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Prevalence and Trends of Underweight among Mississippi Public School Students, 2005 – 2013

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Abstract

This study estimated the prevalence of underweight among Mississippi public school students in grades K-12 and assessed changes in the prevalence between 2005 and 2013. Body Mass Index was calculated using measured height and weight data for weighted, representative samples of 480,383 public school students. Analyses compared 2005, 2007, 2009, 2011, and 2013 CAYPOS data for changes between 2005 and 2013. During 2005-2013, the prevalence of underweight did not differ by gender or race. However, there was a significant difference among elementary, middle, and high school students ($p = 0.004$). Elementary school students had the highest prevalence of underweight. There was no significant linear trend observed for percent of underweight students between 2005 and 2013 ($p = 0.6954$). However, there was a significant quadratic trend ($p = 0.0127$), indicating that underweight decreased from 2005-2009, then increased from 2009-2013. Trend analysis was also performed for students who participated in the 2009, 2011, and 2013 CAYPOS. There was a significant increase in the percent of underweight students from 2009 to 2013 ($p = 0.0039$). These findings are discussed in light of social determinants of health including recent economic trends as well as state and federal policies.

Key Words: Children, Youth, Underweight, Trends.

Introduction

Weight status and its effect on health have been pertinent public health issues for several years. Much attention has been focused upon child weight status, particularly those who fall into the categories of overweight or obese. The Center for Disease Control (CDC) defines overweight as "a Body Mass Index (BMI) at or above the 85th percentile and lower than the 95th percentile for children of the same age and sex" and obesity as "a BMI at or above 95th percentile for children of the same age and sex". BMI is determined by dividing weight (in kilograms) by the square of height (in meters). BMI is considered to be an adequate measure of body adiposity and is simple to calculate. Overweight and obesity are linked to a number of health problems including cardiovascular disease, diabetes, breathing problems, musculoskeletal disease, and psychological distress.[1-2]

For the past ten years, the Child and Adolescent Youth Prevalence of Obesity Survey (CAYPOS) has tracked the prevalence rate of overweight and obesity among Mississippi public school students as a whole and

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within various demographic subgroups using BMI calculations.[3] This biannual study is an initiative of the Center for Mississippi Health Policy and serves to provide a continuously updated picture of weight status among these groups. While this survey has yielded valuable information related to trends in the weight status distribution of vulnerable children in the overweight and obese categories, little is known about children who fall into the extreme ends of weight status distribution. Underweight, defined by the CDC as BMI-for-age weight status less than the 5th percentile based upon 2000 CDC BMI-for-age growth charts, is one of these extreme categories.[9]

The 1963-1965 through 2007-2010 National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control and Prevention (CDC) assessed the prevalence of underweight, as currently defined, at various intervals throughout this time period using previously recorded data. Results indicate that an estimated 3.5% of United States children and adolescents aged 2-19 were underweight as of 2010. This represents a significant drop in underweight since 1971-1974 when 5.1% of the same group was estimated to be underweight. The greatest declines between 1971-1974 and 2007-2010 were among children aged 2-5 (5.8% vs. 3.4%) and those aged 6-11 years (5.3% vs 3.6%). No significant differences were observed among adolescents aged 12-19 over this time period.[9] Though prevalence of underweight appears to be on the decline in the United States, the health risks of falling within this weight category are no less serious for those who remain affected.

Underweight, particularly among young children, has been linked to poor global health and increased special health-care needs.[10] Additionally, underweight children visit the doctor more per year and score lower on measures of overall bodily health than normal-weight children. Diminished immune system function is one of the most significant health risks of underweight and may make these children particularly susceptible to contagious disease.[11] These children are also more likely to suffer from low bone density and impaired cardiovascular systems. Furthermore, parents of underweight children reported that their children experienced negative psychosocial effects due to their weight including increased teasing.[11] Perhaps due to a combination of these experiences, the physical-health-related quality-of-life of underweight children was significantly lower than that of normal weight children, as reported by parents. Much higher scores of parent-reported pain sensitivity among underweight children as compared to normal weight children are a likely contributor to this perception.[11]

The adverse health outcomes suffered by underweight children become more significant when considered in light of recent research indicating a rise in underweight among children in Britain, a country similar to developmental scale to the United States. In 2013, Ogunleye found that 1 in 17 British children aged 9-16 were underweight. Prevalence disparities were evident by race and gender. Asian children were the most likely to be underweight (8.7%), while Black children were the least likely (4.6%). Girls were significantly more likely than boys to be underweight (6.4% vs. 5.5%) (Ogunleye AA, Sandercock GH). These findings of high prevalence of underweight within a developed country coupled with the known health risks of such a weight status made assessment of the prevalence rate of underweight in Mississippi more imperative.

The high rate of poverty in Mississippi presented another variable for further exploration as a possible social determinant of underweight. Though high poverty rates have been most closely linked with overweight and obesity in developed countries, there is also evidence to suggest that poverty may increase risk of

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underweight, particularly among those already genetically predisposed[12]; 34% of children live in poverty in the state of Mississippi.[13]

High rates of overweight and obesity among American children have led to a sharp focus on this population for the past several years. As such, research on children who fall in extreme weight categories, like underweight, is lacking. Unexpectedly high prevalence rates in developed countries and the known health risks associated with underweight heightened the urgency of filling the gaps in existing knowledge. The existing multiyear CAYPOS dataset provided a unique opportunity to assess the prevalence of underweight in one of the most impoverished states in America.

Methods

The sampling frame for this study consisted of all 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 underweight, 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. [3] 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.[3] 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 who 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.

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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 10th 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 Microsoft 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 5th percentile); (2) normal weight (BMI is equal to or greater than the 5th but less than the 85th percentile); (3) overweight (BMI is greater than the 85th but less than the 95th percentile); and (4) obese (BMI is greater than or equal to the 95th percentile). [1]

For the purpose of this study, only those students whose BMI was underweight (less than the 5th percentile) were included. SUDAAN 11.01 was used to calculate weighted estimates and standard errors for each survey year.[14] Due to the relatively small number of underweight students, to increase the precision, the 2005-2013 combined dataset were used to compare the average prevalence of child underweight 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 in overweight and obesity. 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

From 2005 - 2013, 2.1% of the Mississippi public school students (K-12) had BMI less than the 5th percentile. Of these, 2.2% were male and 2.0% were female, 2.3% were White and 1.9% were Black, 2.5% were elementary, 1.4% were middle, and 2.0% were high school students.

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The prevalence of underweight did not differ by gender or race (see Table 1). However, there was a significant difference among elementary, middle, and high school students (p = 0.004). Elementary school students had the highest prevalence of underweight.

When examined over time, there was no significant linear trend observed for percent of underweight students from 2005 - 2013 (p = 0.6954). However, there was a significant quadratic trend (p = 0.0127), indicating that underweight decreased from 2005-2009, then increased from 2009-2013 (see Table 2 and Graph 1). A separate trend analysis was also performed for students who participated in 2009, 2011, and 2013 CAYPOS. There was a significant increase in the percent of underweight students from 2009 to 2013 (p = 0.0039).

Table 1
Underweight by Gender, Race, and Grade Level (2005-2013), CAYPOS

Characteristics	Prevalence (%)	95% CI	P-value
Gender			
Male	2.2	(1.9-2.5)	0.390
Female	2.0	(1.7-2.3)	
Race			0.151
White	2.3	(2.0-2.8)	
Black	1.9	(1.6-2.2)	
Other*	2.4	(1.4-4.0)	
Educational Level			0.004
Elementary	2.5	(2.1-2.9)	
Middle school	1.4	(1.0-1.9)	
High school	2.0	(1.6-2.5)	
Total	2.1	(1.9-2.3)	

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

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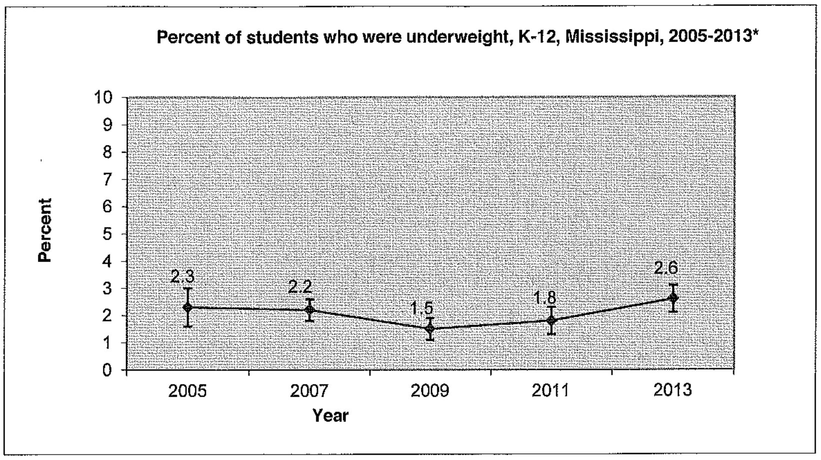
Table 2
Prevalence of Underweight[a] by Gender, Race, and Grade Level and Race, CAYPOS

Characteristics	**2005** (%, 95% CI[b])	**2007** (%, 95% CI)	**2009** (%, 95% CI)	**2011** (%, 95% CI)	**2013** (%, 95% CI)
Gender					
Male	2.1 (1.5-2.9)	1.9 (1.4-2.7)	1.7 (1.2-2.4)	1.8 (1.3-2.5)	3.2 (2.4-4.2)
Female	2.1 (1.3-3.5)	2.5 (1.8-3.5)	1.3 (0.8-2.2)	1.7 (1.1-2.6)	2.0 (1.6-2.6)
Race					
White	2.3 (1.5-3.4)	2.7 (1.9-3.6)	1.8 (1.2-2.8)	1.7 (1.2-2.5)	3.2 (2.3-4.3)
Black	2.4 (1.4-4.1)	1.8 (1.2-2.7)	1.2 (0.7-1.9)	1.6 (1.1-2.4)	2.3 (1.7-2.9)
Grade Level					
Elementary	2.5 (1.4-4.5)	2.2 (1.6-2.9)	1.9 (1.1-3.0)	2.5 (1.8-3.5)	3.3 (2.5-4.4)
Middle school	0.6 (0.2-1.3)	2.3 (1.2-4.6)	1.3 (0.7-2.2)	0.7 (0.3-1.5)	2.0 (1.3-2.9)
High school	3.3 (1.8-5.8)	2.3 (1.8-2.8)	1.2 (0.7-2.2)	1.2 (0.8-1.8)	2.1 (1.5-2.9)
Total*	2.3 (1.6-3.3)	2.2 (1.8-2.8)	1.5 (1.1-2.1)	1.8 (1.3-2.3)	2.6 (2.1-3.3)

[a]Body mass index (BMI) <5th percentile for age and gender.
[b]95% confidence interval.
[*] Except for the total estimates, all other estimates by subcategory are not reliable due to the sample size being less than 50.

Graph 1. Percent of Underweight Students, CAYPOS



* Body mass index (BMI) < 5th percentile for age and gender.

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Discussion

Results from the first analysis of underweight public students in Mississippi indicate that rates of underweight significantly decreased from 2005 - 2009. This decrease reached a trough in 2009 before rates reversed course to increase through 2013, which marked the highest prevalence rate over the entire study period. Contrary to previous literature, no significant differences were observed by gender or race of the pooled sample. However, elementary school children were more likely to be underweight than those in middle or high school. Investigation of the convergence of key national and regional events occurring over 2005-2013 may serve to explain the quadratic trend observed in this sample as well as lend consideration to social determinants that may impact underweight prevalence among Mississippi public students.

Poverty has most recently been linked to increased overweight and obesity in children, but lack of sufficient family income puts children at risk for becoming underweight as well. Growing up in poverty is uniquely responsible for a 12.7% reduction in BMI in children who fall at or below the 10th percentile on BMI scales based upon age.[12] In turn, poverty is strongly linked to the health of the economy. From 2005 - 2008, the unemployment rate in Mississippi was decreasing. Save for a sharp short-term spike in the latter half of 2005 likely related to the impact of Hurricane Katrina, the unemployment rate steadily decreased from 7.2% to 6.1% .[15] Over the same time period, Mississippi's child poverty rate underwent a downward trend with slight fluctuation, falling from 31% in 2005 to 29% in 2007 before reaching 30% in 2008 .[13] These trends align with the progressive decrease in child underweight in Mississippi from 2005-2009.

2005 also marked the landfall of Hurricane Katrina on the Mississippi Gulf Coast. Though the impact was most pronounced within the coastal counties, 49 counties, extending well into the northern parts of the state, were declared eligible for FEMA assistance related to Hurricane Katrina. This natural disaster led to a persistent population loss of an estimated 9.7% of the pre-Katrina population, in the coastal counties alone. Those evacuees who permanently left affected areas were found to differ demographically from those who returned. Specifically, those who permanently left were more likely to be younger, unmarried, African-American, and lacking a college education.[16] As these are demographic variables often associated with higher rates of poverty, it is plausible that at least some of the decline in underweight between 2005-2009 may be related to the exodus of more impoverished Mississippi residents following Hurricane Katrina.

Around the same time that rates of underweight began to rise in Mississippi, the United States entered a national recession. Though this recession officially ended in 2009, many measures of economic health have yet to return to pre-recession levels.[17] Mississippi's unemployment rates increased dramatically beginning in 2008 and eventually reached a peak of 11% in 2011. While unemployment rates have declined since 2011, they still hover above pre-recession levels .[18] The rise in child poverty rates from 2009-2012 are perhaps the most dire. The rate of children living in poverty in Mississippi rose from 31% in 2009 to 35% in 2012, the most recent year for which statistics are available .[13] These data indicate that underweight began to rise in conjunction with rising economic instability.

Changes in the policies and usage rates of federal food aid coincided with this economic uncertainty. The federal 2009 American Recovery and Reinvestment Act (ARRA) increased Supplemental Nutrition Assistance Program (SNAP) benefits for millions of households most affected by economic crisis; SNAP caseloads increased dramatically from between 2007-2011.[18] This is true of Mississippi which saw an sharp increase in households served between 2009 and 2013 (505,920 vs. 668,624).[19]

Over the same time period, household participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) within Mississippi dropped significantly (111,478 vs. 91,652) .[20] Some of this decline is likely attributable to declining birth rates during the recession (4.32 million U.S. births in 2007 vs. 3.92 million U.S. births in 2013),[21] but Mississippi's WIC program is also structured in such a way that ultimately limits ease of accessibility of benefits. For example, Mississippi is the only state in the nation that still utilizes the direct distribution system of food delivery rather than utilizing the retail sector to deliver benefits. Participants are required to travel to a state-run food warehouse to receive their benefits rather than obtaining them through a retail store. This limits participant choice and can serve to increase stigma associated with participation in the WIC program.[22]

These accessibility difficulties combined with a timely increase in SNAP benefits may have pushed families who were previously receiving WIC to discontinue participation and enroll in SNAP instead. Limitations on food choices through SNAP are much less strict than those through WIC, which only allows purchase of specific, nutritional foods .[22] Unfortunately, while WIC participation has demonstrated improvement in child food quality and a decrease in child health risks, the same cannot be said for SNAP participation .[23] These potential shifts in food aid participation may unintentionally result in a rise in underweight among the most at-risk children due to insufficient nutrition.

Another potential variable to consider is the enactment of several state laws related to decreasing childhood obesity through school-based initiatives. These initiatives largely focused upon more rigid nutrition standards and increased requirements for physical activity. These laws were passed in 2007 and implemented in the following years .[24-28] This implementation period coincides with the points at which underweight began rising. It is possible that changes in schools related to these initiatives pushed children that may have been at-risk into an underweight status, especially given the significant declines in overweight and obesity in elementary school children over this time period. As this is the first study to our knowledge that has investigated underweight of public school children within a specific state, further research will need to be done to evaluate what role, if any, state policies and school initiatives may play in relation to underweight students.

Our results suggest that increased risk for underweight status may be most acute among the youngest schoolchildren, elementary school students. This finding stands in contrast to national data indicating that underweight among 6-11 year olds has been steadily declining since 1971 .[9] Considering that the most significant declines in overweight and obesity in the 2005-2013 CAYPOS were among elementary school students[3], it is possible that this finding represents an overall trend of decline in weight of this population that has pushed the most at-risk students into underweight status. This finding is particularly concerning as young children are the most likely to experience negative health outcomes as a result of underweight .[11]

No significant differences in prevalence of underweight by gender or race were apparent. Though rates of underweight seem to correspond to economic trends, black children are significantly more likely to live in poverty than white children in Mississippi (52% vs. 19%).[13] Over the lifetime of the CAYPOS study, black children have not enjoyed the same reduction in overweight and obesity as white children have, particularly at

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the elementary school level.[3] It is possible that poverty tends to predispose black children to overweight rather than underweight in a way that differs from white children.

While this study is methodologically strong in its use of several years of weighed, representative data of Mississippi public school students, limitations exist as well. Small sample sizes prohibit the analysis of demographic subgroups by individual year. The dearth of existing data on underweight children in the United States additionally increases the difficulty of drawing comparisons between Mississippi and the nation as a whole. The assessment of childhood underweight prevalence in the United States is limited to reports issued by the CDC and does not include state-specific data. To our knowledge, this is the first study to assess the prevalence rate of childhood underweight over time within an individual state. Though the prevalence of underweight in Mississippi aligns with the low levels observed throughout the nation as whole, it appears that this prevalence rate is not steady over time and may be linked to economic trends. However, the lack of significant difference in underweight prevalence by race despite vastly different poverty rates between the two, indicate that the relationship is more complex than a simple economic correlation. CDC reports on nationwide underweight prevalence rates do not currently provide prevalence rates by race, which limits further investigation into the trend noted in this study. Further study of underweight prevalence rates among demographic subgroups incorporating larger sample sizes may shed light on this phenomenon.

This study is the first to examine the prevalence of underweight among Mississippi public school students. Though underweight rates in the United States remain low compared to undeveloped countries, the health risks of being underweight are serious nonetheless. Despite the knowledge gained, additional questions remain. This study provides an initial analysis of trends ripe for future study.

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