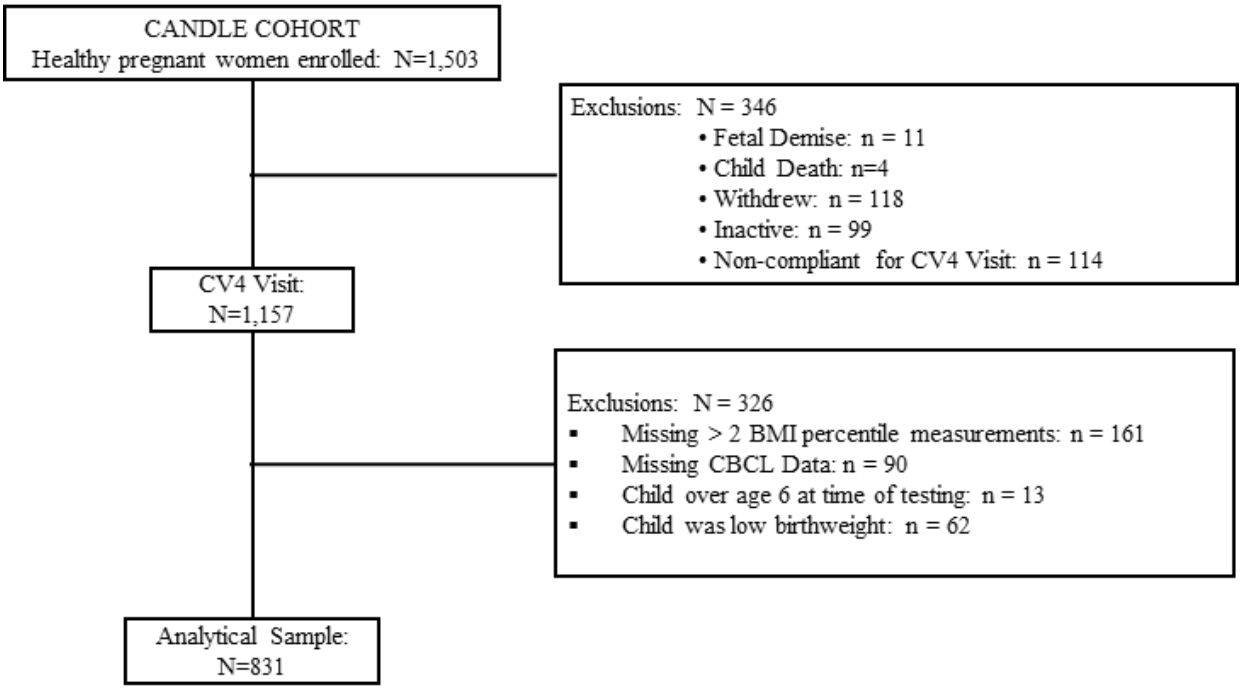


Figure 3 - Exclusion Criteria for Study 2

The children in the final sample were 50% male, 63% African American, and 47% used publicly funded insurance. Of the mothers in the final sample, 55% had less than a college degree at the time of the four-year study visit (Tables 6 and 7). Chi-square tests revealed no significant differences between our original cohort and our analytical sample. The average total problem t-score was 45.0, 44.5, 43.8, and 44.4 for trajectory groups one through four, respectively. Average scores for all scales presented in Table 8.

Crude analysis including only the trajectory group identifier as the predictor and the eight CBCL scales as the outcome yielded no statistically significant results (Table 9).

Table 6 - Comparison of Original Cohort Sample and Analytical Sample for Study 2

| | Study Sample (N=1503) | Analytical Sample (N=831) | Chi-Square (p-value) |
|---|---|---|---|
| Sex, n (%) | | | 0.16 (0.6862) |
| Male | 715 (50.4) | 413 (49.7) | |
| Female | 705 (49.6) | 418 (50.3) | |
| Missing | 83 | 0 | |
| Mother's Race, n (%) | | | 0.93 (0.6297) |
| African American | 936 (62.4) | 511 (61.5) | |
| Caucasian | 467 (31.1) | 270 (32.5) | |
| Other | 98 (6.5) | 50 (6.0) | |
| Missing | 2 | 0 | |

Table 7 - Subject Characteristics by Early Childhood BMI Trajectory for Study 2

| | Total | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Sex, n (%) | 831 | | | | |
| Male | 413 (49.7) | 65 (41.9) | 116 (52.5) | 28 (40.0) | 204 (53.0) |
| Female | 418 (50.3) | 90 (58.1) | 105 (47.5) | 42 (60.0) | 181 (47.0) |
| Child's Race, n (%) | 774 | | | | |
| African American | 484 (62.5) | 101 (68.2) | 125 (60.4) | 41 (63.1) | 217 (61.3) |
| Caucasian | 234 (30.2) | 34 (23.0) | 65 (31.4) | 19 (29.2) | 116 (32.8) |
| Other | 56 (7.2) | 13 (8.8) | 17 (8.2) | 5 (7.7) | 21 (5.9) |
| Marital Status, n (%) | 828 | | | | |
| Single Parent | 329 (39.7) | 64 (41.6) | 83 (37.6) | 29 (41.4) | 153 (40.0) |
| Married/ Cohabitating | 499 (60.3) | 90 (59.4) | 138 (65.4) | 41 (58.6) | 230 (60.0) |
| Insurance Type, n (%) | 825 | | | | |
| Public | 384 (46.6) | 77 (50.0) | 88 (40.0) | 32 (45.7) | 187 (49.1) |
| Private | 441 (53.5) | 77 (50.0) | 132 (60.0) | 38 (54.3) | 194 (50.9) |
| Mother's education, n (%) | 831 | | | | |
| < College Degree | 457 (55.0) | 93 (60.0) | 110 (49.8) | 36 (51.4) | 218 (56.6) |
| ≥ College Degree | 374 (45.0) | 62 (40.0) | 111 (50.2) | 34 (48.6) | 167 (53.4) |

Table 8 - Average Scaled Scores on the CBCL by Early Childhood BMI Trajectory Group

| CBCL Scales, mean (SD) | Overall | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Somatic Complaints | 52.5 | 52.9 (5.2) | 52.3 (4.4) | 52.2 (5.3) | 52.5 (4.8) |
| Sleep | 52.5 | 52.9 (5.2) | 52.3 (4.4) | 52.2 (5.3) | 52.5 (4.8) |
| Affective | 52.8 | 53.4 (5.4) | 52.5 (4.5) | 53.0 (5.4) | 52.8 (5.1) |
| Anxiety | 52.3 | 52.4 (4.4) | 52.4 (5.4) | 52.0 (4.3) | 52.3 (4.5) |
| Pervasive Developmental | 53.7 | 54.1 (6.6) | 53.5 (5.9) | 53.7 (5.9) | 53.8 (6.5) |
| Attention Deficit/Hyperactivity | 52.5 | 52.3 (4.3) | 52.5 (5.2) | 52.6 (3.7) | 52.6 (4.8) |
| Oppositional Defiant | 52.3 | 52.1 (4.7) | 52.0 (4.3) | 52.7 (5.3) | 52.5 (4.7) |
| Total Problems | 44.1 | 44.3 (10.7) | 43.5 (10.4) | 45.1 (10.9) | 44.2 (10.7) |

Table 9 - Crude Linear Regression Analysis of Early Childhood BMI Trajectory Group and Eight Scales on the CBCL

| | Estimate (SE) | p Value |
|---|---|---|
| Somatic Complaints Scale | | |
| Trajectory Group 1 | 0.39 (0.46) | .3944 |
| Trajectory Group 2 | -0.17 (0.41) | .6790 |
| Trajectory Group 3 | -0.31 (0.63) | 0.6216 |
| Trajectory Group 4 | reference | |
| Sleep Problems Scale | | |
| Trajectory Group 1 | 0.39 (0.46) | .3944 |
| Trajectory Group 2 | -0.17 (0.41) | .6790 |
| Trajectory Group 3 | -0.31 (0.63) | 0.6216 |
| Trajectory Group 4 | reference | |
| Affective Problems Scale | | |
| Trajectory Group 1 | 0.62 (0.48) | 0.1947 |
| Trajectory Group 2 | -0.34 (0.42) | 0.4297 |
| Trajectory Group 3 | 0.19 (0.65) | 0.7671 |
| Trajectory Group 4 | reference | |
| Anxiety Problems Scale | | |
| Trajectory Group 1 | 0.10 (0.45) | 0.8166 |
| Trajectory Group 2 | 0.13 (0.40) | 0.7490 |
| Trajectory Group 3 | -0.27 (0.61) | 0.6581 |
| Trajectory Group 4 | Reference | |

Table 9 (Continued)

| | Estimate (SE) | p Value |
|---|---|---|
| PDD Problem Scale | | |
| Trajectory Group 1 | 0.31 (0.60) | 0.6031 |
| Trajectory Group 2 | -0.29 (0.53) | 0.5842 |
| Trajectory Group 3 | -0.10 (0.82) | 0.9030 |
| Trajectory Group 4 | reference | |
| ADHD Problem Scale | | |
| Trajectory Group 1 | -0.33 (0.45) | 0.4614 |
| Trajectory Group 2 | -0.07 (0.40) | 0.8438 |
| Trajectory Group 3 | 0.04 (0.61) | 0.9544 |
| Trajectory Group 4 | reference | |
| ODD Problem Scale | | |
| Trajectory Group 1 | -0.42 (0.44) | 0.3423 |
| Trajectory Group 2 | -0.45 (0.39) | 0.2472 |
| Trajectory Group 3 | 0.22 (0.60) | 0.7099 |
| Trajectory Group 4 | reference | |
| Total Problems Scale | | |
| Trajectory Group 1 | 0.17 (1.01) | 0.8675 |
| Trajectory Group 2 | -0.65 (0.90) | 0.4699 |
| Trajectory Group 3 | 0.89 (1.39) | 0.5202 |
| Trajectory Group 4 | reference | |

Multivariable analysis for all eight outcome scales found no statistically significant interaction effects between child sex and group for any of the outcomes. Additionally, there was no association between BMI trajectory group and any of the outcome scales (Tables 10-17). While many of the confounders remained in the final models, mother's education was the only confounder that was a significant predictor of the score for all eight outcome scales. Race was a significant predictor for both the oppositional defiant problems scale and the total problems scale. Children of mothers with less than a college degree, compared to children of mothers with more education, had 1.13 point higher average scores on the somatic complaints and sleep problems scales. The other scales examined in this study had similar associations with maternal education. Compared to children of mothers with more education, children of mothers with less than a college degree had 1.12, 1.43, 1.98, 1.10, 0.91, and 3.60 higher average scores for the affective, anxiety, pervasive developmental delay, attention deficit hyperactivity disorder, oppositional defiant disorder, and total problems scales, respectively. Compared to Caucasian children, African American children had 0.90 lower average scores for the oppositional defiant disorder scale and 2.16 lower average scores for the total problems scale.

Table 10 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and Somatic Complaints Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.46 (0.47) | 0.3372 |
| Trajectory 2 | 0.09 (0.42) | 0.8402 |
| Trajectory 3 | -0.00 (0.65) | 0.9964 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.76 (0.44) | 0.0840 |
| Other | -1.09 (0.72) | 0.1326 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.07 (0.35) | 0.8329 |
| Female | reference | |
| Insurance Type | | |
| Private | -0.13 (0.42) | 0.7470 |
| Public | reference | |
| Maternal Education | | |
| < College degree | 1.13 (0.39) | 0.0039 |
| ≥ College degree | reference | |

Table 11 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and Sleep Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.46 (0.47) | 0.3372 |
| Trajectory 2 | 0.09 (0.42) | 0.8402 |
| Trajectory 3 | -0.00 (0.65) | 0.9964 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.76 (0.44) | 0.0840 |
| Other | -1.09 (0.72) | 0.1326 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.07 (0.35) | 0.8329 |
| Female | reference | |
| Insurance Type | | |
| Private | -0.13 (0.42) | 0.7470 |
| Public | reference | |
| Maternal Education | | |
| < College degree | 1.13 (0.39) | 0.0039 |
| ≥ College degree | reference | |

Table 12 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and Affective Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.63 (0.49) | 0.1996 |
| Trajectory 2 | -0.02 (0.44) | 0.9555 |
| Trajectory 3 | 0.07 (0.67) | 0.9177 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.40 (0.43) | 0.3519 |
| Other | 0.36 (0.75) | 0.6305 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | -0.29 (0.36) | 0.4294 |
| Female | reference | |
| Insurance Type | | |
| Private | -0.40 (0.43) | 0.3519 |
| Public | reference | |
| Maternal Education | | |
| < College degree | 1.12 (0.41) | 0.0060 |
| ≥ College degree | reference | |

Table 13 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and Anxiety Problems Score

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.20 (0.47) | 0.6716 |
| Trajectory 2 | 0.37 (0.42) | 0.3848 |
| Trajectory 3 | -0.26 (0.65) | 0.6879 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.70 (0.41) | 0.0853 |
| Other | -0.25 (0.71) | 0.7300 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | -0.46 (0.35) | 0.1879 |
| Female | reference | |
| Maternal Education | | |
| < College degree | 1.43 (0.37) | .0001 |
| ≥ College degree | reference | |

Table 14 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and PDD Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.25 (0.62) | 0.6936 |
| Trajectory 2 | -0.03 (0.56) | 0.9624 |
| Trajectory 3 | 0.12 (0.85) | 0.8835 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.76 (0.58) | 0.1894 |
| Other | -0.43 (0.95) | 0.6497 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.24 (0.46) | 0.5957 |
| Female | reference | |
| Maternal Education | | |
| < College degree | 1.98 (0.52) | 0.0001 |
| ≥ College degree | reference | |

Table 15 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory for ADD Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | -0.55 (0.45) | 0.2213 |
| Trajectory 2 | 0.02 (0.40) | 0.9627 |
| Trajectory 3 | 0.06 (0.61) | 0.9197 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | 0.04 (0.39) | 0.9224 |
| Other | 0.48 (0.68) | 0.4783 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.24 (0.33) | 0.4610 |
| Female | reference | |
| Maternal Education | | |
| < College degree | 1.10 (0.35) | 0.0018 |
| ≥ College degree | reference | |

Table 16 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and for ODD Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | -0.54 (0.45) | 0.2390 |
| Trajectory 2 | -0.34 (0.40) | 0.3951 |
| Trajectory 3 | 0.03 (0.62) | 0.9670 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -0.90 (0.39) | 0.0219 |
| Other | 0.52 (0.68) | 0.4457 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.28 (0.33) | 0.4077 |
| Female | reference | |
| Maternal Education | | |
| < College degree | 0.91 (0.35) | 0.0106 |
| ≥ College degree | reference | |

Table 17 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and Total Problems Scale

| | Estimate (SE) | p-Value |
|---|---|---|
| Trajectory 1 | 0.07 (1.04) | 0.9474 |
| Trajectory 2 | -0.03 (0.92) | 0.9732 |
| Trajectory 3 | 0.75 (1.41) | 0.5960 |
| Trajectory 4 | Reference | |
| Race | | |
| African American | -2.16 (0.96) | 0.0243 |
| Other | 0.98 (1.58) | 0.5330 |
| Caucasian | Reference | |
| Child Sex | | |
| Male | 0.72 (0.76) | 0.3413 |
| Female | reference | |
| Maternal Education | | |
| < College degree | 3.60 (0.86) | <.0001 |
| ≥ College degree | reference | |
| Insurance Type | | |
| Private | -0.51 (0.91) | 0.5779 |
| Public | reference | |

**Discussion**

This project examined the effect of BMI percentile trajectory from the first four to six-years of life on socioemotional outcomes measured by the CBCL. There were no significant associations between the trajectory groups and any of the eight examined scales of interest. This remained true for both crude and adjusted analyses. Of the potential confounders included in the multivariable analysis, maternal education was the only significant predictor for all eight examined scales. Child's race was a significant predictor for the oppositional defiant disorder scale as well as the total problems scale.

Other studies that examined these confounders found similar results. However, these studies also found that household income and family structure were significant predictors of socioemotional outcomes, and child sex was an effect modifier, none of which were true for this study.[27-29] This study used insurance type as a proxy for household income because there is missingness in the income data available from the CANDLE study. Therefore, the measure of income is not as precise as what these other studies used, potentially hindering our ability to detect this association seen in other studies.

There was limited variability in the scores on all eight outcomes scales, which may have affected our ability to detect associations. This limited variability may be explained by the measure itself or could be because of the young age of these subjects. While the CBCL is a validated measure for children in this age range, more objective measures of some of these scales do exist for kids who are just slightly older. These measures, including the Children's Depression Inventory (CDI) and the Screen for Child Anxiety Related Emotional Disorders (SCARED), are valid for children as young as seven years old. Another benefit of these surveys is that they are self-administered, instead of parent report.[31,32] Therefore, it would be interesting to examine

slightly older children by using these measures in future studies to ensure the outcomes are being captured most accurately.

These results may support the idea that children just entering school are an ideal population in which to begin weight control interventions, since deleterious social effects were not seen in these young children. Other studies have examined the effects of weight-based teasing on academic performance with the belief that the bullying that comes with child obesity affects school outcomes.[8,10] These studies would also support our findings, since the children in our studies would not yet be subjected to weight-based teasing.

## Chapter IV

**The association between early childhood BMI trajectory and cognition, as measured by the Stanford-Binet Intelligence Scales.**

### Background

Childhood obesity has gained much attention as its prevalence has increased to the current high of 18.5%.[17] While we know that obese children are more likely to become obese adults, who suffer from many deleterious health effects like high blood pressure and high triglycerides,[4] we are just beginning to learn more about the social effects of obesity that can begin in childhood. One study found that obese girls completed fewer years of school than their normal weight peers,[5] while another found that obese adolescents were more likely to have school-related problems, such as absenteeism.[6]

However, studies that have looked directly at cognition or academic performance have been less conclusive. For example, a study by Huang et al. found that obesity was associated with self-reported, but not measured grades.[7] Another study found an association between obesity and cognition, but this association disappeared, once demographic variables were included in their analysis.[13] Yet another study of children who became overweight in the first four years of school found that this change in weight status was a significant risk factor for problems with academic performance in girls but not boys.[27]

The previously mentioned studies have had mixed results, and they are limited because the children included are already school age. This makes is hard to investigate whether the children fair worse because of their abilities, versus some self-esteem problems that can arise because of weight-based teasing in school. Furthermore, most of these studies look at weight and cognition or academic performance cross-sectionally, meaning the measure of weight status and

the outcome measure are concurrent. This design makes it impossible to establish temporality and therefore infer causality. This project attempted to address these gaps in the literature by examining the association between BMI percentile trajectory over the first four years of life and cognition, as measured by the Stanford Binet.

**Methods**

Data for this project was collected as part of the CANDLE study, a prospective birth cohort study that enrolled participants in Memphis, Tennessee and the surrounding Shelby County. Cohort details, along with details of the measurement timeline and collection of data were reported previously. We used data from the CANDLE one, two, three, and four to six-year clinic visits. At each of these visits, CANDLE participants provided informed consent before staff measured the child's height and weight twice for accuracy. At the one year visit only, staff measured the child's recumbent length, instead of height. Length was measured in centimeters using a measuring board, height was measured in centimeters using a wall-mounted stadiometer, and weight was measured in kilograms using a digital scale. These height and weight measurements were converted to BMI percentiles using the SAS Macros provided by the CDC. For children up to two years of age, the WHO guidelines were used for this percentile conversion, while the CDC guidelines were used for children, two and older.

The outcome for this project was the child's score on the Stanford-Binet Intelligence Scales. The Stanford-Binet is a test of cognition that yields the commonly recognized intelligence quotient (IQ) as its scaled score. In the CANDLE sample, the Stanford-Binet was administered at the four to six-year clinic visit by a psychologist or trainee from the Boling Center for Developmental Disabilities. The Stanford-Binet consists of verbal and nonverbal measures in five subtests in a variety of domains including: fluid reasoning, knowledge,

quantitative reasoning, visual-spatial processing, and working memory. All ten subtests were administered to the CANDLE children, providing a full-scale IQ (FSIQ). Researchers point to the FSIQ as the most accurate measure of global ability, which predicts both educational attainment and academic achievement.[33] Children in the CANDLE study were referred for further testing when developmental delay or other problems were indicated by the FSIQ. The Stanford-Binet is appropriate for ages two to 85; therefore, we did not exclude any children from the analysis based on age.

As in the previous studies, the following potential confounders were included in the analysis: child's race, mother's level of education, mother's marital status, and mother's type of insurance coverage, which were collected via survey at the four-year clinic visit. These variables were chosen based on their inclusion in similar studies of weight status and cognition.[9,34] Child's sex, which was abstracted from medical records at the time of delivery, was also included, based on previous research indicating that weight and cognition data should be examined separately for boys and girls.[33] Low birth weight status, which was also abstracted from medical records at the time of delivery, was also considered as a potential confounder since it has been associated with both cognition and later weight status.[35-37] However, due to very low numbers of low birthweight children in this sample, those who were low birth weight were excluded from the final analysis.

**Statistical Analysis**

The BMI percentile trajectory groups, which were identified in the first study were also used in this analysis. The process of identifying these groups was described in detail in that study. Participants who had BMI percentile data for at least two of the four follow-up time points were eligible to be included in the trajectory analysis. An identifier (1-4) was assigned to each participant based on their highest group membership probability. The analytical sample was

compared to the original cohort sample, using Chi-square to test for selection bias, since many participants in the original cohort of 1,503 did not have data available for this analysis.

Descriptive analysis consisted of calculating means and standard deviations of the dependent variable by the four trajectory groups. Also reported are the means and standard deviations for each continuous independent variable, and the frequency and percentage of each categorical independent variable by trajectory group. Next, crude linear regression analysis examined the association between BMI percentile trajectory group and the outcome, the full-scale IQ. Then a multivariable linear regression model was created. First all potential confounders as well as the potential effect modifier were included in the model. Then backward selection was used to systematically delete covariates of the smallest effect sizes first, ensuring that the estimates for the main predictor did not change by more than 10% in the final model.

**Results**

Of the original cohort, 1,157 participants completed the four to six-year clinic visit. Of those, 996 had BMI percentile data for at least two study visits between the one and four to six-year visits and were included in the trajectory analysis. Stanford Binet outcome data were missing for 89 participants, and those who were low birth weight (n=62) were excluded from the analysis due to very low numbers. Also excluded from the analysis were those children who were over the age of six at the time of testing (n=13), since this study was focused on children just entering school (Figure 1). Chi-square tests found no significant differences in the stable descriptive variables between the original study sample and the final analytical sample of 832 participants (Table 1).

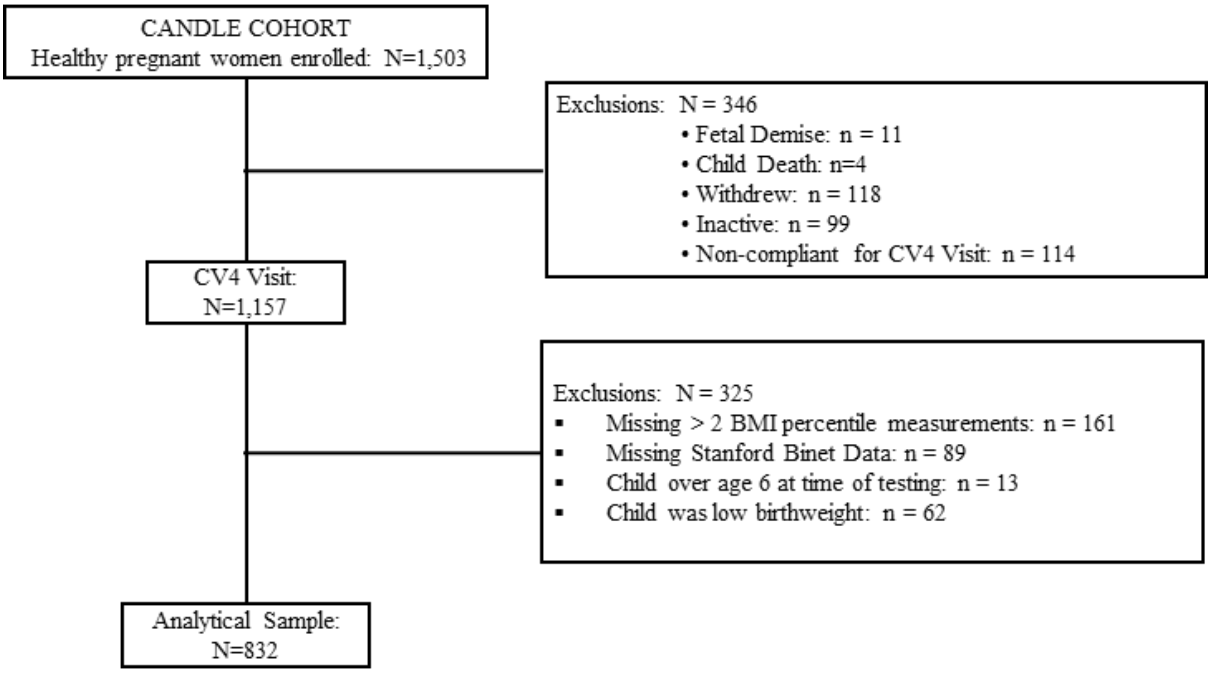


Figure 4 – Exclusion Criteria for Study 3

Table 18 - Comparison of Original Cohort Sample and Analytical Sample for Study 3

| | Study Sample (N=1503) | Analytical Sample (N=832) | Chi-Square (p-value) |
|---|---|---|---|
| Sex, n (%) | | | 0.19 (0.6608) |
| Male | 715 (50.4) | 413 (49.6) | |
| Female | 705 (49.6) | 419 (50.4) | |
| Missing | 83 | 0 | |
| Mother's Race, n (%) | | | 1.02 (0.6017) |
| African American | 936 (62.4) | 511 (61.4) | |
| Caucasian | 467 (31.1) | 271 (32.6) | |
| Other | 98 (6.5) | 50 (6.0) | |
| Missing | 2 | 0 | |

The mean full-scale IQ on the Stanford Binet for the overall sample was 100.77 (14.72), while the IQs were 99.04, 101.10, 101.58, and 99.49 for trajectory groups one through four, respectively. The children in the final sample were 50% male, 63% African American, and 49% reported using publicly funded insurance. The mothers in the final sample were predominately married or cohabitating (58%) and most had less than a college degree at the time of the four to six-year visit (57%) (Table 19).

Crude analysis found no statistically significant association between BMI percentile trajectory group and IQ (Table 20). When the potential confounders and effect modifier were included in the model, there was evidence of effect modification of sex on the association between BMI trajectory group and FSIQ, therefore, all the analyses were stratified by sex. Once stratified, all confounders remained in the model for girls, and all confounders except marital status remained in the model for boys, but there was no significant association between BMI trajectory group and IQ (Tables 21 and 22).

Table 19 - Descriptive Statistics of Sample by Early Childhood BMI Trajectory for Study 3

| | Total | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| FSIQ, mean (SD) | 100.77 | 100.12 (13.4) | 101.80 (14.8) | 103.51 (13.1) | 99.95 (15.4) |
| Sex, n (%) | 832 | | | | |
| Male | 413 (49.6) | 65 (41.9) | 116 (52.5) | 27 (39.1) | 205 (53.0) |
| Female | 419 (50.4) | 90 (58.1) | 105 (47.5) | 42 (60.9) | 182 (47.0) |
| Child's Race, n (%) | 775 | | | | |
| African American | 484 (62.5) | 101 (68.2) | 125 (60.4) | 40 (62.5) | 218 (61.2) |
| Caucasian | 235 (30.3) | 34 (23.0) | 65 (31.4) | 19 (29.7) | 117 (32.9) |
| Other | 56 (7.2) | 13 (8.8) | 17 (8.2) | 5 (7.8) | 21 (5.9) |
| Marital Status, n (%) | 829 | | | | |
| Single Parent | 327 (39.5) | 64 (41.6) | 82 (37.1) | 28 (40.6) | 153 (39.7) |
| Married/ Cohabitating | 502 (60.5) | 90 (58.4) | 139 (62.9) | 41 (59.4) | 232 (60.3) |
| Insurance Type, n (%) | 826 | | | | |
| Public | 383 (46.4) | 76 (49.4) | 89 (40.5) | 31 (44.9) | 187 (48.8) |
| Private | 443 (53.6) | 78 (50.7) | 131 (59.6) | 38 (55.1) | 196 (51.2) |
| Mother's education, n(%) | 832 | | | | |
| < College Degree | 457 (54.9) | 92 (59.4) | 111 (50.2) | 35 (50.7) | 219 (56.6) |
| >= College Degree | 375 (45.1) | 63 (40.7) | 110 (49.8) | 34 (49.3) | 168 (43.4) |

Each of the confounders included in the final models were significant predictors of IQ. For example, compared to those with public insurance, children with private insurance had 4.67 and 4.58 higher average IQ scores for girls and boys, respectively. African American children, compared to Caucasian children had 5.29 and 8.78 lower average IQ scores for girls and boys, respectively. Compared to girls of mothers with more education, girls of mothers with less than a college degree had 4.89 lower average IQ scores. Similarly, boys of mothers with less than a college degree had 5.58 lower average IQ scores, when compared to boys of mothers who had more education. Marital status affected girls but not boys, with girls in married households having 3.05 higher average IQ scores than girls from single parent households.

Table 20 - Crude Linear Regression Analysis of Early Childhood BMI Trajectory and IQ

| | Estimate (SE) | p Value |
|---|---|---|
| Trajectory 1 | -0.45 (1.44) | 0.7563 |
| Trajectory 2 | 1.61 (1.82) | 0.3746 |
| Trajectory 3 | 2.09 (1.15) | 0.0692 |
| Trajectory 4 | reference | |

Table 21 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and IQ for Girls

| | Estimate (SE) | p Value |
|---|---|---|
| Trajectory 1 | 1.13 (1.70) | 0.5059 |
| Trajectory 2 | 1.38 (1.63) | 0.3977 |
| Trajectory 3 | 2.69 (2.34) | 0.2503 |
| Trajectory 4 | Reference | |
| Child's Race | | |
| African American | -5.29 (1.75) | 0.0027 |
| Other | 5.55 (2.79) | 0.0475 |
| Caucasian | Reference | |
| Marital Status | | |
| Married/ Cohabitating | 3.05 (1.54) | 0.0491 |
| Single Parent Household | Reference | |
| Insurance Type | | |
| Private | 4.67 (1.68) | 0.0058 |
| Public | Reference | |
| Mother's education | | |
| < College Degree | -4.89 (1.53) | 0.0015 |
| ≥ College Degree | reference | |

Table 22 - Multivariable Linear Regression Analysis of Early Childhood BMI Trajectory and IQ for Boys

| | Estimate (SE) | p Value |
|---|---|---|
| Trajectory 1 | 1.02 (1.94) | 0.6001 |
| Trajectory 2 | 1.07 (1.58) | 0.4998 |
| Trajectory 3 | 3.53 (2.67) | 0.1866 |
| Trajectory 4 | Reference | |
| Child's Race | | |
| African American | -8.78 (1.67) | <.0001 |
| Other | -6.33 (2.70) | 0.0196 |
| Caucasian | Reference | |
| Insurance Type | | |
| Private | 4.58 (1.54) | 0.0031 |
| Public | Reference | |
| Mother's education | | |
| < College Degree | -5.58 (1.46) | 0.0002 |
| ≥ College Degree | reference | |

**Discussion**

This study examined the association between BMI percentile trajectory group from four to six-years of age and IQ as measured by the Stanford Binet Intelligence Scales. Crude regression analysis found no statistically significant associations. In multivariable analysis, there was evidence of effect modification, therefore, the analysis was stratified by child sex. Once stratified, all potential confounders (mother's marital status, child's race, insurance type,

mother's education) were significant predictors of IQ girls. For boys, all previously mentioned confounders except mother's marital status were significant predictors of IQ. However, there was no significant association between trajectory group and IQ for either girls or boys.

These results are consistent with one study in older children, which found that sociodemographic variables tend to be more important in predicting cognition and school success than BMI[13] It is possible that there was not enough power to detect associations, since the analytical sample was stratified by child sex, and there was limited variability in the IQ . Future studies should plan to analyze results for boys and girls separately, to ensure enough data are available to detect associations.

The trajectories identified as part of this analysis could be a source of misclassification bias, since the participants are assigned to a trajectory based on their highest membership probability. Analysis completed as part of study 1 examined the average BMI percentile of each trajectory group at the four to six-year visit and found that those mean BMI percentiles fit well within the trajectory curves. Another study that examined the trajectory of weight status through childhood found that by the time children are four-years old, their weight status trajectory is usually set, meaning that they stay on the same trajectory from four to eighteen years.[16] This evidence motivated these studies to move forward, even though the CANDLE study only has four time points of data on these children, who were four to six-years old. However, it would be interesting to continue this trajectory work in this cohort, as the children come in for future visits, to see if there are changes in their weight trajectories throughout childhood.

Finally, these study results may support the idea that school-related and cognitive problems seen in obese children are associated with bullying and poor self-esteem, since they were not found in this group of children who were just entering school. Other researchers believe

that there may be a mediating effect of weight-based teasing that is causing deleterious school outcomes in overweight children.[10] Therefore, future research should include measures of bullying and weight-based teasing when examining obesity and cognitive outcomes to ensure this potential association is also explored during the analyses.

# Chapter 5

## Summary

The rising prevalence of childhood obesity over the past 30 years has brought much attention to this health problem. Recent rates of obesity are estimated at 18.5% and show a continuing upward trend.[17] The health consequences of obesity in adulthood are well known and include high blood pressure, type II diabetes, and cardiovascular disease[38]. Indeed, recent studies have also found similar health effects occurring in children with obesity.[6,11] While these health risks are surely important, many researchers are now increasing their focus on the social outcomes of obesity.

As obese teenage girls grew into adults, they were found to have completed less years of school, be less likely to be married, and have less income than their normal weight peers.[5] In fact, many studies have attempted to determine whether childhood obesity is associated with school success. While a few studies seem to support the idea that obesity is more directly associated with cognition,[6,14] many support the notion that obese children are at a disadvantage because of problems with self-esteem, which are likely exacerbated by their peers' and teachers' negative perceptions of them.[7-10]

These projects attempted to disentangle these ideas by examining the effects of obesity in very young children who were just beginning school. Theoretically, these children would not have had time to develop the poor self-esteem brought on by their teachers' and peers' perceptions at the time that their outcomes were measured. Additionally, the longitudinal nature of the CANDLE study gave us the opportunity to create a trajectory of weight status over the first four years of life. Since much of the literature on obesity uses weight and outcomes from the

same timepoint, this design allows the potential for supporting causal associations, that were impossible to assume based on cross-sectional studies.

The first step in these projects was to create the group trajectories of BMI percentiles over the first four to six years of life. Data from 996 children who completed at least 2 follow-up visits in the CANDLE study were used to create these BMI percentile trajectories. Using exploratory analysis and PROC TRAJ, four trajectory groups were identified. Each CANDLE child was then assigned to the trajectory group for which he or she had the highest likelihood membership probability. The four groups consisted of one low steady BMI percentile, one increasing BMI percentile, one decreasing BMI percentile, and one high steady BMI percentile. These trajectories give information about the onset, duration, and intensity of the exposure, and can be beneficial in determining if there are critical time periods in which obesity causes more deleterious effects. In our sample, there are two groups who are at risk of obesity, based on their trajectories: the high steady trajectory and the increasing trajectory.

After their creation, these trajectories were used as the main predictor variable in the analysis for all three projects. The projects looked at the association between the trajectories and school readiness, mental health outcomes, and cognition, respectively. After crude analysis was run, potential confounders were included based on current research. Final models for all three projects found no significant associations between BMI trajectory group and the outcomes.

The final multivariate models for the Bracken School Readiness Composite indicated that child sex is an effect modifier, requiring that analysis be stratified by child sex. Additionally, child race, maternal education, and insurance type were significant predictors of school readiness. These findings are similar to those in two other studies, where the association between

obesity and academic performance became insignificant once sociodemographic variables and maternal education were included in the analyses.[13,14]

The final models for all eight scales examined from the Child Behavior Checklist indicated that maternal education was a significant predictor of the child's problem scores. Child's race was a significant predictor for two of the scales (oppositional defiant problems and total problems). None of these models indicated that child sex is an effect modifier, which is different from the literature available on slightly older children. Two studies we examined found that overweight status led to internalizing and externalizing problems for girls, but not boys. One of these studies did find a significant effect from maternal education level, but the other did not. However, both studies found significant effects of child race on these behaviors.[13,28]

The study examining BMI percentile trajectory and IQ, as measured by the Stanford Binet, found that child sex was an effect modifier, requiring the stratification of the analyses by child sex. Child's race, mother's education, mother's marital status, and insurance type were all significant predictors of IQ for girls. For boys, child's race, mother's education, and insurance type were significant predictors of IQ. It would be inappropriate to compare these results back to much of the literature, which actually looks at academic performance instead of IQ as an outcome. However, we did find one study that showed similar results. Once sociodemographic variables were included in the models, obesity was not a significant predictor of IQ.[34]

Potential limitations of this study design include misclassification bias. Since statistical modeling was used to develop group trajectories of BMI percentile, then the children were each assigned to a trajectory, it is possible that children were assigned to a trajectory different from where they fit best. The PROC TRAJ procedure produces trajectory group membership probabilities, so that the best trajectory can be chosen for each participant, and additional

analysis found that at the four to six-year visit, the average BMI percentile of each trajectory group fit the trajectory curves.

Using the BMI percentile trajectory groups was an innovative way to classify both the duration and intensity of obesity in the young children in our sample. However, previous studies that used this method generally had more years of data, which may have facilitated the characterization of the trajectories, potentially making them more accurate.[16,18,39] However, one of these studies found that the first four years of life was a critical window in which weight trajectories take shape; any significant changes in trajectory were most likely to happen by age four, and generally, children stayed on the same path from age four to eighteen.[16] This evidence led us to believe that having data from only the first four years of life may have been sufficient to detect associations.

It is possible that these studies lacked power to detect differences in the trajectory groups, especially since two of the projects required stratifying the results by child sex. All three of the outcomes measured had limited variability, which also may have affected our ability to detect associations. Future studies of weight and social outcomes should ensure enough participants are included to detect differences, even when results are stratified.

Another limitation of one of these studies was the nature of the survey used to assess child mental health. The CBCL is a parent-report survey, which is appropriate for very young children, but once children are in school other self-report surveys, as well as psychological testing, would better characterize their mental health. Studies that examine children right after school entry should seek out these more objective surveys and testing.

Finally, these studies did not include data on confounders at each timepoint, instead relying on data from only the four to six-year visit to assess confounding. Many of the

confounders examined were things that could change over time, therefore, the results may have been biased by not including these variables in our modeling. PROC TRAJ allows for some inclusion of time-varying covariates, but its process only allows a variable to change values at one time-point during the trajectory follow-up.[23] Therefore, it would not work well for confounders that we examined that could change year by year. One potential solution for including these time-varying covariates would be to model each time-point's BMI percentile by using the covariates from that time point. Then the trajectories would be identified using the predicted BMI percentiles from that modeling. This would, in effect, adjust for the time-varying covariates. At this point, final models would use only these trajectories and stable potential confounders, such as child sex and race to predict outcomes.

Other studies have examined the impact of weight-based teasing and self-esteem on similar outcomes. In each case, the researchers surmised that only overweight or obese children are victims of weight-based teasing, therefore, this teasing may be mediating the association between obesity and negative school or socioemotional outcomes.[8-10] Our studies did not include a measure of bullying, weight-based teasing, or self-esteem, which limits our ability to examine these potential associations. Future research should include these measures in early school-age children to determine when these problems begin, to better characterize this as a risk factor.

Overall, these projects were successful in developing the BMI percentile group trajectories, as well as examining their association with three outcomes of interest. The findings suggest that more work should be done to better characterize how obesity, self-esteem and bullying, and social outcomes are associated in young children.

## References


1. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA.* 2012;307(5):491-497.
2. Prevention CFDCa. Defining Childhood Obesity. 2016; https://www.cdc.gov/obesity/childhood/defining.html. Accessed October 10, 2017, 2017
3. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev.* 2008;9(5):474-488.
4. Umer A, Kelley GA, Cottrell LE, Giacobbi P, Innes KE, Lilly CL. Childhood obesity and adult cardiovascular disease risk factors: a systematic review with meta-analysis. *BMC Public Health.* 2017;17(1):683.
5. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and economic consequences of overweight in adolescence and young adulthood. *N Engl J Med.* 1993;329(14):1008-1012.
6. Halfon N, Larson K, Slusser W. Associations between obesity and comorbid mental health, developmental, and physical health conditions in a nationally representative sample of US children aged 10 to 17. *Acad Pediatr.* 2013;13(1):6-13.
7. Huang TT, Goran MI, Spruijt-Metz D. Associations of adiposity with measured and self-reported academic performance in early adolescence. *Obesity (Silver Spring).* 2006;14(10):1839-1845.
8. Zeller MH, Reiter-Purtill J, Ramey C. Negative peer perceptions of obese children in the classroom environment. *Obesity (Silver Spring).* 2008;16(4):755-762.

9. Wang F, Veugelers PJ. Self-esteem and cognitive development in the era of the childhood obesity epidemic. *Obes Rev.* 2008;9(6):615-623.

10. Krukowski RA, West DS, Philyaw Perez A, Bursac Z, Phillips MM, Raczynski JM. Overweight children, weight-based teasing and academic performance. *Int J Pediatr Obes.* 2009;4(4):274-280.

11. Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA.* 2003;289(14):1813-1819.

12. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics.* 1999;103(6 Pt 1):1175-1182.

13. Judge S, Jahns L. Association of overweight with academic performance and social and behavioral problems: an update from the early childhood longitudinal study. *J Sch Health.* 2007;77(10):672-678.

14. Datar A, Sturm R, Magnabosco JL. Childhood overweight and academic performance: national study of kindergartners and first-graders. *Obes Res.* 2004;12(1):58-68.

15. Sontag-Padilla LM, Burns RM, Shih RA, et al. *The Urban Child Institute CANDLE Study: Methodological Overview and Baseline Sample Description.* Santa Monica, CA2015.

16. Ziyab AH, Karmaus W, Kurukulaaratchy RJ, Zhang H, Arshad SH. Developmental trajectories of Body Mass Index from infancy to 18 years of age: prenatal determinants and health consequences. *J Epidemiol Community Health.* 2014;68(10):934-941.

17. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of Obesity Among Adults and Youth: United States, 2015-2016. *NCHS Data Brief.* 2017(288):1-8.

18. Pryor LE, Tremblay RE, Boivin M, et al. Developmental trajectories of body mass index in early childhood and their risk factors: an 8-year longitudinal study. *Arch Pediatr Adolesc Med.* 2011;165(10):906-912.

19. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat 11.* 2002(246):1-190.

20. Group WMGRS. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl.* 2006;450:76-85.

21. Panter JE, Bracken BA. Validity of the Bracken School Readiness Assessment for predicting first grade readiness.

22. Bracken BA. Bracken Basic Concept Scale Receptive Examiner's Manual. In. Third ed. San Antonio, TX: Harcourt Assessment, Inc.; 2006.

23. Jones BL, Nagin DS. Advances in Group-Based Trajectory Modeling and an SAS Procedure for Estimating Them. *Sociological Methods & Research.* 2007;35(4):542-571.

24. traj: group-based modeling of longitudinal data. 2017; https://www.andrew.cmu.edu/user/bjones/. Accessed August 30, 2018.

25. Zavodny M. Does weight affect children's test scores and teacher assessments differently? *Econ Educ Rev.* 2013;34:135-145.

26. Achenbach TM, Rescorla LA. Manual for the ASEBA Preschool Forms & Profiles. In. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families; 2000.

27. Datar A, Sturm R. Childhood overweight and elementary school outcomes. *Int J Obes (Lond).* 2006;30(9):1449-1460.

28. Datar A, Sturm R. Childhood overweight and parent- and teacher-reported behavior problems: evidence from a prospective study of kindergartners. *Arch Pediatr Adolesc Med.* 2004;158(8):804-810.

29. Fevang SKE, Hysing M, Sommerfelt K, Elgen I. Mental health assessed by the Strengths and Difficulties Questionnaire for children born extremely preterm without severe disabilities at 11 years of age: a Norwegian, national population-based study. *Eur Child Adolesc Psychiatry.* 2017;26(12):1523-1531.

30. Taylor HG, Margevicius S, Schluchter M, Andreias L, Hack M. Persisting behavior problems in extremely low birth weight adolescents. *J Dev Behav Pediatr.* 2015;36(3):178-187.

31. Birmaher B, Khetarpal S, Brent D, et al. The Screen for Child Anxiety Related Emotional Disorders (SCARED): scale construction and psychometric characteristics. *J Am Acad Child Adolesc Psychiatry.* 1997;36(4):545-553.

32. Saylor CF, Finch AJ, Spirito A, Bennett B. The children's depression inventory: a systematic evaluation of psychometric properties. *J Consult Clin Psychol.* 1984;52(6):955-967.

33. Roid GH. Stanford-Binet Intelligence Scales, Fifth Edition, Examiner's Manual. In. Rolling Meadows, IL. Riverside Publishing; 2003.

34. Afzal AS, Gortmaker S. The Relationship between Obesity and Cognitive Performance in Children: A Longitudinal Study. *Child Obes.* 2015;11(4):466-474.

35. Botting N, Powls A, Cooke RW, Marlow N. Cognitive and educational outcome of very-low-birthweight children in early adolescence. *Dev Med Child Neurol.* 1998;40(10):652-660.

36. Taylor HG. Persisting cognitive deficits in survivors of very low birthweight and their implications for adult functioning. *Dev Med Child Neurol.* 2010;52(12):1078-1079.

37. Binkin NJ, Yip R, Fleshood L, Trowbridge FL. Birth weight and childhood growth. *Pediatrics.* 1988;82(6):828-834.

38. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res.* 1998;6 Suppl 2:51S-209S.

39. Ventura AK, Loken E, Birch LL. Developmental trajectories of girls' BMI across childhood and adolescence. *Obesity (Silver Spring).* 2009;17(11):2067-2074.

# Appendix I- IRB Approval


Institutional Review Board
Office of Sponsored Programs
University of Memphis
315 Admin Bldg
Memphis, TN 38152-3370

PI: Lauren Sims Taylor
Co-Investigator: Fawaz Mzayek, Meredith Ray
Advisor and/or Co-PI: Vikki Nolan
Department: Epidemiology, unknown
Study Title: (FACILITATED UTHSC) Early Childhood Weight Status and its Effects on Socioemotional Development, School Readiness, and Cognition
IRB ID: PRO-FY2018-307
Submission Type: Renewal
Level of Review: Expedited

IRB Meeting Date:
Decision: Approved
Approval Date: May 15, 2018
Expiration Date: May 20, 2019

Research Notes:
Findings:

The IRB has reviewed the renewal request.

Approval of this project is given with the following obligations:
1. If this IRB approval has an expiration date, an approved renewal must be in effect to continue the project prior to that date. If approval is not obtained, the human consent form(s) and recruiting material(s) are no longer valid and any research activities involving human subjects must stop.
2. When the project is finished or terminated, a completion form must be completed and sent to the board.
3. No change may be made in the approved protocol without prior board approval, whether the approved protocol was reviewed at the Exempt, Expedited or Full Board level.
4. Exempt approval are considered to have no expiration date and no further review is necessary unless the protocol needs modification.

Thank you,