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Social Inequality

Contribution of discretionary food and drink consumption to socio-economic inequalities in children's weight: prospective study of Australian children

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Abstract

Background: In high-income countries, children with a lower socio-economic position (SEP) are more likely to gain excess weight compared with children with a higher SEP. The extent to which children's consumption of discretionary food and drinks contributes to the development of these inequalities over childhood has not been examined.

Methods: The study sample comprised 3190 children from the nationally representative Longitudinal Study of Australian Children. Linear and logistic regression models were fitted in accordance with the product of coefficients mediation method to determine the contribution of cumulative consumption of sweet drinks, discretionary hot foods, savoury snacks and sweet snacks from the first year of life, over a period of 10 years, on the relationship between SEP and children's body mass index (BMI) z-score at age 10–11 years.

Results: At age 10–11, mean BMI z-score was 0.17 in the highest SEP tertile, 0.33 in the middle and 0.47 in the lowest tertile. Corresponding values for overweight and obesity prevalence were 16.6%, 25.7% and 32.7%, respectively. Eleven per cent [95% confidence interval (CI) 4.77%, 19.84%] of the observed difference in BMI z-score at age 10–11 years was mediated by socio-economic differences in consumption of sweet drinks and discretionary hot foods including pies and hot chips throughout childhood.

Conclusions: Findings indicate that consumption of sweet drinks and discretionary hot food, from the first year of life, is likely to contribute to the development of inequalities in excess weight among children. Poor dietary intake is a key risk factor for excess weight gain among children and a reduction in discretionary food and drinks is likely to contribute to the dual goal of improving overall weight and reducing socio-economic inequalities in weight gain across childhood. To maximally reduce inequalities in weight gain across childhood, additional determinants must also be identified and targeted.

Key words: child, overweight, obesity, health inequalities, mediation

Key Messages

- Weight gain among children in Australia follows a socio-economic gradient whereby those with lower socio-economic position (SEP) have higher BMI z-scores at age 10–11 years compared with children with higher SEP.
- Socio-economic differences in the consumption of discretionary food and drinks emerge at a young age and persist throughout childhood.
- Discretionary food and drink consumption from the first year of life appears to contribute to the development of inequalities in excess weight among Australian children.

Introduction

In high-income countries, children from lower socio-economic backgrounds are more likely to be overweight or obese compared with children with greater social and economic resources.[1] In Australia, 33% of children living in the most disadvantaged areas are overweight or obese, compared with 19% of children living in the least disadvantaged neighbourhoods.[2]

Dietary behaviours follow similar socio-economic gradients. Among children and adolescents, higher socio-economic position (SEP) is associated with healthier dietary patterns[3,4] and better diet quality.[5] In particular, children with higher SEP are more likely to consume and achieve recommended intakes of fruit and vegetables.[6–11]

Discretionary food and drinks can be defined as food and drinks containing added fat, sugar and/or salt and are considered not necessary for a healthy diet.[12] Despite recommendations to limit consumption,[12] they have been found to contribute up to 40% of Australian children's total daily energy intake.[2,13] Children with lower SEP are more likely to consume discretionary food and drinks such as sugar-sweetened beverages (SSBs),[6,10,11,13,14] fruit juice,[7] snack foods[11] and fast food.[10,15] This is concerning because poor diet quality, including consumption of sweet drinks and unhealthy snack foods in childhood, is considered a key risk factor for overweight and obesity.[16–18] Whilst many aspects of diet are important, given their lack of nutritional value and high contribution to children's daily energy intake, discretionary food and drinks are an important policy target.

Whilst there is evidence of socio-economic differences both in children's weight and diet quality, there has been no formal examination of the mediating role of discretionary food and beverages in the development of socio-economic inequalities in children's weight from birth. Identifying the mechanisms by which socio-economic inequalities in weight gain develop across the life course can highlight leverage points for intervention that are both effective and equitable. This is critical, as inequalities in weight translate into inequalities in health.[19]

Using data from the Longitudinal Study of Australian Children (LSAC), this study explored the mediating role of cumulative discretionary food drink consumption during childhood (from age 0–1 year, collected every 2 years) on the development of socio-economic inequalities in weight gain from birth to age 10–11 years.

Methods

Ethics

The LSAC study protocol was approved by the Australian Institute of Family Studies Ethics Committee. Written consent was provided for each participant. This analysis was approved by Deakin University Human Research Ethics Committee (Reference 2016–161) and Monash University Human Research Ethics Committee (Project Number CF14/2574–2014001384).

Study design and sample

LSAC is a nationally representative prospective study following two cohorts of Australian children since 2004[20] (Table 1). Our study comprised participants from the B cohort of LSAC into which 5107 participants were recruited. Our eligible sample included the 3764 children in the B

Table 1. Longitudinal Study of Australian Children (LSAC) study waves

Year	2004	2006	2008	2010	2012	2014
Study wave	1	2	3	4	5	6
B cohort (age in years)	0–1	2–3	4–5	6–7	8–9	10–11
K cohort (age in years)	4–5	6–7	8–9	10–11	12–13	14–15

cohort present at Wave 6 (74%). We excluded participants with missing data for SEP at Wave 1 ($n = 8$), BMI z-score at Wave 6 ($n = 201$), dietary variables of interest at Waves 1, 2, 3, 4 or 5 ($n = 337$) and relevant confounding variables (n=28), resulting in a final analytical sample of 3190 participants. The proportion of participants with missing data was less than 10% for variables included in our analysis. (Further study design details are provided in Supplement A, available as Supplementary Data at *IJE* online.)

Data collection

Data were collected via structured interviews conducted by trained professionals and written questionnaires completed by the child's primary caregiver (typically the child's mother).

Socio-economic position (exposure)

A composite measure of SEP was generated for the LSAC cohort to provide a continuous relative SEP score. The score comprised measures of parents' annual income; years of education of each parent; and the occupational status of each parent, accounting for the number of parents in the home.[21] To capture SEP around the time when discretionary food and drinks are first introduced, we used the SEP score generated at the first wave of data collection to create deciles of SEP, which were used as a continuous measure of SEP in our mediation analysis. From the composite SEP score, we also generated tertiles of SEP, which were used to describe population characteristics according to higher, middle and lower SEP.

Anthropometry (outcome)

Trained professionals measured children's weight to the nearest 50 grams and height to the nearest 0.1 centimetre. From this, BMI (kg/m^2) was calculated and converted into continuous age- and sex-specific BMI z-scores.[22] Overweight and obesity were classified according to International Obesity Taskforce cutoffs.[23]

Diet (mediators)

In face-to-face interviews, parents were asked about their child's consumption of specific food items in the previous 24-hour period. The interviewer asked: 'In the last 24 hours how often did child have (*specified food or drink*)' and response options were 'not at all' (0); 'once' (1); 'more than once' (2). Questions on consumption of sweet drinks were asked from Wave 1 (age 0–1 year) onwards and questions about discretionary foods were asked from Wave 2 (age 2–3 years) onwards. Our analysis examined all available discretionary food and drink variables that we grouped into four categories: sweet drinks, discretionary hot food, savoury snacks and sweet snacks (Table 2).

For our descriptive analysis, participants were identified as 'non-consumers' (answered 'not at all') or 'consumers' (answered 'once' or 'more than once') for consumption in the past 24 hours of any of the food or drink items listed within each discretionary food and drink category, for each survey wave. For mediation analyses, these dichotomous responses were summed across each survey wave, for each discretionary food and drink category, so that each participant was classified as an overall high consumer (consumed discretionary food at $\geq$2 waves or sweet drinks at $\geq$3 or waves) or low consumer (consumed discretionary food at $\leq$1 wave or sweet drinks at $\leq$2 waves) (Table 2).

Covariates

Covariates were identified based on prior evidence of their influence on the relationships examined in our analyses. At the first survey wave, parents reported their child's sex, weight at birth and age in months. Parents reported their child's preference for active or inactive use of free time at each survey wave from age 2–3 years onwards by responding to the question: 'What does Child usually do when she/he has a choice about how to spend free time? Usually chooses inactive pastimes like TV, computer, drawing or reading; just as likely to choose active as inactive pastimes; usually chooses active pastimes like bike riding, dancing, games or sports.' Mother's age in years was self-reported. Parents reported whether their child was of Aboriginal or Torres Strait Islander (ATSI) origin. Mother's main language was determined by the question: 'Does Mother speak a language other than English at home?'

Descriptive analysis

Descriptive statistics examined key demographic (Wave 1) and behavioural characteristics (Waves 1–6) of our analytical population, according to tertile of SEP (Wave 1). Logistic regression models were fitted to examine socioeconomic differences in the prevalence of overweight and obesity at Wave 6 (age 10–11 years), adjusted for child's age, sex, birthweight, mother's age, English as main language and ATSI origin.

Longitudinal mediation analysis

To determine the mediating effect of cumulative discretionary food and drink consumption throughout childhood on the relationship between SEP and BMI z-score at age 10–11 years, we fitted a series of regression models in accordance with the product of coefficients mediation method. A mediator must be associated with SEP (a-relationship) and be associated with BMI z-score at age 10–11 years independently of each other mediator, SEP and

Table 2. Classification of discretionary food and drink categories for mediation analysis

Discretionary food or drink category	Constituents	Data waves used	Low/high consumer cut-points
Sweet drinks	Fruit juice	1, 2, 3, 4, 5	≤2 waves = low consumer
	Soft drink		≥3 waves = high consumer
	Cordial		
Discretionary hot food	Meat pies	2, 3, 4, 5	≤1 wave = low consumer
	Hamburgers		≥2 waves = high consumer
	Sausage rolls		
	Hot dogs		
	Sausages		
	Hot chips		
	French fries		
Savoury snacks	Potato chips	2, 3, 4, 5	≤1 wave = low consumer
	Savoury snacks, i.e. Twisties etc.		≥2 waves = high consumer
Sweet snacks	Biscuits	2, 3, 4, 5	≤1 waves = low consumer
	Doughnuts		≥2 waves = high consumer
	Cake		
	Pie		
	Chocolate		

potential confounders (b-relationship). The proportion mediated (for each individual mediator and for all significant mediators combined) was determined by dividing the indirect effect by the total effect coefficients. We used a bootstrap with 5000 replications to obtain 95% confidence intervals (CIs) for all coefficients and mediated proportions. All models were adjusted for Wave 1 covariates including child's age, sex, birth weight, mother's age, English as main language, ATSI origin and child's preference for active or inactive pastimes at Waves 2–5. A heuristic model of the longitudinal mediation analysis is depicted in Figure 1. (The multiple steps undertaken are outlined in Supplement B, available as Supplementary Data at *IJE* online.)

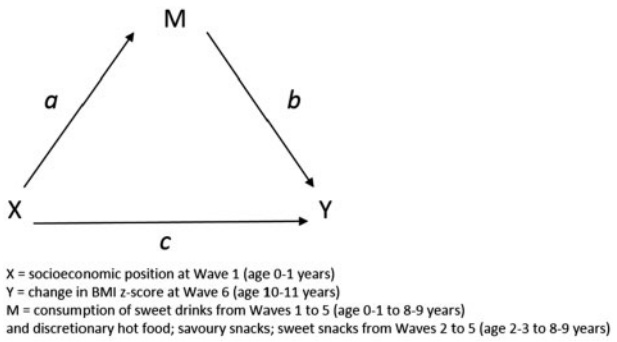

Figure 1. Heuristic model for longitudinal mediation analysis.

Sensitivity analysis

We tested whether our analyses were sensitive to non-response and attrition by applying LSAC sample weights to our descriptive analyses and regression models.[24] We also tested sensitivity of our exposure and outcome indicators in separate models using mother's education at Wave 1 and SEP at Wave 6 as exposures and overweight and obesity at Wave 6 as the outcome.

All analyses were conducted using Stata version 14.[25]

Results

Descriptive analysis

Socio-economic patterning was observed for a number of key characteristics. Weight at birth, birthweight z-score and maternal age increased with increasing SEP. The proportion of ATSI children and child's BMI z-score at age 10–11 years decreased as SEP increased. The proportion of families with mothers who spoke a language other than English was higher among those in the low and high SEP tertiles (Table 3). The proportion of overweight and obesity was lower for each increase in tertile of SEP at each study wave (Figure 2). The consumption of sweet drinks, discretionary hot food and savoury snacks was greater among children with lower SEP across all study waves (Figure 3).

Longitudinal mediation analysis

Of the four potential mediating categories of discretionary food and drinks examined in our study, sweet drinks and discretionary hot food were associated with both exposure (SEP) and outcome (BMI z-score at age 10–11 years). Consumption of sweet drinks from age 0–1 to 8–9 years mediated 5.9% of the relationship between SEP and BMI z-score at age 10–11 years, and consumption of

Table 3. Population characteristics according to tertile of socio-economic position

	Lower SEP	Middle SEP	Higher SEP
n =	808 (25.3%)	1096 (34.4%)	1286 (40.3%)
Baseline			
Sex (% male)	49.9%	50.6%	52.9%
Age (months)	8.6 (2.5)	8.6 (2.6)	8.9 (2.5)
Weight at birth (grams)	3387.1 (638)	3413.4 (583.9)	3475.5 (546.7)
Birth weight z-score	–0.05 (1.1)	–0.03 (1.0)	0.07 (1.0)
Maternal age (years)	29.9 (5.8)	31.6 (4.7)	33.2 (4.0)
Aboriginal or Torres Strait Islander	5.2%	2.3%	0.6%
English as Mother's main language spoken at home	88.6%	90.1%	88.1%
Wave 6			
BMI z-score (age 10–11 years)	0.47 (1.1)	0.33 (1.0)	0.17 (0.9)

Figures in table are means and standard deviations or proportions. SEP, socio-economic position; BMI, body mass index.

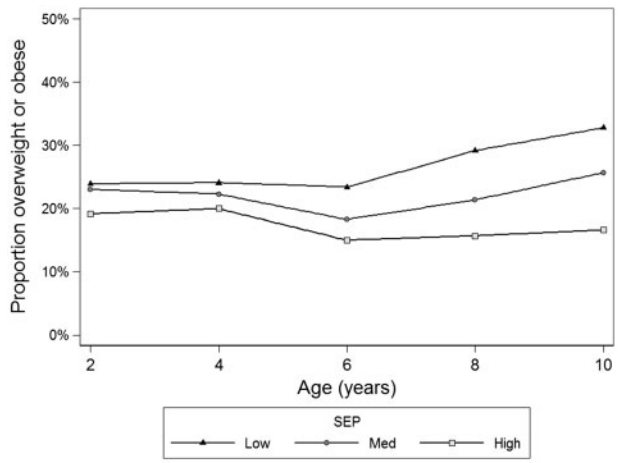

Figure 2. Prevalence of overweight and obesity according to tertile of socioeconomic position (SEP) at each LSAC survey wave.

discretionary hot food between ages 2–3 and 8–9 years mediated 5.4% of the relationship between SEP and BMI z-score at age 10–11 years. Collectively, the intake of these discretionary items across childhood mediated 11.31% (95% CI 4.77%, 19.84%) of the socio-economic differences in BMI z-score at age 10–11 years (Table 4).

Sensitivity analysis

The relationships between SEP and all mediators and between mediators and BMI z-score did not appreciably differ after applying LSAC sample weights (Supplement C, available as Supplementary Data at *IJE* online). Using mother's education (Supplement D, available as Supplementary Data at *IJE* online) and SEP at Wave 6 (Supplement E, available as Supplementary Data at *IJE* online) as the exposures and overweight and obesity as the outcome (Supplement F, available as Supplementary Data at *IJE* online), results were not appreciably different to the primary analysis.

Discussion

This is the first study, to our knowledge, to estimate the mediating effect of specific discretionary food and drink items on the development of socio-economic inequalities in children's weight. Using a contemporary sample of Australian children, followed up every 2 years between birth and age 10–11 years, we found distinct socio-economic differences in the development of overweight and obesity, which increased as SEP decreased. Similar socio-economic differences in the consumption of discretionary food and drinks emerged at a young age and persisted throughout childhood. Childhood consumption of sweet drinks and discretionary hot food was associated with a greater gain in BMI z-score from birth to age 10–11 years. Cumulative consumption of sweet drinks from age 0–1 year and discretionary hot food from age 2–3 years mediated just over 11% (95% CI 4.77%, 19.84%) of the longitudinal relationship between SEP and BMI z-score from birth to age 10–11 years.

Our analysis found that SEP was positively associated with birthweight z-scores, but this association shifted to an inverse association by age 2–3 years, which remained throughout childhood. Other research has also identified this shift in socio-economic patterning from a positive SEP-weight relationship at birth to an inverse relationship in later childhood, commonly reported to occur around the ages of 5–7 years.[24,26]

Our findings of socio-economic differences in adiposity among children are comparable to the observed socio-economic differences in weight among children in LSAC's kindergarten cohort.[27] Similar socio-economic inequalities in children's weight have been reported in a number of high-income countries in recent years.[28,29]

Consumption of discretionary foods appears to begin at an early age, with sweet drink consumption evident among almost half of 0- to 1-year-old children in the lowest tertile

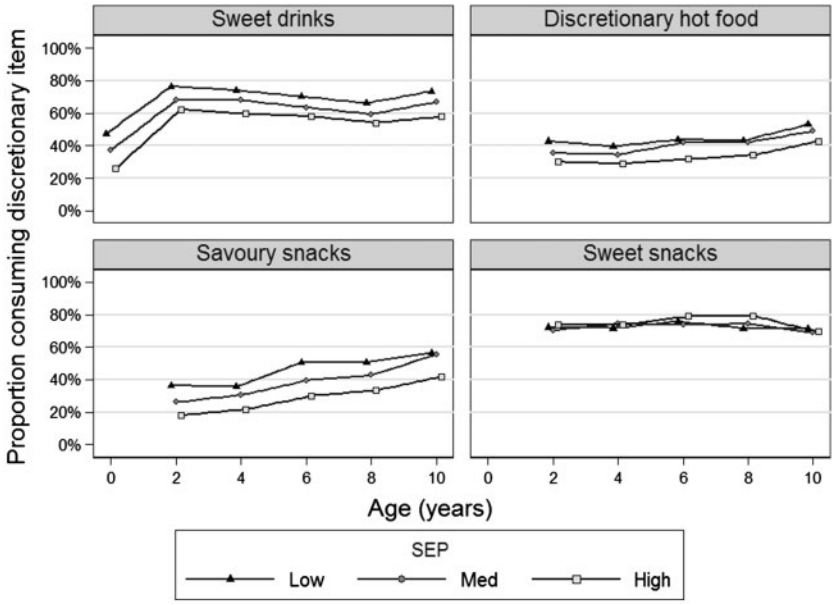

Figure 3. Consumption (once or more) of discretionary food and drinks in the 24-hours prior to survey. Results presented for each LSAC survey wave according to tertile of socioeconomic position (SEP).

Table 4. Results from mediation analysis examining the contribution of discretionary food and drink consumption across childhood on the development of socio-economic differences in BMI z-score from birth to age 10–11 years

	Association between SEP and mediator		Association between mediator and BMI z-score		Mediated effect[b]		Proportion mediated	
	a[a]	95% CI	*b*[a]	95%CI	*ab*	95% CI	%	95% CI
Sweet drinks	–0.14	(–0.17, –0.11)	0.09	(0.01, 0.16)	–0.008	(–0.016, –0.001)	5.94%	(0.89%, 12.45%)
Discretionary hot food	–0.12	(–0.15, –0.09)	0.09	(0.01, 0.16)	–0.007	(–0.014, –0.001)	5.37%	(0.77%, 10.96%)
Savoury snacks	–0.15	(–0.18, –0.12)	–0.05	(–0.12, 0.03)	0.005	(–0.003, 0.013)		
Sweet snacks	0.02	(–0.02, 0.07)	0.06	(–0.06, 0.17)	0.001	(–0.001, 0.003)		
Sum of significant mediators					–0.016	(–0.025, –0.007)	11.31%	(4.77%, 19.84%)

[a]a coefficient adjusted for all confounders (child's age, sex and birth weight, mother's age, ATSI origin and English as mother's main language at home and child's preference for active or inactive pastimes as reported by parents at each wave from age 2–3 to 8–9 years); b coefficient adjusted for all confounders, the exposure (SEP), and all other mediating variables.

[b]Standardized ab coefficients.

of SEP in our sample. We identified socio-economic gradients in the cumulative intake of discretionary food and drink items including sweet drinks, discretionary hot food and savoury snacks throughout childhood. Similar socio-economic patterning in the consumption of sweet drinks and high-sugar, high-fat foods has been observed among children in a number of other high-income countries.[30,31]

We observed a positive association between childhood consumption of sweet drinks and BMI z-score at age 10–11 years. This is consistent with international findings from cross-sectional and longitudinal research indicating that consumption of sweet drinks, including fruit juice, in early childhood is associated with excess weight gain.[32–34] We also observed associations between consumption of discretionary hot food across childhood and higher BMI z-score, but found no association between consumption of sweet and savoury snacks and BMI z-score. The lack of association between consumption of sweet snacks and BMI z-score may be due to the limited variability in consumption, with high prevalence observed among all children. For savoury snacks, the lack of association with BMI z-score may be due to differential reporting bias according to children's weight status; the relatively crude manner in which these items were reported, with little detail regarding quantities consumed; or a true lack of effect.

Our findings showed that cumulative consumption of sweet drinks and discretionary hot foods throughout childhood mediates around 11% of the socio-economic differences in children's BMI z-score at age 10–11 years. Sweet drinks and discretionary hot foods were related to both

children's weight gain and to inequalities in the development of BMI from birth to age 10–11 years. Thus, interventions that reduce intake of these items may contribute to the dual outcome of reduced population weight for children and reduced inequalities in excess weight gain across childhood. Whilst sweet snacks was not identified as a mediator, it was consumed in high quantities by all children, regardless of SEP, and should be considered a target in interventions to improve children's diets across the socio-economic gradient. Our analysis also highlights the critical need to identify and target additional determinants of inequalities in weight gain across childhood.

Additional determinants that may contribute to the development of socio-economic inequalities in children's BMI z-scores include perinatal factors, including maternal weight and diet during pregnancy, commencement and duration of breastfeeding and complementary feeding;[35] behavioural factors in childhood such as overall diet and total energy intake, physical activity, sedentary behaviour and sleep; and more upstream determinants including neighbourhood environments[36] and social and cultural norms.[37,38] A reduction in children's consumption of discretionary food and drinks is therefore an important target for preventive health policy alongside complementary actions to address the range of determinants of socio-economic inequalities in children's weight.

Strengths of this study include six waves of data collected over 10 years, allowing examination of the role of cumulative discretionary food intake on socio-economic inequalities in weight gain from birth to age 10–11. Our study utilized a robust measure of SEP measured at Wave 1, which tracked across study waves with 70% of participants remaining in the same SEP tertile at Wave 6. Our study was further strengthened by objectively measured anthropometric data.

The study also has a number of limitations to note. First, whereas the initial study population was representative of Australian children, non-response across LSAC waves was higher for children whose parents were low-income earners, of ATSI origin or spoke a language other than English as the main language at home. However, sensitivity analyses accounting for LSAC non-response yielded similar results. Second, discretionary food intake was self-reported. Self-reported dietary data can be imprecise and susceptible to underreporting.[39] The extent of differential underreporting according to SEP, e.g. due to social desirability bias, is unclear. Third, information for many discretionary food and drink items were not captured and, of those that were, we had information on frequency of consumption only. Ideally, dietary data would be obtained using data-collection methods validated for use in children[40] and provide greater detail on total dietary intake, including quantities consumed. Fourth, whilst the data used in our study were the most contemporary data available for this age group, earlier waves of data were collected prior to the mounting public awareness of the harms of SSBs and may not fully reflect current perceptions or consumption of sweet drinks. Finally, the measure of physical activity in LSAC is relatively crude, reporting children's preferences for time spent in active or inactive pastimes. The differential attrition, self-reported dietary data and limited dietary detail may mean that the results in this study are underestimates of the true effect of impact of discretionary food and drink consumption on the development of inequalities in children's weight. Our findings demonstrate that intake of discretionary hot foods and sweet drinks throughout childhood contributes to the development of socio-economic differences in childhood weight gain. These findings may be generalizable across high-income countries where similar socio-economic gradients in overweight and obesity are evident. Reducing inequalities in discretionary food and drink consumption among children in high-income countries will require a combination of interventions, which act across the gradient of socio-economic disadvantage. This will likely include interventions that change the structural drivers of unhealthy food and drink intake and a combination of population level and targeted interventions towards more socio-economically disadvantaged groups.[41,42] Evaluation of interventions and ongoing population health monitoring will be critical to our understanding of the impacts of population level and targeted interventions across the socio-economic gradient. Further research is also required to improve understanding of the role of other important modifiable obesity-related risk factors on socio-economic differences in children's weight.

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