ARKANSAS CHILD OBESITY GROWTH PATTERNS AND EVALUATIONS OF PRESCHOOL INTERVENTIONS ON OBESITY IN KINDERGARTEN

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Table of Contents

ARKANSAS SCHOOL CHILDREN CHARACTERISTICS ASSOCIATED WITH KINDERGARTEN TO GRADE 8 GROWTH TRAJECTORY ASSIGNMENTS

Background

The 2020 ACHI Medicaid report included results from a project that addressed two key questions:

- How many underlying patterns of age- and gender-relative BMI growth can be identified in the Arkansas school BMI data?
- Are there underlying demographic and socioeconomic factors that predispose children to exhibit different BMI growth trajectory patterns?

We concluded that Arkansas children followed eight distinct patterns of BMI growth between Kindergarten and Grade 8. We also discovered that children with three characteristics — minority race/ethnicity, lower socio-economic status, and who live in areas where a higher percentage of the population had less than a high school education — were more likely to be assigned BMI growth trajectory patterns with high obesity rates and age- and gender-relative BMI growth.
In last year's report, we cited a key limitation of not having more environmental and social determinant variables to test for differences that explain what distinct BMI growth trajectories children are assigned.

This study continues to build on other studies that have addressed similar questions using different child populations. In 2009, using data from the National Longitudinal Survey of Youths, Nonnemaker and colleagues demonstrated that BMI growth between 8,984 participants 12 to 23 years of age fell into four distinct growth trajectories (Nonnemaker, 2009). In a study of 1,456 children 1 to 18 years of age from the Isle of Wight birth cohort, Ziyab and colleagues also identified four trajectories of BMI growth that were labeled as "normal," "early persistent obesity," "delayed overweight," and "early transient overweight" (Ziyab, 2014). Both Nonnemaker and Ziyab included boys and girls in the same growth trajectory models. Another study from the United Kingdom by Stuart and colleagues, using 9,699 children 3 to 11 years of age from the Millennium Cohort Study, also identified four growth trajectories for boys and girls and labeled them as "low-normal," "mid-normal," "overweight," and "obese" (Stuart, 2016). Using

survey and birth cohort data, these results consistently demonstrated that four growth trajectories adequately depicted longitudinal BMI growth in children over various ages.

In all of the previous studies, the number of growth trajectories has been limited by overall cohort size. Using a larger longitudinal child population, such as that representing the public school population of Arkansas, has enabled identification of additional growth trajectories.

We built on the previous studies, and on results from last year by adding a residential region variable and 14 social determinant of health variables to the analysis. We also employ a more sophisticated version of the growth trajectory model and incorporate child characteristics and predictive variables within the determination of what distinct growth trajectory (pattern) to assign individual children. Using new data and updated methods, we again present responses to the two key questions initially posed. A greater emphasis on studying weight status change from Kindergarten to Grade 8 is also profiled, including a sub-categorical profile of three increasing classes (levels) of obesity.

Methods

DATA SOURCES

Data for this study were obtained from two sources. Child and adolescent school weight and height measures, as well as individual-level demographic and geographic data, were obtained from the Arkansas Department of Education school BMI data housed at ACHI, which comes from the Arkansas Department of Education (DOE). Separately, ACHI has overseen the data collection process through which the height and weight of each public school student in Kindergarten and grades 2, 4, 6, 8, and 10 are collected and reported by school personnel under standardized protocols. All Arkansas student data are securely transferred to ACHI with personal identifiers. Individual identity resolution and linkages from different sources (DOE and schools) within measurement assessment years and for children across measurement assessment years utilize personal identifiers. These data are placed on a secure and protected server without internet access. Personal identifiers of unique individuals are then processed through a generic match engine that assigns an anonymous and unique person identifier. An analytic database is prepared that only contains the anonymous and unique person identifier

and data fields of interest, including gender, race/ethnicity, and free or reduced lunch payment status.

Social determinants of health (SDOH) at the census tract level were obtained from the Centers for Disease Control and Prevention (CDC) and include 14 items that were compiled to form the 2010 Social Vulnerability Index (SVI) (Flanagan, 2011). The CDC compiled SVI items from American Community Survey 5-year summary data. While the index was compiled to assess emergency preparedness in census tracts and counties, there has been recent validation that the index is also predictive of youth physical fitness, (Gay, 2016) and individual index items overlap with social determinants of child obesity (Yusuf, 2020). The 2010 SVI items were chosen for this study given the longitudinal Kindergarten to Grade 8 cohorts that had assessments in Kindergarten beginning in 2004 and through 2011.

STUDY POPULATION

As of the 2018–19 school year, 15 years of height and weight measurements had been collected on Arkansas school children. Of all data collected, eight cohorts of children contain measurements spanning Kindergarten through Grade 8. There are multiple reasons why a student would not be measured in any given year, and students in Grade 10 opt out of measurement at a high rate, hence Grade 10 is not included in the longitudinal measurements.

CALCULATION OF BMI AND CHILD OBESITY

For each child and adolescent student assessment, body mass index (BMI) was compiled as weight measured in kilograms divided by height measured in meters squared. A SAS (SAS Institute, Cary, NC) statistical program obtained from the CDC is used to calculate BMI standardized differences (zscores) based on specific gender and age in months and using a historical height and weight child referent group last updated in 2000 (Kuczmarski, 2002). Cumulative BMI percentiles (pscores) based on low to high zscores are also compiled.

A zscore of 0 (pscore of 50.0) implies that the BMI is equal to the mean BMI of all children in the referent group with the same age and gender. A zscore of 1.96 (pscore of 97.5) or greater would indicate that the BMI is in the top 2.5% of all children in the referent group with the same age and gender. BMI percentiles are more intuitive and comparable than zscores, so in this

study we use the pscore associated with the zscores as the continuous relative BMI measurement to study patterns of change over time. Increasing pscores over time indicates that compared to similar children of the same age and gender, these children are gaining disproportionately in relative BMI. For point of reference, individual children with a pscore of 95.0 or higher are categorized as “obese,” those with a pscore between 85.0 and 95.0 are categorized as “overweight,” those with a pscore between 5.0 and 85.0 are categorized as having “normal weight,” and those with a pscore under 5.0 are categorized as being “underweight.” Obesity was further divided into three BMI hierarchical sub-categories of increasing weight status. Based on the age and gender BMI cut-off value to attain the 95th BMI percentile or higher, all children and adolescents achieved obesity Class 1. If the BMI value was 120% higher than the cut-off value, they were assigned to obesity Class 2, and if the BMI value was 140% higher than the cut-off value, they were assigned to obesity Class 3.

RE-PARAMETRIZATION OF ARKANSAS CHILD BMI ZSCORES AND PSCORES

As previously mentioned, the CDC child growth charts present BMI percentile growth by age and gender based on a national referent group of children and adolescents in the United States. The LMS method is used to calculate the smoothed percentile values for the growth charts (Cole, 2012). Technically, one of the limitations of the LMS method is the inability to precisely calculate values beyond the 97th BMI percentile. Based on a similar population to the referent group, 3% of children are expected to have a BMI based on age and gender that is higher than the 97th percentile. In Arkansas, approximately 11.6% of children in Kindergarten and 18.2% of children in Grade 8 have BMI values in the 97th percentile or higher.

In order to accurately capture BMI percentile trajectories over five time periods, especially in the higher obesity Class 2 and 3 categories, ACHI has compiled BMI growth charts with an Arkansas child and adolescent referent population using the same LMS method as the one CDC implemented. The resulting BMI zscore and pscore values are more precise in the higher BMI percentile ranges and where only 3% of the population have now pscore values greater than 97.0. For the purposes of comparable interpretation, the weight status categories as derived from the CDC growth charts by age and gender are retained. That is, data reflect Arkansas pscores, but CDC weight status categorization is the same.

CREATION OF THE ANALYTIC DATABASE

A longitudinal database of BMI measurements from Kindergarten, and Grades 2, 4, 6, and 8 were combined for each uniquely identified child over the 15 years of data availability. Only children who had non-missing values at each measurement period were retained for analysis. Individual-level demographic, geographic, and school lunch payment status were obtained from Kindergarten records. A variable representing the year in which Kindergarten was completed was created. Missing demographic, geographic, and school lunch payment status data at Kindergarten were filled in with information from neighboring years until complete.

Arkansas BMI pscores at Kindergarten and Grades 2, 4, 6, and 8 are the continuous trajectory variables under study. Individual longitudinal influential pscore values and outliers were assessed using a repeated measures mixed regression model in SAS. Data were processed for each of the eight Kindergarten cohort years and the Cook's D influential statistic produced for each observation was sorted from high to low (Cook, 1979). The five pscore measures comprising each trajectory were visually assessed for outliers. Clear outliers were evident in at least the first 100 sorted highest Cook's D values for each trajectory observation in Kindergarten cohort year. The observations associated with the highest 100 Cook's D values for each Kindergarten cohort year were deleted from this study. After observations with pscore outliers were removed, the analytic database contained 101,817 individuals for study.

Using geographic identifiers at the census tract level, the School BMI data and the SDOH variables were linked. In Arkansas, there are a total of 686 census tracts. Table 1 presents the individual-level variables included in this study along with the variable categories.

TABLE 1: INDIVIDUAL-LEVEL LATENT CLASS GROWTH ANALYSIS STUDY VARIABLES

Individual Level Variables	Categories	
Gender	Male, Female	
Race/Ethnicity	White, Non-White	
School Lunch Payment Status	Free/Reduced, Full Price	
Region (Counties)	Northwest	Benton, Washington, Crawford, Sebastian
	Urban	Pulaski
	Suburban	Faulkner, Lonoke, Jefferson, Saline
	Country	Arkansas, Ashley, Boone, Bradley, Calhoun, Carroll, Clark, Clay, Cleburne, Cleveland, Columbia, Conway, Craighead, Dallas, Drew, Franklin, Garland, Grant, Greene, Hempstead, Hot Spring, Howard, Independence, Jackson, Johnson, Lafayette, Lincoln, Little River, Logan, Madison, Miller, Montgomery, Nevada, Ouachita, Perry, Pike, Poinsett, Polk, Pope, Prairie, Scott, Sevier, Union, White, Yell
	Mountain	Marion, Baxter, Fulton, Sharp, Randolph, Lawrence, Izard, Searcy, Stone, Newton, Van Buren
	Delta	Mississippi, Crittenden, Cross, Woodruff, St Francis, Lee, Phillips, Monroe, Desha, Chicot

Continuous SDOH variables were converted to inter-quartile range categories (lowest quartile, middle half, highest quartile) or dichotomous categories (three lowest quartiles, highest quartile) in the case where most of the responses were the same for the majority of population. SDOH variables are presented in Table 2.

TABLE 2. CENSUS TRACT-LEVEL LATENT CLASS GROWTH ANALYSIS STUDY VARIABLES

SVI Theme	SDOH Covariate	Description	Q1	Q3
Socio-Economic	Poverty	Percentage of census tract residents below poverty level	11.3	23.7
	Unemployment	Percentage of civilian (age 16+) census tract residents unemployed	5.0	10.7
	Per Capita Income	Census tract median income ($)	16,318	23,220
	High School Education	Percentage of census tract residents with no high school diploma	12.8	24.5
Household Composition / Disability	High Age	Percentage of census tract residents aged 65 years or older	10.4	16.7
	Low Age	Percentage of census tract residents aged 17 years or younger	23.1	28.1
	Single Parent	Percentage of census tract single-parent households	9.0	15.4
Minority Status / Language	Minority	Percentage of census tract residents identifying as Non-White	8.1	40.9
	Cannot Speak English	Percentage of census tract residents (age 5+) who speak English "less than well"	2.1	--
Housing Type / Transportation	Multi-Unit	Percentage of census tract residents living in housing structures with 10 or more units	6.3	--
	Mobile Homes	Percentage of census tract housing structures that are mobile homes	2.8	20.6
	Crowded Households	Percentage of census tract households with more people than rooms	0.8	3.5
	No Vehicle	Percentage of census tract households that do not have access to a vehicle	3.2	8.9
	Group Quarters	Percentage of census tract residents residing in group quarters	1.9	--

Abbreviations: SVI = Social Vulnerability Index; SDOH = Social Determinant of Health
Note: Q1 represents the cut-off value for the 25th percentile. Q3 represents the cut-off value for the 75th percentile. SDOH with both a Q1 and Q3 value contain three categories – Lowest Quartile, Middle Half, and Highest Quartile. Covariates with only a Q1 value contain two categories and the value presented is the cut-off value for the 25th percentile.

LATENT CLASS GROWTH ANALYSIS

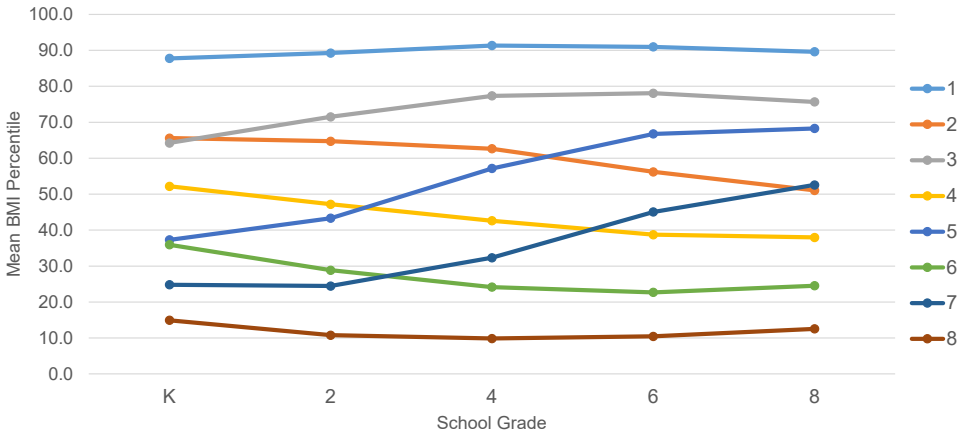
Latent class growth analysis (LCGA) is a person-centered method to identify homogeneous subpopulations within an overall population for the purpose of identifying classes of individuals that share underlying characteristics. The purpose of this study is to create subpopulation groups (classes) where children within the same class share similar Arkansas BMI percentile growth trajectories in common compared to children between different classes.

Two statistical processes comprise the LCGA; one is a repeated measures analysis where children's BMI pscores are measured over time, and another determines the conditional probability of a child being assigned to one latent class or another, based on prior grade BMI pscores.

Using just the five-grade/time-measured BMI pscores at a first stage, statistical measures determine the suitability of the model (fit statistics), how distinct the latent classes are (class separation), and how to determine the right number of classes represented in the data. Through statistical analyses of longitudinal BMI data on Arkansas schoolchildren, a model with eight distinct classes demonstrating good statistical fit and exhibiting very good class separation was determined. The best-fitting LCGA tested contained non-linear (curved) growth trajectories.

At the second stage, all variables depicted in Tables 1 and 2 are included as covariates in the eight-class, non-linear LCGA model. At this stage, covariates are also modeled to be predictive of the growth parameters (trajectory intercept, slope, and quadratic term) and also predictive on the assignment of children to the eight latent classes. Figure 1 depicts the fitted trajectories of each of the eight latent classes underlying in the population under study. BMI percentile values are graphed based on the average BMI percentile at each school grade measurement for all children assigned to the latent trajectory class. Latent class trajectories (LCT) have been numbered based on highest to lowest average BMI percentiles at Kindergarten and will hereafter be labeled LCT1 through LCT8.

FIGURE 1. DISTINCT BMI GROWTH TRAJECTORIES FROM KINDERGARTEN TO GRADE 8 AMONG ARKANSAS SCHOOL CHILDREN



Weight status of children assigned to each latent class will be profiled. As well, individual-level characteristics and census tract-level descriptive variable summaries will be presented based on latent class trajectory assignment. Pairwise comparison of children assigned to latent classes where obesity prevention policy changes may be needed will indicate where subpopulations differ in each latent class.

Pairwise comparisons will be chosen to profile traits that are different between children assigned to two individual latent class trajectories at a time. The pairwise comparisons come in two forms: one is children in two latent class trajectories who begin Kindergarten with similar average BMI percentiles but diverge over time, and second, children in latent class trajectories who begin Kindergarten with very different average BMI percentiles and maintain this difference over time.

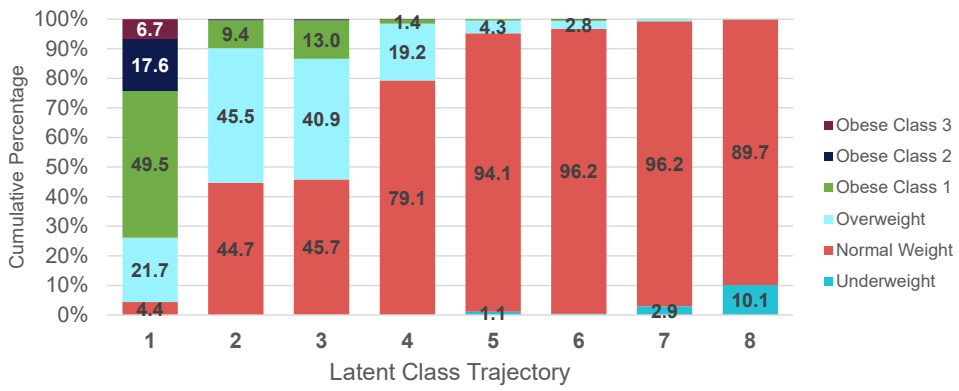
Pairwise comparisons will include LCT5 and LCT6, where children assigned to each of these latent class trajectories have very similar average BMI percentiles at Kindergarten, but those in LCT5 increase in average BMI percentile through Grade 8, while those assigned to LCT6 decrease in average BMI percentile over the same period. A similar divergence in average BMI percentiles is evident for children assigned to LCT3 and LCT2 and children assigned to each of these latent class trajectories will be statistically modeled to determine differences in individual characteristics and census tract-level social determinants of health. Children assigned to latent class trajectories who have very different average BMI percentiles at Kindergarten will also be profiled. These include children assigned to LCT1 and LCT8, and LCT1 and LCT6.

Results

WEIGHT STATUS BY LATENT CLASS

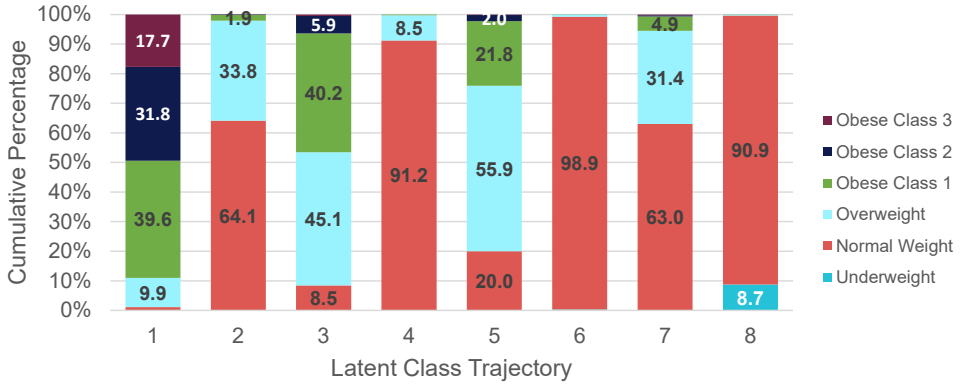
Figure 2 presents the weight status distribution in Kindergarten of children assigned to each of the eight latent class trajectories. Figure 3 contains the same distribution based on weight status assessment performed in Grade 8 for the same children assigned to latent class trajectories. Comparing the slope of the trajectory for each latent class depicted in Figure 1 reveals an alignment between average BMI percentiles and weight status. For example, the decreasing latent class trajectory slope for children assigned to LCT2 is

FIGURE 2. WEIGHT STATUS DISTRIBUTION AT KINDERGARTEN BY LATENT CLASS TRAJECTORY



associated with an additional 19.4% of children being assessed with Normal Weight by Grade 8. Conversely, the increasing latent class trajectory slope for children assigned to LCT3 is associated with 37.2% fewer children being assessed with Normal Weight by Grade 8.

FIGURE 3. WEIGHT STATUS DISTRIBUTION AT GRADE 8 BY LATENT CLASS TRAJECTORY



INDIVIDUAL-LEVEL CHARACTERISTICS PROFILE BY LATENT CLASS TRAJECTORY

To gain insight into how children assigned to different latent class trajectories differ, this section presents individual demographic, geographic, and socio-economic characteristics and census-tract grouped social determinant of health demographics. Table 3 contains a descriptive profile of individual level characteristics by latent class.

TABLE 3. INDIVIDUAL-LEVEL CHILD CHARACTERISTICS BY LATENT CLASS TRAJECTORY

Characteristic	Latent Class Trajectory (n,%)								
Gender	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Male	8,562	4,794	7,552	7,757	3,903	9,210	2,520	8,012	52,310
	51.0	50.8	52.6	55.4	50.2	53.7	42.2	49.1	51.4
Female	8,240	4,644	6,803	6,245	3,865	7,957	3,452	8,301	49,507
	49.0	49.2	47.4	44.6	49.8	46.4	57.8	50.9	48.6
Race/Ethnicity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
White	9,340	5,936	8,776	9,273	5,221	12,194	3,929	11,496	66,165
	55.6	62.9	61.1	66.2	67.2	71.0	65.8	70.5	65.0
Black	4,536	2,194	3,452	3,147	1,612	3,279	1,348	3,134	22,702
	27.0	23.3	24.1	22.5	20.8	19.1	22.6	19.2	22.3
Hispanic	2,605	1,091	1,817	1,283	762	1,258	516	1,162	10,494
	15.5	11.6	12.7	9.2	9.8	7.3	8.6	7.1	10.3
Other	321	217	310	299	173	436	179	521	2,456
	1.9	2.3	2.2	2.1	2.2	2.5	3.0	3.2	2.4
School Lunch	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Full Price	6,026	4,272	5,685	6,591	3,060	8,191	2,452	7,785	44,062
	35.9	45.3	39.6	47.1	39.4	47.7	41.1	47.7	43.3
Free/Reduced	10,776	5,166	8,670	7,411	4,708	8,976	3,520	8,528	57,755
	64.1	54.7	60.4	52.9	60.6	52.3	58.9	52.3	56.7
Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Northwest	2,765	1,903	2,709	2,862	1,539	3,902	1,269	3,476	20,425
	16.5	20.2	18.9	20.4	19.8	22.7	21.3	21.3	20.1
Urban	1,765	1,164	1,539	1,661	762	1,890	653	1,711	11,145
	10.5	12.3	10.7	11.9	9.8	11.0	10.9	10.5	11.0
Suburban	2,158	1,246	1,834	2,012	1,021	2,417	791	2,393	13,872
	12.8	13.2	12.8	14.4	13.1	14.1	13.3	14.7	13.6
Country	7,465	3,855	6,183	5,576	3,275	6,703	2,366	6,554	41,977
	44.4	40.9	43.1	39.8	42.2	39.1	39.6	40.2	41.2
Mountain	887	480	756	797	485	921	356	858	5,540
	5.3	5.1	5.3	5.7	6.2	5.4	6.0	5.3	5.4
Delta	1,762	790	1,334	1,094	686	1,334	537	1,321	8,858
	10.5	8.4	9.3	7.8	8.8	7.8	9.0	8.1	8.7
Total	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
	16,802	9,438	14,355	14,002	7,768	17,167	5,972	16,313	101,817
	16.5	9.3	14.1	13.8	7.6	16.9	5.9	16.0	100.0

Note: In adjusted multivariable models, the following categories are used a referent categories - Males, children of White race, children paying full price for lunch in Kindergarten, and those residing the Northwest region in Kindergarten. Northwest was chosen as the referent region due to having the lowest average BMI percentile at Kindergarten of children from all regions.

There is a range of differences across latent class trajectory assignment. For gender, the percentage of males ranges from 42.2% for children assigned to LCT7, to 55.4% in LCT4. For race/ethnicity, the percentage of children who are White ranges from 55.6% for children assigned to LCT1, to 71.0% for LCT6. The percentage of children from the North West ranges from 16.5% for children assigned to LCT1, to 22.7% in LCT6. Note that LCT1 and LCT6 will also be latent class trajectories that contain the largest percentage range of children assigned based on census-tract level social determinants.

CENSUS TRACT-LEVEL SOCIAL DETERMINANTS OF HEALTH PROFILE BY LATENT CLASS

Tables 4 through 7 presents a census tract-level profile of social determinants of health that children experience in the area that they lived in while in Kindergarten, by the latent class trajectory that they have been assigned. Tables have been broken out by social vulnerability index theme (dimension). Categories represent the number and percentage of children living in a census tract with a percentage of all census tract individuals/households having the same characteristic. For example in Table 4, 20.6% (3,458) of all children assigned to LCT1 resided in a census tract where less than 11.3% of the population lived below the poverty level.

TABLE 4. CENSUS TRACT-LEVEL SOCIOECONOMIC CHARACTERISTICS BY CHILD LATENT CLASS TRAJECTORY ASSIGMENT

Social Vulnerability Index Socioeconomic Theme									
Census Tract Characteristic	Latent Class Trajectories (n,%)								Total
Below Poverty Level	1	2	3	4	5	6	7	8	
< 11.3%	3,458 20.6	2,347 24.9	3,179 22.2	3,669 26.2	1,886 24.3	4,917 28.6	1,526 25.6	4,511 27.7	25,493 25.0
11.3 – 23.7%	8,427 50.2	4,709 49.9	7,438 51.8	6,973 49.8	3,901 50.2	8,431 49.1	2,948 49.4	8,098 49.6	50,925 50.0
> 23.7%	4,917 29.3	2,382 25.2	3,738 26.0	3,360 24.0	1,981 25.5	3,819 22.3	1,498 25.1	3,704 22.7	25,399 25.0
Unemployment Rate	1	2	3	4	5	6	7	8	
< 5.0%	3,584 21.3	2,349 24.9	3,285 22.9	3,570 25.5	1,999 25.7	4,700 27.4	1,542 25.8	4,479 27.5	25,508 25.1
5.0 – 10.7%	8,303 49.4	4,734 50.2	7,230 50.4	7,018 50.1	3,878 49.9	8,626 50.3	2,938 49.2	8,152 50.0	50,879 50.0
> 10.7%	4,915 29.3	2,355 25.0	3,840 26.8	3,414 24.4	1,891 24.3	3,841 22.4	1,492 25.0	3,682 22.6	25,430 25.0
Per Capita Income	1	2	3	4	5	6	7	8	
< $16,318	4,878 29.0	2,414 25.6	3,849 26.8	3,358 24.0	2,007 25.8	3,779 22.0	1,416 23.7	3,567 21.9	25,268 24.8
$16,318 - $23,220	8,769 52.2	4,540 48.1	7,271 50.7	6,859 49.0	3,928 50.6	8,364 48.7	3,055 51.2	8,041 49.3	50,827 49.9
> $23,220	3,155 18.8	2,484 26.3	3,235 22.5	3,785 27.0	1,833 23.6	5,024 29.3	1,501 25.1	4,705 28.8	25,722 25.3
No High School Diploma	1	2	3	4	5	6	7	8	
< 12.8%	3,157 18.8	2,400 25.4	3,279 22.8	3,808 27.2	1,838 23.7	4,962 28.9	1,498 25.1	4,636 28.4	25,578 25.1
12.8 – 24.5%	8,591 51.1	4,655 49.3	7,209 50.2	6,912 49.4	3,951 50.9	8,519 49.6	3,008 50.4	8,168 50.1	51,013 50.1
> 24.5%	5,054 30.1	2,383 25.3	3,867 26.9	3,282 23.4	1,979 25.5	3,686 21.5	1,466 24.6	3,509 21.5	25,226 24.8
Total	1	2	3	4	5	6	7	8	
	16,802 16.5	9,438 9.3	14,355 14.1	14,002 13.8	7,768 7.6	17,167 16.9	5,972 5.9	16,313 16.0	101,817 100

Children assigned to latent class trajectories 1 and 6 experienced the greatest percentage difference across all of the socioeconomic variables in Table 5. Children who lived in a census tract during Kindergarten with greater than 23.7% of the households living in poverty were most likely to be assigned to LCT1 (29.3%) and least likely to be assigned to LCT6 (22.3%). These two latent class trajectories also contained the high (29.3%) and low (22.4%) percentage range of children assigned based on the census tract containing more than 10.7% of adults who were unemployed. Only 18.8% of children assigned to LCT1 resided in a census tract where the median household income was greater than $23,220 compared to 29.3% of LCT6 assigned children. Nearly one-third (30.1%) of children assigned to LCT1 lived in a census tract where one-quarter (24.5%) did not have a high school diploma compared to 21.5% of LCT6 assigned children.

TABLE 5. CENSUS TRACT-LEVEL HOUSEHOLD COMPOSITION/DISABILITY CHARACTERISTICS BY CHILD LATENT CLASS TRAJECTORY ASSIGNMENT

Social Vulnerability Index Household Composition/Disability Theme									
Census Tract Characteristic	Latent Class Trajectories (n,%)								
Population 65+ years	1	2	3	4	5	6	7	8	Total
< 10.4%	4,038 24.0	2,374 25.2	3,596 25.1	3,524 25.2	1,929 24.8	4,332 25.2	1,450 24.3	3,990 24.5	25,233 24.8
10.4 – 16.7%	8,484 50.5	4,700 49.8	7,108 49.5	6,928 49.5	3,862 49.7	8,636 50.3	2,976 49.8	8,264 50.7	50,958 50.1
> 16.7%	4,280 25.5	2,364 25.1	3,651 25.4	3,550 25.4	1,977 25.5	4,199 24.5	1,546 25.9	4,059 24.8	25,626 25.2
Population < 18 years	1	2	3	4	5	6	7	8	Total
< 23.1%	3,997 23.8	2,400 25.4	3,516 24.5	3,579 25.6	1,973 25.4	4,205 24.5	1,515 25.4	4,209 25.8	25,394 24.9
23.1 – 28.1%	8,559 50.9	4,585 48.6	7,158 49.9	6,862 49.0	3,862 49.7	8,669 50.5	3,043 51.0	8,179 50.1	50,917 50.0
> 28.1%	4,246 25.3	2,453 26.0	3,681 25.6	3,561 25.4	1,933 24.9	4,293 25.0	1,414 23.7	3,925 24.1	25,506 25.1
Single-Parent Households	1	2	3	4	5	6	7	8	Total
< 9.0%	3,466 20.6	2,328 24.7	3,328 23.2	3,661 26.2	1,939 25.0	4,651 27.1	1,547 25.9	4,474 27.4	25,394 24.9
9.0 – 15.4%	8,268 49.2	4,610 48.9	7,162 49.9	6,869 49.1	3,915 50.4	8,706 50.7	2,947 49.4	8,245 50.5	50,722 49.8
> 15.4%	5,068 30.2	2,500 26.5	3,865 26.9	3,472 24.8	1,914 24.6	3,810 22.2	1,478 24.8	3,594 22.0	25,701 25.2
Total	1	2	3	4	5	6	7	8	Total
	16,802 16.5	9,438 9.3	14,355 14.1	14,002 13.8	7,768 7.6	17,167 16.9	5,972 5.9	16,313 16.0	101,817 100

There is less than a 1% difference across latent class trajectories in the percentage of children residing in a census tract with greater than 16.7% of the population aged 65 or older. Children who lived in a census tract with greater than 28.1% of the population less than 18 years of age

were most likely to be assigned to LCT2 (26.0%) and least likely to be assigned to LCT7 (23.7%). Nearly one-third (30.2%) of children assigned to LCT1 lived in a census tract where greater than 15.7% of households were headed by a single parent compared to 22.2% of LCT6 assigned children.

TABLE 6. CENSUS TRACT-LEVEL MINORITY STATUS/LANGUAGE CHARACTERISTICS BY CHILD LATENT CLASS TRAJECTORY ASSIGNMENT

Social Vulnerability Index Minority Status/Language Theme									
Census Tract Characteristic	Latent Class Trajectories (n,%)								Total
Minority Population	1	2	3	4	5	6	7	8	
< 8.1%	3,845 22.9	2,179 23.1	3,539 24.7	3,522 25.2	2,039 26.3	4,406 25.7	1,506 25.2	4,341 26.6	25,377 24.9
8.1 – 40.9%	7,781 46.3	4,766 50.5	6,887 48.0	7,004 50.0	3,848 49.5	8,983 52.3	3,052 51.1	8,511 52.2	50,832 49.9
> 40.9%	5,176 30.8	2,493 26.4	3,929 27.4	3,476 24.8	1,881 24.2	3,778 22.0	1,414 23.7	3,461 21.2	25,608 25.2
Speak English “Less Than Well”	1	2	3	4	5	6	7	8	
< 2.1%	4,619 27.5	2,417 25.6	3,719 25.9	3,395 24.3	2,054 26.4	4,113 24.0	1,419 23.8	3,688 22.6	25,424 25.0
≥ 2.1%	12,183 72.5	7,021 74.4	10,636 74.1	10,607 75.8	5,714 73.6	13,054 76.0	4,553 76.2	12,625 77.4	76,393 75.0
Total	1	2	3	4	5	6	7	8	
	16,802 16.5	9,438 9.3	14,355 14.1	14,002 13.8	7,768 7.6	17,167 16.9	5,972 5.9	16,313 16.0	101,817 100

Children who lived in a census tract with greater than 40.9% of the population of non-White race were most likely to be assigned to LCT1 (30.8%) and least likely to be assigned to LCT8 (21.2%) or LCT6 (22.0%). A high of 27.5% of all children assigned to LCT1 lived in census tracts where fewer than 2.1% of the population aged 5 or older speak English “less than well,” compared to a low of 22.6% of children assigned to LCT8.

TABLE 7. CENSUS TRACT-LEVEL HOUSING TYPE/TRANSPORTATION CHARACTERISTICS BY CHILD LATENT CLASS TRAJECTORY ASSIGNMENT

Social Vulnerability Index Housing Type/Transportation Theme									
Census Tract Characteristic	Latent Class Trajectories (n,%)								Total
Mobile Homes	1	2	3	4	5	6	7	8	
< 2.8%	3,891 23.2	2,441 25.9	3,285 22.9	3,562 25.4	1,887 24.3	4,388 25.6	1,391 23.3	4,002 24.5	24,847 24.4
2.8 – 20.6%	8,450 50.3	4,791 50.8	7,487 52.2	7,129 50.9	3,891 50.1	8,710 50.7	3,104 52.0	8,223 50.4	51,785 50.9
> 20.6%	4,461 26.6	2,206 23.4	3,583 25.0	3,311 23.7	1,990 25.6	4,069 23.7	1,477 24.7	4,088 25.1	25,185 24.7
Crowded Homes	1	2	3	4	5	6	7	8	
< 0.8%	3,547 21.1	2,254 23.9	3,210 22.4	3,402 24.3	1,756 22.6	4,366 25.4	1,386 23.2	4,095 25.1	24,016 23.6
0.8 – 3.5%	8,469 50.4	4,742 50.2	7,397 51.5	7,236 51.7	4,036 52.0	8,767 51.1	3,221 53.9	8,522 52.2	52,390 51.5
> 3.5%	4,786 28.5	2,442 25.9	3,748 26.1	3,364 24.0	1,976 25.4	4,034 23.5	1,365 22.9	3,696 22.7	25,411 25.0
Multi-Unit Housing	1	2	3	4	5	6	7	8	
< 6.3%	4,125 24.6	2,520 26.7	3,510 24.5	3,663 26.2	1,903 24.5	4,458 26.0	1,413 23.7	3,965 24.3	25,557 25.1
≥ 6.3%	12,677 75.5	6,918 73.3	10,845 75.6	10,339 73.8	5,865 75.5	12,709 74.0	4,559 76.3	12,348 75.7	76,260 74.9
No Vehicle	1	2	3	4	5	6	7	8	
< 3.2%	3,777 22.5	2,498 26.5	3,505 24.4	3,740 26.7	1,979 25.5	4,995 29.1	1,544 25.9	4,688 28.7	26,726 26.3
3.2 – 8.9%	8,218 48.9	4,565 48.4	7,028 49.0	6,715 48.0	3,825 49.2	8,286 48.3	2,907 48.7	7,875 48.3	49,419 48.5
> 8.9%	4,807 28.6	2,375 25.2	3,822 26.6	3,547 25.3	1,964 25.3	3,886 22.6	1,521 25.5	3,750 23.0	25,672 25.2
Population in Group Quarters	1	2	3	4	5	6	7	8	
< 1.9%	4,586 27.3	2,391 25.3	3,782 26.4	3,518 25.1	1,995 25.7	4,263 24.8	1,535 25.7	4,044 24.8	26,114 25.7
≥ 1.9%	12,216 72.7	7,047 74.7	10,573 73.7	10,484 74.9	5,773 74.3	12,904 75.2	4,437 74.3	12,269 75.2	75,703 74.4
Total	1	2	3	4	5	6	7	8	
	16,802 16.5	9,438 9.3	14,355 14.1	14,002 13.8	7,768 7.6	17,167 16.9	5,972 5.9	16,313 16.0	101,817 100

The highest percentage of children were assigned to LCT1 based on living in census tracts with housing structures containing more than 20.6% of mobile homes (26.6%), greater than 3.5% of crowded households (28.5%), and greater than 8.9% of households having no access to a vehicle (28.6%). For these same census tract characteristics LCT4 (23.7%), LCT8 (22.8%), and LCT6 (22.6%) had the fewest children assigned, respectively. A high of 26.7% of all children assigned to LCT2 lived in census tracts where less than 6.3% of the population living in multi-unit housing compared to a low of 23.7% of children assigned to LCT7. A high of 27.3% of all children assigned to LCT1 lived in census tracts where less than 1.9% of the population lived in group quarters compared to a low of 24.8% of children assigned to both LCT6 and LCT8.

LATENT CLASS GROWTH TRAJECTORY PAIRWISE COMPARISONS

In this section, significant demographic, geographic, socio-economic, and social determinant of health differences between children assigned to different latent class trajectories are explored. The first two pairwise comparison latent class trajectories were chosen based on trajectories that potentially identify opportunities for school intervention. These trajectories are characterized by children assigned to them with similar average BMI percentiles at Kindergarten, but diverge significantly by Grade 8. The next two pairwise comparison latent class trajectories are chosen based on the potential need for policy interventions prior to Kindergarten. In this case, trajectories are characterized by children assigned to them with very different average BMI percentiles at Kindergarten, and who maintain significant differences through Grade 8.

COMPARISON OF CHILDREN ASSIGNED TO LATENT CLASSES 5 AND 6

In total, 7,768 children were assigned to LCT5. At Kindergarten, the average BMI percentile for these children was 37.3%, but by Grade 8 these same children had an average BMI percentile of 68.3% (Figure 4). More children, 17,167, were assigned to LCT6, and these children began Kindergarten with a BMI percentile average of 35.9%, very close to the same average of LCT5 children. However, unlike LCT5 children who have an increasing BMI percentile average that almost doubled through Grade 8, those assigned to LCT6 declined to a BMI percentile average of 24.5%. Table 8 contains a weight status transition profile from Kindergarten to Grade 8 for the children assigned to each of these latent class trajectories.

FIGURE 4. LATENT CLASS GROWTH TRAJECTORIES 5 AND 6 FROM KINDERGARTEN TO GRADE 8

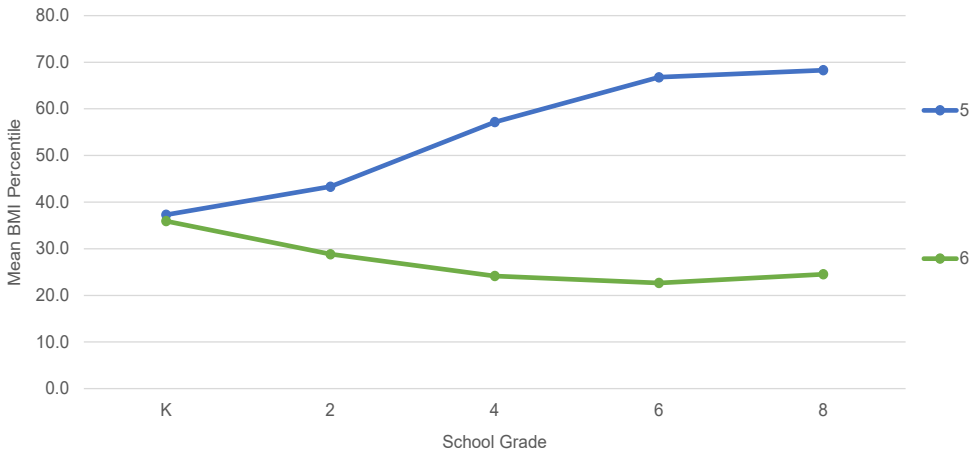


TABLE 8. LATENT CLASS TRAJECTORIES 5 AND 6 WEIGHT STATUS PROFILE IN KINDERGARTEN AND GRADE 8

	Latent Class Trajectory 5		Latent Class Trajectory 6	
	Kindergarten (n, %)	**Grade 8 (n, %)**	**Kindergarten (n, %)**	**Grade 8 (n, %)**
Underweight	87 (1.1)	0 (0.0)	73 (0.4)	57 (0.3)
Normal Weight	7,311 (94.1)	1,551 (20.0)	16,525 (96.3)	16,981 (98.9)
Overweight	332 (4.3)	4,347 (56.0)	473 (2.8)	125 (0.7)
Obese Class 1	38 (0.5)	1,697 (21.8)	74 (0.4)	4 (0.0)
Obese Class 2	0 (0.0)	158 (2.0)	15 (0.1)	0 (0.0)
Obese Class 3	0 (0.0)	15 (0.2)	7 (0.0)	0 (0.0)
Total	7,768 (100)	7,768 (100)	17,167 (100)	17,167 (100)

At Kindergarten, 94.1% of children assigned to LCT5 were assessed to be of Normal Weight. By Grade 8, only 20.0% of the same children were of Normal Weight. By Grade 8, the majority of children in LCT5 were Overweight (56.0%) or in Obese Class 1 (21.8%). Contrary to the weight status shift over time in children in LCT5, those assigned to LCT6 maintained Normal Weight status from Kindergarten (96.3%) to Grade 8 (98.9%). Even the percentage of LCT6 children who were at least Overweight in Kindergarten (3.3%) had decreased by Grade 8 to 0.7%.

Table 9 presents the results of a multivariable comparison of children in these latent class trajectories and the differential likelihood effect each characteristic has on a child of being assigned to LCT5 over LCT6. Adjusted odds ratios (AOR) in bold italics and table cells shaded blue highlight statistically significant differences.

TABLE 9. LIKELIHOOD OF ASSIGNMENT IN LATENT CLASS TRAJECTORY 5 OVER 6

Individual Level	Category	Referent	AOR	95% CI	
Gender	Female	Male	***1.13***	***1.05***	***1.22***
Race/Ethnicity	Non-White	White	***1.08***	***>1.00***	***1.17***
School Lunch	Free/Reduced	Full Price	***1.30***	***1.20***	***1.40***
Region	Urban	Northwest	1.05	0.91	1.21
	Suburban		***1.19***	***1.05***	***1.35***
	Country		***1.18***	***1.05***	***1.31***
	Mountain		1.19	0.98	1.45
	Delta		1.15	0.99	1.35
Census Tract IQR Level	**Category**	**Referent**	**AOR**	**95% CI**	
Percentage in Poverty	<11.3%	> 23.7%	1.01	0.88	1.16
	11.3 – 23.7 %		1.02	0.92	1.13
Per Capita Income	< $16,318	> $23,220	1.11	0.94	1.30
	$16,318 - $23,220		1.11	0.99	1.24
Percentage with No High School Diploma	< 12.8%	> 24.5%	***0.85***	***0.73***	***0.98***
	12.8 – 24.5 %		***0.90***	***0.81***	***<1.00***
Percentage of Population < 18 Years of Age	< 23.1%	> 28.1%	1.09	0.97	1.23
	23.1 – 28.1 %		1.03	0.93	1.13
Population Percent of Minority Race/Ethnicity	< 8.1 %	> 40.1%	1.16	0.99	1.36
	8.1 – 40.1 %		1.10	0.97	1.25
Mobile Home Density	< 2.8%	> 20.6%	1.01	0.90	1.13
	2.8 – 20.6 %		0.97	0.89	1.06
Non-Vehicle Ownership	< 3.2%	> 8.9%	0.92	0.82	1.04
	3.2 – 8.9 %		0.98	0.88	1.08
Non-English Speaking	≤ 2.1%	> 2.1%	***0.86***	***0.78***	***0.95***

Abbreviations: AOR = Adjusted Odds Ratio; CI = Confidence Interval, IQR = Inter-Quartile Range
Notes: Census tract level unemployment, single parent household, crowded households, multi-unit households, and group households were included in the model but not significantly different in any pairwise comparison presented in this study. Results have not been included in the tables.

Based on individual-level characteristics, the following characteristic groups had different likelihoods of being assigned to LCT5 (increasing average BMI percentile trajectory) than LCT6 (decreasing average BMI percentile trajectory):

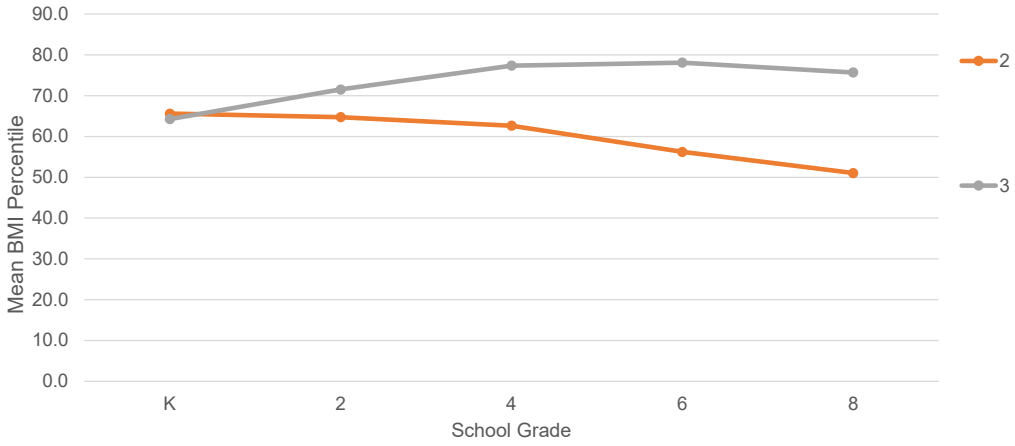
- Female children compared to male children (13% more likely)
- Children of minority race/ethnicity compared to White children (8% more likely)
- Children receiving free or reduced price school lunches compared to those paying full price for lunch (30% more likely)
- Children residing in Suburban- or Country-defined counties compared to children in Northwest counties (18% and 19% more likely, respectively)

Based on the census tract characteristics where a child resides, the following characteristic groups were impactful on having children more likely assigned to LCT5 (increasing average BMI percentile trajectory) than LCT6 (decreasing average BMI percentile trajectory):

- Children residing in census tracts where the percentage of the adult population 25 or older with no high school diploma is less than 12.5% or between 12.5% and 24.5% were 15% and 10% less likely, respectively, to be assigned to LCT5 over LCT6 compared to children residing in a census tract where the percentage was greater than 24.5%.
- Children residing in a census tract where the percentage of the population age 5 or over speaking English "less than well" was 2.1% or less was 15% less likely to be assigned to LCT5 over LCT6 compared to children residing in census tracts where the percentage was 2.1% or higher.

COMPARISON OF CHILDREN AND ADOLESCENTS ASSIGNED TO LATENT CLASSES 3 AND 2

FIGURE 5. LATENT CLASS GROWTH TRAJECTORIES 3 AND 2 FROM KINDERGARTEN TO GRADE 8



In total, 14,355 children were assigned to LCT3. At Kindergarten, the average BMI percentile for these children was 64.3%, but by Grade 8 these same children had an average BMI percentile of 75.7% (Figure 5). There were 9,438 children assigned to LCT2, and these children began Kindergarten with a BMI percentile average of 65.6%, very close to the same average of LCT3 children. However, unlike LCT3 children that have an increasing BMI percentile average through Grade 8, those assigned to LCT2 declined to an average BMI percentile average of 51.0%. Table 10 contains a weight status transition profile from Kindergarten to Grade 8 for the children assigned to each of these latent class trajectories.

TABLE 10. LATENT CLASS TRAJECTORIES 3 AND 2 WEIGHT STATUS PROFILE IN KINDERGARTEN AND GRADE 8

	Latent Class Trajectory 3		Latent Class Trajectory 2	
	Kindergarten (n, %)	**Grade 8 (n, %)**	**Kindergarten (n, %)**	**Grade 8 (n, %)**
Underweight	22 (0.2)	0 (0.0)	0 (0.0)	3 (0.0)
Normal Weight	6,553 (45.6)	1,214 (8.5)	4,217 (44.7)	6,053 (64.1)
Overweight	5,862 (40.8)	6,462 (40.8)	4,294 (45.5)	3,189 (33.8)
Obese Class 1	1,860 (13.0)	5,767 (40.2)	886 (9.4)	180 (1.9)
Obese Class 2	49 (0.3)	844 (5.9)	32 (0.3)	12 (0.1)
Obese Class 3	9 (0.1)	68 (0.5)	9 (0.1)	1 (0.0)
Total	14,355 (100)	14,355 (100)	9,438 (100)	9,438 (100)

At Kindergarten, 45.6% of children assigned to LCT3 were assessed to be of Normal Weight. By Grade 8, only 8.5% of children from LCT3 were of Normal Weight. By Grade 8, the majority of children in LCT3 were Overweight (40.8%) or in Obese Class 1 (40.2%). Contrary to the weight-status shift over time in LCT3 children, those assigned to LCT2 increased Normal Weight status from Kindergarten (44.7%) to Grade 8 (64.1%). Even the percentage of LCT3 children who were at least Overweight in Kindergarten (9.8%) had decreased to 2.0% by Grade 8. While children assigned to these two latent class trajectories both began Kindergarten with almost identical average BMI percentiles, the trajectories diverged by the time children were in Grade 8.

Table 11 presents the results of a multivariable comparison of children in these latent class trajectories and differential likelihood effect each characteristic has on a child of being assigned to LCT3 over LCT2. Adjusted odds ratios (AOR) in bold italics and table cells shaded blue highlight statistically significant differences.

TABLE 11. LIKELIHOOD OF ASSIGNMENT IN LATENT CLASS TRAJECTORY 3 OVER 2

Individual Level	Category	Referent	AOR	95% CI	
Gender	Female	Male	***0.93***	***0.87***	***0.99***
Race/Ethnicity	Non-White	White	1.03	0.95	1.12
School Lunch	Free/Reduced	Full Price	***1.21***	***1.13***	***1.31***
Region	Urban	Northwest	0.96	0.84	1.11
	Suburban		1.04	0.91	1.19
	Country		1.06	0.95	1.18
	Mountain		0.99	0.81	1.21
	Delta		1.08	0.92	1.27
Census Tract IQR Level	**Category**	**Referent**	**AOR**	**95% CI**	
Percentage in Poverty	<11.3%	> 23.7%	1.03	0.89	1.19
	11.3 – 23.7 %		1.07	0.96	1.19
Per Capita Income	< $16,318	> $23,220	1.10	0.94	1.29
	$16,318 - $23,220		1.09	0.98	1.22
Percentage with No High School Diploma	< 12.8%	> 24.5%	1.09	0.95	1.26
	12.8 – 24.5 %		1.01	0.91	1.11
Percentage of Population < 18 Years of Age	< 23.1%	> 28.1%	0.96	0.85	1.08
	23.1 – 28.1 %		1.01	0.92	1.12
Population Percent of Minority Race/Ethnicity	< 8.1 %	> 40.1%	1.08	0.92	1.27
	8.1 – 40.1 %		0.96	0.84	1.09
Mobile Home Density	< 2.8%	> 20.6%	***0.87***	***0.78***	***0.98***
	2.8 – 20.6 %		0.97	0.89	1.06
Non-Vehicle Ownership	< 3.2%	> 8.9%	0.96	0.85	1.09
	3.2 – 8.9 %		0.96	0.87	1.07
Non-English Speaking	≤ 2.1%	> 2.1%	0.94	0.86	1.03

Abbreviations: AOR = Adjusted Odds Ratio; CI = Confidence Interval, IQR = Inter-Quartile Range
Notes: Census tract level unemployment, single parent household, crowded households, multi-unit households, and group households were included in the model but not significantly different in any pairwise comparison presented in this study. Results have not been included in the tables.

Based on individual-level characteristics, the following groups had different likelihoods of being assigned to LCT3 (increasing average BMI percentile trajectory) than LCT2 (decreasing average BMI percentile trajectory):

- Female children compared to male children (7% less likely)
- Children receiving free or reduced price school lunches compared to those paying full price for lunch (21% more likely)

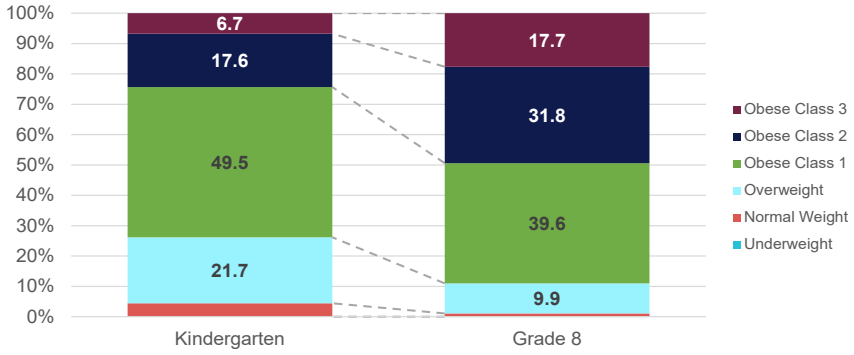
Based on the census tract characteristics where a child resides, the following groups were impactful on having different likelihoods of being assigned to LCT3 (increasing average BMI percentile trajectory) than LCT2 (decreasing average BMI percentile trajectory):

- Children residing in census tracts where the percentage of households living in mobile homes was less than 2.8% were 13% less likely to be in LCT3 than LCT2, compared to children living in census tracts where the percentage was greater than 20.6%

COMPARISON OF CHILDREN AND ADOLESCENTS ASSIGNED TO LATENT CLASSES 1 AND 8

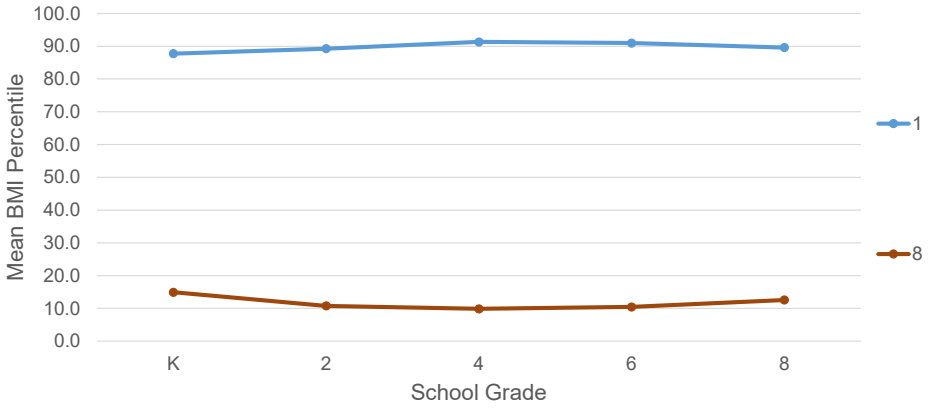
Latent class trajectory groups 1 and 8 contain children with the largest differences in average BMI percentiles and level trajectories over all 5 assessment periods (Figure 6). In total, 16,802 children were assigned to latent class trajectory 1 (LCT1). At Kindergarten, the average BMI percentile for these children was 87.8%, and by Grade 8 these same children maintained a high average BMI percentile of 89.6%. A similar number of children, 16,313, were assigned to latent class trajectory 8 (LCT8), and these children commenced Kindergarten with a BMI percentile average of 14.9%. Children assigned to LCT8 maintained steady weight status between Kindergarten (Normal – 89.7%; Underweight – 10.1%) and Grade 8 (Normal – 90.9%; Underweight – 8.7%) – data not shown.

FIGURE 6. WEIGHT STATUS DISTRIBUTION AT KINDERGARTEN AND GRADE 8 OF CHILDREN ASSIGNED TO LATENT CLASS TRAJECTORY 1



While LCT1 appears to have a relatively steady trajectory as well, there are significant shifts in weight status, especially between obesity classes (Figure 7). In Kindergarten, 14.3% of all children assigned to LCT1 were assessed to have a BMI that categorized them in Obese Class 2 (17.6%) or Obese Class 3 (6.7%). By Grade 8, nearly half (49.5%) of all children in LCT1 had remained in, or attained, Obese Class 2 (31.8%) or Obese Class 3 (17.7%) weight status.

FIGURE 7. LATENT CLASS GROWTH TRAJECTORIES 1 AND 8 FROM KINDERGARTEN TO GRADE 8



Individual- and census tract-level characteristics between children assigned to LCT1 and LCT8 are presented in Table 12. Results contain the differential likelihood effect each characteristic has on a child of being assigned to LCT1 over LCT8. Adjusted odds ratios (AOR) in bold italics and table cells shaded highlight statistically significant differences.

TABLE 12. LIKELIHOOD OF ASSIGNMENT IN LATENT CLASS TRAJECTORY 1 OVER 8

Individual Level	Category	Referent	AOR	95% CI	
Gender	Female	Male	***0.92***	***0.86***	***0.98***
Race/Ethnicity	Non-White	White	***1.71***	***1.66***	***1.76***
School Lunch	Free/Reduced	Full Price	***1.17***	***1.09***	***1.26***
Region	Urban	Northwest	1.15	0.99	1.32
	Suburban		***1.36***	***1.19***	***1.55***
	Country		***1.52***	***1.36***	***1.71***
	Mountain		***1.71***	***1.38***	***2.10***
	Delta		***1.28***	***1.10***	***1.49***
Census Tract IQR Level	**Category**	**Referent**	**AOR**	**95% CI**	
Percentage in Poverty	<11.3%	> 23.7%	***1.18***	***1.03***	***1.35***
	11.3 – 23.7 %		1.04	0.94	1.14
Per Capita Income	< $16,318	> $23,220	1.12	0.97	1.31
	$16,318 - $23,220		***1.20***	***1.07***	***1.34***
Percentage with No High School Diploma	< 12.8%	> 24.5%	***0.65***	***0.57***	***0.75***
	12.8 – 24.5 %		***0.82***	***0.75***	***0.90***
Percentage of Population < 18 Years of Age	< 23.1%	> 28.1%	1.09	0.97	1.23
	23.1 – 28.1 %		***1.15***	***1.04***	***1.26***
Population Percent of Minority Race/Ethnicity	< 8.1 %	> 40.1%	***0.81***	***0.69***	***0.94***
	8.1 – 40.1 %		***0.82***	***0.73***	***0.92***
Mobile Home Density	< 2.8%	> 20.6%	0.96	0.86	1.08
	2.8 – 20.6 %		0.97	0.89	1.06
Non-Vehicle Ownership	< 3.2%	> 8.9%	1.11	0.99	1.25
	3.2 – 8.9 %		***1.11***	***1.01***	***1.22***
Non-English Speaking	≤ 2.1%	> 2.1%	***0.89***	***0.81***	***0.97***

Abbreviations: AOR = Adjusted Odds Ratio; CI = Confidence Interval, IQR =Inter-Quartile Range
Notes: Census tract level unemployment, single parent household, crowded households, multi-unit households, and group households were included in the model but not significantly different in any pairwise comparison presented in this study. Results have not been included in the tables.

Based on individual-level characteristics, the following groups had different likelihood of being assigned to LCT1 (high average BMI percentile at Kindergarten) than LCT8 (low average BMI percentile at Kindergarten):

- Female children compared to male children (8% less likely)
- Children of minority race/ethnicity compared to White children (71% more likely)
- Children receiving free or reduced price school lunches compared to those paying full price for lunch (17% more likely)
- Children residing in Suburban, Country, Mountain, and Delta counties compared to children in Northwest counties (36%, 52%, 71%, and 28% more likely, respectively)

Based on the census tract characteristics where a child resides, the following groups were impactful on having different likelihoods of being assigned to LCT1 (high average BMI percentile at Kindergarten) than LCT8 (low average BMI percentile at Kindergarten):

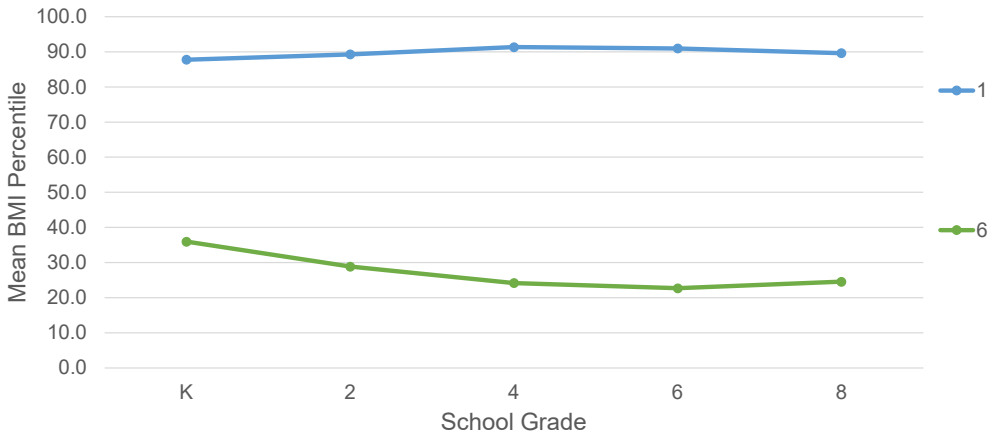
- Children residing in census tracts where the percentage of households living below 100% of the poverty level is less than 11.3% are 18% more likely to be in LCT1 than LCT8, compared to children living in census tracts with more than 23.7% of households living below 100% of the poverty level. This is a counter-intuitive finding and must be taken into consideration jointly with other socio-economic results in the model that are consistent with low socio-economic status associated with highly likelihood of being assigned to LCT1.
- Children residing in census tracts with an average median income between $16,318 and $23,220 are 20% more likely to be in LCT1 than LCT8, compared to children residing in census tracts with an average median income higher than $23,220.
- Children residing in census tracts where the percentage of the adult population 25 years of age or older with no high school diploma is less than 12.5% or between 12.5% and 24.5% were 35% and 18% less likely, respectively, to be assigned to LCT1 over LCT8, compared to children residing in a census tract where the percentage was greater than 24.5%.
- Children residing in census tracts where the percentage of children and adolescents younger than 18 comprise less than 23.1% of the population are 15% more likely to be in LCT1 than LCT8, compared to children residing in census tracts where the percentage of children and adolescents younger than 18 years comprise more than 28.1% of the population.
- Children residing in census tracts where the percentage of the population is comprised of less than 8.1% or between 8.1% and 40.1% of minority race/ethnicity status are 19% and 18% less likely, respectively, to be in LCT1 than LCT8, compared to children residing in census tracts where the percentage of the population is comprised of more than 40.1% of the population that is minority race/ethnicity status.
- Children residing in census tracts where the percentage of households that have no vehicle was less than 3.2% are 11% more likely to be in LCT1 than LCT8, compared to children residing in census tracts where the percentage of households with no vehicle was more than 8.9%.
- Children residing in a census tract where the percentage of the population 5 or older speak English “less than well” was 1.9% or less was 11% less likely to be assigned to LCT5 over

LCT6, compared to children residing in census tracts where the percentage was 1.9% or higher.

COMPARISON OF CHILDREN AND ADOLESCENTS ASSIGNED TO LATENT CLASSES 1 AND 6

In part to serve as a validation test of the characteristic differences found between children assigned to LCT1 and LCT8, this pairwise comparison is between LCT1 and LCT6 (Figure 8).

FIGURE 8. LATENT CLASS GROWTH TRAJECTORIES 1 AND 6 FROM KINDERGARTEN TO GRADE 8



Another reason to use LCT6 as a comparison latent class trajectory for LCT1 is due to the presence of approximately 10% of children in LCT8 who were in the Underweight category at Kindergarten. There may be something systematically different with these children that would confound comparison results. In total, 16,802 children were assigned to LCT1. At Kindergarten, the average BMI percentile for these children was 87.8%, and by Grade 8, these same children maintained a high average BMI percentile of 89.6%. A similar number of children, 17,167, were assigned to LCT6. These children began Kindergarten with an average BMI percentile of 35.9%. The vast majority were of Normal Weight status (96.3%), with 2.3% assessed to be Overweight. By Grade 8, the average BMI percentile of children assigned to LCT6 had declined to 24.5% and nearly all were of Normal Weight status (98.9%).

Table 13 presents the results of a multivariable comparison of children in these latent class trajectories and the differential likelihood effect each characteristic has on a child of being assigned to LCT1 over LCT6. Adjusted odds ratios (AOR) in bold italics and table cells shaded blue highlight statistically significant differences.

TABLE 13. LIKELIHOOD OF ASSIGNMENT IN LATENT CLASS TRAJECTORY 1 OVER 6

Individual Level	Category	Referent	AOR	95% CI	
Gender	Female	Male	***1.10***	***1.03***	***1.16***
Race/Ethnicity	Non-White	White	***1.86***	***1.82***	***1.89***
School Lunch	Free/Reduced	Full Price	***1.15***	***1.08***	***1.22***
Region	Urban	Northwest	***1.14***	***1.02***	***1.27***
	Suburban		***1.46***	***1.32***	***1.62***
	Country		***1.53***	***1.40***	***1.67***
	Mountain		***1.53***	***1.31***	***1.78***
	Delta		***1.31***	***1.16***	***1.48***
Census Tract IQR Level	**Category**	**Referent**	**AOR**	**95% CI**	
Percentage in Poverty	<11.3%	> 23.7%	1.06	0.95	1.18
	11.3 – 23.7 %		1.01	0.93	1.10
Per Capita Income	< $16,318	> $23,220	1.06	0.94	1.20
	$16,318 - $23,220		***1.20***	***1.10***	***1.31***
Percentage with No High School Diploma	< 12.8%	> 24.5%	***0.64***	***0.57***	***0.71***
	12.8 – 24.5 %		***0.80***	***0.74***	***0.86***
Percentage of Population < 18 Years of Age	< 23.1%	> 28.1%	***1.19***	***1.08***	***1.31***
	23.1 – 28.1 %		***1.14***	***1.05***	***1.22***
Population Percent of Minority Race/Ethnicity	< 8.1 %	> 40.1%	0.96	0.84	1.09
	8.1 – 40.1 %		0.94	0.85	1.04
Mobile Home Density	< 2.8%	> 20.6%	***0.92***	***0.84***	***<1.00***
	2.8 – 20.6 %		***0.93***	***0.87***	***<1.00***
Non-Vehicle Ownership	< 3.2%	> 8.9%	1.05	0.96	1.16
	3.2 – 8.9 %		1.06	0.98	1.15
Non-English Speaking	≤ 2.1%	> 2.1%	***0.92***	***0.85***	***0.99***

Abbreviations: AOR = Adjusted Odds Ratio; CI = Confidence Interval, IQR = Inter-Quartile Range
Notes: Census tract level unemployment, single parent household, crowded households, multi-unit households, and group households were included in the model but not significantly different in any pairwise comparison presented in this study. Results have not been included in the tables.

Based on individual-level characteristics, the following groups had different likelihoods of being assigned to LCT1 (high average BMI percentile at Kindergarten) than LCT6 (low average BMI percentile at Kindergarten):

- Female children compared to male children (10% more likely)
- Children of minority race/ethnicity compared to White children (86% more likely)
- Children receiving free or reduced price school lunches compared to those paying full price for lunch (15% more likely)
- Children residing in Urban, Suburban, Country, Mountain, and Delta counties compared to children in Northwest counties (14%, 46%, 53%, 53%, and 31% more likely, respectively).

Based on the census tract characteristics where a child resides, the following groups were impactful on having different likelihoods of being assigned to LCT1 (high average BMI percentile at Kindergarten) than LCT6 (low average BMI percentile at Kindergarten):

- Children residing in census tracts with an average median income between $16,318 and $23,220 are 20% more likely to be in LCT1 than LCT6, compared to children residing in census tracts with an average median income higher than $23,220.
- Children residing in census tracts where the percentage of the adult population 25 or older with no high school diploma is less than 12.5% or between 12.5% and 24.5% were 36% and 20% less likely, respectively, to be assigned to LCT1 over LCT6, compared to children residing in a census tract where the percentage of adults with no high school diploma was greater than 24.5%.
- Children residing in census tracts where the percentage of children and adolescents younger than 18 comprise fewer than 23.1% or between 23.1% and 28.1% of the population were 19% and 14% more likely, respectively, to be in LCT1 than LCT6, compared to children residing in census tracts where the percentage of children and adolescents younger than 18 comprise more than 28.1% of the population.
- Children residing in census tracts where the percentage of households living in mobile homes was less than 2.8% or between 2.8% and 20.6% were 8% and 7% less likely, respectively, less likely to be in LCT1 than LCT6, compared to children living in census tracts where the percentage of households living in mobile homes was more than 20.6%.
- Children residing in a census tract where the percentage of the population age 5 or older speaking English “less than well” was 1.9% or less were 8% less likely to be assigned to LCT1 over LCT6 compared to children residing in census tracts where the percentage was 1.9% or higher.

Discussion

This study has produced interesting and important findings, further highlighting differences among children assigned to latent class trajectory classes (loosely defined as groups), based on patterns of BMI percentile growth between Kindergarten and Grade 8. Compared to last year, this year’s findings are based on cleaner data (observations with egregious longitudinal BMI percentiles over five measurements were deleted), augmented data including Arkansas region of residence at Kindergarten and social determinant of health data, and a more sophisticated statistical model that incorporates individual- and census tract-level variables into the class assignment process, to add more precision into the latent class trajectory assignment of children.

The latent class trajectories derived suggest that there are two types of trajectory slope change, those where children assigned increase or decrease in average BMI percentile from Kindergarten to Grade 8, and those who remain relatively stable over time. Comparison of children assigned to latent class trajectories that increase over time, with those that decrease, especially when they commence Kindergarten with very similar average BMI percentiles, offers an opportunity to guide targeted interventions at the school-level. In the case of the comparison of children assigned to LCT1 and LCT6, where individual- and census-tract level characteristics differ the most, it is imperative to intervene with children assigned to LCT1 in the preschool years.

The next sections present evaluative findings from two interventions targeting the preschool child care environment in Arkansas. The first will assess if there is a short- to medium-term reduced obesity benefit from receiving preschool child care from centers/facilities that are accredited to be able to accept federal vouchers. For those that accept vouchers, we will identify if there is increased positive benefit from receiving preschool child care in centers/facilities that have increasingly higher quality rating scores. Also, we will present a case study on children receiving a preschool intervention called Together We Inspire Smart Eating (WISE) to identify if this program is associated with children starting Kindergarten with lower rates of obesity compared with similar at-risk (e.g., low income) children who did not participate in the intervention.

KINDERGARTEN WEIGHT PROFILE OF CHILD CARE ASSISTANCE VOUCHER PROGRAM

Background

Previous studies by this research team have shown that among students who experienced obesity at the start of Kindergarten in Arkansas, 74% continued to experience obesity in Grade 8 (ACHI, 2019). It also is known that the incidence of overweight and obesity weight status starts prior to entering Kindergarten (Magarey, 2003; Nader, 2006).
The development of childhood obesity is commonly conceptualized within an ecological framework in which family, community and social factors, social policies, and national legislation may impact a child's weight status (Serbune Hawkins, 2006) . Children consume daily meals and engage in physical activities during preschool child care, which creates opportunities to help promote or hinder healthy weight outcomes among young children.

Unlike the public school setting in which children, starting at age 5 or 6, spend full or half days in a structured curriculum, preschool-aged children spend their days in various settings. In 2016, 60% of U.S. preschool-aged children were in some daycare arrangement other than parental care. Among these children, 41% were cared for by a relative at least once per week, 22% were cared for in a private home by someone not related to them at least once per week, and 59% participated in center-based care at least once per week. Some children participated in more than one of these three weekly arrangements (Corcoran, 2019).

Findings from studies on the association of child care arrangement with overweight and obesity weight status in preschool aged children are mixed (Swyden, 2017). Some studies find no association between the type of child care and obesity (Isong, 2016; Kimbro, 2007). Some studies show a positive association between formal child care centers and obesity, while others show a negative association between the two (Allel, 2020; Maher, 2008). There are also studies that show the impact of "high quality" child care centers on reducing obesity (Lumeng, 2015; Reynolds, 2021). In this report, we will provide an Arkansas perspective on the potential association of preschool child care and weight status, overall and by the quality score of the child care centers, among children from low-income households.

The Child Care and Development Fund (CCDF) — administered by the Arkansas Department of Human Services, Division of Child Care and Early Childhood Education (DCCECE) — provides

low-income families subsidies to pay for early childhood care and education (ECCE) arrangements. Child care is essential for single parents and two-parent working households, and the subsidies enable parents to work or attend training and education programs (Mckelvey, 2021). More than 9,000 children in Arkansas are estimated to receive child care subsidies each month (Hardy, 2018). The child care subsidies can be used at licensed child care centers that participate in the CCDF program and the linkage of the CCDF enrollment and the public school BMI assessment datasets holds a promise of identifying factors that impact the weight status of CCDF children at Kindergarten. To our knowledge, this is the first study that looks at the association of a child care subsidies program with the effect on weight status when children start Kindergarten.

The primary goal of this study is to profile the weight status at Kindergarten of CCDF recipients. Furthermore, we contribute to future childhood obesity research by identifying desired variables that are missing from CCDF datasets that, once included, would better enable researchers to rigorously study the impact of early childhood child care. In order to demonstrate research potential using the CCDF dataset, we address the following research questions.

- Among children from low-income households, does the exposure to center-based preschool child care through the Child Care Assistance Program prior to entering Kindergarten impact their weight status compared to similar low-income children who were never enrolled in the program? In addition, does a duration of exposure, characterized as the number of distinct years of program participation, result in differential impact on CCDF enrollees' weight status?
- Is there an association between higher quality certification scores and Head Start accreditation status of the child care centers and lower overweight and obesity rates of Kindergarten children?

Methods

DATA SOURCES

In 2021, ACHI received the CCDF roster dataset from DCCECE. The linkage of Kindergarten school and CCDF roster datasets was performed using Social Security Number by an honest broker at ACHI and the research team received a de-identified dataset with personalized identifying information removed. The CCDF roster dataset contained unique information about

the CCDF recipient's child and family demographics, child care center facility numbers, year of receipt, funding categories that specify the qualification reasons for the subsidies, and for certain qualification categories, income or work training information.

In this initial use of the CCDF roster dataset, inherent limitations were discovered. First, the cumulative length of a child's attendance is not included in the dataset. As a proxy for the length of the time the child received center-based care, we defined the exposure count as the number of discrete ages that appear in the record. Second, the dataset does not document whether the attendance was part-time or full-time.

STUDY POPULATION

Children were selected for participation in this study if they attended an Arkansas public school and had a valid BMI record found for Kindergarten in school year 2018-19 or school year 2019-20. The compiled analytic database contained a cohort of 56,903 children, out of which 3,104 children had received the CCDF subsidy at least once in preschool. Children within this cohort are profiled and summary demographics are presented in Table 14.

METRICS AND DEFINITIONS

Throughout this analysis, we modeled BMI for age and gender percentile using the CDC referent group. This permits us to measure BMI growth across ages and genders using a standardized metric. Children were classified as obese using the 95th percentile BMI cut-point by age and gender, as recommended by the CDC. A weight status classification of Overweight was assigned to those between the 85th and 95th BMI percentiles and a classification of Normal Weight was assigned for those between the 5th and 85th BMI percentiles. Additionally, three sub-classifications of obesity status for children were assigned as proposed by Skinner et al. (Skinner, 2015). Obese Class 1 included children who had a calculated BMI between the 95th percentile and 20% more than the 95th percentile BMI cut-point. Obese Class 2 included children who 45 had a BMI between 20% and 40% more than the 95th percentile. Obese Class 3 included children with a BMI of 40% or more above the 95th percentile cut-point.

Better Beginnings, a program implemented by the Arkansas Department of Human Services, is a system by which licensed child care and early childhood education entities are given quality certification scores. This certification is given to child care centers that consistently provide a care environment above minimum licensing requirements (Arkansas Department of Human Services, 2020). Better Beginnings distinguishes the quality of each Arkansas child care facility by a 1-, 2-, and 3-star rating beyond minimum licensing (0 star). We will test to determine if attending child care facilities with higher ratings is positively correlated with lower rates of children experiencing overweight and obesity status in Kindergarten.

An additional characteristic of facilities that was examined was participation in Early Head Start (EHS)/Head Start (HS) program. EHS programs serve low-income families with infants and toddlers and HS programs serve low-income 3- and 4-year-old children and their families. Attending a Head Start designated preschool has been shown to promote healthier weight by the time of Kindergarten entrance (Lumeng, 2015).

Demographic characteristics are identified or calculated from school roster records at Kindergarten. We report gender, race and ethnicity, rural-urban commuting area code (RUCA) assigned at ZIP-code level, and individual-level school lunch payment category as possible confounding factors affecting Kindergarten obesity status. Children from low-income households receive free or reduced-price lunch while children from higher income households pay full price. Children in households receiving Supplemental Nutrition Assistance Program (SNAP) benefits are directly certified to receive a free lunch (United States Department of Agriculture, 2018).

STATISTICAL ANALYSIS

To address the first research question, we restricted the sample to children from low-income households who qualified for a free or reduced price lunch in Kindergarten. A categorical Pearson chi-square was used to test if there was an association between the weight status of the child and the center-based child care attendance through the CCDF program. Similarly, using a continuous t-test, we compared the CDC BMI percentile of children who attended center-based child care through the CCDF program with those who did not attend. We also fitted a multivariable logistic regression model to account for how gender, race, rurality, and free or reduced lunch status contributed to the probability of experiencing obesity. The analytic process outlined above was applied to investigate the possible association of Kindergarten

weight status and (i) the number of distinct years of participation in the CCDF program, (ii) the Better Beginnings score of the facility that child attended, (iii) and the EHS/HS credential of the facility that child attended.

Results

Table 14 presents a Kindergarten age summary demographic and descriptive profile of CCDF recipients, and non-recipients. Compared to Non-CCDF recipients, children who received CCDF at least once during the preschool period (1-4 years old) had a different race/ethnicity profile, had a slightly different geographic distribution (statistical significance likely driven by high numbers), and were less likely to pay full price for lunch in Kindergarten.

TABLE 14. DESCRIPTIVE PROFILE (n, %) OF CHILDREN WITH AND WITHOUT CHILD CARE AND DEVELOPMENT (CCDF) PRESCHOOL ATTENDANCE

Variable	Category/ Unit	CCDF Recipients N=3,104	Non-CCDF Recipients N=53,799	P-value*
Gender	Male	1,561 (50.3)	25,968 (51.2)	0.312
	Female	1,543 (49.7)	24,727 (48.8)	
Race	White	1,462 (47.1)	30,444 (60.1)	***<0.001***
	Black	1,139 (36.7)	9,144 (18.0)	
	Hispanic	265 (8.5)	6,599 (13.0)	
	Others	238 (7.7)	4,508 (8.9)	
RUCA	Urban	1,986 (66.4)	31,590 (64.3)	***<0.001***
	Large rural	274 (9.2)	3,688 (7.5)	
	Small rural	667 (22.3)	12,288 (25.0)	
	Isolated	62 (2.1)	1,535 (3.1)	
Lunch	Full Price	1,019 (33.6)	25,540 (51.6)	***<0.001***
	Reduced Price	149 (4.9)	2,648 (5.4)	
	Free	940 (31.0)	12,533 (25.3)	
	Direct Certification	923 (30.5)	8,773 (17.7)	

Note: * P-value based on chi-square, comparing those who had at least one count to CCDF subsidy and no subsidy. Demographic data were recorded in School Years 2018-19 and 2019-20.
Among CCDF recipients, 115 and 73 children were missing RUCA and Lunch status, respectively; among non-CCDF recipients, 1,657 and 1,242 children were missing RUCA and Lunch status.
Abbreviations: RUCA=rural-urban commuting area code.

Table 15 presents a Kindergarten age summary descriptive profile categorized by the number of distinct years that children participated at least once in the CCDF program. White children were more likely to participate in only one year of the program. Conversely, Black children were more likely to participate in the program for all four years. Similarly, children residing in urban areas were more likely to participate in the program all four years, while children residing in small rural areas were more likely to participate in only one year of the program.

TABLE 15. DESCRIPTIVE PROFILE (n, %) OF CHILDREN WHO HAD ONE, TWO, THREE, OR FOUR YEARS OF CHILD CARE AND DEVELOPMENT FUND (CCDF) EXPOSURE PRESCHOOL

Variable	Category/ Unit	One N=1,458	Two N=843	Three N=488	Four N=315	P-value*
Gender	Male	738 (50.6)	420 (49.8)	241 (49.4)	162 (51.4)	0.927
	Female	720 (49.4)	423 (50.2)	247 (50.6)	153 (48.6)	
Race/ Ethnicity	White	743 (51.0)	394 (46.7)	212 (43.4)	113 (35.9)	***<0.001***
	Black	465 (31.9)	308 (36.5)	214 (43.9)	152 (48.3)	
	Hispanic	132 (9.1)	78 (9.3)	32 (6.6)	23 (7.3)	
	Others	118 (8.1)	63 (7.5)	30 (6.1)	27 (8.6)	
RUCA	Urban	898 (64.1)	525 (64.4)	337 (71.7)	226 (74.6)	***0.002***
	Large rural	146 (10.4)	75 (9.2)	31 (6.6)	22 (7.3)	
	Small rural	321 (22.9)	203 (24.9)	91 (19.4)	52 (17.2)	
	Isolated	36 (2.6)	12 (1.5)	11 (2.3)	3 (1.0)	
Lunch	Full Price	490 (34.2)	247 (30.4)	164 (34.3)	118 (38.2)	0.209
	Reduced	70 (4.9)	48 (5.9)	16 (3.3)	15 (4.9)	
	Free	448 (31.3)	257 (31.6)	153 (32.0)	82 (26.5)	
	Direct Certification	423 (29.6)	261 (32.1)	145 (30.3)	94 (30.4)	

Note: * P-value based on chi-square for multiple categorical variables, comparing CCDF recipients with one, two, three, and four years of participation. Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=rural-urban commuting area code.

The weight status of CCDF recipients compared to low-income non-CCDF recipients, measured in school years 2018–19 and 2019–20 and restricted to students who attended a public Kindergarten is presented in Table 16. The low-income status was determined based on free and reduced lunch status. In this analysis, which does not take into account the impact of child demographics, we did not observe an association between CCDF attendance and Kindergarten weight status.

TABLE 16. KINDERGARTEN WEIGHT STATUS OF CHILDREN WITH AND WITHOUT CCDF PRESCHOOL ATTENDANCE, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENT

Variable	Category/Unit		At least once N=2,012	CCDF non-Recipients N=23,954	P-value*
BMI CDC percentile mean (SE)	Percentile		67.0 (0.60)	66.0 (0.18)	0.123
Weight Category (n, %)	Underweight		34 (1.7)	613 (2.6)	0.089
	Normal weight		1,310 (65.1)	15,262 (63.7)	
	Overweight		312 (15.5)	3,765 (15.7)	
	Obese	Class 1	250 (12.4)	2,882 (12.0)	
		Classes 2 & 3	106 (5.3)	1,432 (6.0)	

Note: * P-value is based on t-test for continuous variables and chi-square for categorical variables, comparing those who had at least one exposure and no exposure. BMI measurements were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: BMI=Body Mass Index; CAT=Category; SE = Standardized Error; CCDF= Child Care and Development Fund

Table 17 presents the weight status of CCDF recipients further categorized by the number of distinct years of participation in the program. Similar to the previous analysis, we did not observe any association between increased exposure to the CCDF program and obesity status.

TABLE 17. KINDERGARTEN WEIGHT STATUS OF CHILDREN WHO HAD ONE, TWO, THREE, OR FOUR YEARS OF CCDF EXPOSURE, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENT

Variable	Category/Unit		Once N=941	Twice N=566	Three times N=314	Four times N=191	P-value*
BMI CDC percentile mean (SE)	Percentile		66.8 (0.90)	67.8 (1.09)	66.7 (1.54)	66.2 (2.00)	0.877
Weight Category (n, %)	Underweight		17 (1.8)	6 (1.1)	7 (2.2)	4 (2.1)	0.081
	Normal weight		603 (64.1)	380 (67.1)	205 (65.3)	122 (63.9)	
	Overweight		150 (15.9)	86 (15.2)	46 (14.6)	30 (15.7)	
	Obese	Class 1	108 (11.5)	72 (12.7)	44 (14.0)	26 (13.6)	
		Classes 2 & 3	63 (6.7)	22 (3.9)	12 (3.8)	9 (4.7)	

Note: *P-value based on t-test for continuous variables and chi-square for categorical variables, comparing those who had at least one exposure and no exposure. BMI measurements were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: BMI=Body Mass Index; CAT=Category; SE = Standardized Error; CCDF= Child Care and Development Fund

The results of multivariate logistic regression (shown in Table 18) revealed that CCDF participation is not predictive of obesity status (yes/no) when adjusted by lunch status, gender, race and ethnicity, and RUCA. Consistent with our previous years' analysis, Black children were 1.4 times more likely and Hispanic children were 1.9 times more likely to experience obesity in Kindergarten than White children. Children residing in large or small rural areas were 1.2 times as likely to experience obesity in Kindergarten as children residing in urban areas.

TABLE 18. LIKELIHOOD OF BECOMING OBESE BY KINDERGARTEN, RESTRICTED TO FREE OR REDUCED LUNCH RECIPIENTS, BY CCDF STATUS

Effect	Category	Adjusted Odds Ratio Estimate	95% Confidence Interval	
Treatment (ref: no CCDF)	CCDF	1.01	0.89	1.14
Lunch Status (ref: reduced lunch)	Free lunch	1.08	0.97	1.21
	Direct Certification	0.98	0.87	1.09
Gender (ref: Male)	Female	0.96	0.90	1.02
Race/Ethnicity (ref: White)	Black	***1.36***	***1.25***	***1.47***
	Hispanic	***1.86***	***1.70***	***2.03***
	Other	1.11	0.97	1.28
RUCA (ref: Urban)	Isolated	1.16	0.98	1.38
	Large Rural	***1.20***	***1.07***	***1.36***
	Small Rural	***1.26***	***1.17***	***1.36***

Note: Statistically significant results are presented in bold italic and shaded blue. Multivariable logistic regression was fitted to estimate Odds Ratio of belonging to obese category in Kindergarten.
Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=Rural-urban commuting area code; CCDF= Child Care and Development Fund

The results of another multivariate logistic regression model (shown in Table 19) also indicated that the number of distinct years participating in CCDF program at least once does not affect the obesity status (yes/no) when adjusted by lunch status, gender, race and ethnicity, and RUCA. In this restricted analytic sample, the race effect persisted. Black children were 1.4 times more likely and Hispanic children were 1.7 times more likely to experience obesity in Kindergarten than White children. Children residing in large rural areas were 1.5 times as likely to experience obesity in Kindergarten as children residing in urban areas.

TABLE 19. LIKELIHOOD OF BECOMING OBESE BY KINDERGARTEN, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENT AND BY NUMBER OF DISTINCT YEARS PARTICIPATING IN CCDF PROGRAM

Effect	Category	Adjusted Odds Ratio Estimate	95% Confidence Interval	
Number of distinct years participating in CCDF program (ref: 1)	2	0.87	0.66	1.16
	3	0.96	0.68	1.36
	4	1.01	0.67	1.53
Gender (ref: Male)	Female	0.92	0.73	1.16
Lunch Status (ref: Reduced lunch)	Free lunch	1.00	0.64	1.56
	Direct Certification	0.71	0.45	1.12
Race/Ethnicity (ref: White)	Black	***1.40***	***1.06***	***1.83***
	Hispanic	***1.74***	***1.17***	***2.60***
	Other	1.14	0.66	1.97
RUCA (ref: Urban)	Isolated	0.54	0.21	1.38
	Large Rural	***1.53***	***1.03***	***2.27***
	Small Rural	1.01	0.75	1.36

Note: Statistically significant results are presented in bold italic and shaded blue. Multivariable logistic regression was fitted to estimate Odds Ratio of belonging to obese category in Kindergarten.
Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=Rural-urban commuting area code; CCDF= Child Care and Development Fund

Next, we will present the description of CCDF recipients based on the center characteristics. In a case where a child attends more than one center in the observation period, they are assigned to the last center of attendance before commencing Kindergarten. Figure 9 displays the number of unique child care centers that participated in the CCDF program in 2017-2020 within counties and the mean Better Beginnings score per county (note that not all child centers were in operation over the full time period). The Better Beginnings scores were obtained from 2017 and 2020 facilities list obtained from Arkansas Licensed Child Care Providers Database (Arkansas Child Care Information, 2021). When the scores in 2017 and 2020 differ for the same facility, Better Beginnings scores from 2020 were used. As expected, there are geographic concentrations of child care facilities in population dense area; however, no apparent association between the population density and the Better Beginnings scores.

FIGURE 9. NUMBER OF CHILD CARE CENTERS THAT PARTICIPATE IN THE CCDF PROGRAM (LEFT) AND MEAN BETTER BEGINNINGS SCORE BY COUNTY, 2017-2020

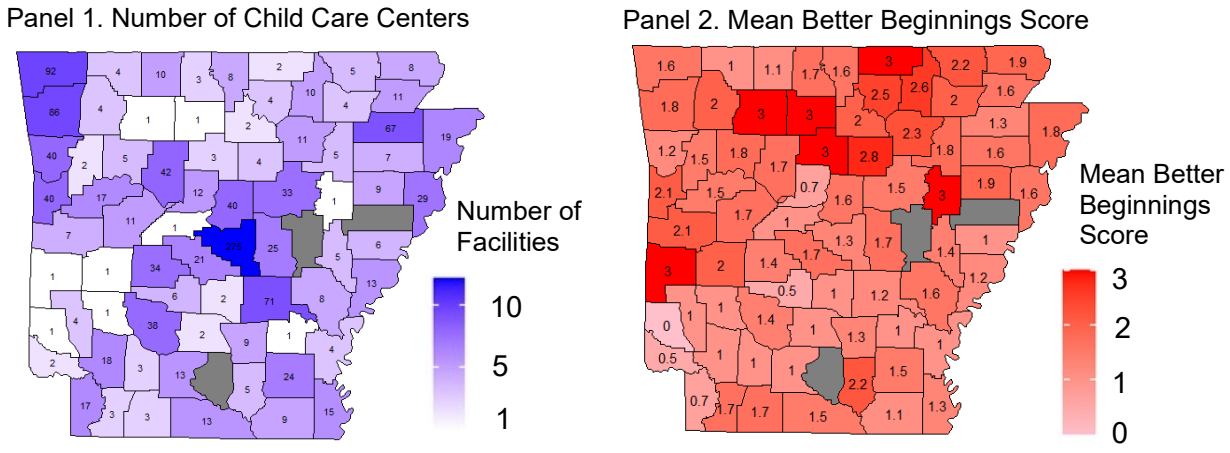


Table 20 depicts and compares CCDF recipients who attended EHS/HS facilities with recipients who attended non-EHS/HS facilities. EHS/HS enrollees were more likely to be White, less likely to live in urban areas, and more likely to pay full price for lunch in Kindergarten, compared to non-EHS/HS facility enrollees.

TABLE 20: DEMOGRAPHIC PROFILE (n, %) OF CHILDREN WHO ATTENDED EHS/HS FACILITY COMPARED TO NON-EHS/HS FACILITY BEFORE ENTRANCE TO KINDERGARTEN

Variable	Category/ Unit	EHS/HS N=178	Non- EHS/HS N=2,926	P-value*
Gender	Male	97 (54.5)	1,464 (50.0)	0.248
	Female	81 (45.5)	1,462 (50.0)	
Race	White	135 (75.8)	1,327 (45.4)	***<0.001***
	Black	12 (6.7)	1,127 (38.5)	
	Hispanic	15 (8.4)	250 (8.5)	
	Others	16 (9.0)	222 (7.6)	
RUCA	Urban	53 (30.6)	1,933 (68.6)	***<0.001***
	Large rural	11 (6.4)	263 (9.3)	
	Small rural	108 (62.4)	559 (19.9)	
	Isolated	1 (0.6)	61 (2.2)	
Lunch	Fully Paid	91 (51.7)	928 (32.5)	***<0.001***
	Reduced	6 (3.4)	143 (5.0)	
	Free	33 (18.8)	907 (31.8)	
	Direct Certification	46 (26.1)	877 (30.7)	

**Note: *** P-value compares the characteristics of Head Start enrollees with non-EHS/HS enrollees using chi-square test. Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=rural-urban commuting area code; EHS=Early Head Start; HS= Head Start

Table 21 categorizes children by the Better Beginnings score (centers meeting minimum licensing criteria are assigned 0; and Better Beginnings facility scores are graded 1, 2, and 3, which is the highest standard) of the facility the child attended last. Due to small numbers, centers with scores of 0 (minimum licensing criteria) or 1 are combined into one category. Children of White race, residents of large or small rural areas, and children who pay full price for lunch are more likely to attend higher tier centers.

TABLE 21: DEMOGRAPHIC PROFILE (n, %) OF CHILDREN WHO ATTENDED A BETTER BEGINNING SCORE 0/1, 2, OR 3 PRE-KINDERGARTEN

Variable	Category/Unit	BB Score 0/1 N=1,436	BB Score 2 N=289	BB Score 3 N=1,215	P-value*
Gender	Male	703 (49.0)	141 (48.8)	640 (51.8)	0.299
	Female	733 (51.0)	148 (51.2)	595 (48.2)	
Race	White	547 (38.1)	126 (43.6)	725 (58.7)	***<0.001***
	Black	701 (48.8)	108 (37.4)	266 (21.5)	
	Hispanic	78 (5.4)	25 (8.7)	156 (12.6)	
	Others	110 (7.7)	30 (10.4)	88 (7.1)	
RUCA	Urban	964 (70.2)	206 (73.6)	741 (61.4)	***<0.001***
	Large rural	111 (8.1)	21 (7.5)	136 (11.3)	
	Small rural	275 (20.0)	50 (17.9)	299 (24.8)	
	Isolated	23 (1.7)	3 (1.1)	30 (2.5)	
Lunch	Fully Paid	436 (31.1)	95 (33.6)	451 (37.4)	***<0.001***
	Reduced	44 (3.1)	13 (4.6)	86 (7.1)	
	Free	434 (31.0)	89 (31.4)	378 (31.3)	
	Direct Certification	488 (34.8)	86 (30.4)	292 (24.2)	

**Note: *** P-value compares the characteristics of CCDF enrollees by the Better Beginnings score of the facility of attendance using chi-square test. Minimum licensed and Better Beginnings score 1 centers are combined into one category. Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=rural-urban commuting area code.

Kindergarten weight status and BMI CDC percentile, categorized by EHS/HS status of the center last attended during preschool, are presented in Table 22 for children who received free or reduced lunch. There was no statistical difference in the weight status of Head Start and non-Head Start enrollees.

TABLE 22: KINDERGARTEN WEIGHT STATUS OF CHILDREN WHO ATTENDED EHS/HS FACILITY COMPARED TO NON-EHS/HS FACILITY BEFORE ENTRANCE TO KINDERGARTEN, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENTS

Variable	Category/Unit	Head Start N=85	Non-Head Start N=1,927	P-value*
BMI CDC percentile mean (SE)	Percentile	66.8 (2.97)	67.0 (0.62)	0.953
Weight Category (n, %)	Underweight	3 (3.5)	31 (1.6)	0.444
	Normal weight	56 (65.9)	1,254 (65.1)	
	Overweight	9 (10.6)	303 (15.7)	
	Obese	17(20.0)	339 (17.6)	

Note: * Continuous variable P value based on t-test for continuous variables and chi-square for categorical variables, comparing those who attended EHS/HS facilities and non-EHS/HS facilities. BMI measurements were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: BMI=Body Mass Index; SE = Standardized Error; EHS=Early Head Start; HS= Head Start

Table 23 compares the Kindergarten weight status and BMI CDC percentile of children by Better Beginnings score. No differences were observed in obesity status of children who attended varying facilities.

TABLE 23: KINDERGARTEN WEIGHT STATUS OF CHILDREN BY BETTER BEGINNINGS (BB) SCORE, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENTS

Variable	Category/Unit		BB Score 0/1 N=579	BB Score 2 N=544	BB Score 3 N=957	P-value*
BMI CDC percentile mean (SE)	Percentile		67.4 (0.86)	65.6 (1.92)	66.9 (1.01)	0.681
Weight Category (n, %)	Underweight		17 (1.8)	--	13 (1.7)	0.394
	Normal weight		626 (64.8)	129 (68.6)	481 (63.6)	
	Overweight		153 (15.8)	31 (16.5)	116 (15.3)	
	Obese	Class 1	115 (11.9)	17 (9.0)	105 (13.9)	
		Classes 2 & 3	55 (5.7)	--	41 (5.4)	

Note: * Continuous variable P value based on one way ANOVA for continuous variables and chi-square for categorical variables. Information in table cells containing fewer than 11 children have been suppressed, denoted by "—". BMI measurements were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: BMI=Body Mass Index; CAT=Category; SE = Standardized Error

The results of multivariable logistic regression (shown in Table 24) showed that the EHS/HS accreditation status of the facility that a child attends does not impact obesity status (yes/no) when adjusted by lunch status, gender, race/ethnicity, and RUCA. Remaining adjusted odds ratios were very similar to those presented in Table 19. Black and Hispanic children were 1.4 times and 1.7 times as likely, respectively, to experience obesity in Kindergarten as White children.

TABLE 24. LIKELIHOOD OF BECOMING OBESE BY KINDERGARTEN, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENT AND BY EHS/HS FACILITY STATUS

Effect	Category	Adjusted Odds Ratio Estimate	95% Confidence Interval	
EHS/HS Status (ref: Non-EHS/HS Start)	EHS/HS	1.38	0.78	2.44
Gender (ref: Male)	Female	0.92	0.73	1.17
Lunch Status (ref: Reduced lunch)	Free lunch	0.97	0.62	1.51
	Direct Certification	0.68	0.43	1.08
Race (ref: White)	Black	***1.38***	***1.05***	***1.83***
	Hispanic	***1.70***	***1.14***	***2.56***
	Other	1.02	0.58	1.81
RUCA (ref: Urban)	Isolated	0.47	0.16	1.34
	Large Rural	***1.51***	***1.01***	***2.25***
	Small Rural	1.01	0.75	1.38

Note: Statistically significant results are presented in bold italic and shaded blue. Multivariable logistic regression was fitted to estimate Odds Ratio of belonging to obese category in Kindergarten.
Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=Rural-urban commuting area code; CCDF= Child Care and Development Fund; EHS=Early Head Start; HS=Head Start

Finally, the results of multivariate logistic regression (shown in Table 25) revealed that the Better Beginnings Scores of the facility that a child attends is not predictive of obesity status (yes/no) when adjusted by lunch status, gender, race, and RUCA. Consistent with our previous years' analysis, Black and Hispanic children were more likely to experience obesity in Kindergarten. In this restricted analytic sample, the effect of race was unchanged from the previous analyses. Black and Hispanic children were 1.4 times more likely and 1.7 times more likely, respectively, to experience obesity in Kindergarten as White children.

TABLE 25. LIKELIHOOD OF BECOMING OBESE BY KINDERGARTEN, RESTRICTED TO FREE/REDUCED LUNCH RECIPIENT AND BY BETTER BEGINNINGS SCORE

Effect	Category	Adjusted Odds Ratio Estimate	95% Confidence Interval	
Better Beginnings Score (ref: 0)	1	1.58	0.74	3.38
	2	1.07	0.45	2.52
	3	1.73	0.80	3.75
Gender (ref: Male)	Female	0.93	0.73	1.19
Lunch Status (ref: Reduced lunch)	Free lunch	1.04	0.66	1.63
	Direct Certification	0.74	0.47	1.18
Race/ethnicity (ref: White)	Black	***1.38***	***1.04***	***1.84***
	Hispanic	***1.65***	***1.10***	***2.48***
	Other	1.06	0.60	1.88
RUCA (ref: Urban)	Isolated	0.45	0.16	1.30
	Large Rural	1.43	0.95	2.14
	Small Rural	1.03	0.76	1.39

Note: Statistically significant results are presented in bold italic and shaded blue. Multivariable logistic regression was fitted to estimate Odds Ratio of belonging to obese category in Kindergarten.
Demographic data were obtained from Kindergarten records in School Year 2018/2019 or 2019/2020.
Abbreviations: RUCA=Rural-urban commuting area code; CCDF= Child Care and Development Fund

Discussion

No differences were observed in the weight status of low-income Kindergarten weight status based on CCDF participation. There were also no gradients, according to preschool child care quality tiers, in a child's likelihood to experience overweight or obesity by Kindergarten. The lack of association in our analyses may be due to missing some key data elements that measure duration and intensity of CCDF program exposure. Adding starting and ending dates as well as part-time/full-time status will add a rigor to the analyses.

Another limitation is a lack of data from external resources that may promote or hinder healthy weight, such as WIC. Adding these variables can separate confounding factors and help shed light on the impact of the CCDF program on early childhood obesity.

The next step for building on this analysis will be to add the missing data elements delineated above and apply more restrictive inclusion criteria to construct a study sample (e.g., include only full-time CCDF recipients who have had at least one year of continuous enrollment).

CASE STUDY: WISE PROGRAM IMPACT ON KINDERGARTEN WEIGHT STATUS

Background

This study examined a direct education intervention, Together We Inspire Smart Eating (WISE), which is a research-based, nutrition promotion curriculum specifically designed for preschool children from families with limited resources. WISE was developed by the UAMS Department of Family and Preventive Medicine and has been tested in over 182 Head Start and preschool sites (430 classrooms), and has expanded to more than 600 classrooms nationwide (Whiteside-Mansell, 2018; L. Whiteside-Mansell, Swindle, T., & Selig, J.P, 2019). WISE has demonstrated effectiveness in improving children's diets in at-risk environments with children in the program consuming more fruits and vegetables while reducing their consumption of sugary snacks or beverages (L. Whiteside-Mansell, and Swindle, T.M, 2019; L. Whiteside-Mansell, Swindle, T., & Davenport, K, 2019). WISE is certified by the USDA Food and Nutrition Service as the evidence-based Supplemental Nutrition Assistance Program Education (SNAP-Ed). In this study, we link Arkansas school BMI data with WISE enrollment data and BMI records from Early Head Start facilities that served as control and treatment groups in White-Mansell's original WISE evaluation (L. Whiteside-Mansell, and Swindle, T.M, 2019) to (1) describe the preschool and Kindergarten weight status of WISE treatment recipients overall and (2) examine the relationships between changes in weight and exposure to the WISE program.

Methods

DATA SOURCES

ACHI received WISE roster and BMI measurement records from the UAMS Department of Family and Preventive Medicine. Both of these datasets were linked with BMI public school records at the individual level using a hash tagged identifier (HASH ID). ACHI utilizes an established methodology to link data sources at the individual level to enable longitudinal analyses of individuals across data sources. The HASH ID is a 44-character anonymous and unique identifier based on last name and date of birth, which, when combined with gender, provides a unique identification for more than 97% of the state population. ACHI has demonstrated the ability to link personally identified data from external sources through the HASH methodology to support policy evaluations and will apply these methods in the generation

of the analytic files required for this study. The UAMS International Review Board (IRB) has reviewed and approved utilizing this linkage strategy.

STUDY POPULATION

During the 2014–15 school year, a non-randomized experiment with standardized pre- and post-test assessments was conducted by the WISE evaluation team to test changes in nutrition knowledge. In six Head Start centers, 268 children received weekly food tasting experiences from educators trained in WISE, while another group of 258 children in nine Head Start centers received weekly food experiences structured at the discretion of the educators untrained in WISE (L. Whiteside-Mansell, Swindle, T., & Davenport, K, 2019). The heights and weights of children in both groups were measured at the beginning of the school year (baseline measurement). Many of the children who did not receive the treatment in the initial control group from school year 2014–15 received a treatment in subsequent years as the WISE program was expanded to the control facilities. These children are assigned to the treatment group in this study. We were unable to specify the reason children did not receive any treatment. The final study population contains children with a successful linkage to public school BMI records and comprises 261 children in the treatment group and 147 children in the comparison group.

METRICS AND DEFINITIONS

The CDC algorithm based on a national referent group population produces the standardized difference (zscore) from the mean of children of a similar age by gender. The dependent variable under study is the CDC-algorithm produced BMI standardized zscore at Kindergarten. Independent variables for statistical models include a binary variable that specifies WISE classroom attendance or not, demographic variables (gender, race/ethnicity), a geographic variable (rural-urban commuting area code, RUCA, assigned to the county of residence at Kindergarten), and a socio-economic proxy (free and reduced, or full-price school lunch status), and age at baseline BMI assessment.

STATISTICAL ANALYSIS

We conducted Analysis of Covariance (ANCOVA) to detect the differences across treatment and comparison groups in the children under study. Difference-in-difference (DID) is another study design commonly used in healthcare policy and other epidemiological research to assess differences pre- and post-intervention based on whether or not children had access to treatment. However, ANCOVA is often preferred in place of DID for its higher statistical power when a lack of power to detect differences across treatment and comparison children may be an issue (McKenzie, 2012; Ozler, 2015). Given the sample size, estimated standard deviation, and correlation matrix, we calculated the power to detect a significant difference at the significance level of α=0.05 using difference-in-difference study design to be not acceptable at 0.267 (Warton, 2018). Thus, we only report the results from ANCOVA analysis.

Results

Children in the treatment group differed from children in the comparison group on some characteristics (Table 26). Children in the treatment group were less likely to be White or Hispanic, and less likely to live in urban area than comparison children.

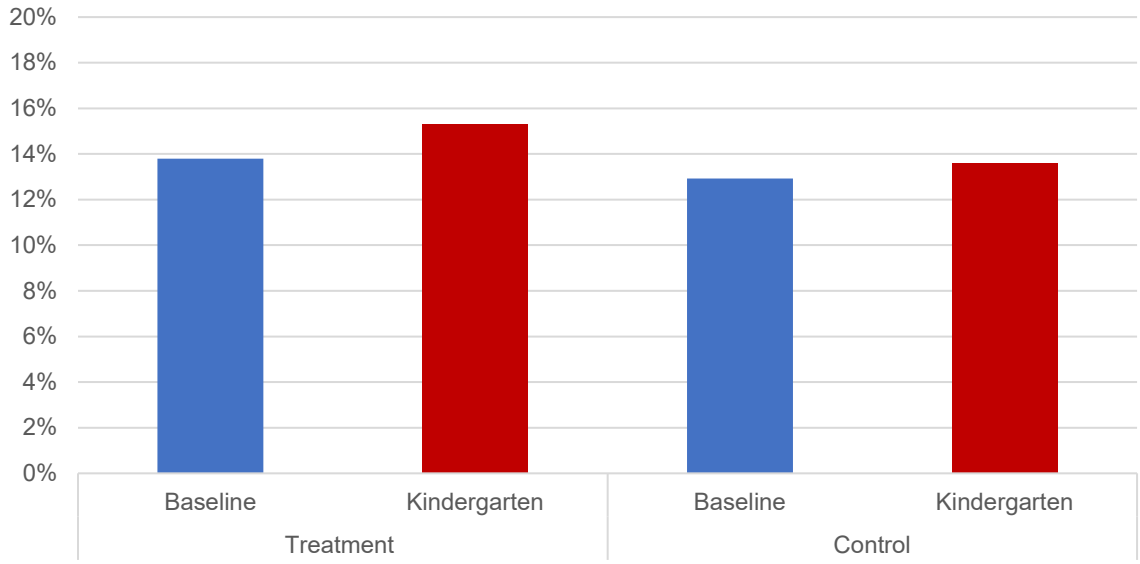
TABLE 26. SUMMARY CHARACTERISTICS OF STUDY POPULATION BY WISE INTERVENTION STATUS

Variable	Category/ Unit	Treatment N=261	Comparison N=147	P-value*
Gender	Male	132 (50.6)	71 (48.3)	0.659
	Female	129 (49.4)	76 (51.7)	
Race	White	7 (2.7)	12 (8.2)	***<0.001***
	Black	65 (24.9)	15 (10.2)	
	Hispanic	14 (5.4)	11 (7.5)	
	Others	175 (67.0)	109 (74.1)	
RUCA	Urban	17 (6.6)	21 (14.5)	***0.035***
	Large rural	74 (28.7)	30 (20.7)	
	Small rural	166 (64.3)	93 (64.1)	
	Isolated	*	*	
Lunch	Full Price	73 (28.6)	32 (22.9)	0.132
	Reduced	28 (11.0)	*	
	Free	25 (9.8)	17 (12.1)	
	Direct Certification	129 (50.6)	83 (59.3)	
Mean age at baseline (SE)	Month	41.2 (0.61)	41.9 (0.87)	0.51

Note: * Chi-square tests for categorical variables compare WISE enrollees and non-enrollees. Among WISE enrollees, 3 and 6 children were missing RUCA and Lunch status, respectively; among non-WISE enrollees, 2 and 6 children were missing RUCA and Lunch status.
Abbreviations: RUCA=rural-urban commuting area code. SE= Standardized Error

Figure 10 presents a graphical comparison of the proportion of children experiencing obesity at baseline and Kindergarten by WISE intervention status. At baseline, 36 out of 261 children (13.8%) in WISE experienced obesity and 19 out of 147 children (12.9%) in the comparison group experienced obesity. In Kindergarten, both groups saw a slight increase in the number of children experiencing obesity, with 40 children (15.3%) in WISE and 20 children in the comparison group (13.6%).

FIGURE 10: PROPORTION OF STUDENTS WHO ARE OBESE AT BASELINE AND KINDERGARTEN BY INTERVENTION STATUS



Detailed categorization of weight status at baseline and Kindergarten by intervention status is shown in Table 27.

TABLE 27. COMPARISON OF BASELINE AND KINDERGARTEN PROPORTION OF STUDENTS WHO ARE OBESE BY INTERVENTION STATUS

Variable	Category/Unit	Treatment		Control	
		Baseline	Kindergarten	Baseline	Kindergarten
BMI CDC percentile mean(SE)	Percentile	61.6 (1.47)	59.0 (2.54)	65.6 (1.35)	63.4 (2.37)
Weight Category (n, %)	Underweight	--	--	--	--
	Normal weight	170 (65.1)	176 (67.4)	105 (71.4)	102 (69.4)
	Overweight	47 (18.0)	42 (16.1)	18 (12.2)	22 (15.0)
	Obese	36 (13.8)	40 (15.3)	19 (12.9)	20 (13.6)

Note: Severity of obese (Category I, II, III) is not reported due to small numbers. – Cells with number less than 10 are not shown.
Abbreviations: BMI =Body Mass Index; SE = Standardized Error

Results from ANCOVA, adjusted by baseline measurement age, gender, race/ethnicity, and school lunch payment status show that the effect of WISE enrollment on the change in BMI zscore was not significantly different between the treatment and comparison groups (p=0.285).

Discussion

The association between WISE participation and the Kindergarten weight status among low-income children was not observed. The existing literature on WISE supports the program's impact on children's food preference. There are a few reasons that the association of WISE participation with healthy food preferences did not translate to a lower obesity rate in Kindergarten in our study. By the nature of the longitudinal study, the treatment group in our study contains children who received the intervention after the original investigation led by Whiteside-Mansell. The fidelity of the program implementation may be questionable once the program expanded to some classrooms that were originally in comparison group. Given this limitation, we applied an intent-to-treat research design as well, which also showed no difference in the change of zscores between children who were initially assigned to treatment and control groups during school year 2014–15. Another limitation includes a small sample size — we were not able to retain the size of the original investigation due to lack of data elements needed for the linkage. We also considered the duration of WISE exposure. The differential effects of the number of years of WISE exposure were examined and resulted in similar findings — with the number of years in WISE program not making a difference in weight status.

This case study is the first analysis in which we longitudinally linked a promising preschool intervention program and investigated the impact of the program on Kindergarten weight status. Our findings underscore the unyielding nature of childhood obesity trajectory — even enrollment in a preschool nutrition intervention program with demonstrated effectiveness in improving children's food preference may not be able to prevent and reduce the risk of early childhood obesity alone.

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