



Short Communication

Persistent disparities in obesity risk among public schoolchildren from childhood through adolescence



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ABSTRACT

Introduction. Arkansas is among the poorest states and has high rates of childhood obesity. In 2003, it became the first state to systematically screen public schoolchildren for unhealthy weight status. This study aims to examine the socioeconomic disparities in Body Mass Index (BMI) growth and the risk of the onset of obesity from childhood through adolescence.

Methods. This study analyzed (in 2015) the data for a large cohort of Arkansas public schoolchildren for whom BMIs were measured from school years 2003/2004 through 2009/2010. A linear growth curve model was used to assess how child-level sociodemographics and neighborhood characteristics were associated with growth in BMI z-scores. Cox regression was subsequently used to investigate how these factors were associated with the onset of obesity. Because children might be classified as obese in multiple years, sensitivity analysis was conducted using recurrent event Cox regression.

Results. Survival analysis indicated that the risk of onset of obesity rose sharply between ages of 5 and 10 and then again after age 15. The socioeconomic disparities in obesity risk persisted from kindergarten through adolescence. While better access to full service restaurants was associated with lower risk of the onset of obesity (Hazard Ratio (HR) = 0.98, 95% CI = 0.97–0.99), proximity to fast food restaurants was related to increased risk of the onset of obesity (HR = 1.01, 95% CI = 1.00–1.01).

Conclusions. This analysis stresses the need for policies to narrow the socioeconomic gradient and identifies important time periods for preventative interventions in childhood obesity.

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1. Introduction

According to the 2011 National Survey of Children's Health (NSCH), about 20% of children ages 10 to 17 in Arkansas were obese, which was almost 10 percentage points higher than the states with lowest childhood obesity rates (Levi et al., 2014). Longitudinal studies indicate that, overall, about half of obese school-age children subsequently become obese adults, although estimates differ across studies (Serdula et al., 1993). Understanding the determinants of childhood obesity in the state of Arkansas is thus critical to developing policies for early intervention and prevention of adult obesity in this state-specific population.

A multitude of recent studies have documented the socioeconomic gradient in childhood obesity in the United States, and some indicate

that the gradient has increased since 2003 (Frederick et al., 2014; Singh et al., 2010). This could be related to the underlying socioeconomic disparities in food intake and physical activities. A recent review found that low-income children who participated in the Supplemental Nutrition Assistance Program (SNAP) consumed a poorer diet than higher-income non-participating children (Andreyeva et al., 2015). Another review of adolescent physical activity by socioeconomic status indicated that adolescents with higher SES had more physical activities than those with low SES, although discordant findings also existed (Stalsberg and Pedersen, 2010).

Another concern is that low-income children lack access to healthy foods. A review by Cobb et al. (2015) suggested that exposure to fast food around children's home was consistently found to be positively associated with obesity among low-income populations. This agrees with the conclusion from another review by Williams et al. (2014) who found evidence of a positive association between fast food availability surrounding children's schools and obesity. However, there are

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limitations to some of the studies included in the review, including a paucity of longitudinal studies, use of self-reported weight outcomes, and absence of individually specific exposure measures.

We employed a large longitudinal cohort in Arkansas based on objectively measured BMI z-scores and incorporated survival analysis into the study of obesity. This method has been used to study the role of naturalistic weight-reduction efforts in obesity prevention (Stice et al., 1999), but it has rarely been used in the examination of the roles of socioeconomic status and food environment in childhood obesity. A recent study based on data on public schoolchildren in Arkansas suggested that exposure to food desert was positively associated with BMI z-scores (Thomsen et al., 2016).

The aims of this study are to 1) examine BMI growth trajectories among a cohort of children; 2) assess the risk of the onset of obesity among this cohort over the study period; and 3) investigate the socioeconomic, gender, and racial disparities in BMI growth and the risk of the onset of obesity while controlling for food environment and other factors.

2. Methods

2.1. Study sample

Due to concerns over the rise in childhood obesity, the Arkansas General Assembly passed Act 1220 of 2003, which required that schools conduct annual BMI screenings. From school years 2003/2004 through 2006/2007, all public school children from kindergarten through 12th grade in the state of Arkansas were screened, but since school year 2007/2008, only children in even grades (K, 2, 4, 6, 8, 10) were screened. The height and weight measurements of schoolchildren were collected by trained personnel who followed statewide protocols to ensure uniformity in both measurement procedures and equipment. This study analyzed a longitudinal dataset on all children who were in kindergarten, second or fourth grades in academic year 2003/2004 and who could be followed through subsequent waves of data collection ($N = 21,639$) until academic year 2009/2010.

2.2. Measures

BMI was calculated as a ratio ($[\text{weight in pounds} / (\text{height in inches})^2] \times 703$) and was then converted to age-gender specific z-scores following guidelines from the Centers for Disease Control and Prevention. Obesity was defined as a BMI greater than or equal to the 95th percentile for children of the same age and sex. The 95th percentile corresponds to a BMI z-score of 1.645.

The BMI dataset also contained basic sociodemographic information including age, gender, and race/ethnicity. School meal status was a dichotomous variable indicating whether the child qualified for free or reduced price lunches. School meal status has been widely used as a proxy for socioeconomic status.

A measure of the child's food desert status indicated whether a student lived in a food desert. Our definition of a food desert was based on that used by the USDA Food Access Research Atlas except that we used a food desert measure that is specific to each child's residence.

The BMI data were geocoded and matched with food store locations by personnel from the Arkansas Center for Health Improvement (ACHI). The numbers of full service, and fast food restaurants (including fast food restaurants, and other limited service restaurants such as sandwich and pizza restaurants) were measured as counts along the most direct street route from the child's residence to the school within a 50 meter buffer on either side of the street. Further details on this measure are available elsewhere (Dunn et al., 2015).

Additional neighborhood characteristics were obtained from 2005 to 2009 American Community Survey (ACS) and were measured at the census block-group level. Specifically, we controlled for neighborhood educational attainment, proportion of working mothers,

proportion of population below poverty level, housing vacancy rates, and proportion with access to vehicles.

2.3. Statistical analysis

A growth curve model was used to examine the trajectories of children's BMI z-scores over the six BMI measurement occasions, and how child-level sociodemographics and neighborhood characteristics were associated with BMI z-score growth. Initial examination of these data suggested that the mean BMI z-scores followed a nearly linear growth path over time. Likelihood-ratio tests indicated that a growth curve model was preferred to ordinary least squares. To complement the analysis using the growth curve model, we also assessed the onset of obesity using Cox regression analysis while controlling for child-level sociodemographics and neighborhood characteristics. We first examined the time to the first occurrence of obesity using Cox regression. Because it is possible for a child to be classified as obese in some periods but not in others, we also examine obesity status as a recurrent event to test the sensitivity of the model. To investigate the socioeconomic disparities in the risk of the onset of obesity, the hazard of obesity was estimated by meal status based on the single event Cox regression. Observations with missing values in any of the variables were excluded from the analyses. All analyses were conducted using the Stata® software package, version 14.

3. Results

The overall average BMI z-score was 0.68 across all years (Table 1) and increased almost linearly from 0.63 in academic year 2003/2004 to 0.74 in academic year 2009/2010. Consequently, obesity prevalence also increased as our cohorts aged. The average across all cohorts increased from 17.96% (2003/2004) to 22.21% (2009/2010), with an average of 20.60% across the study period.

Results from the growth curve model indicated that the average BMI z-score for children in the free or reduced price meal group was about 0.01 higher than the comparison group. Girls, in general, had lower BMI z-scores than boys. Compared to whites, all the other racial/ethnic groups including blacks, Hispanics, and others had higher BMI z-scores, with Hispanics being the highest among all the groups. Living in neighborhoods featuring higher proportions of people with a college degree or higher was negatively associated with BMI z-scores; whereas living in neighborhoods with higher proportions of working mothers and people below poverty level were positively associated with BMI z-scores.

Cox regression indicated that the hazard for the onset of obesity over the study period for children in the free or reduced price meal group was about 17% higher than the full price meal group (Hazard Ratio (HR) = 1.17, 95% CI = 1.10–1.24). This model-implied obesity hazard measures the instantaneous risk of obesity, given that obesity has not happened yet. It rose from age 5 to 10, decreased thereafter before rising sharply at about 15 years of age (Fig. 1). Girls had lower hazard for the onset of obesity than boys. Blacks and Hispanics had higher hazard for the onset of obesity than whites during the study period. Better access to full service restaurants on the route from a student's home to school was associated with lower hazard for the onset of obesity over the study period, whereas fast food restaurant was associated with higher hazard. With exception of one educational attainment measure, other neighborhood level characteristics were not significantly associated with the onset of obesity. Treating obesity as a recurrent event in the Cox regression yielded similar results.

4. Discussion

This paper innovatively incorporated survival analysis into the study of obesity. Both the growth curve model and the cox regression indicated significant socioeconomic disparities in obesity risk. The cox regression also picked up significant association between access to

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