Antipoverty programs mitigate socioeconomic disparities in hippocampal volume and internalizing problems among U.S. youths

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Abstract

Can public policies that increase financial resources for families with low income reduce socioeconomic disparities in brain development and mental health? We leverage the Adolescent Brain and Cognitive Development (ABCD) study of over 10,000 youth across 17 states to answer this question. Lower income was associated with smaller hippocampal volume and higher internalizing psychopathology. These associations were stronger in states with higher cost of living. However, in high cost-of-living states with larger cash benefits for lower-income families, socioeconomic disparities in hippocampal volume were reduced by 36%, such that the association of family income with hippocampal volume resembled that in the lowest cost-of-living states. We observed similar patterns for internalizing psychopathology. These patterns were robust to controls for a wide range of state-level social, economic, and political characteristics. These findings suggest that anti-poverty policies may exert a buffering effect against the negative neurodevelopmental and mental health consequences of low income.

Introduction

Adults who were raised in families with lower income as children have lower educational attainment, are more likely to rely on public assistance, and tend to have more mental and physical health problems than those raised in higher income families.^{1–3} Increasing evidence demonstrates that family income is associated with structural differences in the developing brain,^{4–8} which may contribute to these disparities in later-life outcomes. Numerous environmental processes contribute to these patterns. Financial hardship constrains the time, material, cognitive, and emotional resources caregivers have to dedicate to their children and is associated with higher exposure to stressful life events (e.g., violence), chronic stressors (e.g., food insecurity), and a less predictable environment.^{9,10} Public policies that limit the financial burden of low income for families may help to mitigate these links with adverse experiences and health and neurodevelopmental outcomes. This study uses novel data from the national multisite Adolescent Brain and Cognitive Development (ABCD) Study of children in the United States to evaluate whether U.S. state-level anti-poverty policies mitigate the associations of low income with brain structure and mental health in early adolescence.

Family income is consistently associated with children's brain structure.^{4–8} Smaller hippocampal volume, in particular, among children from families with lower income is perhaps the most well replicated association between family income and brain structure.^{7,11–15} One likely explanation for this link is that increased exposure to stressors among children growing up in low income contexts contributes to reduced hippocampal volume.^{2,9} Indeed, low family income is associated with exposure to more stressful life events—such as neighborhood violence, conflict, and caregiver separation—in childhood.^{9,16} In animal models, chronic stress has toxic effects on hippocampal neurons, leading to reductions in dendritic branching and neuronal loss.^{17–19}

Consistent with this hypothesis, greater exposure to stress mediates the association of family income with children's hippocampal volume.¹⁵ Similarly, family income is consistently associated with higher levels of internalizing and externalizing psychopathology in children and adolescents.^{2,3,20}

However, broad social and economic factors may alter the associations between low income, mental health, and neural outcomes. For example, in the U.S. the federal poverty line is used to determine which families are eligible for federal resources aimed at supporting families with low income. While this metric assumes that the costs of meeting basic needs are the same across the U.S., the cost of living in fact varies widely, leading to geographical disparities in the value of a dollar. For example, an item that costs \$1.10 in California costs 92 cents in Oklahoma based on regional price parity.²¹ Thus, living in a region with a high cost of living may enhance financial strain for families with low income and magnify the impact of low income on children's hippocampal volume and mental health.

Conversely, public policies designed to help families in poverty may lessen the impact of low income on children's hippocampal volume and mental health. Government sponsored antipoverty programs are intended to ensure that families have the ability to provide for basic necessities such as food, shelter, and medical care. These programs include cash assistance programs like the Earned Income Tax Credit (EITC) and Temporary Assistance for Needy Families (TANF), as well as programs that provide benefits that meet specific needs, like the health insurance provided to low-income families by Medicaid. The EITC provides a tax credit to increase the income of working families below a certain income threshold, and TANF provides temporary cash assistance to families that are out of work. More generous and accessible cash benefits are associated with better family functioning, physical health, academic

achievement, and overall wellbeing for children in families who receive benefits relative to those who do not (assessed via comparisons generated by geographic or temporal differences in policy adoption).^{22–24} As another example, the Affordable Care Act funded expanded access to health insurance through Medicaid to all U.S. citizens with income up to 138% of the federal poverty line, although not all states adopted these expanded benefits. Parents in states where Medicaid was expanded report reduced problems paying medical bills and lower psychological distress than those in states that did not expand Medicaid.²⁵ However, the availability and generosity of these three antipoverty programs varies widely across U.S. states. Importantly, other public policies may also mitigate the impact of low income on child development,²⁶ but their generosity does not vary between U.S. states. These policies include the Supplemental Nutrition Assistance Program (i.e., food stamps) and, recently, the child tax credit. In addition, policies at the county, city, or school district level may also contribute to an environment that lessens socioeconomic disparities.

Until recently, it has been challenging to examine whether contextual factors, such as anti-poverty policies, moderate the association between family income and neural outcomes. The ability to examine this question has been hindered by the fact that most neuroimaging studies are conducted in a single community, such that all participants within each study are exposed to the same macro-social context (precluding comparisons across contexts). However, two recent studies suggest that structural factors, such as anti-poverty policies, may impact neurodevelopmental outcomes. For example, the associations of income with total brain volume and cognitive outcomes were weaker in studies conducted in Europe than in the U.S.²⁷ This finding *could* be driven by macrosocial and policy differences across these contexts; however, the researchers did not directly test that explanation. More relevant, one-year-olds whose

families received unconditional cash payments of \$333 a month in a large randomized controlled trial exhibited greater power in high-frequency bands during electroencephalography, a pattern that is associated with later cognitive skill development.²⁸ This finding suggests that increased income of a magnitude similar to that provided by anti-poverty cash assistance programs may have a positive influence on neurodevelopment.

The current study builds on this recent work to examine whether the association of family income with hippocampal volume and mental health outcomes is smaller in states with more generous anti-poverty policies using data from the large, multisite ABCD study. This study is uniquely suited to answering our research question because it sampled respondents from across 21 sites (in 17 states) that differed in terms of their cost of living and anti-poverty policy climates. Using these data, we examine the associations of family income with hippocampal volume and mental health and determine whether state-level characteristics—including cost of living and the generosity of the three largest anti-poverty programs that vary by state (i.e., EITC, TANF, and Medicaid)—moderate the influence of family income on those outcomes. These programs have documented efficacy at improving family functioning, physical health, academic achievement, and overall wellbeing and reducing psychological distress based on natural experiments.^{22–25} More generous anti-poverty policies may also help to mitigate the impacts of low income on children’s neural development and mental health in states where those policies are implemented, leading to reduced socioeconomic disparities. Importantly, the correlational analyses described in this study are not intended to serve as a direct evaluation of these specific policies. Rather, the policies selected in this study are intended to serve as quantitative indicators of the broader structural environment in which families with different levels of income are embedded,

which we are able to operationalize on a meaningful scale (e.g., dollars) and at a meaningful level of regional variability (U.S. states) at which these policies are actually implemented.

We hypothesized that lower family income would be associated with smaller hippocampal volume and higher internalizing and externalizing problems. We additionally expected that higher cost of living would increase the magnitude of those associations, but that more generous anti-poverty programs would lessen their magnitude, particularly in high cost of living states. Importantly, we also evaluated at what levels of income cost of living and antipoverty programs were associated with study outcomes for any significant interactions. The presence of this moderating influence among participants who were eligible for antipoverty benefits combined with a lack of this moderating influence on non-eligible respondents would help bolster inferences that it may be the generosity of antipoverty policies that are reducing the association of family income with hippocampal volume and mental health. Finally, in order to rule out plausible alternative explanations and to reduce spurious contextual influences, we examined whether our results were robust to controls for a wide range of state-level social, economic, and political characteristics that may be associated with the generosity of state anti-poverty programs and thus may operate as confounders. These characteristics included population density, economic conditions of the state (economic inequality, unemployment rate), non-economic characteristics reflecting the social and political climate in the state (political preferences, women's political participation, reproductive rights, incarceration rate, tightness/looseness i.e. cultural differences around rule and norm adherence), and characteristics reflecting equity in the education system (state-funded preschool enrollment, reading proficiency among students from low-income backgrounds).

Results

Family income, hippocampal volume, and psychopathology

Higher family income—as reflected in log income-to-needs ratio—was positively associated with hippocampal volume when controlling for total intracranial volume, age, and sex ($B=62.61$, $SE=8.12$, $\beta=.079$, $p<.001$), such that hippocampal volume was larger for participants with higher family income. However, there was considerable variability in both the intercept of hippocampal volume ($SD\ of\ random\ intercepts =69.94$) and in the slope of the association between family income and hippocampal volume ($SD\ of\ random\ slopes=21.79$) across the 21 ABCD sites (Figure 1).

Family income was negatively associated with internalizing ($B=-0.59$, $SE=0.15$, $\beta=-.058$, $p<.001$) and externalizing ($B=-1.50$, $SE=0.23$, $\beta=-.152$, $p<.001$) problems, again with considerable variability in the intercepts and slopes of internalizing ($SD=1.40$ and 0.469 , respectively) and externalizing ($SD=1.57$ and 0.949 , respectively) problems across the 21 ABCD sites.

State-level moderators of the associations of family income with hippocampal volume

Cost of living and the generosity of state anti-poverty programs—including two cash assistance programs (EITC and TANF) and the presence of Medicaid expansion—were investigated as potential moderators of the association of family income with youth hippocampal volume. Cash assistance was operationalized as the mean of the average monthly EITC and TANF benefit in each state. Medicaid expansion was a dichotomous variable indicating whether or not the state had expanded Medicaid benefits. State-level characteristics are summarized in Table 1.

Results of moderation analyses are summarized in Table 2. We observed a 3-way interaction between family income, cost of living, and generosity of cash assistance programs in

predicting hippocampal volume ($B=-2.62$, $SE=.766$, $p<.001$). Decomposing this interaction revealed that low-income participants living in states with high cost of living (i.e., states with a cost of living 1 SD above the mean, equivalent to a regional price parity of 1.07) and high cash benefits (i.e., states with cash assistance 1 SD above the mean, equivalent to a mean monthly cash benefit of \$531) have hippocampal volumes that are on average 60 mm³ larger than low-income participants living in states with high cost of living (i.e., states with a cost of living at the mean, equivalent to a regional price parity of 1.01) and low cash benefits (i.e., states with cash assistance 1 SD below the mean, equivalent to a mean monthly cash benefit of \$317) (see Figure 2). Of state with low cash benefits (i.e., 1 SD below the mean), none had cost of living that was 1 SD above the mean, so mean cost of living was used for this comparison to avoid extrapolating beyond the true range of the data, making these estimates conservative. On average, the difference in hippocampal volume between low- and high-income participants in high cost of living states with low cash benefits is 211 mm³, but only 134 mm³ in states where cost of living and cash benefits are both high. Thus, more generous cash benefits are associated with income disparities in hippocampal volume that are about 36% lower in states with high cost of living. Importantly, a simple slopes analysis demonstrates that the interaction between cost of living and cash benefits is only significant when log income-to-needs ratio is low—about 1 SD below the mean, equivalent to about 80% of the poverty line. This suggests that cost of living and the generosity of antipoverty policies are associated with hippocampal volume only for children in low-income families who are eligible for the benefits of these programs.

There was a similar 3-way interaction between family income, cost of living, and Medicaid expansion in relation to hippocampal volume ($B=-824$, $SE=232$, $p<.001$). Decomposing this interaction revealed that among adolescents living in states with higher cost of

living, the association between family income and hippocampal volume was weaker in states that expanded Medicaid (Figure 2C, 2D) than in states that did not. In high cost of living states (1 SD above the mean), the disparities in hippocampal volume between high (1 SD above the mean) and low (1 SD below the mean) income participants were 50% smaller in states that expanded Medicaid than in states that did not.

There were no significant 2-way interactions between family income and cost of living, nor between family income and the generosity of antipoverty programs in relation to hippocampal volume. In a supplemental analysis, we examined the 3-way interactions of family income, cost of living, and the state minimum wage—an alternative indicator of the relative generosity of the social safety net for low-income families—in relation to hippocampal volume and found the interaction was significant and pattern of results the same as for cash assistance and Medicaid expansion (Supplemental table S8).

State-level moderators of the associations of family income with psychopathology symptoms

We also examined whether cost of living and the generosity of anti-poverty programs moderated the association between family income and adolescent internalizing and externalizing problems. We observed 3-way interactions between family income, cost of living, and both the generosity of cash assistance programs ($B=.0376$, $SE=.0162$, $p=.021$) and Medicaid expansion ($B=11.7$, $SE=4.90$, $p=.017$) in predicting internalizing problems. Decomposing this interaction revealed that among adolescents living in states with a higher cost of living, the association between family income and internalizing problems was lower in states with more generous anti-poverty cash assistance programs (Figure 4A) and in states that expanded Medicaid (Figure 4B) relative to states with less generous cash assistance and that did not expand Medicaid,

respectively. On average, the difference in internalizing problems t-scores between low- and high-income participants in high cost of living states with low cash benefits is 2.11, but only 1.08 in states where cost of living and cash benefits are both high. Thus, more generous cash benefits are associated with income disparities in internalizing symptoms that are approximately 49% lower in high cost of living states. A simple slopes analysis demonstrates that the interaction between cost of living and cash benefits is not significant at any level of log income-to-needs ratio present in the data. However, when income is low, the cash benefit by cost of living interaction is negative, such that in higher cost of living states, more generous cash benefits are associated with greater reductions in internalizing problems. Conversely, when income is high, the cash benefit x cost of living interaction is positive. This suggests that cost of living and the generosity of antipoverty policies are associated with lower internalizing problems only for children in low-income families who are eligible for these benefits relative to children in high-income families who are not.

There was no similar 3-way interaction between family income, cost of living, and the generosity of antipoverty programs in relation to externalizing problems (see Supplemental Materials). There were no significant 2-way interactions between family income and cost of living or between family income and the generosity of antipoverty programs in relation to internalizing or externalizing psychopathology symptoms. As with hippocampal volume, we conducted supplemental analyses examining the 3-way interactions of family income, cost of living, and the state minimum wage in relation to internalizing and externalizing problems, and found the interaction was significant in both analyses (see supplemental table S7).

Sensitivity Analyses

To determine if heterogeneity in the state-level associations between family income and study outcomes (i.e., hippocampal volume and internalizing problems) was specifically related to cost of living and the generosity of anti-poverty programs, and not to other potentially correlated state-level characteristics that do not as plausibly or specifically benefit low-income families, we conducted sensitivity analyses. Each analysis controlled for one of 10 state-level social, economic, and political characteristics that may serve as alternative explanations for these patterns. These characteristics included population density, economic inequality, unemployment rate, tightness/looseness, political preferences, women's political participation, reproductive rights, incarceration rate, state-funded preschool enrollment, and reading proficiency among students from low-income backgrounds. Our reported findings were robust to controlling for each of these wide-ranging state-level characteristics as well as their interactions with family income (see Tables S4 and S5 for details).

Discussion

We found that lower family income is associated with smaller hippocampal volume and greater internalizing and externalizing psychopathology in early adolescence, replicating prior findings in smaller samples^{7,11–15,20} and previous analyses of a smaller portion of the ABCD sample.²⁹ Critically, however, we demonstrate that the magnitude of these associations varies as a function of state-level macro-economic factors—including the cost of living and generosity of anti-poverty programs. The disparities between high- and low-income participants in hippocampal volume and internalizing problems were 36% to 49% smaller, respectively, in states that had a high cost of living but that provided more generous benefits for lower-income families, as compared to high cost of living states with less generous benefits. In high cost of living states where antipoverty programs were more generous, the association of family income

with hippocampal volume and internalizing problems resembled that of the lowest cost of living states. Importantly, these associations were robust to controls for other state-level social, economic, political, and educational factors—including population density, unemployment rate, political preferences, and state-funded preschool enrollment—thereby ruling out some alternative explanations. These controls capture a diverse set of structural characteristics that covary geographically with cost of living and the generosity of antipoverty programs, with varying degrees of relevance for children and families with low income. Together, these findings suggest that macro-social factors related to poverty have a powerful influence on socioeconomic disparities in hippocampal volume and internalizing problems, and that structural policy interventions may be an effective strategy for reducing these disparities.

One way that cost of living and the generosity of anti-poverty programs may influence the links between family income, hippocampal volume, and mental health is by amplifying or reducing stressors associated with low income. Having greater financial resources may shield families from experiencing some of the chronic stressors associated with low income that can influence hippocampal development.^{15,16,30} Further, by increasing financial resources and access to healthcare (i.e., in states that expanded Medicaid benefits), it is plausible that more generous anti-poverty programs could decrease the negative impact of some stressful life events on hippocampal volume and internalizing problems. Cumulative stress exposure is by no means the only potential processes linking family income with neurodevelopment and mental health that might be impacted by the generosity of antipoverty programs, however. For example, low income is also associated with lower cognitive stimulation, less supervision by adults, and a less predictable environment.^{9,31,32} An ongoing experimental study that randomized families to receive cash benefits³³ has already found that those benefits may contribute to alterations in

neural function²⁸ and thus may shed light on the role of these processes in explaining how the generosity of antipoverty programs may mitigate the influence of low family income on neurodevelopment and mental health.

Given that we observed the same type of 3-way interaction of family income and cost of living with cash assistance and Medicaid expansion, we expect that these policy differences—while helpful in and of themselves—are likely indicative of a broader collection of policies and structural supports for families facing economic hardship that were not directly measured in this study (e.g., availability of free or reduced cost early childhood education programs). Indeed, in supplemental analyses, we examined the 3-way interactions of family income, cost of living, and the state minimum wage—another indicator of the generosity of the social safety net for families with low income—in relation to hippocampal volume, internalizing problems, and externalizing problems, and found the interaction was significant in all three analyses. In addition, the study design only allows us to evaluate whether antipoverty programs that differ between states may mitigate socioeconomic disparities in hippocampal volume and mental health. Programs such as SNAP, which are administered uniformly across states, have also been demonstrated to reduce adverse childhood experiences and improve health and educational outcomes.^{26,34,35}

These findings have broad methodological implications for research on environmental factors in psychology and cognitive neuroscience. Most psychology and neuroimaging studies are conducted in a single community. In such designs, all participants experience the same macro-social context, which requires a focus solely on individual- and interpersonal-level explanations for observed associations. However, our results, together with other recent studies,³⁶ demonstrate that the magnitude of individual-level associations between environmental factors—like family income, and developmental outcomes—like brain structure and

psychopathology, vary systematically as a function of characteristics of the macro-social context. This context therefore demands consideration when comparing results collected in different communities and may provide an explanation for replication failures in studies focused on associations measured solely at the individual level. The degree to which different aspects of macrosocial context influence other individual-level associations is an important question that could be explored in many additional ways in the ABCD data.

Some limitations are worth noting. First, this is a cross-sectional and observational study. However, it is implausible that children's hippocampal volume could alter their family's income or state-level characteristics, and simple slopes analyses suggested that the interaction of antipoverty programs and cost of living in relation to hippocampal volume was specific to low-income participants who would benefit from antipoverty programs. We also conducted numerous sensitivity analyses to ensure that alternative state-level social, economic, educational, and political characteristics did not explain these patterns. Further, the observational associations we document based on existing anti-poverty programs complement emerging causal evidence of the impact of cash assistance on children's neurodevelopment.²⁸ That said, we cannot entirely rule out the possibility that other factors beyond cost of living and the generosity of anti-poverty programs may be explaining the variation in associations of family income with hippocampal volume and internalizing problems. Natural experiments may one day be feasible with this dataset as policy changes at the state level unfold in the future. However, this type of design is not possible at this time with the ABCD data because there have been no changes in these poverty-relevant policies during the data collection period in the states where ABCD data were collected. Nor to our knowledge are there any other datasets that have collected harmonized

neuroimaging data on children living in different contexts over time to allow policy changes to be examined as predictors of changes in neural outcomes.

Second, although the ABCD study is one of the largest of its kind, the study sites are located in only 17 states. This restricted range would have reduced our statistical power to detect moderation, and thus our estimates are likely conservative. At the same time, cost of living and the generosity of antipoverty programs are correlated within those states, which limits our ability to tease apart the independent impacts of these factors. Third, the state-level macrosocial factors examined here are confounded with scanner and the demographics of the sample at each site to some degree. However, we control for both scanner and the racial and ethnic makeup of the sample in our analyses. While it is possible that scanner differences contribute to systematic differences in volume estimation of the hippocampus (i.e., the mean volume in each state), it is implausible that scanner differences would produce systematic changes in the association between family income and hippocampal volume. In addition, state-level cost of living is used, which ignores potential variability in cost of living within states. Further, the ABCD sites may vary in the extent to which their local cost of living is consistent with the cost of living in the state. In general, however, the costs of living in the metropolitan areas where the data were collected tracks closely with the costs of living in the states where the data were collected ($r=.73$ across the 21 sites). Each ABCD site was a regional center recruiting between 300 and 1000 participants from wide catchment areas that in most cases spanned beyond the metropolitan statistical area in which the site was located. Given that the anti-poverty benefits that are the focus of the paper are policies enacted at the state level, not metropolitan area, using cost of living estimates from the state level ensures that the fixed effects in the model are drawn from the same geographical level of analysis. Finally, all participants in the sample were 10-11 years

old at the time of data collection, so our ability to generalize these findings to other ages is limited. However, as the ABCD cohort ages, and potentially, as state-level policies and macroeconomic conditions change over time, there will be opportunities to address this limitation and expand upon these findings in the future.

Lower family income is associated with smaller hippocampal volume and higher internalizing problems. However, we show that these relationships are magnified in states with high cost of living but reduced in states with more generous anti-poverty programs. Anti-poverty programs reduced socioeconomic disparities in hippocampal volume by approximately 36% and internalizing problems by approximately 49% in states where cost of living is high. In states where antipoverty programs were more generous, the associations of family income with hippocampal volume and internalizing problems in high cost of living states resembled that of low cost of living states. This finding demonstrates that macroeconomic conditions related to poverty are associated with strength of the association between family income and children's neurodevelopment and mental health and suggests that public policies that increase family's financial resources may reduce socioeconomic disparities at both neural and behavioral levels. Further, investments in social safety net programs may therefore contribute to considerable long-term financial savings, given the high cost of addressing mental health, educational, and economic challenges resulting from socioeconomic disparities in neurodevelopment.

Materials and Methods

Sample

Data come from the ABCD study, the largest study of brain development in the U.S. (<https://abcdstudy.org>). We drew data from the baseline assessment (ABCD 3.0) of 11,864 youth with data on parent-reported psychopathology and 11,533 youth with brain structure data (mean

age 9.91 years, $SD=.622$). Twenty-one study sites from 17 states were included from across the U.S. From these sites, a stratified probability sample of schools within the catchment areas for each site were selected, and eligible youth were recruited from each school. The ABCD study approximates a multi-stage probability sample but is not nationally-representative (for greater details on sample selection see³⁷). The imaging procedures were harmonized across sites.³⁸

Measures

Family Income. Parents reported total family income at the baseline visit by selecting one of 10 income ranges. The midpoint of the income range selected was used for each participant. Parents also reported the number of people in the household. Income-to-needs ratio was calculated by dividing the parent-reported family income by the poverty threshold for a family of that size for the year 2017 as indicated by the U.S. Census Bureau.³⁹ Consistent with prior work on childhood SES and neurodevelopment,^{5,40} the natural log of income-to-needs ratio was used as a measure of family income in all analyses to reflect that associations of income with neural outcomes are stronger at the lower end of the income distribution (Figure 1). Site-level differences in the average number of family members living in the home are small, and there is no evidence that site-level variability in family size is likely to be a confounder in these analyses

Hippocampal volume. Hippocampal volume at the baseline visit was obtained from the structural data release. This data release had volume estimates for 11,533 participants. ABCD guidelines were followed with regard to exclusion of participants based on data quality, including exclusion of structural data that was rated as severe in any of the five categories of image artifact or reconstruction inaccuracy: motion, intensity inhomogeneity, white matter underestimation, pial overestimation, and magnetic susceptibility artifact.⁴¹ A total of 471 participants were excluded from further analyses based on these criteria. The rate of exclusion varied between study sites.

However, the rate of exclusion was unrelated to cost of living or the generosity of antipoverty programs (see supplemental materials).

Volume measures of left and right hippocampus, obtained using automatic segmentation in FreeSurfer 5.3, were summed to produce a measure of total hippocampal volume to reduce the number of analyses and because there is no apparent pattern of laterality in the association between SES and hippocampal volume in the literature.^{7,11–15} Automatic segmentation was also used to obtain estimates of total intracranial volume, which was controlled for in all analyses.

Internalizing and externalizing problems. Internalizing and externalizing problems were assessed using parent reports on the Child Behavior Checklist (CBCL),⁴² collected at the baseline visit. The age-corrected T-scores were used for each measure.

State-level moderators. The following state-level moderators characterize the U.S. state of the site in which each participants' data was collected. These state-level characteristics as well as the demographics of the sample at the state level are summarized in Table 1.

Cost of living is based on Regional Price Parity (RPP) for the year 2017 – the median year in which the ABCD baseline data was collected – obtained from the U.S. Bureau of Economic Analysis.²¹ RPP indexes the expected cost of an equivalent item in each state as a factor of the mean cost across all 50 states. For example, an item that costs \$1 on average costs \$1.10 in California (RPP=1.10) and 92 cents in Oklahoma (RPP=0.92).

Cash assistance is the mean of the average monthly Earned Income Tax Credit (EITC) and Temporary Assistance for Needy families (TANF) benefit in each state. States vary in the amount of additional EITC they grant as a proportion of the federal EITC. In 2017, the average federal EITC for families with children was \$266 a month.⁴³ The monthly EITC benefit in each state was therefore calculated as \$266 x (1 + state EITC as a proportion of federal EITC). The

mean was then taken between the average monthly EITC (range: \$266-\$399) and the monthly TANF benefit⁴⁴ (range: \$286-\$789) in each state to compute a variable indicating the average cash benefit received by either unemployed (TANF) or working (EITC) low-income families in that state.

Medicaid expansion is a dichotomous variable indicating whether or not that state had expanded Medicaid eligibility through the Affordable Care Act by the end of 2017.⁴⁵

Analysis

Analyses were conducted using linear mixed-effects models with the nlme package in R. Analyses were restricted to participants who reported family income. These included 9,921 participants for analyses with hippocampal volume as the outcome and 10,628 participants for analyses with mental health outcomes. The proportion of participants missing data on income varied between states but was unrelated to cost of living or the generosity of anti-poverty programs (see supplemental materials). Random intercepts were included for study site. While including random effects for family proved untenable, as the models all failed to converge, we reran all analyses, randomly including only one sibling from each family with multiple siblings in the sample, and results remained unchanged (see supplemental materials). To estimate the association between income-to-needs ratio and hippocampal volume, fixed effects were included for log-income-to-needs ratio, total intracranial volume (ICV), scanner, age, and sex. To determine the association between log-income-to-needs ratio and mental health (internalizing problems, externalizing problems), fixed effects were calculated for income-to-needs ratio, age, and sex.

Cost of living and cash assistance were grand mean centered. To evaluate state-level moderation, random intercepts and random slopes of income-to-needs ratio at the study site level

were included in all analyses. To determine if the association between income-to-needs ratio and each outcome was moderated by cost of living, cash assistance, or Medicaid expansion, a separate model was fit for each state-level moderator in which fixed effects were included for income-to-needs ratio, the proportion of the sample at that study site that was White, Black, and Latinx, antipoverty programs, each of the 2-way interactions between antipoverty programs, cost of living, and log income-to-needs ratio, and the 3-way interaction between log-income-to-needs ratio, cost of living, and each of the anti-poverty programs. In models where hippocampal volume was the outcome, fixed effects were also included for ICV and the type of MRI scanner used at each site. Models were also fit with only the 2-way interactions between cost of living and family income and antipoverty programs and family income, without the 3-way interaction, or the interaction between cost of living and antipoverty programs. Results of those models are provided in supplemental materials (Table S7).

To evaluate whether anti-poverty programs were plausible moderators of the association between family income and these outcomes, we examined whether model fit was improved when random slopes were included in the model. Based on the likelihood ratio test, model fit was significantly improved when random slopes were included for the relation between log income-to-needs ratio and externalizing problems (likelihood ratio = 53.05, $p < .001$), but not for hippocampal volume (likelihood ratio = 3.52, $p = .172$) and internalizing problems (likelihood ratio = 5.50 $p = .067$) when random effects were included in the model at the site level. However, when a model was instead fit with clustering at the *state* level, inclusion of random slopes significantly improved model fit for both hippocampal volume (likelihood ratio = 8.23, $p = .016$) and internalizing problems (likelihood ratio = 7.58, $p = .023$), suggesting that state-level anti-poverty programs are plausible moderators of the association between log income-to-needs ratio

and these outcomes. Importantly, it is worth noting that significant cross-level interactions are possible even when inclusion of random slopes does not significantly improve model fit in the types of multi-level models estimated here.⁴⁶

Sensitivity Analyses

We conducted sensitivity analyses controlling for 10 state-level social, economic, educational, and political characteristics that may serve as alternative explanations for state-level variability in hippocampal volume, internalizing problems, and their associations with SES. The control measures are described and rationales for their inclusion are provided in the supplemental materials. The results of the sensitivity analyses are summarized in Supplemental Table S2 and S3.

We also conducted sensitivity analyses to address some other issues. Because including random effects for family proved untenable, as the models all failed to converge, we reran analyses, randomly including only one sibling from each family, and results remained unchanged. We include these results in supplemental materials. We included the percentage of participants at each site that were Black, White, and Latinx as covariates in all analyses, as site-level demographics are plausible confounders. Conversely, it is our view that using individual-level racial categories as variables of interest or covariates presumes a biological basis for these racial categories that is not supported by evidence. However, in the interest of demonstrating that our results hold whether race and ethnicity are included as site-level or individual-level variables, we conducted additional sensitivity analyses controlling for race and ethnicity at the individual level, and our results remain virtually unchanged. We include the results of these sensitivity analyses in supplemental materials.

Data Availability

Reproducible code for all analyses can be found in supplemental materials. All data and code are available at <https://osf.io/t3ev7/>.

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Table 1: Summary of state-level variables and sample characteristics

State	N	% Black	% Latinx	% White	RPP	EITC	TANF	Mean Cash	Expanded Medicaid
California	1934	9.5	50.5	62.7	1.10	.45	785	585	Yes
Colorado	565	8.5	22.3	92.2	1.02	.10	508	400	Yes
Connecticut	634	27.6	22.9	68.9	1.06	.23	698	513	Yes
Florida	1085	24.3	46.3	73.2	1.01	0	303	285	No
Maryland	605	46.6	7.2	52.2	1.07	.50	709	554	Yes
Michigan	722	27.7	9.0	73.8	0.93	.06	492	387	Yes
Minnesota	607	8.7	5.7	91.1	0.97	.35	532	446	Yes
Missouri	705	36.6	3.6	66.4	0.92	0	292	279	No
New York	339	29.5	14.3	71.7	1.10	.30	789	567	Yes
Oklahoma	743	24.0	19.6	76.3	0.92	.05	292	286	No
Oregon	585	8.0	16.3	88.0	1.01	.09	506	398	Yes
Pennsylvania	455	63.7	3.6	41.8	0.99	0	421	344	Yes
South Carolina	379	34.6	3.8	66.2	0.94	.42	286	332	No
Utah	1002	2.9	10.8	94.8	0.99	0	498	382	No
Virginia	552	34.6	7.9	67.6	1.01	.20	442	381	Yes
Vermont	578	3.1	3.0	94.6	1.01	.36	640	501	Yes
Wisconsin	385	17.7	9.9	86.5	0.93	.11	653	474	No

Note: RPP = Regional Price Parity, EITC = State-level Earned Income Tax Credit as a proportion of the federal EITC, TANF = monthly Temporary Assistance for Needy Families' benefit in dollars, % Black, % Latinx, and % White represent the racial and ethnic makeup of the ABCD sample within that state.

Table 2: Results of Moderation Analyses

Hippocampal Volume							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	84.4	9.64	<.001	Income	107.3	18.9	<.001
Cost of Living (COL)	-167	338	.630	COL	-240	502	.639
Cash Benefit (Cash)	.024	.243	.922	Medicaid Expansion (ME)	-10.5	48.2	.830
Income x COL	229	138	.098	Income x COL	613	209	.003
Income x Cash	-.142	.111	.202	Income x ME	-35.4	21.1	.092
COL x Cash	1.90	1.87	.327	COL x ME	314	539	.570
Income x COL x Cash	-2.62	.766	<.001	Income x COL x ME	-824	232	<.001
Internalizing Problems							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	-.917	.198	<.001	Income	-1.22	.405	.003
COL	-1.85	8.38	.829	COL	4.11	13.6	.767
Cash	-.00179	.00655	.789	ME	-1.11	1.36	.428
Income x COL	-.692	2.87	.809	Income x COL	-7.37	4.48	.100
Income x Cash	-.00069	.00231	.764	Income x ME	.476	.448	.289
COL x Cash	.0114	.0541	.836	COL x ME	-5.29	15.3	.735
Income x COL x Cash	.0376	.0162	.021	Income x COL x ME	11.7	4.90	.017
Externalizing Problems							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	-1.76	.337	<.001	Income	-1.69	.722	.019
COL	-2.15	6.55	.748	COL	4.72	10.3	.653
Cash	-.00196	.00512	.708	ME	-1.02	1.02	.333
Income x COL	2.39	4.98	.631	Income x COL	-2.59	8.14	.750
Income x Cash	-.00058	.00397	.884	Income x ME	-.171	.794	.830
COL x Cash	-.00966	.0420	.821	COL x ME	-8.18	11.5	.488
Income x COL x Cash	.0288	.0288	.317	Income x COL x ME	9.85	8.86	.266

Note: Age, sex, and the proportion of participants at each site that were White, Black, and Latinx were also included as covariates in all analyses. Total intracranial volume and scanner type were included as covariates in models with hippocampal volume as the outcome. Reproducible code and full model output for all analyses is included in supplemental materials.

Figure 1

Figure 1: Left panels illustrate that log-transformed income-to-needs ratio better characterizes the association between family income and both hippocampal volume and internalizing problems in the ABCD sample than raw income-to-needs ratio. Right panels illustrate the variability between states in the strength of the linear association between log-income-to-needs ratio and both hippocampal volume (top) and internalizing problems (bottom).

Figure 2

Figure 2: Visualizations of the 3-way interactions among log-income-to-needs ratio, cost of living, and cash assistance in relation to hippocampal volume. (A) The distribution of cost of living and generosity of anti-poverty programs were correlated across the 17 states. (B) The

simple slopes are plotted to reflect the values actually present in the distribution of cost of living and cash benefits in the ABCD data. The hippocampal volume estimate for low cost of living, low cash benefit states is based on the intercept estimates for hippocampal volume when log income-to-needs ratio is 1 SD above or below the mean, and cost of living and cash benefits are both 1 SD below the mean. The estimate for high cost of living, high cash benefit states is based on the intercept estimates when cost of living and cash benefits are both 1 SD above the mean. The estimate for high cost of living, low cash benefit states is based on the intercept estimates when cost of cost of living is at the mean, and cash benefits are 1 SD below the mean, as no state with cost of living 1SD above the mean had low cash benefits in our data. The estimate for low cost of living, high cash benefit states is based on the intercept estimates when cost of living is 1 SD below the mean, and cash benefits are at the mean, as no state with low cost of living had cash benefits that were 1SD above the mean in our data. This is illustrated in Figure S1 in supplemental materials.

Figure 3

Figure 3: Visualizations of the 3-way interactions among log-income-to-needs ratio, cost of living, and Medicaid expansion in relation to hippocampal volume. (A) The distribution of cost of living and Medicaid expansion in the 17 states. The simple slopes are plotted to reflect the

values actually present in the distribution of cost of living and cash benefits in the ABCD data.

(B) The hippocampal volume estimate for states that did not expand Medicaid is based on the intercept estimates for hippocampal volume when log income-to-needs ratio is 1 SD above or below the mean, and cost of living is 1 SD below the mean. The estimates for high cost of living states that expanded Medicaid are based on the intercept estimates when cost of living is 1 SD above the mean. The estimate for high cost of living states that did not expand Medicaid is based on the intercept estimates when cost of cost of living is at the mean, as no states with income 1SD above the mean did not expand Medicaid. This is illustrated in Figure S2 in supplemental materials.

Figure 4

Figure 4: Visualizations of the 3-way interactions among log-income-to-needs ratio, cost of living, and antipoverty programs in relation to internalizing problems. Details on high and low income-to-needs, cost of living, and cash benefits is the same as in Figures 2 and 3.

Supplemental Materials

Sensitivity Analyses

To determine if heterogeneity in the state-level associations between family income, hippocampal volume, and mental health was specifically related to cost of living and the generosity of anti-poverty programs, and not to other potentially correlated characteristics, we conducted sensitivity analyses controlling for 11 state-level social, economic, educational, and political characteristics, respectively, that may serve as alternative explanations. The rationale for selecting these specific characteristics is provided below. Because the number of these state-level characteristics is almost as high as the total number of states included in the ABCD sample, it was not possible to simultaneously control for all 11 characteristics. As such, we constructed a series of models that controlled for each of these characteristics individually in predicting hippocampal volume and internalizing problems. We examined whether our three-way interactions between family SES, cost of living, and generosity of anti-poverty policies remained significant after controlling for these state-level characteristics as a main effect (Table S2) and as a moderator of the association of SES with each of these outcomes (Table S3).

The measures of those characteristics were operationalized as follows, based on values at the time of data collection for the baseline ABCD sample.

Income inequality was operationalized by the state GINI index from the 2019 American Community Survey 5-year estimates.¹ The GINI index is a value between 0 and 1 indicating the distribution of economic resources in the population, where 0 indicates total economic equality and 1 indicates total economic inequality.²

Population density was calculated by dividing the estimated 2017 state population by the estimated land area of the state as reported by the U.S. Census Bureau.¹ Regions with greater

population density tend to have both higher costs of living and more generous antipoverty policies. However, the direct mechanisms through which population density may mitigate or augment the impacts of low SES are not currently known.

Unemployment is the average percentage of the labor force in the state that was unemployed in 2017 as reported by the U.S. Bureau of Labor Statistics.⁴ Unemployment rates reflect economic conditions and would be expected to relate to family incomes and potentially to the generosity of anti-poverty policies.

Incarceration rate is the number of individuals incarcerated in the state out of every 100,000 in population as reported by the U.S. Bureau of Justice Statistics.⁵ Because people who are incarcerated tend to come from lower SES backgrounds than those who are never incarcerated,⁶ it is plausible that the impacts of low SES may be augmented in states that are more punitive and incarcerate a greater proportion of their population.

State Preschool Enrollment is the proportion of 4-year old children in each state enrolled in state-funded prekindergarten during the 2016-2017 school year as reported by the National Institute for Early Education Research.⁷ It is plausible that providing preschool to a greater proportion of the population may mitigate the impacts of low SES on neurodevelopmental outcomes.

^{4th} *Grade Reading* proficiency is the average reading score on the National Assessment of Educational Progress (NAEP) among students receiving free or reduced price lunch as reported by the National Center for Education Statistics.⁸ It is plausible that these educational outcomes reflect the quality of the schools attended by low SES children in the state, potentially mitigating the impacts of low SES on neurodevelopmental outcomes.

Political preferences were estimated based on the results of the 2020 presidential election. These values reflect the proportion of votes in each state that were cast for Joe Biden during the 2020 presidential election as reported by CNN and officially confirmed by the Federal Election Commission.^{9,10} Regions that vote more Democratic tend to have both higher costs of living and more generous antipoverty policies. However, outside of a greater tendency to implement more generous antipoverty policies, the direct mechanisms through which political preferences may mitigate or augment the impacts of low SES on developmental outcomes are not currently known.

Women's political participation (Women's PP) is a composite score calculated by the Institute for Women's Policy Research¹¹ based on four indicators of women's political status: voter registration, voter turnout, representation in elected office, and women's institutional resources. Regions where women have higher political participation tend to have both higher costs of living and more generous antipoverty policies. However, the direct mechanisms through which women's political participation may mitigate or augment the impacts of low SES on developmental outcomes are not currently known.

Reproductive rights is a composite score calculated by the Institute for Women's Policy Research¹¹ based on nine indicators of women's reproductive rights: mandatory parental consent or notification laws for minors receiving abortions, waiting periods for abortions, restrictions on public funding for abortions, the percent of women living in counties with at least one abortion provider, pro-choice governors or legislatures, Medicaid expansion or state Medicaid family planning eligibility expansions, coverage of infertility treatments, same-sex marriage or second-parent adoption for individuals in a same-sex relationship, and mandatory sex education. Regions with greater reproductive rights tend to have both higher costs of living and more generous

antipoverty policies. Further, greater access to abortion, contraception, adoption, and sex education may directly impact family SES by increasing family size and needs. However, the potential role of reproductive rights in mitigating the impacts of SES on developmental outcomes is not currently known.

Tightness-looseness is a measure of the strength of punishment (tightness, e.g., the severity of punishment for violating laws) and the degree of permissiveness (looseness, e.g., access to alcohol) in a state.¹² Higher scores indicate greater tightness and lower looseness. Tightness-looseness has been found to predict other state characteristics, such as rates of inequality, discrimination, social stability, and homelessness. However, the direct mechanisms through which tightness-looseness may augment or mitigate the impacts of low SES on developmental outcomes are not currently known.

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Supplemental Tables and Figures

Table S1. Distribution of family income across the States in the ABCD Sample

State	Mean Income- to-needs ratio	Below poverty*	1-2x poverty*	2-5x poverty*	>5x poverty*
CA	3.76	.20	.14	.32	.34
CO	4.42	.05	.10	.47	.39
CT	4.15	.15	.10	.38	.38
FL	2.55	.29	.22	.35	.14
MD	3.79	.22	.09	.33	.35
MI	3.80	.14	.13	.43	.31
MN	4.49	.03	.10	.46	.40
MO	3.09	.18	.17	.48	.17
NY	3.61	.21	.10	.34	.35
OK	2.72	.24	.22	.37	.17
OR	4.32	.06	.11	.44	.39
PA	1.80	.44	.26	.23	.08
SC	3.71	.16	.15	.36	.33
UT	3.12	.09	.22	.56	.13
VA	3.45	.16	.13	.48	.24
VT	4.70	.04	.08	.39	.49
WI	4.15	.09	.07	.50	.34

*Numbers represent the proportion of the sample in that state within that income bin.

Table S2. Correlations

	1	2	3	4	5	6	7	8	9
1. Sex (female)	-								
2. Age	-.021	-							
3. Log income-to-needs ratio	-.002	.038	-						
4. Cash assistance	-.004	-.007	.113	-					
5. Cost of living	-.003	-.008	.011	.779	-				
6. Medicaid expansion	.004	.028	.110	.687	.564	-			
7. Hippocampal volume	-.304	.065	.202	-.018	.009	-.020	-		
8. Internalizing problems	-.090	.008	-.065	-.044	-.022	-.065	.009	-	
9. Externalizing problems	-.080	-.028	-.160	-.056	-.022	-.062	-.049	.588	-

Table S3. Participant Exclusion by State

State	Outcome	Participants with data	# excluded for poor data quality	# Missing data on income	% Excluded from Analyses
CA	Hippocampal Volume	1800	100	285	21.4
	Psychopathology	1934		304	15.7
CO	Hippocampal Volume	554	4	32	6.5
	Psychopathology	565		33	5.8
CT	Hippocampal Volume	620	18	81	16.0
	Psychopathology	634		83	13.1
FL	Hippocampal Volume	1075	7	146	14.2
	Psychopathology	1085		149	13.7
MD	Hippocampal Volume	591	18	91	18.4
	Psychopathology	605		96	15.9
MI	Hippocampal Volume	706	96	44	19.8
	Psychopathology	722		47	6.5
MN	Hippocampal Volume	595	6	29	5.9
	Psychopathology	607		30	4.9
MO	Hippocampal Volume	684	14	48	9.1
	Psychopathology	705		49	7.0
NY	Hippocampal Volume	339	8	44	15.3
	Psychopathology	339		44	13.0
OK	Hippocampal Volume	734	87	78	22.5
	Psychopathology	743		78	10.5
OR	Hippocampal Volume	582	4	42	7.9
	Psychopathology	585		43	7.4
PA	Hippocampal Volume	427	24	75	23.2
	Psychopathology	455		82	18.0
SC	Hippocampal Volume	375	7	52	15.7
	Psychopathology	379		53	14.0
UT	Hippocampal Volume	1000	6	30	3.6
	Psychopathology	1002		30	3.0
VA	Hippocampal Volume	538	21	61	15.2
	Psychopathology	552		62	11.2
VT	Hippocampal Volume	573	23	36	10.3
	Psychopathology	578		36	6.2
WI	Hippocampal Volume	340	28	20	14.1
	Psychopathology	385		23	6.0

Table S4. Summary of sensitivity analyses controlling for additional state-level characteristics

Control variable	Dependent Variable											
	<u>Hippocampal Volume</u>						<u>Internalizing Problems</u>					
	Income x Cost of Living x Cash Benefits			Income x Cost of Living x Medicaid Expansion			Income x Cost of Living x Cash Benefits			Income x Cost of Living x Medicaid Expansion		
	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>
Population Density	-2.63	.766	<.001	-819	232	<.001	.0374	.0163	.022	11.7	4.90	.017
Tightness	-2.61	.766	<.001	-821	232	<.001	.0375	.0164	.022	11.7	4.95	.018
GINI coefficient	-2.61	.766	<.001	-820	232	<.001	.0379	.0162	.020	11.7	4.93	.018
Political Preferences	-2.62	.766	<.001	-819	228	<.001	.0370	.0161	.022	11.7	4.85	.016
Incarceration Rate	-2.61	.766	<.001	-821	232	<.001	.0374	.0162	.022	11.7	4.92	.018
Unemployment Rate	-2.62	.776	<.001	-829	232	<.001	.0375	.0162	.021	11.7	4.89	.017
State Preschool	-2.65	.775	<.001	-841	237	<.001	.0375	.0163	.022	11.7	4.93	.018
Women's PP	-2.59	.772	<.001	-824	232	<.001	.0368	.0163	.024	11.7	4.91	.017
4th Grade Reading	-2.67	.766	<.001	-823	235	<.001	.0372	.0164	.023	11.7	4.91	.017
Reproductive Rights	-2.62	.767	<.001	-830	233	<.001	.0377	.0163	.021	11.7	4.92	.018

Table S5. Summary of sensitivity analyses controlling for state-level characteristics as moderators of the association of SES with hippocampal volume and internalizing problems

Control variable	Dependent Variable											
	<u>Hippocampal Volume</u>						<u>Internalizing Problems</u>					
	Income x Cost of Living x Cash Benefits			Income x Cost of Living x Medicaid Expansion			Income x Cost of Living x Cash Benefits			Income x Cost of Living x Medicaid Expansion		
	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>p</i>
Population Density x Income	-2.48	.810	.002	-772	240	.001	.0429	.0169	.011	13.3	5.19	.011
Tightness x Income	-2.91	.817	<.001	-908	241	<.001	.0250	.0154	.104	9.48	4.75	.046
GINI coefficient x Income	-2.71	.843	.001	-828	239	<.001	.0332	.0189	.079	11.1	5.25	.035
Political Preferences x Income	-2.96	.930	.002	-838	238	<.001	.0377	.0205	.066	11.4	5.17	.028
Incarceration Rate x Income	-2.19	.998	.028	-781	245	.001	.0076	.0173	.661	8.62	4.72	.068
Unemployment Rate x Income	-2.76	.830	<.001	-840	244	<.001	.0322	.0185	.085	11.2	4.99	.024
State Preschool x Income	-2.58	.774	<.001	-881	238	<.001	.0378	.0170	.026	11.9	5.17	.021
Women's PP x Income	-2.51	.773	.001	-773	236	.001	.0381	.0159	.017	13.1	4.95	.008
4th Grade Reading x Income	-2.93	.850	<.001	-983	420	.019	.0335	.0190	.077	15.9	8.62	.066
Reproductive Rights x Income	-2.76	.792	<.001	-835	245	<.001	.0347	.0172	.044	13.0	5.09	.011

Table S6: Results for 3-way interactions when controlling for race and ethnicity at the individual level

Hippocampal Volume							
<i>B</i> <i>SE</i> <i>p</i>			<i>B</i> <i>SE</i> <i>p</i>				
Income x Cost of living x Cash Benefits	-2.88	.762	<.001	Income x Cost of Living x Medicaid Expansion	-923	230	<.001
Internalizing Problems							
<i>B</i> <i>SE</i> <i>p</i>			<i>B</i> <i>SE</i> <i>p</i>				
Income x Cost of Living x Cash Benefits	.0331	.0154	.033	Income x Cost of L x ME	9.91	4.81	.040

Table S7: Results of Models with only 2-way interactions between income and cost of living and income and the generosity of antipoverty programs

Hippocampal Volume							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	60.9	7.89	<.001	Income	58.2	16.4	<.001
Cost of Living (COL)	-163	360	.658	COL	14.7	275	.958
Cash Benefit (Cash)	.0519	.258	.843	Medicaid Expansion (ME)	-26.1	36.9	.490
Income x COL	166	167	.320	Income x COL	-72.2	117	.541
Income x Cash	-.198	.135	.142	Income x ME	6.42	22.9	.779
Internalizing Problems							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	-.595	.149	<.001	Income	-.473	.300	.115
COL	-1.28	8.18	.878	COL	.158	6.75	.982
Cash	-.00206	.00640	.752	ME	-.816	.979	.418
Income x COL	-.861	3.11	.782	Income x COL	2.47	2.14	.247
Income x Cash	-.00089	.00255	.728	Income x ME	-.201	.417	.630
Externalizing Problems							
Cash Benefits				Medicaid Expansion			
	<i>B</i>	<i>SE</i>	<i>p</i>		<i>B</i>	<i>SE</i>	<i>p</i>
Income	-1.52	.234	<.001	Income	-1.07	.456	.019
COL	-2.83	6.37	.663	COL	-2.03	5.01	.691
Cash	-.00214	.00500	.663	ME	-.559	.751	.469
Income x COL	3.73	4.78	.435	Income x COL	5.72	3.23	.076
Income x Cash	-.00040	.00396	.920	Income x ME	-.713	.629	.256

Table S8: Results of moderation analyses examining the 3-way interaction between income, cost of living, and the minimum wage

Hippocampal Volume			
	<i>B</i>	<i>SE</i>	<i>p</i>
Income	87.7	9.61	<.001
Cost of Living (COL)	-112	314	.726
Minimum Wage (MW)	-.542	10.8	.961
Income x COL	420	140	.003
Income x MW	-16.1	5.03	.001
COL x MW	56.3	109	.518
Income x COL x MW	-150	38.9	<.001
Internalizing Problems			
	<i>B</i>	<i>SE</i>	<i>p</i>
Income	-.948	.201	<.001
COL	7.02	7.93	.391
MW	-.473	.292	.128
Income x COL	-2.04	3.02	.498
Income x MW	.115	.107	.281
COL x MW	-.438	2.61	.869
Income x COL x MW	1.96	.816	.016
Externalizing Problems			
	<i>B</i>	<i>SE</i>	<i>p</i>
Income	-2.03	.325	<.001
COL	5.26	6.26	.415
MW	-.385	.229	.115
Income x COL	-5.11	5.09	.315
Income x MW	.280	.177	.113
COL x MW	-1.37	2.04	.512
Income x COL x MW	2.87	1.35	.033

Minimum wage is the states' minimum wage in 2017 as reported by the U.S. Department of Labor.³ The federal minimum wage was used for states with no established minimum wage or with a minimum wage lower than the federal minimum wage.

Figure S1. Distribution of Cost of Living Relative to Mean Cash Benefits and Centering For Simple Slopes Analysis.

Figure S2. Distribution of Cost of Living Relative to Medicaid Expansion and Centering For Simple Slopes Analysis.