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Research Article

Maternal and Early Childhood Risk Factors for Overweight and Obesity among Low-Income Predominantly Black Children at Age Five Years: A Prospective Cohort Study

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Objective. To identify maternal and early childhood risk factors for obesity and overweight among children at age 5 in the state of Alabama. *Methods*. We recruited 740 mothers during early pregnancy from University of Alabama Prenatal Clinics in a prospective cohort study and followed them throughout pregnancy. We followed their children from birth until 5 years of age. The main outcome measure was obesity (BMI for age and sex ≥ 95th percentile) at 5 years of age. We used poisson regression with robust variance estimation to compute risk ratio (RR). *Results*. At the 5th year of followup, 71 (9.6%) of the children were obese and 85 (11.5%) were overweight (BMI ≥ 85th–<95th percentile). In multivariable analysis, maternal prepregnancy overweight (RR: 2.30, 95% CI: 1.29–4.11) and obesity (RR: 2.53, 95% CI: 1.49–4.31), and child's birth weight >85th percentile (RR: 2.04, 95% CI: 1.13–3.68) were associated with childhood obesity. Maternal prepregnancy BMI, birth weight, and maternal smoking were associated with the child being overweight 1–12 cigarettes/day versus 0 cigarettes/day (RR: 1.40, 95% CI: 1.02–1.91). *Conclusion*. Children of overweight and obese mothers, and children with higher birth weight, are more likely to be obese and overweight at age 5. Maternal smoking 1–12 cigarettes per day is associated with the child being overweight.

1. Introduction

Obesity has reached epidemic proportions in the United States (US) where, in 2007-08, 34% of adults were obese and 68% were overweight [1]. The situation is worse in some southern states like Louisiana, Mississippi, and Alabama where almost 1 person out of 3 is obese or overweight. Obesity is particularly more common in the African-American population (44%) than in their white counterparts (33%) [1]. In 2007-08, among children 2 to 5 years of age, 11% of African-Americans compared to 5.5% of Whites were obese and 26% versus 9% were overweight [2]. Complications of obesity are also more severe among African-Americans [3, 4]. The increasing prevalence of obesity and overweight has important health and economic implications [5, 6]. If current trends continue, the higher prevalence of obesity may result in a decline in life expectancy in the United States [3, 4]. This increase in mortality risk arises from a higher risk of many comorbidities, including type 2 diabetes, hypertension, hypercholesterolemia, osteoarthritis, gallbladder disease, and some cancers [7]. Obesity can also produce psychological morbidity, especially among women and children [8]. A study focusing on the burden of obesity in the US has revealed that relative to normal-weight men and women,

overweight men and women lost 270,000 and 1.8 million quality adjusted life years in the year 2000, respectively. Obese men and women lost 1.9 million and 3.4 million quality-adjusted life years in the year 2000, respectively [4].

Several studies have reported that early childhood obesity predicts later obesity in adulthood; hence preventive measures should start early during childhood [9–12]. Studies have indicated that childhood obesity is associated with the development of noninsulin-dependent diabetes at an early age. In addition to adverse physical health, obese children are more likely to suffer mental health issues and psychosocial problems and even discrimination [8].

Since treatment and management of obesity is difficult and childhood obesity persists during adulthood, determining perinatal, and early childhood risk factors provides an avenue for early interventions. Several studies have assessed the factors that predict childhood obesity. Maternal prepregnancy BMI, weight gain during pregnancy, smoking during pregnancy, low socioeconomic status, birth weight, increased weight gain during early years, and poor home environment have been reported to predict early childhood obesity [2, 5, 7, 13–15]. However, most of studies in the United States have assessed the prepregnancy and early childhood risk factors among predominantly white populations [16, 17] largely ignoring the African-American and Hispanic populations [18–21]. We assessed maternal and early childhood risk factors for being obese at 5 years of age for a low-income predominantly African-American cohort.

2. Methods

2.1. Study Design and Population. Data for this study came from a longitudinal study of pregnancy outcomes and childhood psychomotor development at the age of 5 years. Details of population and measurements have been reported previously [22, 23]. The mothers of children were recruited from a population of low-income women seeking prenatal care through the public health system in Birmingham, Alabama from December 1985 to October 1988. In this population, <5% of the women breast-fed their infants and virtually all were eligible for the special supplemental program for women, infants, and children (WIC). Mothers were enrolled during early pregnancy and were followed through pregnancy until delivery. Their children were followed from birth until about 5 years of age.

2.2. Outcome. The primary outcome measure in this study was obesity among children at age 5 years. We developed the outcome variable by employing age- and sex-specific values of BMI using the Centers for Disease Control and Prevention's reference growth charts for children and the Expert Committee's recommendations about childhood obesity [24, 25]. Children whose age- and sex-specific BMIs were ≥95th percentile at 5 years of age were considered obese and those with BMIs ≥ 85 and <95th percentile were considered overweight [25].

2.3. Determinants. Main variables included maternal and family attributes collected at enrollment and during pregnancy and child characteristics at birth and in early childhood. Maternal data used in this analysis included information regarding sociodemographic characteristics including, age, race (black/white), years of schooling, total number of children in the family, total number of adults at home, employment status of mother, and whether the family received any kind of assistance from state or federal agencies such as WIC or food stamps. Information on mothers smoking status was also collected at each visit during pregnancy. Since there were more missing data from the 2nd and 3rd trimesters, we used 1st trimester smoking status as our indicator for smoking during pregnancy [26]. Maternal prepregnancy BMI was computed from the subject's reported prepregnancy weight, and height measured at first prenatal visit. Prepregnancy self reported weight was highly correlated with weight at enrollment in first prenatal visit ($r = 0.96$, $R^2 = 0.92$).

Quality of the home environment has been reported to be associated with obesity among children [27]. We measured the quality of home environment using Home Screening Questionnaire (HSQ). A score of 41 and greater reflects adequate home environment while less than 41 was considered less than adequate.

Length/height and weight was measured at birth, at age one year, and at age five years.

2.4. Statistical Analysis. We computed the mean for continuous variables and proportions for categorical variables to describe the distribution of the characteristics of study participants. We compared the independent variables using chi-square and cross-tabulation for categorical variables and t-test or ANOVA or nonparametric for continuous variables, whichever was appropriate.

Maternal prepregnancy BMI was categorized into low and normal (<18.5–24.9), overweight (25.0–29.9) and obese (≥30.0). Maternal smoking, measured as number of cigarettes smoked during the 1st trimester, was categorized into high-frequency smokers who smoked ≥13 cigarette per day (≥85th percentile), smokers with some degree of smoking (1–12 cigarettes per day), and nonsmokers. Age was categorized into <20 and ≥20 years, education into <12 grades and ≥12 grades, HSQ scores into <41 and ≥41, and the number of children at home was dichotomized at the median into ≤2 and >2. Birth weight was analyzed as a continuous variable and then categorized based on gestational age and race-specific percentiles for the United States population as ≤85th percentile and >85th percentile [28].

We computed risk ratios (RR) to estimate the association of risk factors with outcomes. Two approaches have been proposed to compute risk ratio in prospective studies with common outcomes; log binomial regression and poisson regression with robust variance estimation [15, 29]. When outcomes are common, the odds ratio provides inflated estimates of association. Sometimes log binomial regression models do not converge. We also experienced the same problem. Thus, we used poisson regression with robust variance

estimation to compute crude and adjusted RRs and 95% confidence intervals implemented through Proc GENMOD in SAS [30]. Interaction of prepregnancy BMI and birth weight was not significant. We also identified determinants of overweight using the same approach as outlined for obesity. We conducted all analyses using SAS version 9.2.

3. Results

We had data for 740 singleton births with the infants followed to an average age of 5.4 years. After exclusion of cases with missing information about the variables used in the analyses, data for 649 subjects were available that contributed to the final model. We compared the proportion of overweight children between participants included in final model and those who could not be included because of missing information. We found no significant differences between participants who were included in the final model (n = 65/649, 10.2%) versus those who were not included in the model (n = 6/91, 6.6%, P = 0.3).

3.1. Characteristics of the Study Sample. African-Americans constituted the majority of the sample (77%). Most of the births occurred at term (79%). The mean birth weight was 2892.6 ± 641.9 g with a median of 2845 g (range: 640–5175 g). The proportion of low birth weight (LBW) was 24% and 6.7% were above the 85th percentile of birth weights in the United States (Table 1). Mean age of the mother at the time of delivery was 24 years. Sixty-six percent of the mothers had at least a 12th grade education, 61% were employed, 34% were on wellfare, 17.5% were enrolled in WIC, and 59.2% received food stamps. The mean number of children at home was 2.7. The mean (SD) and median [range] prepregnancy BMI was 24.5(7.1) kg/m^2, 22.5 [13–50], and 17.8% of the mothers were obese (BMI ≥ 30) before pregnancy. The mean (SD) and median [range] number of cigarettes smoked during the 1st trimester were 5.4 (9.5) and 0 [0–63]; 61.4% did not smoke, and 15.3% smoked ≥13 cigarettes per day (Table 1).

3.2. Overweight and Obesity. At the 5th year of follow-up visit, 9.6% of the children were obese according to their age- and sex-specific BMI using the ≥95th percentile as the reference definition of obesity [24, 25]. At the same visit, 11.5% children were overweight (BMI ≥ 85th–<95th percentile) (Table 1).

Those children who had higher birth weight (P = 0.001) or higher weight at 1.2 years of age (P = 0.002) were more likely to be obese at the 5th year of followup. Girls were more likely to be obese than boys (60.1% versus 39.4%, P = 0.041). Obese mothers were 2.9 times more likely to have obese children (P < 0.001). Children of mothers who had <12th grade education were also more likely to be obese as compared to those who completed 12th grade (RR: 1.67, 95% CI: 0.99–2.83). Having two or less children at home was also associated with increased obesity (P = 0.007). Employment status of the mother, use of food stamps, WIC, maternal age, father's education, race/ethnicity, quality of home environment, and number of adults at home were not significantly associated with obesity (Table 2).

Multiple poisson regression models with robust variance estimation for risk factors associated with obesity revealed that children of mothers who were overweight (RR: 2.30, 95% CI: 1.29–4.11) or obese before pregnancy (RR: 2.53, 95% CI: 1.49–4.31) were more likely to be obese. Furthermore, children who were above the 85th percentile of birth weight were also more likely to be obese at age five (RR: 2.04, 95% CI: 1.13–3.68). Having two or less children at home (RR: 1.64, 95% CI: 1.01–2.64) and being a female child (RR: 1.67, 95% CI: 1.08–2.72) were also associated with being obese. Children of mothers smoking 1–12 cigarettes/day during the 1st trimester were more likely to be obese as compared to those who did not smoke (RR: 1.42, 95% CI: 0.88−2.30) while if mothers smoked ≥13 cigarettes their children were less likely to be obese (RR: 0.53, 95% CI: 0.22–1.27). Neither relationship was statistically significant (Table 3).

The multivariable model for determinants of being overweight at age 5 showed similar results (Table 4). In the model for childhood overweight, the mother being overweight or obese before pregnancy, birth weight >85th percentile, and mother smoking 1–12 cigarettes/day were each associated with being overweight. Children of mothers smoking 1–12 cigarettes/day during the 1st trimester were more likely to be overweight as compared to those who did not smoke (RR: 1.40, 95% CI: 1.02–1.91).

4. Discussion

In this study of a predominantly African-American population, we found that high prepregnancy BMI, high birth weight, fewer number of children at home, female sex of the child, and mothers smoking 1–12 cigarettes/day during the 1st trimester were associated with being both overweight and obese at age 5. Some of these factors such as maternal smoking and prepregnancy BMI are modifiable and can be the target of interventions. Others, like female gender and number of children at home, are not modifiable. Nonmodifiable factors stress the importance of understanding underlying processes and their cultural context that put individuals with certain attributes more at the risk of overweight. A recent analysis of data from the early child care and youth development longitudinal sample suggests that children with a BMI ≥ 85th percentile are more likely to gain weight and reach obese status as compared to those who remain below 50th percentile. Children who become obese at an early age are more likely to be obese during late childhood and adolescence [36]. Hence, prevention of pediatric obesity early on is important and may be achieved by recognizing and identifying obesity at an early stage and offering counseling and proactive treatment strategies.

Association of maternal prepregnancy BMI with pediatric obesity has been reported consistently in both retrospective and prospective cohorts [17, 27, 37]. A large retrospective cohort study in Ohio reported increased odds of childhood overweight with increasing maternal BMI during

Table 1: Characteristics of the participants and early childhood determinants of obesity at the age of 5 in Alabama ($n = 740$).

Variables	n	%	Mean	SD	Median [range]
Maternal characteristics					
Race					
Black	570	77.0			
White	170	23.0			
Mother age at delivery (years)					
Mean (SD)			24.0	(4.6)	23 [14–43]
<20	118	16.0			
20–29	534	72.2			
>29	88	11.89			
Mother's mean (SD) years of schooling			11.8	(2.2)	12 [0–18]
Mother completed 12th grade	487	66.2			
Employed, %	374	61.1			
Using food stamps, %	370	59.2			
On welfare, %	191	34.0			
Parity, mean (SD)			1.3	(0.8)	1 [0–9]
Prepregnancy BMI, mean (SD)			24.5	(7.1)	22.5 [13–50]
BMI groups					
Low (<18.5)	100	14.7			
Normal (18.5–24.9)	349	51.2			
Overweight (25–29.9)	111	16.3			
Obese (≥30)	121	17.8			
Number of cigarettes smoked during 1st trimester			5.4	(9.5)	0 [0–63]
0 cigarette	454	61.4			
1–12 cigarette (61–85th percentile)	179	24.2			
≥13 cigarette (>85th percentile)	107	15.3			
Alcohol intake during pregnancy, %	186	31.9			
Child characteristics					
Sex, % female	362	48.9			
Birth weight (grams)					
Mean (SD)			2892.6	(642.0)	2845 [640–5170]
<2500	176	23.8			
2500–2999	251	33.9			
3000–3900	285	38.5			
4000	28	3.8			
Above 85th percentile	50	6.7			
Preterm, %	149	20.1			
BMI at age 5 years					
Normal weight (<85th percentile)	584	78.9			
Overweight (85th to <95th)	85	11.5			
Obese (≥95th percentile)	71	9.6			

the first trimester of pregnancy [17]. Maternal prepregnancy BMI has also been reported as a risk factor for adiposity in African-American children in Philadelphia [18]. Many mechanisms have been proposed for maternal obesity leading to childhood obesity including inheritance of genes that enhance susceptibility, [13, 38] feeding and eating behaviors; obese mothers may have poor eating habits, which may negatively impact the intrauterine environment [39]. These findings emphasize the importance of childhood obesity prevention very early on or even before the start of pregnancy.

In this study, being a female child was associated with a higher risk of obesity. Among African-American children and adolescents, a higher proportion of females are obese [2, 6]. The findings from the National Health and Nutrition Examination Survey (NHANES), National Growth and Health Study (NGHS), and many other studies indicate that African-American girls have higher BMIs than white girls of similar ages [2, 40–42]. Cultural attitudes about body image among African-American communities indicate that African-Americans are relatively more tolerant of a large

Table 2: Crude risk ratio and 95% CI of prepregnancy and early childhood factors associated with being obese (≥95th percentile) at the age of 5.

Variable	Obese			P	RR	95% CI
	N	n	%			
Child characteristics						
Sex						
Male	378	28	7.4		1.00	
Female	362	43	11.9	0.041	1.60	(1.02–2.52)
Birth weight (Kg)*						
≤85th percentile	690	60	8.7		1.00	
>85th percentile	50	11	22.0	0.001	2.53	(1.42–4.50)
Gestational age						
Preterm	149	12	8.1		1.00	
Term	591	59	10.0	0.479	1.24	(0.68–2.25)
Maternal and family attributes						
Maternal prepregnancy BMI						
Normal and low (<24.9)	449	28	6.2		1.00	
Overweight (25–29.9)	111	16	14.4	0.005	2.31	(1.30–4.12)
Obese (≥30)	121	22	18.2	<0.001	2.92	(1.73–4.91)
Smoking during 1st trimester						
0 cigarette	454	43	9.5		1.00	
1–12 cigarette (61–85th percentile)	179	23	12.8	0.209	1.36	(0.84–2.18)
≥13 cigarette (>85th percentile)	107	5	4.7	0.125	0.49	(0.20–1.22)
Maternal education						
≥12th grade	239	17	7.1		1.00	
<12th grade	445	53	11.9	0.054	1.67	(0.99–2.83)
Maternal age (years)						
≥19	622	64	10.3		1.00	
<19	118	7	5.9	0.153	1.73	(0.82–3.69)
Race						
White	170	13	7.6		1.00	
Black	570	58	10.2	0.332	0.75	(0.42–1.34)
Number of children at home						
≤2	353	45	12.7	0.007	1.88	(1.19–2.98)
>2	384	26	6.8		1.00	
Number of adults at home						
1	304	27	8.9		1.00	
2	324	31	9.6	0.776	1.08	(0.66–1.76)
≥3	109	13	11.9	0.354	1.34	(0.72–2.51)
Home screening questionnaire score						
Adequate (>41)	160	18	11.3		1.00	
Less than adequate (≤41)	580	53	9.1	0.65	1.23	(0.74–2.04)
Self-employed						
Yes	374	40	10.7		1.00	
No	238	20	8.4	0.354	0.79	(0.47–1.31)
Food stamp						
No	255	26	10.2		1.00	
Yes	370	30	8.1	0.37	0.8	(0.48–1.31)
WIC						
No	443	41	9.3		1.00	
Yes	94	11	11.7	0.464	1.26	(0.68–2.37)
Alcohol intake during pregnancy						
No	398	47	11.8		1.00	
Yes	186	18	9.7	0.448	0.82	(0.49–1.37)

CI: confidence interval, RR: risk ratio; *based on gestational age and race specific birth weight percentiles for US population.

Table 3: Multivariable model showing adjusted risk ratio for maternal and early childhood determinants of obesity (≥95th percentile) at the age of 5 in Alabama $n = 678$*.

Variables	Adjusted RR* (95% CI)	P
Maternal prepregnancy BMI		
Normal and low (<24.9)	1.00	
Overweight (25–29.9)	2.3 (1.29–4.11)	0.005
Obese (>30)	2.53 (1.49–4.31)	<0.001
Birth weight (Kg)†		
≤85th percentile	1.00	
>85th percentile	2.04 (1.13–3.68)	0.018
Number of children at home		
≤2 (<median)	1.64 (1.01–2.64)	0.043
>2 (≥median)	1.00	
Sex		
Male	1.00	
Female	1.67 (1.05–2.66)	0.031
Smoking during 1st trimester‡		
0 cigarette	1.00	
1–12 cigarette (61–85th percentile)	1.42 (0.88–2.3)	0.152
≥13 cigarette (>85th percentile)	0.53 (0.22–1.27)	0.154

CI: confidence interval.
*Adjusted risk ratio computed using poisson regression model with robust variance estimation.
†Based on gestational age and race specific birth weight percentiles for US population.
‡Cigarettes smoked per day.

Table 4: Multivariable model showing adjusted risk ratio for maternal and early childhood determinants of overweight (85th to <95th percentile) at the age of 5 in Alabama $n = 681$*.

Variables	Adjusted RR* (95% CI)	P
Maternal prepregnancy BMI		
Normal and low (<24.9)	1.00	
Overweight (25–29.9)	1.9 (1.34–2.7)	<0.001
Obese (>30)	1.88 (1.33–2.65)	<0.001
Birth weight (Kg)		
≤85th percentile		
>85th percentile	1.94 (1.33–2.83)	<0.001
Sex		
Male	1.00	
Female	1.27 (0.96–1.7)	0.099
Smoking during 1st trimester‡		
0 cigarette	1.00	
1–12 cigarette (61–85th percentile)	1.40 (1.02–1.91)	0.035
≥13 cigarette (>85th percentile)	0.98 (0.63–1.54)	0.937

CI: confidence interval.
*Adjusted risk ratio computed using poisson regression model with robust variance estimation.
†Based on gestational age and race specific birth weight percentiles for US population.
‡Cigarettes smoked per day.

body size [43]. It is believed that African-American men prefer the women to have a fuller figure [44]. However, among younger African-American children, a higher prevalence of obesity among females suggests that both biological as well as behavioral mechanisms are in play. If the behavioral mechanism of social acceptance of a fuller body size (imposed by parents/caregivers) plays an early role, it can explain the higher likelihood of obesity among Afri-can-American girls. How body size perceptions play into childhood obesity at age 5 when children may not have any strong perception about their body image, and whether parents' perception of their female child's fuller body size also translates into obesity among girls, needs to be investigated.

An association between birth weight and obesity during childhood has been reported, but results have been inconsistent [17, 18, 37, 45, 46]. In our study, this association was significant in the presence of other factors such as the number of children at home, prepregnancy BMI, and child gender. High birth weight helps to identify children who will be at a higher risk of obesity and thus provides an opportunity for modifying their feeding and eating behaviors and controlling weight gain from an early stage.

Having fewer children at home was also associated with obesity among children. If there are fewer children at home, they usually receive more attention and hence parents may indulge in overfeeding. Overfeeding children has been reported in African-Americans with parental perception of the child being thin [21, 47]. A previous study in an African American population has also reported that the first born child was at a higher risk of becoming overweight [18]. Other studies have also reported that being a first born child and having fewer children at home were risk factors for childhood obesity [17, 48].

In our study, smoking 1–12 cigarettes per day in the first trimester increased the risk of overweight and obesity among children compared to children of mothers who did not smoke. Many studies—including a meta-analysis—have reported that children exposed to smoking during pregnancy are more likely to become overweight at age 5 or later [17, 20, 21, 33, 37, 49–52]. Suggested mechanisms include the biological effect of smoking, priming the developing brain to later obesity, or an unhealthy postnatal home environment [53–56]. Animal models also indicate an obesogenic effect of smoking during pregnancy [57, 58]. Prenatal nicotine exposure reduces birth weight, but the offspring become heavier later in life [57, 58]. In our study, a higher frequency of smoking was not associated with increased risk. This finding is in agreement with the biologic hypothesis and epidemiologic data suggesting that early growth retardation is associated with later obesity [55, 56, 59–62]. However, the age at which the shift from growth restriction to overweight/obesity happens by dose of smoking (duration/frequency) is not consistent across studies. This may be related to methodological differences or difference in other pre-/postnatal exposures (genetic/environmental) across studies. In summary, our

results indicate that smoking during pregnancy is associated with increased risk of obesity or overweight at age 5. Hence, reduction or elimination of smoking during pregnancy could promote healthy weight among children.

Association of lower socioeconomic status with overweight has been reported by various studies of white populations. However, limited studies of African-American population did not find any positive association of lower socioeconomic status and obesity [18, 48].

Previous studies have computed odds ratios as a proxy for risk ratio for evaluating the strength of association between risk factors and overweight among children. When the outcome occurrence is common such as obesity/overweight (incidence > 10%), odds ratios do not approximate risk ratio [63]. Furthermore, odds ratios are commonly but wrongly interpreted as risk ratio [14]. Hence, it is suggested that risk ratio is a more desirable measure of effect in prospective investigations [63]. A unique strength of the study was its prospective data collection that reduced the possibility of selection and recall bias. Anthropometric measurements were performed under standardized measurement protocol.

Smoking was based on self-report and it has been suggested that women tend to underreport the number of cigarettes they smoke during pregnancy, leading to misclassification of those who indulge in low-intensity smoking to nonsmoker or very-low-degree smoking categories [64]. If this misclassification occurred, this may have led to an underestimation of effect. In such circumstances, true risk will be higher than currently reported in the study. However, studies have reported that self-reporting of smoking during pregnancy has shown reasonable validity [65]. Information was missing for some variables at later followup, thus preventing utilization of the entire sample. However, there was no difference in outcome between those who contributed data in the final model and those who did not. In this study, we did not have enough power to assess differentials in overweight and obesity by race.

5. Conclusion

Children of overweight and obese mothers, and those with higher birth weights, are more likely to be overweight at age 5. Girls are at a higher risk of being overweight at age 5. Further investigation of the caregiver/parental perception of a larger body size being more socially desirable and the eating/feeding behaviors of parents can provide valuable information about biological versus environmental origins of overweight among girls. The association of high prepregnancy BMI and obesity substantiates earlier findings and indicates that interventions directed at prevention of childhood obesity should come into play early on, targeting prepregnancy BMI. Smoking 1–12 cigarettes per day during the first trimester was associated with increased risk of childhood overweight and obesity, while high frequency of smoking ($\geq$13 cigarettes/day) was not associated with increased obesity. Whether it is the unhealthy diet behavior of parents who smoke or fetal programming due to exposure *in utero*, needs to be investigated further.

Conflict of Interests

The authors declare that they have no conflict of interests.

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