PREVALENCE AND TRENDS OF SEVERE OBESITY AMONG MISSISSIPPI PUBLIC SCHOOL STUDENTS, 2005-2013

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Abstract—This study estimated the prevalence of class 2 and 3 obesity and severe obesity (combination of class 2 and 3 obesity) in Mississippi public school students in grades K-12 and assessed changes in prevalence between 2005 and 2013. During the study period, the average prevalence of class 2 and 3 obesity was 6.2% and 3.5%, respectively. A significant linear trend was observed for class 3 obesity, decreased from 4.6% in 2005 to 3.3% in 2013. In addition, a significant linear decrease was observed for severe obesity among males, whites, and elementary school students. These findings are compared to the national, other state studies, and the previous studies using the same surveys. It is also discussed in light of policy initiatives and on health disparity.

Keywords—Childhood, Severe obesity, Trends.

INTRODUCTION

High prevalence rates of childhood obesity have been on the forefront of the minds of researchers and public health officials alike for the past several years. The Centers for Disease Control and Prevention (CDC) has traditionally defined obesity as "having a BMI greater or equal to the 95th percentile for age and sex". Recently, there has been a movement in the public health field to differentiate between severity levels of obesity as research increasingly suggests that true differences exist in the impact of obesity based upon severity. The American Heart Association recommends defining class 2 obesity as a BMI greater than 120% of the 95th percentile for age and sex. Class 3 obesity has been defined by as a BMI greater than 140% of the 95th percentile for age and sex.[1] These two classes constitute "severe obesity". Further stratifying obesity based upon these classes serves to more accurately indicate the severity of obesity prevalence present within a population as well as track changes in weight distribution over the long term.

Severe obesity is exceptionally detrimental, both to individuals and society as a whole. Children who meet criteria experience increased physical health risks compared to both normal-weight children and their less obese counterparts. Such risks include increased cardiovascular risk due to high blood pressure and elevated inflammation of the heart and blood vessels, metabolic risks including insulin resistance and prediabetes, obstructive sleep apnea syndrome, nonalcoholic fatty liver disease, and serious musculoskeletal problems including knee pain, higher rates of fractures, and higher rates of lower-extremity malalignment. Health risks related to childhood and adolescent severe obesity are likely to continue into adulthood, particularly increased risk of cardiovascular disease, lower extremity venous edema, walking limitations, kidney dysfunction, diabetes, hypertension, respiratory problems, and polycystic ovary syndrome.[2-3]

Serious psychosocial problems are associated with severe obesity as well including deficits in emotional, social, and school functioning, increased risk of being the victim of cyber-bullying, self-reported low quality of life, and increased rates of depression and social anxiety.[2,4-5] Though severely obese adolescents engage in risk-taking behaviors at roughly the same rate as their normal-weight peers, they are more likely to do so in increasingly risky ways. For example, severely obese girls were found to be more likely to use alcohol/drugs before their most recent sexual encounter while severely obese boys were more likely to begin smoking before age 13. Rates of adolescent tobacco use are also higher among the severely obese.[6]

The societal economic impact of severe obesity is similarly notable. The multiplier effect of direct medical expenses of the severely obese ranges between 1.5 to 3.9 as compared to the expenses of a normal weight person. Lost productivity costs of the severely obese are even more extreme with a multiplier effect ranging from 1.7 to 8.0.[7] Recent projections estimate that an 130% increase in severe obesity will be observed in the United States by 2030 due to an increasingly skewed trend towards severe obesity among adults. This projected increase has already been identified as an impediment to health care cost containment measures.[8] As debate rages over the ever-increasing cost of health care in the United States, these figures are particularly significant. The prognosis for severe childhood obesity is poor with many of this

group continuing to suffer obesity-related health problems in adulthood.

Since 2005, the Child and Adolescent Prevalence of Obesity Survey (CAYPOS) has been conducted every two years in Mississippi.[9-14] The 2013 iteration of this survey suggested that overall overweight and obesity prevalence continues to remain stable in Mississippi while racial disparities continue to be apparent. Specifically, declines in overweight and obesity have been observed among white students while the prevalence rate among black students holds steady. Disparities by educational level were also observed with elementary school students experiencing significantly lower rates of obesity than had been observed in the past. Both the disparities by race and educational level were also gender-specific in that they were more pronounced among females.[14]

Though these biannual surveys have illustrated the landscape of childhood overweight and obesity prevalence across the state via a weighted and representative sample, they have not differentiated between classes of obesity in the past. Analysis of national data suggest that severe obesity prevalence rates among children aged 2-19 have been increasing overall since 1999, with 5.9% of children currently meeting criteria for class 2 obesity and 2.1% of children currently meeting criteria for class 3 obesity. Furthermore, racial disparities, similar to those seen in CAYPOS obesity data, where blacks demonstrate a significantly higher prevalence of severe obesity compared to whites, are indicated on the national level. These differences in prevalence by race are apparent in subjects as early as three years of age. As most obesity prevention initiatives take place on the state level, researchers have called for inquiry into state-specific severe obesity prevalence rates;[1] investigation of such rates in Mississippi is both timely and warranted. The present study seeks to evaluate prevalence of class 2 and class 3 obesity among Mississippi public schoolchildren as a whole and by specific demographic subgroups as well as examine trends in this weight distribution from 2005-2013.

METHODS

The sampling frame for this study consisted of students in Mississippi public schools offering kindergarten or any combination of grades K through 12 in Mississippi who participated in the CAYPOS between 2005 and 2013. In order to examine trends in severe obesity, it was necessary to pool data collected through the 2005, 2007, 2009, 2011 and 2013 CAYPOS.

Each CAYPOS employed a two-stage stratified probability design.[9-14] The first stage included the random selection of approximately 10% of all public schools. A systematic sample of schools was drawn with probability proportional to the enrollment in grades K-12 of each school. In the second stage of sampling, classes were randomly selected within the sampled schools. Classes were selected using equal probability systematic sampling. All eligible students in the selected classes were asked to participate in the survey. The sample was designed to yield a self-weighting sample so that every eligible student had an equal chance of selection, thereby, improving the precision of the estimates.

The weighting process was intended to develop sample weights so that the weighted sample estimates accurately represented the entire K-12 public school students in Mississippi. Every eligible student was assigned a base weight, which was equal to the inverse of the probability

of selection for the student. Adjustments were made to the initial weights to remove bias from the estimates and reduce the variability of the estimates.

Each of the CAYPOS received Institutional Review Board approval through the Human Subjects Committee at The University of Southern Mississippi.[9-14] With each CAYPOS, once selected schools agreed to participate and classes were chosen, a written protocol, measuring equipment (i.e., digital scales and stadiometers) and passive consent forms were delivered to the schools. Each school designated a school nurse who was responsible for collecting data and had been trained on the use of equipment. Two or three days before data collection began, students in the selected classes were read a prepared paragraph containing information about the study. Each student was then given a passive parental consent form to take home to parents or guardians. If a parent did not want his or her child to participate in the study, the parent was instructed to indicate such on the form, sign it, and have the child return it to the teacher. Prior to the collection of height and weight, the nurse would check with the teacher to determine if any students returned a signed form. Students who returned a signed form did not participate in the study. There were neither consequences for nonparticipation nor rewards for participation.

With each CAYPOS, the protocol for making measurements required that the weight scale be placed on a hard, smooth surface; carpeted areas were not to be used. The scale was calibrated to zero before use and recalibrated after every 10^{th} student. All students were weighed and measured in a location where the information gathered would be confidential. Other students were not able to read the scale or height measurement or hear a weight or height given. Nurses reported the height and weight, rounded to the nearest whole inch or quarter pound, respectively, along with age, gender, date of birth, racial or ethnic background, and the school code number. No allowance was made for weight of clothing; however, students were asked to remove belts, heavy jewelry, jackets, and shoes. No student names were written on the data collection forms.

Nurses returned the completed data forms to The University of Southern Mississippi by fax or mail. This data was then entered into Excel by a Research Assistant. The completed database was submitted for statistical analysis to identify prevalence rates and trends of the whole and various subgroups. All completed data forms were destroyed once data had been entered and analyzed.

DATA ANALYSIS

In each CAYPOS, BMI was computed for each responding student based on height (in meters) and weight (in kilograms). The height in feet and inches was first converted to meters. The weight in pounds was then converted to kilograms. BMI was calculated using the SAS program, gc-calculate-BIV.sas as follows: BMI = Weight (in kg)/[Height (in m)]^2. BMI values were checked to ensure that the results were biologically plausible, using the limits developed by the CDC. BMI percentiles were computed using the SAS program, gc-calculate-BIV.sas. Children and adolescents were classified into four categories: (1) underweight (BMI is less than the 5^{th} percentile); (2) normal weight (BMI is equal to or greater than the 5^{th} but less than the 85^{th} percentile); (3) overweight (BMI is equal to or greater than the 85^{th} but less than the 95^{th} percentile); and (4) obese (BMI is greater than or equal to the 95^{th} percentile).[15] For the obese category, we used the American Heart Association

recommendations to define class 2 obesity as a BMI greater than 120% of the 95th percentile for age and sex, and class 3 obesity as a BMI greater than 140% of the 95th percentile for age and sex. Severe obesity included both class 2 and class 3 obesity. For the purpose of this study, included were only those students whose BMI was 120% or 140% or higher of the 95th percentile for age and sex.

SUDAAN 11.01[16] was used to calculate weighted estimates and standard errors for each survey year. Due to the relative small number of severe obese students, to increase the precision, the 2005-2013 combined dataset were used to compare the average prevalence of severely obese children among different subgroups, such as gender, race, and grade level, and considered statistically significant if the p-values from the Chi-square tests were less than 0.05. The estimate and its 95% CI were marked as unreliable if the sample size was less than 50. In addition, SUDAAN logistic regression procedure was used to investigate linearity of the longitudinal trends for class 2 and class 3 obesity. Class 2 and class 3 obesity were also combined to create the category of severe obesity in order to increase the sample size and allow the trend analysis by gender, race, and educational level. Since elapsed time was the same between successive CAYPOS surveys, the logistic regression used orthogonal variables to model longitudinal trends while controlling for students' gender, race, and grade level. The linear coefficient (-2, -1, 0, 1, 2) and quadratic coefficients (2, -1, -2, -1, 2) were assigned over the years 2005, 2007, 2009, 2011, and 2013, respectively.

RESULTS

Characteristics and Trends of Class 2 and Class 3 Obesity

During 2005-2013, 6.2% of the Mississippi public school students (K-12) were class 2 obese (Table 1). Of these, 6.6% were male and 5.8% were female, 4.7% were white and 7.7% were black, and 6.0% were elementary, 7.1% were middle, and 5.9% were high school students. In addition, 3.5% of the Mississippi public school students (K-12) were class 3 obese. Of these, 3.4% were male and 3.6% were female, 2.3% were white and 4.6% were black, and 3.1% were elementary, 3.9% were middle, and 3.8% were high school students.

Table 1. Severe Obesity Prevalence by Gender, Race, and Grade Level, CAYPOS, Mississippi, 2005-2013

	Class 2 Obesity			Class 3 Obesity		
Characteristics	Prevalence (%)	95% CI	P-value	Prevalence (%)	95% CI	P-value
Gender			0.012			0.693
Male	6.6	(6.1-7.2)		3.4	(3.1-3.8)	
Female	5.8	(5.4-6.2)		3.6	(3.0-4.1)	
Race			<.001			<0.001
White	4.7	(4.2-5.3)		2.3	(2.0-2.6)	
Black	7.7	(7.1-8.3)		4.6	(4.1-5.2)	
Other*	4.3	(3.1-5.8)		2.3	(1.4-3.6)	

Educational Level			0.009			0.113
Elementary (K-5)	6.0	(5.5-6.5)		3.1	(2.6-3.7)	
Middle school (6-8)	7.1	(6.4-7.9)		3.9	(3.3-4.7)	
High school (9-12)	5.9	(5.4-6.5)		3.8	(3.2-4.5)	
Total	6.2	(5.9-6.6)		3.5	(3.2-3.8)	

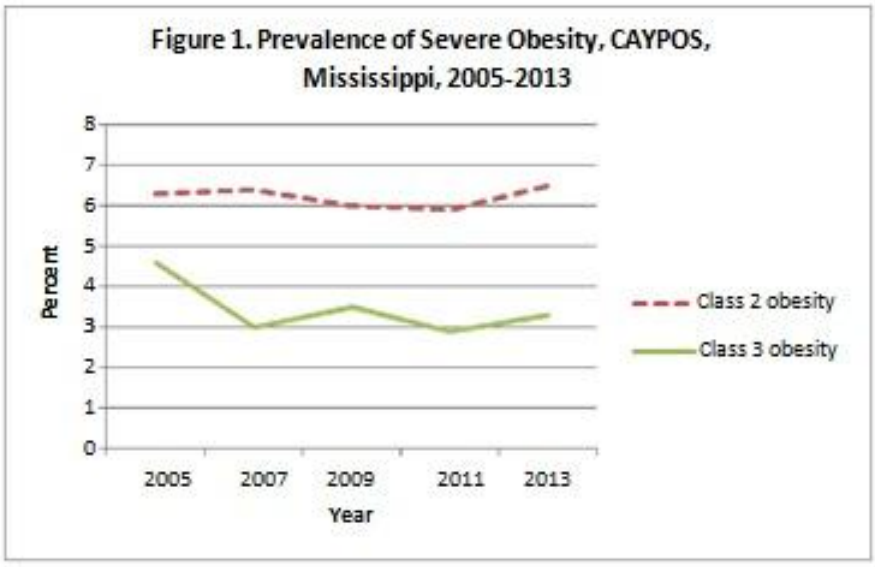
* Sample size was less than 50, so the results may not be reliable.

For class 2 obesity, the prevalence differed by gender (p = 0.012), race (p<0.001), and educational level (p = 0.009) (Table 1). Male, black, and middle school students had the highest prevalence of class 2 obesity than their count parts. For class 3 obesity, the prevalence did not differ by gender and educational level (Table 1). However, black students had a significant higher prevalence of class 3 obesity than students with other races (p < 0.001).

When examined over time, there was no significant linear trend observed for percent of class 2 obese students during 2005-2013 (p = 0.8705), nor a significant quadratic trend (p = 0.3961). However, for class 3 obesity, there was a significant linear decrease (p = 0.0183). It also showed a borderline significant quadratic changes (p = 0.0483), indicating the class 3 obesity prevalence has been fluctuate during the study period (Table 2 and Figure 1).

Table 2. Severe Obesity Prevalence and Trends, CAYPOS, Mississippi, 2005-2013

Category	% (95% CI)	P-value for Linear Trend	P-value for Quadratic Trend
Class 2 obesity			
2005	6.3 (5.5-7.2)		
2007	6.4 (5.6-7.2)		
2009	6.0 (5.1-7.1)	0.8705	0.3961
2011	5.9 (5.1-6.7)		
2013	6.5 (5.8-7.3)		
Class 3 obesity			
2005	4.6 (3.7-5.8)		
2007	3.0 (2.3-4.0)		
2009	3.5 (3.0-4.2)	0.0183	0.0483
2011	2.9 (2.3-3.7)		
2013	3.3 (2.6-4.2)		



Characteristics and Trends of Severe Obesity

Prevalence of severe obesity, class 2, and class 3 obesity by gender, race, and educational level were presented in Table 3. When examined over time, there was no significant linear trend observed for percent of severe obese students during 2005-2013 ($p = 0.1048$), nor a significant quadratic trend ($p = 0.0852$) (Table 4). However, when the trends were furthered assessed by subgroup, we found there was a significant linear decline among males ($p = 0.0397$), white students ($p = 0.0030$), and elementary school students ($p= 0.0175$). No significant quadratic trends were observed among the subgroups.

Table 3. Prevalence of Severe Obesity, Class 2 and 3 Obesity by Gender, Race, and Grade Level, CAYPOS, Mississippi , 2005, 2007, 2009, 2011, and 2013

	Severe obesity[a] (%, 95% CI[d])	Class 2 obesity[b] (%, 95% CI)	Class 3 obesity[c] (%, 95% CI)
Total			
2005	10.9 (9.4-12.8)	6.3 (5.5-7.2)	4.6 (3.7-5.8)
2007	9.4 (8.3-10.7)	6.4 (5.6-7.2)	3.0 (2.3-4.0)
2009	9.6 (8.3-11.0)	6.0 (5.1-7.1)	3.5 (3.0-4.2)
2011	8.8 (7.6-10.0)	5.9 (5.1-6.7)	2.9 (2.3-3.7)
2013	9.8 (8.7-11.1)	6.5 (5.8-7.3)	3.3 (2.6-4.2)
Male			
2005	11.4 (9.6-13.4)	7.1 (5.9-8.5)	4.3 (3.4-5.5)
2007	10.2 (8.7-11.8)	6.8 (5.8-8.0)	3.3 (2.5-4.5)
2009	10.0 (8.5-11.8)	6.5 (5.3-7.9)	3.6 (2.8-4.5)
2011	9.4 (7.9-11.3)	6.2 (5.1-7.4)	3.3 (2.4-4.4)
2013	9.3 (8.2-10.6)	6.6 (5.7-7.6)	2.8 (2.1-3.7)
Female			
2005	10.5 (8.4-13.1)	5.6 (4.4-7.1)	4.9 (3.7-6.6)
2007	8.7 (7.2-10.5)	5.9 (4.8-7.2)	2.8 (1.8-4.2)*
2009	9.1 (7.6-11.0)	5.6 (4.3-7.2)	3.5 (2.7-4.6)
2011	8.0 (6.8-9.4)	5.5 (4.7-6.5)	2.5 (1.8-3.5)
2013	10.4 (8.8-12.2)	6.4 (5.4-7.6)	3.9 (3.0-5.2)
White			
2005	8.4 (7.1-9.9)	5.2 (4.1-6.5)	3.2 (2.4-4.4)*
2007	7.1 (5.7-8.9)	4.5 (3.7-5.4)	2.6 (1.8-3.9)*
2009	7.0 (5.4-9.0)	4.2 (3.0-5.7)	2.8 (2.1-3.8)*
2011	5.8 (4.7-7.2)	4.4 (3.5-5.5)	1.5 (1.1-2.0)*
2013	6.7 (5.4-8.1)	5.3 (4.2-6.6)	1.4 (1.0-2.0)*
Black			
2005	13.3 (10.8-16.2)	7.3 (6.1-8.7)	6.0 (4.5-8.0)
2007	11.5 (9.6-13.7)	8.0 (6.6-9.7)	3.5 (2.5-4.9)
2009	12.1 (10.4-14.0)	7.8 (6.5-9.3)	4.3 (3.6-5.3)
2011	11.9 (10.1-14.0)	7.6 (6.4-9.0)	4.3 (3.3-5.7)
2013	12.6 (10.7-14.8)	7.7 (6.6-9.0)	5.0 (3.8-6.5)
Elementary school			
2005	10.5 (8.3-13.3)	6.0 (5.0-7.4)	4.5 (3.2-6.4)
2007	9.8 (8.1-11.9)	7.0 (5.8-8.3)	2.9 (1.9-4.2)
2009	10.0 (8.2-12.0)	6.4 (5.2-7.8)	3.6 (2.8-4.7)
2011	7.0 (5.6-8.7)	5.1 (4.1-6.3)	1.9 (1.3-2.8)*
2013	8.4 (6.6-10.6)	5.6 (4.6-6.7)	2.9 (1.9-4.4)

Middle school			
2005	12.5 (10.2-15.2)	7.6 (6.1-9.5)	4.9 (3.7-6.5)*
2007	9.4 (7.2-12.3)	5.9 (4.2-8.2)	3.6 (2.1-6.1)*
2009	10.0 (7.1-13.9)	6.3 (4.4-9.1)	3.7 (2.5-5.3)*
2011	12.4 (9.5-15.9)	7.7 (6.3-9.4)	4.7 (3.0-7.2)*
2013	11.1 (8.9-13.7)	8.2 (6.4-10.5)	2.9 (2.0-4.1)*
High school			
2005	10.5 (8.5-12.9)	5.8 (4.8-7.0)	4.7 (3.4-6.5)*
2007	8.7 (7.2-10.4)	5.7 (4.8-6.7)	3.0 (1.8-4.8)*
2009	8.7 (6.7-11.2)	5.3 (3.7-7.5)	3.4 (2.5-4.4)*
2011	9.2 (7.8-10.8)	5.8 (4.6-7.3)	3.4 (2.3-5.0)*
2013	11.2 (9.3-13.4)	6.9 (5.8-8.2)	4.4 (2.9-6.6)

[a] A BMI is at or greater than 120% of the 95th percentile for age and sex.

[b] A BMI is at or greater than 120% but less than 140% of the 95th percentile for age and sex.

[c] A BMI is at or greater than 140% of the 95th percentile for age and sex.

[d] 95% confidence interval.

* Sample size was less than 50, so the results may not be reliable.

Table 4. Prevalence and Trends of Severe Obesity, by Gender, Race, and Grade Level, CAYPOS, Mississippi , 2005, 2007, 2009, 2011, and 2013

	Severe obesity[a] (%, 95% CI[b])	P-value for linear trend	P-value for quardratic trend
Total			
2005	10.9 (9.4-12.8)		
2007	9.4 (8.3-10.7)		
2009	9.6 (8.3-11.0)	0.1048	0.0852
2011	8.8 (7.6-10.0)		
2013	9.8 (8.7-11.1)		
Male			
2005	11.4 (9.6-13.4)		
2007	10.2 (8.7-11.8)		
2009	10.0 (8.5-11.8)	0.0397	0.5028
2011	9.4 (7.9-11.3)		
2013	9.3 (8.2-10.6)		

Female			
2005	10.5 (8.4-13.1)		
2007	8.7 (7.2-10.5)		
2009	9.1 (7.6-11.0)	0.6334	0.0610
2011	8.0 (6.8-9.4)		
2013	10.4 (8.8-12.2)		
White			
2005	8.4 (7.1-9.9)		
2007	7.1 (5.7-8.9)		
2009	7.0 (5.4-9.0)	0.0030	0.1921
2011	5.8 (4.7-7.2)		
2013	6.7 (5.4-8.1)		
Black			
2005	13.3 (10.8-16.2)		
2007	11.5 (9.6-13.7)		
2009	12.1 (10.4-14.0)	0.6986	0.2845
2011	11.9 (10.1-14.0)		
2013	12.6 (10.7-14.8)		
Elementary school			
2005	10.5 (8.3-13.3)		
2007	9.8 (8.1-11.9)		
2009	10.0 (8.2-12.0)	0.0175	0.5926
2011	7.0 (5.6-8.7)		
2013	8.4 (6.6-10.6)		
Middle school			
2005	12.5 (10.2-15.2)		
2007	9.4 (7.2-12.3)		
2009	10.0 (7.1-13.9)	0.8493	0.3768
2011	12.4 (9.5-15.9)		
2013	11.1 (8.9-13.7)		
High school			
2005	10.5 (8.5-12.9)		
2007	8.7 (7.2-10.4)		
2009	8.7 (6.7-11.2)	0.7142	0.0807
2011	9.2 (7.8-10.8)		
2013	11.2 (9.3-13.4)		

[a] A BMI is at or greater than 120% of the 95th percentile for age and sex. [b] 95% confidence interval.

DISCUSSION

Prevalence rates of severe obesity among Mississippi students during 2005-2013 align closely with national rates reported during 2011-2012.[1] 6.2% of Mississippi students meet criteria for class 2 obesity compared to 5.9% of children across the nation. Similarly, 3.5% of Mississippi students meet criteria for class 3 obesity as compared to 2.1% nationally. Educational level and racial disparities seen among those meeting criteria for class 2 obesity in Mississippi also track closely to national trends with adolescents and blacks having the highest prevalence rates. A gender disparity of higher class 2 obesity prevalence rates among males was also noted within Mississippi, though this was not observed on the national level. While racial disparities were also apparent for class 3 obesity across Mississippi and national data, the class 3 obesity age disparity found in national data was not observed among Mississippi students.

Perhaps the biggest discrepancies between Mississippi and national data can be observed when considering trends in prevalence rates over time. Nationally, a downward linear trend was observed for obesity, class 2 obesity, and class 3 obesity during 2009-2012.[1] In contrast, Mississippi obesity (data not shown) and class 2 obesity rates held steady, and only class 3 obesity rates declined . Though overall obesity rates for the state of Mississippi have hovered between one-fifth and one-quarter of students during 2005-2013[9-14], the decline observed in class 3 obesity indicates an encouraging trend towards less severe categories of obesity. When both class 2 and class 3 obesity in Mississippi were evaluated together as one category of "severe obesity", significant linear declines were observed among males, whites, and elementary school students. While overall prevalence of obesity among males has remained roughly the same during 2005-2013,[9-14] it appears that they are shifting out of the most severe categories of obesity. Declines were also observed among whites and elementary students within the "severe obesity" category. These declines follow overall downward trends of obesity observed among these groups in earlier CAYPOS studies.[9-14] These findings run contrary to national data indicating that white females and black adolescent males are most prominently influencing the linear increase in class 3 obesity.[1] This divergence from national severe obesity trends is particularly striking as Mississippi continues to rank highly in terms of childhood obesity prevalence rates when compared to other states.[17]

State-specific analysis of severe obesity prevalence and trends is limited, but it is possible to draw comparisons between Mississippi and New York, a northern state that differs from Mississippi in multiple ways.[18] The prevalence of severe obesity (class 2 obesity and class 3 obesity combined) significantly declined among New York children during 2006-2011. Gender, age, and, racial disparities similar to those in Mississippi (class 2 obesity) were also observed in New York, with the highest prevalence rates of severe obesity occurring among males, blacks, and adolescents aged 11-14. While severe obesity decreased among every subgroup of New York students, the most significant linear decreases were observed among whites and elementary school students. This corresponds with Mississippi trends although no gender disparity in the downward trend was noted in New York. Though the overall severe obesity prevalence rate is lower in New York than in Mississippi (5.7% vs. 9.7%), the similarities between trends and subgroup prevalence of severe obesity between the

two states is noteworthy considering their vastly different median incomes, childhood poverty rates, adult obesity rates, and levels of educational attainment.[19-22]

The findings of this study can also be compared to existing Mississippi data on childhood obesity. The 2005-2013 CAYPOS revealed that obesity prevalence rates have largely held steady though disparities among different subgroups are apparent.[14] Higher prevalence rates observed among black students persisted for both class 2 and class 3 obesity while higher prevalence among middle school students persisted for class 2 obesity. The most evident difference between the 2005-2013 CAYPOS obesity data as a whole and data separated into severe obesity classes is that of gender prevalence rates. Class 2 obesity prevalence was significantly higher for males than females; no such gender disparity was noted for the obesity category as a whole in 2013. This finding indicates that obese males are more likely to fall into the category of severe obesity, specifically class 2, while obese females are more evenly distributed within obesity categories. However, males also experienced greater downward shifts within the different classes of obesity as indicated by a linear decrease among males when class 2 and class 3 obesity were considered together as one "severe obesity" category.

It is not immediately apparent why males are more highly represented within class 2 obesity. There is some evidence to suggest that males are subject to less social stigma and bias associated with being obese and, thus, may not experience the same societal pressure to manage weight as females.[23] However, adolescent obese males report impairment in their psychosocial adjustment and dissatisfaction with body image, indicating that males do perceive some social drawbacks to obese weight status.[24] It is possible that males are moving from class 3 obesity to class 2 obesity while female obesity status remains more constant. More research is needed to determine why males are more heavily represented in class 2 obesity as well as the mechanism by which rates of severe obesity are decreasing among males but not females.

The differences in obesity prevalence rates and trends over time between black and white students are well-documented and enduring.[25] This difference appears to additionally extend into severe obesity categories. The emergence of obesity prevalence rate disparities by race occurs as early as pre-school[26] and has been hypothesized to be the result of numerous differences in early child-rearing (e.g. higher maternal weight, lower rates of breast-feeding, earlier introduction of solid foods, etc.)[27] as well as cultural differences related to the social acceptability of overweight and obesity.[28-29]

Finally, a significant decrease in obesity prevalence among elementary school students was observed in the 2005-2013 CAYPOS.[14] This drop was not impactful enough to lead to a drop in the overall childhood obesity rate for the state, but it occurred in conjunction with declining rates of class 3 obesity. Declining rates of severe obesity were also identified among elementary school students. It remains uncertain whether this decrease in rates among elementary school students is indicative of actual decline of obesity rates among school-aged children or the result of fewer obese children entering elementary school. National data indicate that severe obesity rates are lower among young children, but may begin to rise during puberty.[1]

Continued study of this cohort would be

beneficial in determining the trajectory of severe obesity, particularly in light of the higher rates of class 2 obesity among Mississippi middle school students.

Evaluation of classes of severe obesity among Mississippi students over time has revealed several important trends. Higher prevalence rates among middle school students for class 2 obesity and among black students for class 2 and 3 obesity mirror trends observed in the evaluation of the entire obesity category in the most recent CAYPOS study. One unexpected finding was the higher rate of class 2 obesity among males even as the prevalence rate of severe obesity in males has decreased over time. Earlier CAYPOS studies only indicated disparities among females, especially in conjunction with race.[13-14] The division of the obesity category into classes suggests that males may also be a population of concern although the decline observed among this population in the severe obesity categories is encouraging. Furthermore, the linear decrease and quadratic change in class 3 obesity is an exciting development in a state known for high childhood obesity rates. The decreases observed among males, whites, and elementary school students in the severe obesity category indicate that these groups may be driving this decline. As this finding stands in contrast to the national data, it is more important than ever to continue to investigate the mechanism underlying this decrease. It is worth noting that these declines have occurred during the implementation of the Mississippi Healthy Students Act.[30-34]

The potential impact of this legislation is another avenue for future consideration.

This study is methodologically strong in its large sample size and five years' worth of collected data. Additionally, this study employs the most stringent definitions of class 2 and class 3 obesity[1] to more clearly delineate differences between the two. This allows for longitudinal evaluation of trends related to childhood obesity within the state and compared to the nation as a whole. This is, to our knowledge, the first study of severe obesity rates and trends within Mississippi. The information gained through this study allows for a better understanding of trajectories within the extreme classes of severe obesity and reveals vulnerable populations in need of further study.

Limitations of this study include small sample size within the individual classes of obesity that prohibit class-by-class comparison of demographic subgroups over time. The paucity of state-specific studies of severe obesity as well as varying definitions of severe obesity also present a challenge in adequately drawing comparisons between Mississippi data and that of other areas of the country. More research is needed to better understand the factors that impact the decrease in class 3 obesity and combined severe obesity as well as the gender and education level disparities observed in this study. Continuous re-evaluation will allow for a greater understanding of the trajectory of childhood obesity within the state of Mississippi.

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