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# Trajectories of Socioeconomic Status Across Children's Lifetime Predict Health

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## ABSTRACT

**OBJECTIVE.** Socioeconomic status is one of the most robust social factors associated with health, but the dynamics of how socioeconomic status over time affects children's health remains unclear. This study tested how various models of childhood socioeconomic status (accumulation, change, variability, and critical periods of family income) would predict health outcomes at a final time point in childhood.

**METHODS.** This was a prospective, longitudinal study of 6306 children who were aged 10 to 11 years and whose families were interviewed every other year from birth onward. The sample came from the US National Longitudinal Survey of Youth-Children. In the same data set, a replication sample of 4305 14- to 15-year-old children was also examined. Primary outcomes included parent report of asthma and conditions that limited activity and school and required physician treatment.

**RESULTS.** Lower cumulative family income was associated with higher odds for having a condition that limited childhood activities, as well as a condition that required treatment by a physician at ages 10 to 11. Cumulative family income was a stronger predictor than change in income or variability in income. Lower family income early in life (ages 0–5 years) was associated with higher odds for having a condition that limited activities and a condition that required treatment by a physician at ages 10 to 11, independent of current socioeconomic status. Findings were replicated in the 14- to 15-year-old sample.

**CONCLUSIONS.** These findings suggest that the accumulation of socioeconomic status in terms of family income across childhood is more important than social mobility or variability in socioeconomic status, although there may be certain periods of time (early life) that have stronger effects on health. These findings suggest the importance of childhood interventions for reducing health disparities.

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### Key Words

socioeconomic status, health status, children, longitudinal

### Abbreviations

SES—socioeconomic status  
NLSY-C—National Longitudinal Survey of Youth-Children  
OR—odds ratio  
CI—confidence interval

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ONE OF THE most robust social environment factors associated with physical health is socioeconomic status (SES). Individuals who have lower SES consistently have poorer health across a variety of diseases and risk factors for disease.<sup>1-4</sup> Moreover, this pattern has been documented to emerge during childhood.<sup>5-8</sup> However, the majority of research in this field has focused on concurrent associations of SES with health, when, in actuality, SES across an individual's lifetime may be important for shaping current health profiles.<sup>9,10</sup> A number of different models have been proposed for how SES over time (ie, trajectories of SES) may influence health, and this study tested the viability of these models in predicting children's health.

Accumulation models suggest that duration of low SES is important to health, because effects of SES measures, such as occupation and poverty status, have been found to aggregate over time to affect health.<sup>11,12</sup> Change models suggest that changes in SES are important to health; for example, declines in occupational status over time have been associated with poorer health.<sup>13,14</sup> Variability models suggest that instability in SES is important to health; for example, repeated large drops in income may be particularly detrimental to health.<sup>15</sup> Finally, period models suggest that SES at certain time points will be most strongly associated with health. For example, current poverty status has effects on health over and above poverty history.<sup>16</sup> Alternatively, there may be a window of time, or "critical period," during which SES exerts potent effects on health. In particular, early-life environments have been proposed to program a pattern of biological and behavioral responses that have long-term effects on health.<sup>17,18</sup> This study used a longitudinal design of a large US sample of children to test how dynamic patterns of SES, as defined by family income across a child's lifetime, related to health outcomes at a final time point.

## METHODS

### Participants

Participants were children who were aged 10 to 11 from the National Longitudinal Survey of Youth-Children (NLSY-C). The NLSY contains a US sample of adolescents who are aged 14 to 22 years and first surveyed in 1979. Beginning in 1986, women who were in NLSY and had children were asked permission to follow the children. Informed consent for asking mothers questions about their child was obtained from mothers. Every other year from 1986 to 2000, mothers were interviewed about their children. Retention rates across all of the years of follow-up have remained close to 90%. This study's sample consisted of 51.59% boys and 33.49% black, 21.77% Hispanic, and 44.7% nonblack/non-Hispanic children.

A total of 6306 children had data at ages 10 to 11. Of

these, 5874 had at least 1 income variable at any time point, 6306 had data about asthma, 5362 had data about activity limitations, 5321 had data on school limitations, and 5360 had data on physician treatment (the limitations and treatment questions were asked only in a subset of the interview strobos, thus yielding a smaller number of data points).

### Study Design

In this longitudinal design, mothers were interviewed every other year from 1986 to 2000 about their children. Existing children could enter the study at any age in 1986, and new children were enrolled at subsequent interviews. For the primary analyses in this study, we selected 1 age group so that income trajectories would consist of the same number of assessments across children and so that health outcomes would be assessed at the same point in the lifespan across children. We chose 10- to 11-year-old children because this allowed us to maximize both the number of data points for lifetime income trajectories (younger children would have had too few data points to create income trajectories) and the number of participants (the sample size for older children was smaller, given that fewer of them had been interviewed across their entire lifetime). Thus, 10- to 11-year-olds had family income data at 5 different ages: 0 to 1, 2 to 3, 4 to 5, 6 to 7, and 8 to 9 (because interviews are conducted every other year, at each time point the cohort has a 2-year age span). Health data are analyzed at ages 10 to 11.

In secondary analyses, we tested the replicability of findings using a second age group from the NLSY-C. For these analyses, we chose 14- to 15-year-old children because they had a greater number of data points for income trajectory calculations,<sup>7</sup> although a smaller sample size (4305 for asthma, 1335 for activity limitations and condition that required physician treatment, and 1323 for school limitations, with limitations and treatment questions asked in only a subset of interview strobos, thus yielding a smaller number of data points). A total of 3989 of children in the 14- to 15-year-old data set were also in the 10- to 11-year-old data set. Although many of the same children are in both data sets, health outcomes are measured 4 years later in this replication group.

### Assessments

#### SES

Although there are many approaches to measuring SES, income is considered 1 of the most dynamic of the SES measures.<sup>19</sup> Given our interest in trajectories of SES over time, we chose family income as the SES variable most likely to fluctuate over time. Family income was assessed by asking parents about total net family income in the previous 12 months. Income is reported in units of thou-

sands of dollars and was assessed every other year from 1986 to 2000. Income at each time point was converted to dollar equivalents for the year 2000 using the gross domestic product deflator so that income could be compared across years.

### Health Outcomes

Health outcomes included chronic or limiting conditions at ages 10 to 11, assessed by maternal report: (1) asthma (yes/no), (2) presence of a condition that limits child's activities (yes/no), (3) presence of a condition that limits child's ability to attend school (yes/no), and (4) presence of a condition that requires treatment from a doctor or frequent attention (yes/no).

### Statistical Analyses

Income variables were calculated to reflect the 4 models of SES trajectories: (1) accumulation of SES was calculated as mean income across the child's lifetime, (2) variability in SES was calculated as the SD of income across the child's lifetime, (3) changes in SES were calculated as the slope of income across the child's lifetime, and (4) periods of SES included both current SES (income drawn from the same year as health outcomes) and early-life SES (average income across ages 0–5 of a child's life).

All models were fit using Stata/SE 9.2 (Stata Corp, College Station, TX). Logistic regression analyses were conducted to test the significance of each income variable (accumulation, variability, change, and periods) in predicting child health variables. Race and gender were controlled in all analyses. Simultaneous regression analyses (also controlling race and gender) were conducted to determine the independent contributions of each type of income marker in predicting child health. Statistical tests were 2-tailed with a significance level of  $P = .05$ .

## RESULTS

### Descriptive Information

Prevalence rates for childhood health conditions at ages 10 to 11 were as follows: asthma, 3.46%; activity limitations, 3.60%; school limitations, 2.35%; and condition that required physician treatment, 6.57%. At ages 14 to 15, prevalence rates were as follows: asthma, 9.99%; activity limitations, 3.37%; school limitations, 1.96%;

and condition that required physician treatment, 6.29%. Of children who had asthma at ages 14 to 15, 40.0% also had asthma at ages 10 to 11. Of those who had an activity limitation at 14 to 15, 17.5% had an activity limitation at ages 10 to 11. Of those who had a school limitation at 14 to 15, 4.5% had a school limitation at ages 10 to 11. Of those who had a condition that required physician treatment at age 14 to 15, 30.8% also required physician treatment at ages 10 to 11. Income mean was negatively correlated with income slope ( $r = -0.36$ ).

### Accumulation Hypothesis

Table 1 shows a summary of analyses reported next for 10- to 11-year-olds. Lower mean family income across childhood was associated with a higher odds for having a condition that limited childhood activities ( $P < .05$ ), as well as with a higher odds for having a condition that required treatment by a physician ( $P < .01$ ) at ages 10 to 11.

In the replication sample of 14- to 15-year-olds, lower mean family income across childhood also was associated with a higher odds for having a condition that limited childhood activities (odds ratio [OR]: 0.986; 95% confidence interval [CI]: 0.972–0.1.000;  $P = .05$ ) and having a condition that required treatment by a physician (OR: 0.984; 95% CI: 0.971–0.998;  $P < .05$ ). No significant findings with asthma or school limitations emerged in either sample.

### Variability Hypothesis

Variability in income across childhood was not associated significantly with any health outcomes at ages 10 to 11 or ages 14 to 15.

### Change Hypothesis

Income slope across childhood was associated with activity limitations ( $P < .05$ ) such that declines in income over time were associated with a higher odds for having an activity limitation at ages 10 to 11 (Table 1). In the replication sample of 14- to 15-year-olds, income slope across childhood also was associated with activity limitations (OR: 0.876; 95% CI: 0.772–0.993;  $P < .05$ ). No other outcomes were significant in either sample.

Given that both accumulation of income and change

**TABLE 1** Logistic Regression Analyses of Models of SES Trajectories Predicting Child Health at Ages 10 to 11

Outcome	Accumulation Model		Variability Model		Change Model	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Activity limitation	0.988 (0.980–0.997)	<.05	0.998 (0.995–1.002)	.31	0.936 (0.886–0.990)	<.05
School limitation	0.992 (0.983–1.002)	.11	0.997 (0.995–1.000)	.06	0.970 (0.932–1.008)	.12
Physician treatment	0.994 (0.989–0.998)	<.01	0.998 (0.996–1.000)	.13	0.980 (0.954–1.007)	.14
Asthma	0.998 (0.995–1.001)	.14	0.998 (0.994–1.001)	.17	0.993 (0.974–1.013)	.50

Regression analyses included race and gender as covariates, then the relevant SES variable predicting health outcomes. Accumulation is calculated as mean income across the lifespan. Variability is calculated as SD of income across the lifespan. Change is calculated as slope of income across the lifespan. Income is coded in thousands of dollars. All outcomes are coded as 1 = yes, 0 = no.

in income were associated with activity limitations, we conducted simultaneous regression analyses to determine which had the stronger influence on activity limitations. When included simultaneously, mean income but not slope of income across childhood predicted activity limitations at ages 10 to 11 (mean: OR: 0.985 [95% CI: 0.973–0.998;  $P < .05$ ]; slope: OR: 0.986 [95% CI: 0.963–1.008; nonsignificant). This indicates that the accumulation of family income is a stronger predictor of child activity limitations than change in family income. In the replication sample, mean income but not slope of income across childhood also predicted activity limitations at ages 14 to 15 (mean: OR: 0.983 [95% CI: 0.968–0.999;  $P < .05$ ]; slope: OR: 0.945 [CI: 0.878–1.016; nonsignificant).

### Periods of SES

Table 2 shows details of the results described next for the 10- to 11-year-olds. Lower early-life family income (0–5 years of age) was associated with a higher odds for having a condition that limited activity ( $P < .001$ ) and of having a condition that required treatment by a physician ( $P < .01$ ) at ages 10 to 11. Current family income was associated with a higher odds for having a condition that limited activity ( $P < .05$ ) at ages 10 to 11.

In the replication sample, lower early-life family income also was associated with a higher odds for having a condition that limited activity (OR: 0.980; 95% CI: 0.964–0.996;  $P < .05$ ) and of having a condition that required treatment by a physician (OR: 0.986; 95% CI: 0.974–0.999;  $P < .05$ ) at ages 14 to 15. Current family income was associated with the odds for having a condition that limited activity (OR: 0.984; 95% CI: 0.971–0.997;  $P < .05$ ) and a condition that required physician treatment (OR: 0.987; 95% CI: 0.975–0.999;  $P < .05$ ) at ages 14 to 15. No significant findings with asthma or school limitations emerged in either sample.

We next conducted simultaneous regression analyses to determine which period of family income had the stronger influence on child health. After controlling for current income, early-life income remained a significant predictor of activity limitations at ages 10 to 11 (OR: 0.983; 95% CI: 0.974–0.993;  $P < .01$ ). In contrast, after controlling for early-life SES, current income no longer was associated with activity limitations (OR: 0.999; 95%

CI: 0.994–1.004; nonsignificant). Similarly, early-life income predicted having a condition that required physician treatment after controlling for current income (OR: 0.992; 95% CI: 0.985–0.998;  $P < .05$ ). In contrast, current income was not associated with having a condition that required physician treatment after controlling for early-life income (OR: 1.000; 95% CI: 0.998–1.002; nonsignificant). This indicates that early-life family income is a stronger predictor of child health than current family income. However, in the 14- to 15-year-old sample, simultaneous regression analyses resulted in neither income variable's being a significant predictor of activity limitations or a condition that required physician treatment.

### Trajectory Groupings

To depict the various SES trajectories across the lifespan, we categorized families as either low or high in income early in life and currently, using a median split. Children were classified into 1 of 4 groups at ages 10 to 11: low early-life/low current income, low early-life/high current income, high early-life/low current income, and high early-life/high current income (Fig 1). Consistent with earlier analyses, evidence for the accumulation effect was seen in that those who stayed low in family income across childhood (low/low) had a higher odds for activity limitations (OR: 1.815; 95% CI: 1.279–2.575;  $P < .01$ ), school limitation (OR: 1.617; 95% CI: 1.052–2.485;  $P < .05$ ), and having a condition that required treatment by a physician (OR: 1.727; 95% CI: 1.325–2.251;  $P < .001$ ) compared with those who stayed high in family income across childhood (high/high). Findings for asthma were marginal (OR: 1.331; 95% CI: 0.962–1.840;  $P = .08$ ). Evidence also emerged for the importance of early-life family income, as the differences between low and high income were more evident for early-life indicators than current indicators (eg, for conditions that required physician treatment, low early-life differed from high early-life income [low/low versus high/low: OR: 1.565 (95% CI: 0.994–2.466;  $P = .05$ ); low/high versus high/high: OR: 1.590 (95% CI: 1.122–2.252;  $P < .01$ )], but low current SES did not differ from high current SES [low/low versus low/high: OR: 1.086 (95% CI: 0.779–1.516; nonsignificant); high/low versus high/high: OR: 1.103 (95% CI: 0.704–1.728; nonsignif-

**TABLE 2** Logistic Regression Analyses of Periods of SES Predicting Child Health at Ages 10 to 11

Outcome	Early-Life Income		Current Income	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Activity limitation	0.982 (0.974–0.990)	<.001	0.992 (0.984–0.999)	<.05
School limitation	0.989 (0.978–1.000)	.06	0.998 (0.995–1.002)	.34
Physician treatment	0.990 (0.984–0.996)	<.01	0.997 (0.994–1.001)	.11
Asthma	0.997 (0.994–1.000)	.098	0.996 (0.992–1.000)	.083

Regression analyses included race and gender as covariates, then the relevant SES variable predicting health outcomes. Early-life income is calculated as the mean income during ages 0 to 5. Income is coded in thousands of dollars. All outcomes are coded as 1 = yes, 0 = no.

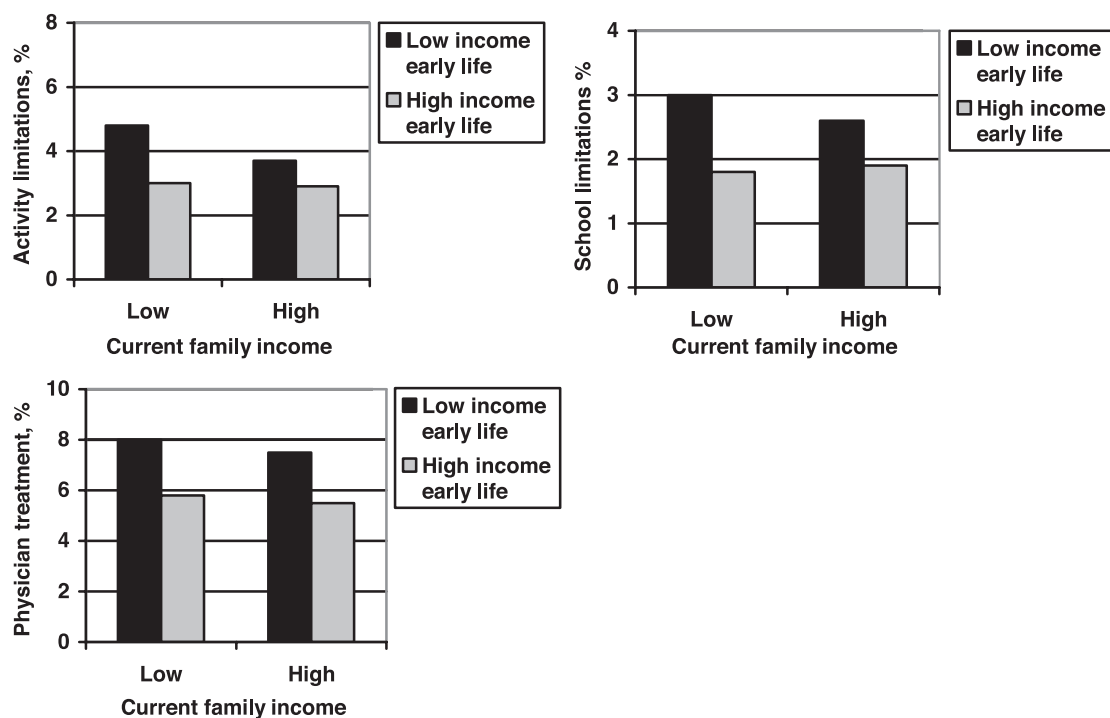


FIGURE 1

Prevalence rate of health conditions at ages 10 to 11 by SES trajectory grouping. As described in "Results," children were classified into 1 of 4 groups: low early-life/low current family income, low early-life/high current family income, high early-life/low current family income, or high early-life/high current family income. Findings are depicted for activity limitations, school limitations, and physician treatment, with findings for asthma being nonsignificant.

icant)). Importantly, changes in family income were not able to "undo" the effects of early-life income, as indicated by the fact that those who moved up in family income (low/high) did not differ from those who stayed low in family income (low/low) on any outcome (asthma: OR: 0.689 [95% CI: 0.433–1.097; nonsignificant]; activities: OR: 0.742 [95% CI: 0.469–1.174; nonsignificant]; school: OR: 0.821 [95% CI: 0.479–1.408; nonsignificant]; physician treatment: OR: 0.920 [95% CI: 0.660–1.284; nonsignificant]).

## DISCUSSION

This study demonstrated that the accumulation of family income across a child's life predicts limiting health conditions at ages 10 to 11. Specifically, lower cumulative family income across childhood predicted a greater likelihood of having childhood activity limitations and having a condition that required physician treatment. Furthermore, cumulative family income was a stronger predictor than change in income or income instability. Finally, persistently low income (low early-life income/low current income) was associated with poorer health outcomes (higher odds for activity limitations, school limitations, and conditions that require physician treatment) compared with persistently high income. Taken together, these findings suggest that the pattern of changes in family income over time (eg, declines in income, instability in income) is less important than the

additive contribution of family income throughout childhood. Furthermore, understanding an individual's lifetime history of family income may be more important than understanding current income conditions in predicting child health.

These findings are consistent with previous research in adults that documented that cumulative SES measures, such as poverty status and occupation over time, are important predictors of physical function, cardiovascular risk factors, and mortality.<sup>12,14,20</sup> Previous research also shows patterns that were obtained in adults that lifetime occupational status is more important than social mobility or occupational status at a certain time in predicting adult self-reported health.<sup>11,21</sup> In addition, findings are consistent with research showing the detrimental effects of persistently low income on adult outcomes such as risk for mortality.<sup>15</sup> This study extends this body of work by prospectively assessing family income throughout childhood and documenting that the effects of cumulative family income emerge as early as age 10.

Relationships with asthma were not consistent with the patterns seen for activity limitations and physician treatment. In part, this may be because SES is more consistently associated with asthma severity, rather than asthma prevalence<sup>5</sup>; however, in this data set, we were unable to distinguish between severity and prevalence. School limitations also showed few associations, perhaps

because the prevalence rate of school limitations was the lowest of all of the health conditions examined.

The importance of cumulative family income does not preclude the possibility that income at certain time points has stronger effects than at other time points. Our analyses revealed that the very early years are important to future health. Lower early-life family income predicted higher odds for having activity limitations and conditions that require physician treatment. These effects were independent of current income in the 10- to 11-year-old sample. This evidence supports theories that early-life environments may be able to program biological changes that persist over time,<sup>17,18</sup> which would have implications for health. Empirically, these findings are consistent with animal data showing that early-life environments are associated with persistent hormonal and epigenetic changes.<sup>22,23</sup> These data are also consistent with adult human studies that document that early-life SES in terms of parental occupational status predicts adult cardiovascular risk and periodontal disease and that social mobility does not change these effects.<sup>24</sup>

Furthermore, the importance of very early life was evident in that changes in later family income did not offset the effects of early-life income. That is, those whose families changed from low income early in life to high income currently were not different from those who remained low in income across childhood in terms of children's odds for having asthma or a condition that limited activity, limited school, or required physician treatment. These findings suggest that targeting interventions early in life is critical for influencing health later in childhood.

Overall, these findings suggest that factors that have an impact on children's health aggregate across childhood, although there may be periods when certain factors have a greater impact on later health. The effects of detrimental social environments may operate through pathways such as health behaviors (eg, diet, smoke exposure), psychosocial factors (eg, stress, lack of social support), and experiences with health care delivery systems.<sup>25–28</sup> In turn, the accumulation of such factors may create a cumulative burden on biological systems,<sup>29</sup> resulting in a higher likelihood of health conditions over time.

Strengths of this study include the longitudinal design starting at birth, which allowed for accurate reporting of income across time (not having to rely on retrospective recall) and for firmer conclusions about the directionality of income–health effects. In addition, the large sample size of US children was a strength. Finally, the similarity in results across the 2 samples (10- to 11-year-olds and 14- to 15-year-olds) supports the robustness of these findings.

Limitations of this study included the reliance on maternal report for health conditions. Although this is common practice in large, national surveys, the lack of

physician verification of physical conditions raises the possibility that reporting biases could in part account for the findings. A second limitation is the reliance on income as the sole indicator of SES. We chose income because it is the most dynamic of the SES measures; nonetheless, future studies that include additional measures of SES would allow us to test the generalizability of these findings. The study also did not measure severity of health conditions, a factor that may be more tightly related to SES than prevalence of conditions. In addition, a more comprehensive set of health questions and/or biological assessments (eg, blood pressure, BMI) would enable future studies to test further the associations of childhood SES measures with other health indicators. As with all longitudinal studies, there is the possibility that those who were lost to follow-up may have skewed the sample in a way that biased the study findings. Finally, we note that there are other valid approaches to creating SES trajectories in addition to the ones that we used.<sup>10,16</sup>

## CONCLUSIONS

This study demonstrated that the accumulation of family income across all of childhood was a more important predictor of childhood health conditions than was social mobility or variability in income. In addition, early-life income mattered more than current income in predicting current child conditions. These findings suggest that recent interest in understanding health disparities in the United States may be best addressed by focusing on the childhood years. Interventions during these early years of life may help move children onto healthier trajectories, with the hope of maximizing health across the lifetime.

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