



Association between household poverty dynamics and childhood overweight risk and health behaviours in the United States: a 8-year nationally representative longitudinal study of 16 800 children

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Summary

Background: No study has examined how the pattern of income dynamics influences both of children's body mass index (BMI) trajectory and health behaviours.

Objectives: To examine the association between household poverty dynamics and childhood overweight risk in the USA.

Methods: Using the longitudinal data of 16 800 children (from kindergarten to the 8th grade) in the nationally representative US cohort-Early Childhood Longitudinal Study, Kindergarten Class 1998–1999, we examined the differences in BMI trajectory, weight-related health behaviours and risk of overweight in association with household poverty dynamics during follow-up (never [no experience of poverty], transient [once], recurrent [≥ 2 times] and persistent poor [remained]) using mixed models with fractional polynomial functions and estimating equation models.

Results: Overall, children experiencing poverty were more likely to have adverse BMI growth trajectory and eating and sedentary behaviours compared with the never poor. The recurrently poor children (12.8%) had the fastest BMI trajectory, highest overweight/obesity prevalence from 5 to 16 years old and highest proportion of excessive soda/fast food consumption and irregular exercise at 8th grade than did others ($p < 0.05$). The persistently poor (8.4%) were the lowest in BMI growth trajectory but became the second highest in childhood obesity through a steady increase in BMI over time. Children in the recurrently poor group had a 1.5 times (95% CI = 1.0–2.2) higher risk of overweight than those having never experienced poverty during follow-up.

Conclusions: The experience of recurrent household poverty had a significant association with children's adverse eating behaviours and increased obesity risk subsequently.

Keywords: Child, household income, obesity, poverty.

Introduction

The relationship between socio-economic status (SES) and obesity is complex, varies by population groups and may change over time (1–3). Family SES is viewed as a major risk factor for childhood obesity (4–7). Children from low-socio-economic households had a three to four times higher odds of obesity than children from higher socio-economic households (8). The magnitude of the socio-economic disparities in overweight/obesity prevalence increased between 2003 and 2007, with

substantial social inequalities persisting even after controlling for behavioural factors (8).

For offspring during the years of childhood, the economic conditions of their families can be more dynamic than their parents' educational achievements. Experiencing poverty during childhood has especially shown its associations with a wide variety of children's health outcomes, as well as with their occupational and educational achievements, according to findings from cross-sectional studies (2,9). A few longitudinal studies suggested the associations between income dynamics and children's risk of obesity. One study

found that children whose families had moved into low-income status during their childhood had a 2.4 times higher odds of being adolescents with obesity than children who had never experienced low income (10). Also, an increase in family income over a 4-year period was associated with a significant decrease in body mass index (BMI) Z-scores among girls (11).

However, variable definitions of household income and statistical modelling approaches for classifying income dynamics have impeded consistent findings in the association with children's obesity risk in previous studies (12,13). No study has examined how the pattern of income dynamics influences both of children's BMI trajectory and health behaviours.

Utilizing federal poverty thresholds and rigorous statistical methods, this study aimed to better understand the impact of household SES dynamics on child health behaviours and overweight/obesity risk from early childhood to adolescence. The findings may provide further insight about the vulnerable health needs of children and how to support them during times of economic challenge.

Methods

Study design and study sample

We used data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K 1998–1999), which followed a nationally representative sample of kindergarteners from diverse socioeconomic and ethnic backgrounds in the US to 8th grade. The present study included children with complete data on sex, ethnicity, height and weight (measured at least once during follow-up), and household poverty status (reported at least once during follow-up); the final sample size in this analysis was 16 800. All reported numbers about the sample size were rounded to the nearest 10 due to the confidentiality policy of the US Department of Education.

Assessment and measures

Household poverty dynamics

The Early Childhood Longitudinal Study, Kindergarten Class 1998–1999 data provide a composite variable indicating whether the child lived in households with an income below, at, or above the federal poverty threshold during follow-up (14). Household poverty dynamics were classified as never poor; the transient poor (household became poor only once during follow-up); the recurrent poor (household became poor more than once) and the persistent poor (household was poor for four consecutive waves during follow-up), corresponding to classifications in previous

literature (10,12). Additional analysis was done by excluding those who had only a one-time observation of household poverty status during follow-up ($n = 3460$; 17.3% of the never poor and 59.9% of the persistent poor) to examine whether including a one-time poverty report may result in a different association between poverty dynamics and childhood obesity risk.

Child weight status

Child height and weight were measured twice by trained test administrators during the direct child assessments of the ECLS following the standardized protocol (14). More than 90% of ECLS-K participants had ≥ 1 times of repeated height and weight measurements, and the missing rates of anthropometric measurements remained relatively low across follow-up waves. Children's BMI was obtained as a composite variable of the ECLS. We defined child BMI Z-score by age-specific and sex-specific BMI percentiles in the 2000 US CDC Growth Charts; overweight was defined as \geq the 85th BMI percentile (15).

Child health behaviours

Soda/fast food consumption. The ECLS-K asked about the frequency of eating a meal or snack from a fast food restaurant and drinking soda pop, sports drinks or fruit drinks in the past week using a 7-point scale. The answers were converted into daily frequencies of consumption: 0, 0.2, 0.5, 1, 2, 3 and 4 times per day (14). We classified soda/fast food consumption levels as binary dietary behaviour outcomes for the analysis: ≥ 4 times per week or less (16).

Daily exercise. Children were asked how many of the past 7 days they had exercised or participated in physical activity that made them sweat and breathe hard for at least 20 min, such as soccer, running, swimming laps or similar aerobic exercise. We defined the appropriate level of exercise as daily physical activity compared with irregular exercise (17).

Screen time. We assessed children's time spent on watching television, playing computer/video games or using the Internet for e-mailing, school work, etc. on typical weekdays. We set >3 h of daily recreational screen time as an excessive sedentary behaviour (18).

Socio-demographic characteristics

To consider the effects of family and household socio-demographic characteristics on childhood obesity,

we used information about child age, sex, ethnicity (non-Hispanic White, non-Hispanic Black or African American, Hispanic, and Asian/Native Hawaiian or other Pacific Islander/American Indian or Alaska Native/non-Hispanic more-than-one-race), parental educational level (up to high school, above), the structure of the family (single parent, two parents) and maternal job status (full time, part time, not working).

Statistical analysis

We examined the distribution of socio-demographic characteristics of children and their families using baseline data (kindergarten, $n = 16\,240$) and described children's BMI Z-scores and overweight/obesity prevalence in five waves of the ECLS-K cohort (kindergarten, 1st grade [$n = 14\,840$], 3rd [$n = 13\,490$], 5th [$n = 10\,890$] and 8th grades [$n = 8760$]) according to household poverty dynamics. Also, we compared the

distributions of children's adverse health behaviours at the last follow-up wave (8th grade) in the ECLS-K cohort, e.g., soda/fast food intakes, exercise and screen time, also according to household poverty dynamics.

To define children's BMI trajectories from 5 to 16 years under different household poverty dynamics, we used mixed effect models with fractional polynomial functions. We chose the best combination of fractional polynomial functions (Fig. 1) for modelling childhood BMI trajectories as a function of age after testing the models' goodness of fits in diverse combinations of age terms (19). With the estimated household poverty subgroup-specific fixed beta coefficients for fractional polynomial terms, we fit and plotted four BMI trajectory curves to present household poverty-specific predicted mean BMI by age (in months).

Finally, to examine the longitudinal association between household poverty dynamics (classified as four

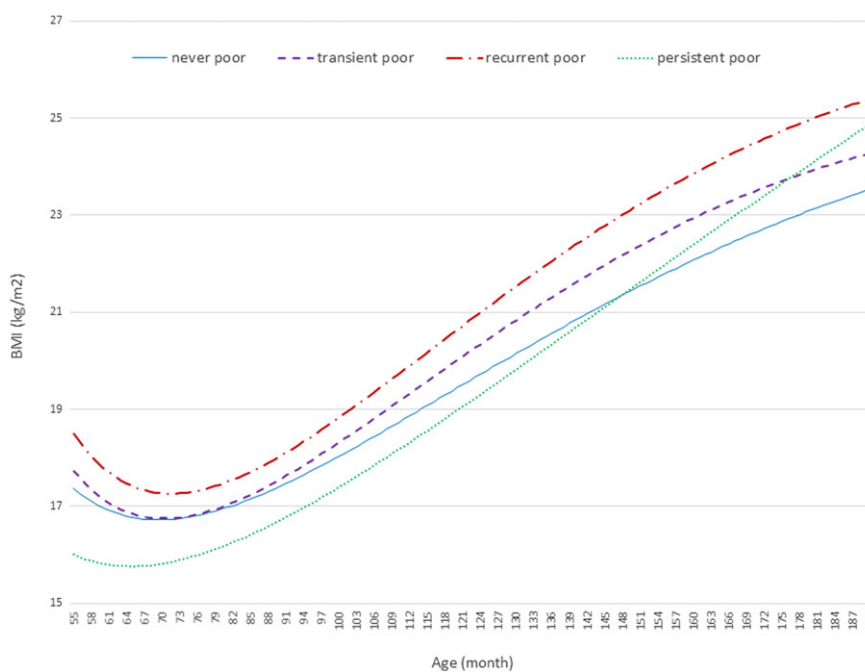


Figure 1 Household poverty dynamic-specific predicted mean BMI from 5 to 16 years among the US children: the ECLS-K 1998–1999 of the US ($n = 16\,800$). Data collected during five waves from ECLS-K were analysed using mixed effect models with fractional polynomial functions for the household poverty dynamic-specific BMI growth curves with considering the complex sample design of ECLS. Household poverty dynamics during follow-up were classified as the never poor; the transient poor (household became poor only once from 1st to 8th grade); the recurrent poor (household became poor more than once) and the persistent poor (household was poor for four consecutive waves). The best fit mixed effect models for BMI trajectories by subgroups of household poverty dynamics were: Expected value of BMI = $-165.9 + 640.4 \cdot \text{age}^{(-2)} + 16.3 \cdot \text{age}^{(-0.5)} - 0.4 \cdot \text{age} + e$ in never poor group; $-250.4 + 924.4 \cdot \text{age}^{(-2)} + 24.4 \cdot \text{age}^{(-0.5)} - 0.7 \cdot \text{age} + e$ in transient poor group; $-272.6 + 1012.0 \cdot \text{age}^{(-2)} + 26.2 \cdot \text{age}^{(-0.5)} - 0.7 \cdot \text{age} + e$ in recurrent poor group; $-84.4 + 371.3 \cdot \text{age}^{(-2)} + 7.8 \cdot \text{age}^{(-0.5)} - 0.1 \cdot \text{age} + e$ in persistent poor group. BMI, body mass index; ECLS-K, Early Childhood Longitudinal Study, Kindergarten Class.

groups, see earlier) and risk of childhood overweight/obesity (repeated measures in five consecutive waves), we used estimating equation models using logistic link and unstructured covariance matrix after adjusting for sex, race/ethnicity, wave, family structure, parental education, mother's work status and the interaction between household income dynamic and race/ethnicity. Our models included fixed and random effects (allowing individuals to have their own intercepts) and combinations of age terms (age, age (2) and age (3)) based on the statistical significance of the model.

All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC) and STATA 14 (StataCorp., College Station, TX) after considering the longitudinal sampling weights of the ECLS to reflect the outcomes of the initial population and give nationally representative estimates.

Results

Household poverty dynamics and childhood trajectories in body mass index and overweight/obesity

At baseline, the children's average age was 6.3 years (standard deviation = 0.4); about 50% were boys (Table S1). During the 8-year period, about 30% of

these children experienced household poverty at least once, 12.8% were in poverty more than two times ('recurrent poor') and 8.4% maintained poverty status ('persistent poor') through follow-up.

The recurrent and persistent poor groups had similar socio-demographic characteristics: they had a higher rate of African-American (31.5, 45.0%, respectively) and Hispanic (33.3, 30.6%, respectively) populations, lower levels of parental education (up to high school: 71.6%, 83.3%, respectively) and greater single-parent status (43.5%, 53.4%, respectively) than those in the transient (became poor only once during follow-up) or never-poor groups. The persistently poor group had the highest rate of non-working mothers (59.3%) compared with other groups that experienced poverty.

Table 1 shows the cross-sectional comparison of mean BMI Z-scores and overweight/obesity rates by household poverty dynamics. The recurrently poor maintained the highest mean BMI Z-scores and overweight/obesity rates in the four consequent waves, although there was no significant difference in this group for the initial kindergarten wave. The transient poor followed, with higher BMI Z-scores than the other poverty groups; however, the persistently poor became the second highest group in childhood obesity by the 8th grade.

Table 1 Comparing mean BMI Z-score and overweight/obesity prevalence (%) by household poverty dynamics* in five waves of ECLS-K 1998–1999 of the US

	Kindergarten (n = 16 240)	1st Grade (n = 14 840)	3rd Grade (n = 13 490)	5th Grade (n = 10 890)	8th Grade (n = 8760)
1. BMI Z-score					
Full sample	0.35	0.34	0.51	0.60	0.57
Never poor	0.32	0.31	0.48	0.53	0.51
Transient poor	0.39	0.39	0.57	0.76	0.62
Recurrent poor	0.50	0.48	0.65	0.87	0.82
Persistent poor	0.31	0.35	0.48	0.59	0.70
p	0.14	<0.001	0.12	0.003	<0.001
2. Overweight/obesity prevalence† (%)					
Full sample	25.2	24.9	32.5	38.1	34.6
Never poor	24.4	23.7	30.8	34.8	31.7
Transient poor	26.4	27.2	36.1	44.7	38.2
Recurrent poor	30.0	30.1	39.5	51.4	45.3
Persistent poor	23.0	23.5	31.7	37.9	39.0
p	0.24	0.09	0.02	<0.001	<0.001

Sample sizes rounded to the nearest 10 according to the ECLS-K requirement for restricted-use data. Population projected percentage was presented from survey procedures in SAS after accounting the complex sample design of ECLS. BMI, body mass index; ECLS-K, Early Childhood Longitudinal Study, Kindergarten Class.

*Household poverty level was obtained as composite variables of ECLS (living in households with incomes below the federal poverty threshold vs. at or above). Household poverty dynamics during follow-up were classified as the never poor; the transient poor (household became poor only once from 1st to 8th grade); the recurrent poor (household became poor more than once); the persistent poor (household was poor for four consecutive waves).

†BMIs were obtained as composite variables of ECLS and BMI Z-score was defined by the in the age-sex-specific CDC 2000 growth chart. Overweight and obese were defined by ≥ 85 percentile of CDC growth charts 2000.

Our longitudinal analysis described household-poverty-dynamic-specific childhood BMI trajectories (Fig. 1). The recurrent poor had the highest BMI curves from ages 5 to 16 years. The transient poor kept the second highest BMI up to 177 months. The persistent poor had the lowest BMI at an early age; however, they had the steepest slope of BMI increase afterward and became the second highest group in BMI trajectory starting at 178 months and beyond. The never poor became the lowest BMI group after 143 months. Additional data analysis without the children having only a one-time poverty report showed a similar association between household poverty dynamics and childhood BMI trajectory (not reported).

Association between household poverty dynamics and childhood health behaviours at 8th grade

We cross-sectionally compared childhood obesity-related health behaviours by household income dynamics and found a significant difference in children's soda and fast food intakes, exercise frequency and screen time duration at the 8th grade (the last follow-up wave; $p < 0.05$, Table 2). Overall, about one-third of the children drank soda more than three times per week (31.8%); two-thirds did not exercise for at least 20 min a day (75.1%) and had heavy screen time ($>3 \text{ h} \cdot \text{d}^{-1}$, 72.1%).

In general, children experiencing poverty were more likely to have adverse eating and sedentary behaviours compared with the never poor; the recurrent poor had higher rates of frequent soda and fast food consumption (≥ 4 times per week: 38.8%, 27.9%, respectively) and more irregular exercise (81.5%) than the others. The persistently poor had the highest rate of excessive screen time (81.6%).

Longitudinal association of household poverty dynamics with overweight and obesity risk

Longitudinal analysis of the association between household income dynamics and overweight/obesity risk during the 8-year follow-up showed that the recurrent poor were 1.5 times more likely to be children with overweight/obesity than the never poor ($\text{OR} = 1.49$ [95% CI = 1.01–2.18]) during follow-up from ages 5 to 16 years, after adjusting for individual and household characteristics. No significant difference was shown in the childhood obesity risk among transiently ($\text{OR} = 1.17$ [95% CI = 0.89–1.55]) or persistently poor children ($\text{OR} = 1.11$ [95% CI = 0.59–2.08]) vs. the never poor. No significant interactions were found between race/ethnicity ($p = 0.42$), gender ($p = 0.41$) and weight status at baseline ($p = 0.28$) with household poverty dynamics on the longitudinal risk of childhood overweight/obesity. Our additional sensitivity analysis of data without the children having only a one-time poverty report showed a similar association between household poverty dynamics and childhood obesity risk (not reported).

Discussion

This study used nationally representative longitudinal data and reported the relationship between family SES and BMI trajectories and overweight risk during childhood and adolescence with a large study sample. The pattern of household poverty dynamics affects childhood BMI growth and overweight/obesity risk in the US. Recurrently and persistently, poor groups were characterized by being primarily African American and Hispanic, having less-educated parents and having more single parents than the other groups. In particular, the recurrent poor had the highest BMI and overweight/obesity rate from the

Table 2 Association between household poverty dynamics and child eating and physical activity behaviours at the 8th grade (the final wave): the ECLS-K 1998–1999 of the US

	n^{\dagger}	% Full sample	Never poor	Transient poor	Recurrent poor	Persistent poor	p
1) Soda ≥ 4 times per week	5320	31.8	30.1	35.5	38.8	32.5	0.03
2) Fast food ≥ 4 times per week	6190	16.6	13.1	22.0	27.9	24.6	<0.001
3) Doing exercise* not everyday	6440	75.1	73.4	79.2	81.5	75.6	0.005
4) Screen time [‡] $>3 \text{ h} \cdot \text{d}^{-1}$	6320	72.1	68.5	79.9	80.8	81.6	<0.001

ECLS-K, Early Childhood Longitudinal Study, Kindergarten Class.

*Do exercise or participate in physical activity for at least 20 min that made child sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing or similar aerobic exercise.

[†]Defined by the sum of time spent on TV, video and internet use in a week.

[‡]Available data were varied by children's response rates for each survey questions.

ages of 5 to 16 years; the persistently poor had started with the lowest BMI level in the early ages but became the second highest in BMI trajectories and overweight/obesity rate by the 8th grade. The experience of childhood poverty was associated with child health behaviours at the 8th grade as well: the recurrently poor were more likely to have excessive soda and fast food intake and irregular exercise than the other poverty groups. More than 80% of the persistently poor had excessive screen time. In the longitudinal analysis, the recurrently poor had a 1.5 times higher risk of being children with overweight/obesity during follow-up than the never poor, after adjusting for various socio-demographics.

The US population has a higher poverty rate ratio than other developed countries (USA: 0.17 vs. Finland: 0.07, France: 0.08, United Kingdom: 0.10, Canada: 0.13 in OECD 2013) (20). The official US Census Bureau statistics estimated that 43 million persons were poor in 2015, and 19.7% of children were living in poverty (21). African-American and Hispanic children have a higher poverty rate than White children (2). Children experiencing the longest years in poverty were those with mothers who were unmarried (average time: 5.4 years) or did not have a high school degree (5.0 years) (22). Our study also found consistent socio-demographic characteristics in poor groups defined by household poverty dynamics. Children from persistently and recurrently poor households were reported to constitute 21.2% of those in the US in 1999, and they were more likely to be African American or Hispanic, having a low parental education level, and more single parents than other poverty status groups.

While entire households experience poverty, children are especially vulnerable to inadequate food, energy, transportation, and housing and the absence of psychological buffering from the stresses and harms of poverty, which can lead to adverse physical health, socioemotional development and academic achievement through a lifetime (23). In life course perspective, patterns of poverty experience during childhood could have a strong effect in a person's health trajectories. Children may remain in poverty throughout childhood or rotate in and out of poverty over time. Worldwide, about 37% of children experience some level of poverty for some period of time (24). Most studies investigating the association between childhood SES and adulthood obesity or chronic diseases use cross-sectional data for one measure of childhood SES (10). The few longitudinal studies have found that downward mobility or persistently low income were associated with a greater risk of obesity during childhood in the US (10,11,25). A birth cohort

in New York state found that children who moved into low income during their childhoods were 2.4 times more likely to be adolescents with obesity, while children who were held in poverty were 2.4 times more likely to maintain overweight (10). Girls in the Early Childhood Longitudinal Survey Birth Cohort also had a significant decrease in BMI Z-score during the ages of 2 to 6 years due to an increase in poverty to income ratio (=family income divided by poverty status; $\beta = -0.002$; 95% CI = $[-0.042, -0.002]$) (11). However, variable definitions of household income and statistical modelling approaches for classifying income dynamics have impeded consistent findings in the association with children's obesity risk in previous studies (12,13); and no study has examined how children's BMI trajectory and health behaviours are influenced by the pattern of income dynamics with which they live (26,27).

Our study found that children from recurrently poor households were 1.5 times more likely to be children with overweight or obesity during follow-up from ages 5 to 16 years compared with children who had never been poor. The recurrently poor were also the highest in BMI level and overweight/obesity prevalence compared with the persistently or transiently poor groups, as well. The persistently poor had the lowest rate of childhood obesity at the beginning of follow-up but grew to be the second highest group at 8th grade after steady increases in BMI throughout childhood. There are two potential explanations for these findings. First, the mechanisms that could cause obesity in children who rotated in and out of poverty over time compared with children who remained in poverty are likely different (10). Children with persistent household poverty may have low birth weight and premature risks in early life and be used to food insecurity and fewer physical activity resources in low-income neighbourhoods (28). In contrast, some family events such as divorce, loss of jobs or accidents/disasters may place children in more stressful circumstances due to experiencing the ups and downs of SES throughout cycles of rotating in and out of poverty, which may lead to further mental stress and worsen child eating behaviours and levels of physical activity (10,29). In addition, the accumulated exposure of adverse eating habits and an excessively sedentary life may lead both recurrently and persistently poor groups to have higher risks of childhood obesity than the other poor groups (30). We found that at the age of 16, the recurrently poor had the highest BMI and overweight/obesity rate, but the persistently poor could exceed the obesity risk of the recurrently poor group during late adolescence or adulthood. Much additional work is needed to confirm our results and

to examine the mechanisms connecting poverty dynamics to obesity risk.

This study has some limitations. Due to missing responses and those lost to follow-up, only a part of child health behaviours in the 8th grade was examined. The relatively small sample size of the poor groups may not allow us to detect significant differences in the association between household poverty dynamics and childhood obesity risk by ethnicity, gender or baseline weight status. However, this study uses a nationally representative sample, and longitudinal data and offers a life course perspective on examining how household poverty experience influences the development of adverse child health behaviours and overweight/obesity risks. Further investigation may help to address whether the obesity risk among the persistently poor would increase more than that in the recurrently poor if there were long-term follow-up. These findings provide insight as to how to better support child health when families experience economic challenges.

In conclusion, childhood poverty experience associates with significant differences in children's health behaviours and obesity risks in the US. Supporting effort for the children who rotate in and out of poverty needs to focus on healthy eating and physical activity to prevent childhood obesity.

Conflict of interest statement

The authors declare no conflict of interest.

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Supporting information

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1. Socio-demographic characteristics of children and their family by household poverty dynamics from baseline data (Kindergarten spring), Early Childhood Longitudinal Study (ECLS), Kindergarten class of 1998-99 ($n = 16,240$)