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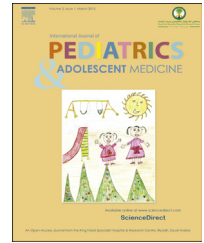


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ORIGINAL RESEARCH ARTICLE

The obesity epidemic in children: Latino children are disproportionately affected at younger ages



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Abstract *Background and objectives:* National surveillance clearly illustrates that U.S. children are becoming increasingly overweight. However, the timing of the onset of childhood overweight has not been well-described.

Patients and methods: An accelerated failure time (AFT) model was used to describe the emergence of overweight based on a 12-year collection of height and weight data of over 40,000 children. Race, sex, insurance status and their interactions were specifically examined as predictors of earlier onset of overweight. The outcome of interest was an estimate of the age at which the model predicted that a subgroup would attain a 20% prevalence of overweight.

Results: The three-way interaction of race, sex, and insurance status was a significant predictor of onset of overweight. The model estimated that the publicly insured Latino male subgroup had the earliest onset of overweight, attaining a prevalence of 20% overweight by 4.3 years of age. The emergence of overweight in Latino subjects was significantly earlier than that for black or white subjects, irrespective of sex or insurance status.

Conclusion: Regardless of sex or insurance status, overweight emerges at significantly younger ages in Latino children when compared to black and white children. Substantial numbers of Latino male children are predicted to develop overweight at preschool ages. Obesity

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prevention may need to be directed toward parents or children well before children enter grade-school.

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1. Introduction

National surveillance has convincingly demonstrated that the incidence of pediatric obesity in the U.S. is increasing [1–3]. This is concerning because this rise in pediatric obesity is associated with increased risks of co-morbid health conditions, including type 2 diabetes and cardiovascular disease [4–6]. In addition, overweight children are reported to have a lower health-related quality of life [7,8] and lower high school performance, educational attainment, psychosocial functioning, and socioeconomic attainment [9].

The increase in overweight coupled with the presence of risk factors for type 2 diabetes and cardiovascular disease in childhood indicate the need for primary prevention of obesity in children [10–13]. Targeted prevention efforts may prove beneficial for subsets of children defined not only by family history and metabolic risk factors but also by environmental, cultural, and socioeconomic factors that increase the risk of overweight at younger ages.

Although several large studies have examined the emergence of overweight in children, they had important limitations. National surveillance studies have been limited by widely spaced time points in data collection, indirect observation (e.g., parental or self-report of height and weight), insufficient follow-up to track weight patterns from early childhood through adolescence, and limited enrollment and follow-up of minority children [14–18]. We addressed some of these limitations by investigating the age of emergence of overweight in a large cohort of children who received primary care in an urban pediatric clinic system. In addition, we examined the relationships between insurance type, race/ethnicity and sex, and age of onset of obesity.

2. Patients and methods

2.1. Cohort identification

We queried the Regenstrief Medical Record System (RMRS) to identify children between the ages of 3 and 16 years that had been seen at a network of seven urban primary care clinics (Indiana University Medical Group) in Marion County, Indiana between the calendar years of 1993 and 2004. The RMRS is one of the oldest and largest electronic medical record systems in the United States [19]. We identified a subset of these children whose height and weight had been measured on the same day. We excluded children with medical documentation suggestive of pregnancy, congenital heart disease, chromosomal abnormalities, anomalies of the adrenal gland, multiple congenital anomalies, cystic

fibrosis, and cerebral palsy. We extracted demographic information, including birth year, race/ethnicity, gender, and health insurance status, for all children meeting these study criteria. The race/ethnicity categories used were Latino, non-Latino white, and non-Latino black, which represent the major race/ethnic populations in the region. For simplicity, we refer to these groups as Latino, white, and black. Health insurance status was categorized as either publicly (i.e., Medicaid only) or privately insured.

2.2. Definitions of overweight

We used the Centers for Disease Control and Prevention (CDCP) definition of overweight in children, which is a body mass index (BMI) greater than or equal to the 95th percentile for age and sex [20]. SAS codes available on the website of the CDCP (www.CDC.gov) were used to first flag biologically implausible values for height and weight measures and subsequently calculate age and sex-adjusted BMI percentiles. There are no BMI-for-age references or consistent definitions for overweight for children younger than 2 years; thus, children younger than 3 years of age were excluded.

2.3. Accelerated failure models of onset of overweight

SAS 9.1 (Procedure LIFEREG; SAS Institute Inc., Cary, NC) was used to generate an Accelerated Failure Time (AFT) model describing the risk of overweight as a function of age in our cohort [21–23]. Similarly, AFT modeling was previously used to compare differences in the onset of obesity between black and white children among a smaller cohort assembled for studying hypertension [24]. To generate the AFT models, we established rules for censoring the data based on whether a study subject never became overweight during the data collection period, was overweight when entering the study, or transitioned from being normal weight to overweight. For those children who never became overweight during the entire study period, the data points were right censored at the last time the child was measured. If a child was observed as being overweight at the time of their first recorded measurement, the data points were left censored at the first measurement, and all subsequent measurements were ignored. If the child became overweight following at least one non-overweight measurement during the study period, the data points were interval censored. This interval starts from the last time the child was non-overweight to the first time the child's BMI exceeded the 95th percentile for age and sex so that the true date of onset of overweight lies within the

interval. All measurements following the interval were ignored.

In addition to birth year, race, sex, insurance and their two-way and three-way interactions were included as main effects in the AFT model. The distribution of failure time, i.e., age of overweight onset in this study, was initially assumed to be log-normal. Type III chi-square statistics were computed to assess the significance of these variables in predicting the age at which a child would become overweight. A graph showing the overweight prevalence versus the estimated age for each subgroup of children was generated from the quantile estimates of this AFT model. We set the significance level at $P = .05$.

3. Results

3.1. Cohort

The study cohort was 51,115 children with 148,715 BMI values collected from 1993 to 2004. After excluding those children whose medical record indicated "other" race or unknown insurance type, there were 43,842 individuals with valid information for analysis (Table 1). This sample was evenly distributed by sex, and the distribution of race/ethnicity reflects the overall patient population served by the Indiana University Medical Group primary care clinics. Public insurance was more prevalent than private insurance. The percentage of Hispanic children in the sample increased steadily over time, especially for those born after 1995 (Table 2). This is consistent with the increasing prevalence of Latino migration to central Indiana that occurred during the study period, based on the 1990 and 2000 U.S. Censuses. In addition, Census data suggested that the majority of Latino subjects were Mexican.

3.2. Rates of overweight

The number of individuals whose data were either left, right or interval censored, and the mean ages for each censoring category are presented in Table 3. The percentage of overweight Hispanic children (29.7%), i.e., combined percentage of Hispanic children who were overweight at their first visit (left-censored) and became overweight at a subsequent visit (interval-censored), was higher than that for white (22.4%) and black (23.1%) children. Based on interval censored observations, the mean age at which children were determined to be overweight was younger for Hispanic children than for white and black children (Table 4).

Table 1 Demographic information for race by gender and insurance status.

Race	N (%)	N (%) female	N (%) public
Black	24,523 (56)	12,688 (53)	16,855 (69)
Hispanic	4001 (9)	1981 (50)	3588 (90)
White	15,318 (35)	7804 (51)	8146 (53)
Total N (%)	43,842 (100)	22,473 (51)	28,589 (65)

Table 2 Demographic information for birth year by race.

Birth year	N (%)	% White	% Black	% Hispanic
1977	172 (0.4)	39.5	60.5	0
1978	430 (1.0)	39.5	60.2	0.2
1979	601 (1.4)	41.3	57.7	1.0
1980	761 (1.7)	40.7	58.5	0.8
1981	968 (2.2)	41.7	57.1	1.1
1982	1070 (2.4)	41.8	56.9	1.3
1983	1311 (3.0)	39.8	58.6	1.6
1984	1452 (3.3)	42.6	56.0	1.4
1985	1614 (3.7)	40.2	57.7	2.1
1986	1771 (4.0)	42.2	54.0	3.8
1987	2134 (4.9)	40.1	55.6	4.3
1988	2610 (6.0)	40.3	55.4	4.3
1989	2984 (6.8)	39.4	54.8	5.8
1990	3179 (7.3)	38.7	55.7	5.7
1991	2969 (6.8)	36.0	57.7	6.4
1992	2687 (6.1)	36.0	55.3	8.7
1993	2460 (5.6)	35.5	55.1	9.4
1994	2246 (5.1)	32.9	55.7	11.4
1995	2185 (5.0)	31.3	55.7	13.1
1996	2051 (4.7)	27.9	55.8	16.3
1997	2062 (4.7)	26.6	56.2	17.3
1998	2010 (4.6)	24.8	55.4	19.8
1999	1846 (4.2)	22.9	54.8	22.3
2000	1483 (3.4)	19.9	56.4	23.7
2001	786 (1.8)	20.2	52.3	27.5

Table 3 Mean ages for censoring categories.

Censoring category	N subjects (%)	Mean age \pm std dev
Right-censored	33,555 (77)	8.8 \pm 4.2
Left-censored	7003 (16)	8.3 \pm 4.2
Interval-censored	3284 (7)	6.8 \pm 3.4 (age 1) 8.4 \pm 3.6 (age 2)

Table 4 Mean ages for censoring categories by race.

Race	Censoring category	N subjects (%)	Mean age \pm std dev
Black	Right-censored	18,851 (77)	8.9 \pm 4.2
	Left-censored	3676 (15)	8.5 \pm 4.3
	Interval-censored	1996 (8)	6.7 \pm 3.3 (age 1) 8.5 \pm 3.6 (age 2)
Hispanic	Right-censored	2814 (70)	7.7 \pm 3.8
	Left-censored	906 (23)	6.8 \pm 3.8
	Interval-censored	281 (7)	5.7 \pm 2.9 (age 1) 6.6 \pm 3.1 (age 2)
White	Right-censored	11,890 (78)	9.1 \pm 4.2
	Left-censored	2421 (16)	8.5 \pm 4.2
	Interval-censored	1007 (6)	7.3 \pm 3.6 (age 1) 8.8 \pm 3.7 (age 2)

Table 5 Accelerated failure time (AFT) model estimates: predicted ages of onset of overweight.

Prevalence of overweight	Publicly insured subjects					
	Black males (n = 8215)	Latino males (n = 1819)	White males (n = 4050)	Black females (n = 8640)	Latina females (n = 1769)	White females (n = 4096)
	Mean age (years)			Mean age (years)		
0.18	7.4	4.0	6.5	7.3	5.4	7.7
0.20	8.1	4.3	7.1	8.0	5.9	8.4
0.22	8.8	4.7	7.7	8.6	6.4	9.1
Prevalence of overweight	Privately insured subjects					
	Black males (n = 3620)	Latino males (n = 201)	White males (n = 3463)	Black females (n = 4048)	Latina females (n = 212)	White females (n = 3708)
	Mean age (years)			Mean age (years)		
0.18	6.9	5.2	7.4	7.2	4.5	8.9
0.20	7.6	5.7	8.1	7.8	4.9	9.7
0.22	8.2	6.2	8.8	8.5	5.3	10.5

The three way interaction term between race, sex, and insurance status was a significant predictor in the AFT models, X^2 (DF 2) = 8.83, $P < .05$. Table 5 lists the predicted ages at which each of the subgroups defined by race, sex, and insurance status would attain a prevalence of overweight equal to 18%, 20%, 22% and 24%. Publicly insured Latino males were shown to become overweight at

the youngest ages, as indicated by the leftmost positioning of their AFT curve (Fig. 1). This subgroup of children reached a prevalence of 20% overweight by 4.2 years of age. Privately insured, Latina females had the second youngest onset of overweight, reaching a prevalence of 20% overweight by approximately 4.9 years of age (Fig. 1). The model indicated that Latino children, irrespective of

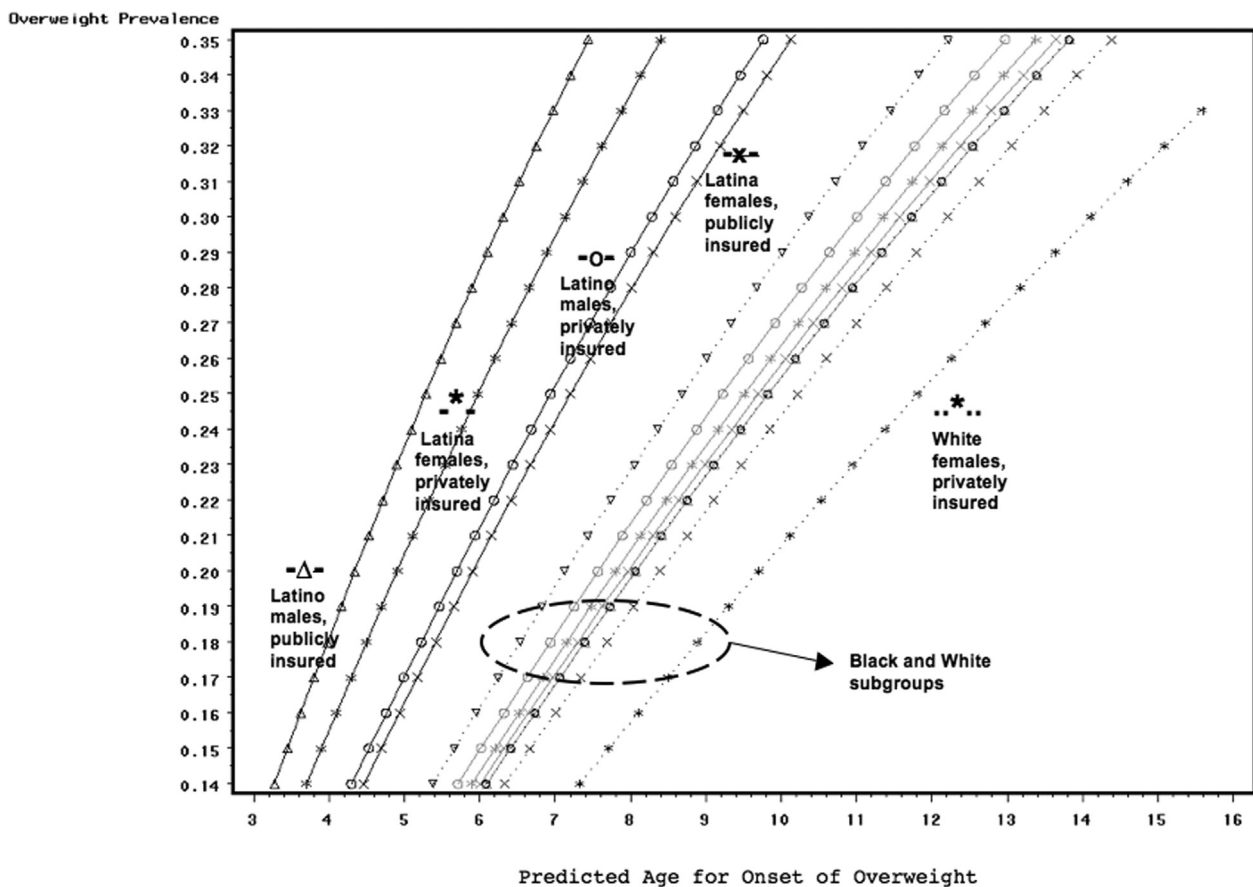


Figure 1 Accelerated failure time model results for onset of overweight.

insurance status, would have an earlier onset of overweight than white and black children. In comparison, white and black children reached a prevalence of 20% overweight by approximately 7–9 years of age, with white females having the latest emergence of overweight (Fig. 1). The effect of insurance status on the predicted onset of overweight varied by race/ethnicity and gender.

4. Discussion

Our data indicate that Latino children become overweight at younger ages than children of other races/ethnicities. Moreover, significant proportions of Latino children become overweight before entering grade school, suggesting that grade-school-based obesity prevention is too late for this high-risk population. Our study contributes to a growing body of evidence that indicates an increased risk of overweight in Latino preschoolers, and our study is distinguished by its large body of longitudinal data. This study also adds to our understanding of the epidemiology of childhood overweight by emphasizing the need to consider interactions between race, sex, and insurance status in determining obesity risk [16,17,24].

Though other studies have not observed significant differences in the emergence of overweight between Hispanic children and black and white children until adolescence [17,18], several national surveillance programs have found differences in the prevalence of overweight by race/ethnicity in preschool age children. The 1999–2002 National Health and Nutrition Examination Survey estimated a prevalence of overweight among 739 two-to five-year-old Mexican American children to be 13.1% compared to 8.6% for non-Hispanic black children and 8.8% for non-Hispanic white children [24]. Data from the year 2000 from the Special Supplemental Nutrition Program for Women, Infants, and Children for more than two million 2- to 4-year-old children estimated the prevalences of overweight for non-Hispanic white, non-Hispanic black, and Hispanic children to be 11.4%, 11.7%, and 17.9%, respectively [25]. Data collected for 2452 three-year-old children between 2001 and 2003 through the Fragile Families and Child Well-being Study found the prevalences of overweight to be 25.8% among Hispanics (any race), 16.2% among blacks, and 14.8% among whites [26]. Although differences in study period, age categories, and geographic location limit comparisons, the findings of the Fragile Families and Child Well-being Study are consistent with those of the aforementioned studies both in terms of the relative prevalence and magnitude of rates of overweight across racial/ethnic groups. Also of note, in an analysis using data from the 1979 National Longitudinal Survey of Youth, McTigue et al noted marked ethnic-based differences in the development of obesity among young U.S. adults, with obesity developing most rapidly in Hispanic men [27].

The causes of overweight disparities between races/ethnicities are complex, and the extent to which racial differences in the patterns of obesity represent cultural versus genetic differences is unclear. Year 2000 U.S. Census data for the county where most of the subjects of this study reside suggest that approximately 91% of the Latino subjects in this study were of Mexican descent [28]. Those with

Mexican lineage may have genetic compositions that are more prone to overweight, as previously suggested in the “thrifty gene” hypothesis [29,30]. Several studies have identified compelling differences related to cultural dietary and exercise practices [31], the process of acculturation [32], perceptions of body image [33], and self-esteem [34] that would constitute elevated obesity risk for subgroups defined by race or ethnicity. Findings such as these should be evaluated for inclusion in customized obesity interventions that seek to contend with socio-demographic factors.

Because of the racial distribution of this population and the regional basis of this study, its findings cannot be generalized. However, our study group included large numbers of blacks and Hispanics who have previously been shown to be at higher risks for obesity-related morbidity and mortality in studies of adults [24,35]. Data were not collected prospectively with the specific intent to answer the study hypotheses; thus, the extent of the longitudinal data varied across individual subjects. Because of our statistical methods, variation in the patterns of seeking care (i.e., when subjects came to the clinics for routine health maintenance visits) between races could have generated bias. Finally, the retrospective nature of the analysis does not allow for the determination of causal relationships.

While it has been suggested that efforts to decrease overweight and diabetes risks should be directed at school-aged children, the present study suggests that population-based prevention efforts should begin at earlier ages [36]. Pre-school aged children are a population sub-group for whom data on obesity prevention and evidence of effectiveness of any such program are scarce [37,38]. This is of concern because, as our data indicate, many children, particularly minority children, become overweight before the age of 6 years. Moreover, Latino and other minority children are at a particularly high risk for the development of type 2 diabetes and other co-morbidities of obesity [36,39–41]. Our study adds to the body of literature calling for prevention efforts aimed towards minority children who have a substantial increased risk for overweight at very young ages [42–44].

In summary, this study demonstrates that onset of overweight occurs in substantial proportions of children of preschool and early primary-grade ages. Hispanic children were found to become overweight at earlier ages than black and white children in our study population. Further studies should focus on the emergence of further metabolic and cardiovascular risk factors and on developing targeted prevention and intervention strategies in young children, their families, and the communities in which they live.

Conflicts of Interest

The authors have no conflicts of interest to report.

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