Associations between socioeconomic status and mental health trajectories during early adolescence: Findings from the ABCD Study

Short title: Socioeconomic status and mental health trajectories

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Abstract

Objective. Low socioeconomic status (SES) during childhood is associated with higher levels of youth psychopathology. However, limited longitudinal work has examined the role of both household and neighborhood SES in shaping mental health trajectories over time using large population-based data. The goal of the present study was to characterize associations between SES and changes in mental health problems during early adolescence.

Methods. We investigated independent and joint associations of household income-to-needs ratio, parent educational attainment, material hardship, and neighborhood disadvantage with internalizing, externalizing, and attention symptom trajectories using longitudinal data from the Adolescent Brain Cognitive Development Study. Youth-reported mental health was assessed across six time-points from age 10 to 13 years (M=10.4, SD=0.63 years at T1, N=9,488) and SES was assessed six months prior to T1.

Results. Main effects indicated that high SES was associated with lower mental health symptoms. However, longitudinally, higher SES was associated with greater increases in mental health problems over time. A higher income-to-needs ratio predicted greater increases in internalizing, externalizing, and attention problems. Two-way interactions between SES indicators predicting changes in symptoms were non-significant.

Conclusion. Our finding that youth from higher-SES backgrounds exhibited greater increases in mental health problems during early adolescence contrasts with findings from prior cross-sectional studies. However, mental health problems are on the rise and the landscape of risk for psychopathology is changing. More research is needed to understand how childhood SES contributes to risk and resilience for psychopathology during the transition to adolescence.

Introduction

Low socioeconomic status (SES) during childhood is associated with higher levels of youth internalizing, externalizing, and attention symptoms (1–5). Systematic reviews and meta-analyses demonstrate that children from socioeconomically disadvantaged backgrounds are two to three times more likely to develop mental health problems than their more advantaged peers (3,4). This relationship exists across different measures of socioeconomic status, such as parental income, education, and neighborhood-level disadvantage. Further, SES disparities in youth psychopathology persist even after controlling for other types of adverse childhood experiences (1), suggesting that SES plays a unique role in shaping mental health in young people. However, longitudinal work that considers the role of different measures of SES in shaping mental health *trajectories* has been limited, particularly in population-based samples. Given that mental health problems contribute significantly to global burden of disease in youth (6) and frequently have their onset during adolescence (7), understanding how SES influences the onset and development of psychopathology during this period can inform strategies aimed at reducing mental health disparities in young people.

SES is a complex construct that can be measured in numerous ways that reflect access to both economic and non-economic resources. Common ways to measure SES in young people include parent income or income-to-needs ratio, educational attainment, and neighborhood disadvantage—typically measured through neighborhood-level income, education, and employment levels (8). These different metrics of SES are only moderately correlated (9) and may represent distinct aspects of the environment that influence psychopathology through different pathways (3,10,11). The income-to-needs ratio reflects access to financial resources. Low income-to-needs can place constraints on parent's time and resources and thus be associated with access to nutrition, housing, and other basic necessities; availability and quality of childcare; and the ability to provide stimulating learning opportunities both in and out of the home. In addition, direct measures of financial strain may provide additional information about material hardship as differences in location, expenses, lifestyle, and other responsibilities make income, even when adjusted for

family size, only a cursory measure of income relative to need (12). Parental educational attainment may be associated with cognitive stimulation, linguistic input, and the duration and quality of parent-child interactions (13). Neighborhood SES, which is often an aggregate of neighborhood level income, employment, and education, captures distinct characteristics, such as access to green space and exposure to crime, violence, and pollution, that may also influence development and mental health (14). Therefore, in addition to household SES, examining the role of neighborhood SES in adolescent mental health trajectories is of crucial importance.

While income, educational attainment, and neighborhood disadvantage have all been linked to higher levels of psychopathology during childhood and adolescence, these different socioeconomic indicators may influence mental health in unique ways. Indeed, different measures of SES have been shown to have distinct associations with type of psychopathology as well as with the onset, persistence, and severity of different mental health problems (2,15), but findings at the level of the specific SES indicator are mixed. For example, previous work has found education, but not income or relative measures of SES, to be associated with different classes of mental disorders, including mood, anxiety, externalizing, and substance use disorders (2). It has also been shown that material hardship, operationalized as food insecurity, but not income or community-level inequality, is associated with mental health across domains (15). In contrast, findings based on a large sample of adolescents suggest that material hardship and poverty status, but not education, are associated with depression and anxiety (16). However, both income and education have also been to play a role in adolescent mental health in some studies (17,18).

Further, differential associations of various SES measures with youth psychopathology were also reported in a recent meta-analysis of population-based studies from the United States (3). Specifically, the study revealed that specific SES indicators, such as receiving public assistance, demonstrated stronger correlations with child psychopathology compared to other indicators. Furthermore, this meta-analysis found SES to be more strongly associated with childhood externalizing problems than with internalizing psychopathology (3). Longitudinally, one study revealed that neighborhood SES did not correlate with

trajectories of depressive symptoms from adolescence to adulthood (19). However, this study did not consider the role of household income and focused solely on depression as an outcome, leaving unanswered questions regarding the influence of various SES indicators on different mental health outcomes over time. Therefore, further research is needed to clarify associations between SES and mental health during adolescence. Indeed, no research to our knowledge has specifically examined associations between these different SES metrics (i.e., parent income, education, neighborhood disadvantage, and material deprivation) and the longitudinal development of mental health symptoms during adolescence, particularly using socioeconomically and ethnically diverse population-based data, limiting understanding of whether associations between SES and mental health persist, diminish, or magnify across development. This is particularly important to examine during adolescence, a developmental period when risk for psychopathology increases dramatically (7).

Some have argued that different SES indicators may interact in predicting child outcomes under a protective, additive, or mismatch framework (20–23). Specifically, some models predict that more advantaged neighborhoods should lead to improved outcomes for low-SES but not high-SES children (20–23). Other models predict that a mismatch between children's home and neighborhood environments should predict poorer outcomes (20–23). A final model suggests that family and neighborhood income contribute independently and additively to children's outcomes (20–23), similar to a cumulative risk framework (24). Interactions between different SES indicators in predicting youth mental health have previously been found in cross-sectional studies. For example, McLaughlin and colleagues (15) found a significant interaction between parental education and subjective social status in predicting externalizing disorders; higher subjective status was associated with lower odds of externalizing disorders for most respondents, except for those with parents who had the lowest education level. Similarly, Weinberg and colleagues (2019) showed that high subjective SES has a protective effect on the negative association between parental SES and adolescent mental health problems. Whether such interactions exist for absolute measures of SES remains unknown, particularly using longitudinal data.

The goal of this study was to investigate associations of different SES metrics—including income-to-needs, parent educational attainment, material hardship, and neighborhood disadvantage—with changes in symptoms of internalizing and externalizing psychopathology and attention problems during early adolescence using longitudinal data from the Adolescent Brain Cognitive Development (ABCD) Study. A recent meta-analysis of population-based studies suggests that all indicators of low SES are likely to be associated more strongly with externalizing than internalizing symptoms, however they did not specially examine changes in symptoms over time (3). As such, we expected low SES to be associated with greater increases in mental health problems over time. Given the paucity of longitudinal literature that has considered both household and neighborhood SES and change in mental health symptoms, we refrained from forming concrete hypotheses about associations between specific SES indicators and mental health domains. We additionally examined interactions between the SES indicators in predicting mental health trajectories.

Methods

Analysis plans were pre-registered on the Open Science Framework (https://osf.io/w5kug) (26). All deviations from the pre-registration have been fully described.

Participants

Participants were from the ongoing ABCD Study (https://abcdstudy.org/; release 5). The ABCD study is a large multi-site longitudinal study which has recruited over 11,800 children (aged 9–10 years) in order to comprehensively characterize psychological and neurobiological development from early adolescence to early adulthood (27). All parents submitted their written, informed consent, and all children gave their consent. The rights of participants were protected under the local institutional review boards.

The present study utilized data from the baseline and 6-month, 1-year, 18-month, 2-year, 30-month, and 3-year post baseline time points. After excluding for missing data on any of the four SES variables at baseline, the final sample for the main analysis consisted of 9721 participants who had complete baseline SES data as well as data on internalizing, externalizing, and/or attention symptoms at a minimum of one time point. The sample consisted of 9488 (4521 females) at the first time point (i.e., 6 months post baseline). The sample size and demographic information at each time point is provided in Table 1 and differences in baseline SES and mental health at the first time point between those who dropped out versus those who didn't are provided in the Supplement (Table S1).

Measures

Socioeconomic status

SES was assessed at baseline (age 9-10 years). The income-to-needs ratio was calculated as total household income (i.e., median value of the income band) divided by the federal poverty line for a family of that size. A value of 1 reflects income exactly at the poverty threshold and values greater than and less than 1 reflect being above and below the threshold, respectively). Income-to-needs was not calculated for individuals

missing either household income or household size. We calculated parent educational attainment as the average education for both parents (in years). Data for one parent was used when data for both parents was unavailable. Finally, we utilized the Parent-Reported Financial Adversity Questionnaire (PRFQ; sum of 7 items) to assess material hardship. The PRFQ asks seven yes or no questions about ability to afford basic needs (e.g., food, health care, and shelter). Individuals missing >30% items on PRFQ were not included in analyses including PRFQ. The PRFQ was recoded so higher values indicate lower material hardship. We used a composite measure of neighborhood disadvantage based on the participants' primary address: the area deprivation index (ADI). ADI was calculated at the census-tract level based on 17 different factors including employment, education, income, and housing quality. ADI provides rankings of neighborhoods by socioeconomic disadvantage as a national percentile (28,29). ADI values were recoded so higher values indicate lower disadvantage. This variable is therefore referred to as neighborhood advantage in this manuscript. See the Supplemental Figure S2 and Figure S4 for correlations between SES variables and distributions, respectively.

Mental health

We utilized youth-reported symptoms of psychopathology on the Brief Problem Monitor (BPM). Outcome variables included scores on the three BPM subscales: internalizing, externalizing, and attention problems. Youth-reported mental health was assessed at six time points starting at six months following baseline. Data from all available time points were utilized to model longitudinal change in symptoms. Although not preregistered, given the skewed nature of the data, we transformed the raw values based on the Yeo Johnson method for transformation (using the *bestNormalize* package in R). Distributions of transformed and untransformed values at each time point and plots for transformed versus non-transformed values are provided in Figure S1 and S3, respectively. Model residuals with both transformed values and raw values as well as model output with raw values have been included in the Supplement.

Statistical analysis

To examine associations between SES and mental health trajectories, we ran linear mixed models using the *lme4* package in R with scores on the BPM subscales as time varying dependent variables (six time-points; 6-month, 1-year, 18-month, 2-year, 30-month, and 3-year post baseline) using three separate models for each outcome (i.e., internalizing, externalizing, and attention symptoms). The *lmerTest* package was used to obtain *p* values. Predictors included time-invariant measures of baseline SES (i.e., income-to-needs ratio, parent educational attainment, material hardship, and ADI), age (modeled as time-varying; six time-points), and interactions between each SES variable and age. SES and age were standardized for analyses. In addition, to interpret associations of SES with mental health symptoms across all time points, we report the main effects of SES from these models. Since age was standardized, the main effects represent associations of SES with mental health at the mean age.

Sex and race/ethnicity have previously been shown to be associated with mental health trajectories (30–33). As such, interactions of sex and race/ethnicity with age were included as covariates. However, since effects of race/ethnicity and disadvantage can be difficult to disentangle (34), model output without race/ethnicity as a covariate is included in the Supplement. Lower-order main effects were automatically included in the model. Subject and family were modelled as random effects. Site was not modelled as a random effect as it accounted for minimal variance and contributed to model convergence issues. See the Supplement for model equations. Because we estimated associations between SES and three separate mental health outcomes, findings were considered significant at $p < 0.0167$. For meta-analytic purposes we tested independent models (where the interaction between age and only one SES variable was included at a time; reported in the Supplement Table S3). Further, in sensitivity analyses for significant effects we included the relevant SES variable (interacting with age) as the sole predictor in the model to ensure that the inclusion of covariates did not impact findings. See the Supplement for model equations.

To examine interactions between individual and neighborhood SES as described in the introduction, we added the following interactions (with age) to the models described above: i) income to needs ratio and ADI, ii) educational attainment and ADI, and iii) material hardship and ADI. In addition, to evaluate whether

one form of SES buffers or magnifies the associations of other aspects of SES with mental health, we also examined interactions between i) income-to-needs and educational attainment and ii) educational attainment and material hardship. Lower-order main and interaction effects were automatically included in the model. See the Supplement for model equations. We accounted for multiple comparisons using False Discovery Rate (FDR) correction at $p\text{FDR} < 0.0167$ (to account for 15 models run across three outcomes).

Non-preregistered supplemental analyses. To aid with interpreting our results, we conducted additional analyses that examine associations of SES with COVID-19 related changes that may influence mental health. Specifically, we examined associations of SES with self-reported COVID-19 life impact and changes in familial and social relationships. In addition, we also examined parent involvement in schoolwork as a measure of support. These additional data were gathered through a dedicated COVID-19 sub-study conducted during the pandemic period. Given that these analyses were not preregistered and were conducted solely to provide context for our results, we have included them in the Supplementary Materials and briefly addressed them in the Discussion to bolster our interpretation.

Results

Demographic information

Demographic information (at each time point) is available in Table 1.

Follow up time-point	6 months	1-year	18 months	2-year	30 months	3-year
N (Females)	9488 (4521)	9357 (4468)	9276 (4414)	9186 (4368)	8635 (4130)	8712 (4140)
Age in years	10.4 (0.63)	10.93 (0.64)	11.4 (0.64)	12.03 (0.67)	12.41 (0.64)	12.91 (0.65)
Internalizing	1.78 (2.06)	1.72 (2.1)	1.52 (1.92)	1.8 (2.21)	1.81 (2.28)	2.02 (2.38)
Externalizing	1.92 (1.98)	1.96 (1.97)	1.75 (1.87)	2.07 (1.98)	1.88 (1.9)	2.08 (1.98)
Attention	3.14 (2.52)	3.15 (2.66)	2.87 (2.5)	3.3 (2.69)	3.14 (2.61)	3.58 (2.75)
Neighborhood advantage	62.3 (26.2)	62.25 (26.26)	62.34 (26.2)	62.27 (26.18)	63.13 (25.74)	62.86 (25.97)
Educational attainment	15.34 (2.5)	15.35 (2.5)	15.36 (2.49)	15.36 (2.49)	15.4 (2.48)	15.42 (2.47)
Income-to-needs ratio	3.71 (2.39)	3.72 (2.39)	3.73 (2.39)	3.71 (2.38)	3.77 (2.38)	3.76 (2.38)
Low material hardship	6.57 (1.06)	6.57 (1.06)	6.57 (1.05)	6.57 (1.06)	6.59 (1.04)	6.58 (1.04)

Table 1: Sample size and demographic information (mean and standard deviation) at each time point for participants that had data for all four SES variables at baseline. Values of baseline SES have been reported for participants at each time point. This table reports recoded values of ADI (as neighborhood advantage) and material hardship (as low material hardship).

Main effects of SES on mental health symptoms

To clarify the association with SES and overall mental health in the sample cross-sectionally, we report the main effects of SES. Since age was standardized for analyses, the coefficients for the main effects represent the intercept (i.e., associations of SES with mental health at the mean age across all time points). A high income-to-needs ratio was associated with lower internalizing and externalizing symptoms. Higher educational attainment was associated with lower internalizing and attention symptoms. Neighborhood advantage and lower material hardship were associated with lower mental health problems across all three domains. See Table 2 for model output.

Table 2: Model output for main effects

Mental health variable	SES Variable	B	SE	T	p
Internalizing	Income-to-needs	-0.027	0.011	-2.486	0.013
	Education	-0.023	0.011	-2.184	0.029
	Low material hardship	-0.074	0.009	-8.488	<0.001
	Neighborhood advantage	-0.049	0.010	-4.704	<0.001
Externalizing	Income-to-needs	-0.060	0.011	-5.323	<0.001
	Education	-0.008	0.011	-0.717	0.474
	Low material hardship	-0.074	0.009	-8.177	<0.001
	Neighborhood advantage	-0.035	0.010	-3.559	<0.001
Attention	Income-to-needs	-0.014	0.012	-1.242	0.214
	Education	-0.051	0.011	-4.419	<0.001
	Low material hardship	-0.085	0.009	-9.004	<0.001
	Neighborhood advantage	-0.037	0.011	-3.495	<0.001

SES and mental health trajectories over time

When income-to-needs, neighborhood advantage, educational attainment, and material hardship were included in the same model, only income to needs was associated with mental health trajectories (Figure 1; Table 3). Specifically, income-to-needs ratio was associated with trajectories of internalizing (B = 0.002, SE = 0.0004, $p < .001$; Figure 1A), externalizing (B = 0.001, SE = 0.0004, $p = .002$; Figure 1B), and attention (B = 0.001, SE = 0.0004, $p < .001$; Figure 1C) symptoms, whereby a higher income-to-needs ratio was associated with *greater* symptom increases over time across all three domains. All indicators except material hardship were associated with changes in mental health symptoms in independent models (where only one SES variable was included at a time; see Table S3). Further, sensitivity analyses revealed that results remained unchanged when INR was included in the model as the sole predictor (i.e., without sex and race/ethnicity as covariates); higher INR was associated with greater increases in internalizing, externalizing, and attention symptoms (model output available in the Supplement; Table S7). Analyses with

raw (i.e., untransformed) values also revealed higher INR to be associated with greater increases in internalizing and attention symptoms (Table S8).

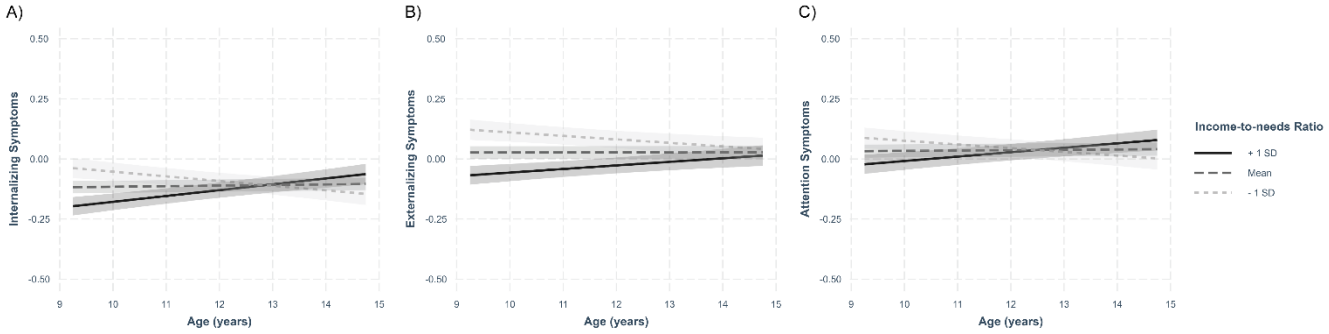

Figure 1: Associations between income-to-needs and trajectories of internalizing (A), externalizing (B), and attention (C) problems during adolescence. The y-axis represents transformed values. To enhance visibility of slopes, the y-axis scale has been reduced. Plots with the full y-axis scale are available in the supplement.

Table 3: Model Output

Mental health variable	SES Variable	B	SE	T	p	
Internalizing	Income-to-needs	0.024	0.005	4.546	< 0.001	*
	Education	0.007	0.005	1.419	0.156	
	Low material hardship	0.0003	0.004	0.081	0.935	
	Neighborhood advantage	0.010	0.005	2.023	0.043	
Externalizing	Income-to-needs	0.016	0.005	3.167	0.002	*
	Education	-0.006	0.005	-1.170	0.242	
	Low material hardship	0.002	0.004	0.389	0.697	
	Neighborhood advantage	0.002	0.005	0.489	0.625	
Attention	Income-to-needs	0.018	0.005	3.779	< 0.001	*
	Education	0.004	0.005	0.747	0.455	
	Low material hardship	-0.001	0.004	-0.306	0.760	
	Neighborhood advantage	0.006	0.005	1.250	0.211	

Table 2. Model output for independent associations between SES indicators and internalizing, externalizing, and attention symptom trajectories. Results are from models where all four SES indicators were included simultaneously. The table reports uncorrected p values. * $p < 0.0167$

ADI = area deprivation index, EDU = educational attainment in years, INR = income-to-needs ratio, MD = material hardship

Joint associations between SES and mental health trajectories

We found no significant joint associations of SES indicators with mental health trajectories. Model output is available in the Supplement (Table S2).

Discussion

The aim of this study was to characterize independent and joint associations between SES and trajectories of internalizing, externalizing, and attention symptoms from 10 to 13 years in a large national sample of adolescents. High SES was associated with lower mental health problems cross-sectionally. However, in contrast to our hypotheses, higher income-to-needs was associated with greater increases in mental health symptoms. Over the past few years, a period which included the global COVID-19 pandemic, we observe the opposite association between SES and youth mental health than has typically been observed in longitudinal (35) and population-based cross-sectional studies (3). We speculate that either the pandemic or other recent changes in the landscape of child mental health may have, at least temporarily, altered the role that income plays in the emergence of psychopathology during adolescence.

We found that high SES was associated with lower mental health problems cross-sectionally (i.e., the intercept and at the first time-point) across SES indicators and mental health domains (barring a few exceptions). Our findings suggest that in general, higher financial and non-financial resources at the household and neighborhood level are associated with lower mental health problems in early adolescence. These results align with prior meta-analytic work on population data and systematic reviews that have similarly shown that high SES is associated with lower risk for psychopathology (3,4). There are several factors that may contribute to these associations. For example, greater financial stability as a function of higher household SES may contribute to lower stress and anxiety (36). Further, higher SES is often linked to better educational opportunities for children such as school quality, enrichment programs, and extra-curricular activities, which can promote cognitive and emotional development (37,38). Higher SES is also associated with lower exposure to adverse childhood experiences such as violence, neglect, and family instability, which are well-documented risk factors for developing mental health problems (39). Finally, high SES neighborhoods usually offer safer environments, better recreational facilities, more opportunities for social engagement, and greater social support systems, all of which may buffer stress and contribute to positive mental health outcomes (40,41).

Given the vast literature showing links between low SES and greater mental health problems (3,4), we expected low SES to be associated with greater increases in psychopathology over time. However, although higher income-to-needs was associated with lower mental health problems cross-sectionally, the longitudinal trajectories tell a different story. Specifically, higher income-to-needs was associated with greater increases in mental health symptoms over time across all three domains when change associated with the other SES indicators, race, and sex were accounted for. Similar findings of high SES being associated with greater increases in mental health problems have previously been demonstrated, but not interpreted, in the ABCD study using prior releases that had partial data available for the later timepoints (42). Importantly, all four SES indicators were associated with mental health problems cross-sectionally when all four variables were included in the same model. In addition, in pre-registered supplemental analyses, in which we ran separate models for each SES measure, we found that higher SES across all indicators (except material hardship) was associated with change in mental health symptoms. These findings are consistent with prior cross-sectional work showing low SES, across different measures of SES, to be associated with worse mental health problems (3,4). However, considering the paucity of longitudinal literature, the finding that neighborhood advantage, material hardship, and parent educational attainment did not predict trajectories of mental health symptoms over time when change associated with other SES variables were accounted for, is harder to interpret. To our knowledge, the longitudinal studies that examined associations between SES and changes in symptoms (e.g., 19,35,43), did not consider the role of the same socioeconomic indicators, making it challenging to reconcile findings. However, consistent with our results, Lansford and colleagues (35) also showed that income, but not education, was associated with changes in symptoms over time. Our findings may also be a function of the specific life period examined. It is possible that these indicators of SES influence mental health differentially during different life periods (e.g., early childhood vs adolescence). For example, the effects of neighborhood advantage may become more evident as adolescents grow older and spend more time outside their homes (44). Further work with data spanning across adolescence and emerging adulthood is needed.

While speculative, one interpretation of higher income being associated with greater increases in symptoms relates to the potential impact of the COVID-19 pandemic on adolescent psychopathology, during which some of the data from the later waves of the ABCD study was collected. The COVID-19 pandemic introduced innumerable stressors into the lives of adolescents and families. Past work has shown that the experience of moderate levels of adversity promote and foster subsequent resilience in the face of stressors (45,46). Specifically, results from a multiyear, national study found that individuals who had experienced some adversity in their lives had better mental health and well-being outcomes compared to those with either a high or no history of adversity (45), a finding that has since been replicated (47). Although speculative, this idea can be extended to explain why low SES was associated with lower increases in symptoms in our analyses. Low income is linked with heightened parental stress and mental health challenges given the numerous constraints that low income places on families such as difficulty affording basic necessities, challenges accessing childcare, unstable employment, and exposure to neighborhood violence. This heightened parental stress can influence the way parents interact with and support their children (48–51). During the pandemic, there was a general increase in parental job loss, financial adversity, many forms of chronic stress, and mental health problems (52–54), which could have contributed to increases in parent-child conflict and family violence (55). Based on this idea, it is possible that children from lower income backgrounds may have developed greater skills for coping with stress and adversity than children from higher income backgrounds, making them more resilient to the increase in stressors brought on by the pandemic. However, given evidence showing that early-life stress increases sensitivity to later stressors (56), as well as work showing that the pandemic disproportionately impacted those from disadvantaged backgrounds (57), this explanation is unlikely. We provide other possible interpretations below.

Another possible explanation for our findings is that parents from low SES backgrounds (particularly in the ABCD study) may have responded to the pandemic differently than parents from high SES backgrounds in ways that contributed to lower pandemic-related stressors or less impact of these stressors on mental

health for children. For example, in the ABCD sample, families who experienced more family- and neighborhood-level disadvantage reported more frequent supportive and open dialogues about COVID-19 and ways to reduce its spread, as well as more frequent youth preventative actions than families from higher SES backgrounds (58). Protective measures taken by these families may have reduced fear of infection with COVID-19, thus contributing to lower increases in symptoms of stress-related mental health problems. Further, in supplemental analyses, we showed that higher INR was positively associated with self-reported life impact, and more negative changes in communication and general relationship quality with family, but not friends. That is, adolescents from higher income families reported that their life was more severely impacted by the pandemic. They also reported that there were more negative changes in familial communication and relationship quality. Further, higher INR was also associated with lower parent involvement in schoolwork during the pandemic. These results support the idea that parents from higher income backgrounds behaved differently than parents from lower income backgrounds, at least as perceived by their children, during the pandemic in this sample. We speculate that these differences may have contributed to our finding of higher income children experiencing greater increases in mental health problems during this time. However, it is important to note that these results may be specific to the ABCD sample and may not apply to the general population.

There are also other explanations for our findings. Mental health problems have been increasing drastically over the last decade (59). Nationally representative data indicate that depressive symptoms, suicide-related outcomes, and suicide deaths have increased markedly among American adolescents during that time (60). Given this increase in mental health problems, it is likely that the landscape of risk for mental health problems is also changing. For example, adolescents are also spending substantially more time online and interacting through electronic devices and less time engaging in non-screen activities like face-to-face social interaction, reading print media, and participating in sports or exercise; these changes have been linked to greater risk for depression and suicidal thoughts and behaviors (60). In addition, there has also been an evolution in parenting styles in recent years, with 'helicopter parenting' and over-involved parenting

styles on the rise, particularly in high-income contexts (61), which can influence children's well-being (62). This type of parenting has a differential impact based on SES, with more negative outcomes for high-income relative to low-income youth (63). As such, changes in children's behavior and the digital landscape as well as changes in parenting behaviors may interact in new and unique ways with SES to confer risk for mental health problems. More research is needed to explore these questions. However, it is also possible that our findings may have been influenced by the nature of the attrition in the ABCD sample or regression to the mean effects. There are more high SES children present in later waves due to greater attrition from lower SES families (Table S1). Further, children who had higher mental health problems at the 6-month time point were also more likely to have missed subsequent visits. Our results could have been influenced by this attrition; higher attrition in children from lower SES backgrounds and higher psychopathology could contribute to the observed association between higher SES and greater increases in mental health symptoms. Finally, our findings may also reflect cohort effects or be specific to the ABCD sample. More longitudinal work using other datasets is needed to test the generalizability of these findings.

Our analysis did not reveal significant interactions between the various SES indicators in predicting mental health trajectories. No other studies to our knowledge have examined the interactive effects of different SES indicators in predicting changes in mental health during adolescence, making our findings challenging to reconcile with existing literature. However, our results stand in contrast to previous cross-sectional research by McLaughlin et al. (2), who identified an interaction between parental education and subjective social status when predicting externalizing disorders in young people. Their study demonstrated that while higher subjective social status generally reduced the risk of behavior problems, individuals with parents who had the lowest level of education did not experience this protective effect. It is possible that only subjective social status, which reflects an individual's own perception of their social standing and self-worth and was not measured in the ABCD study, interacts with other absolute SES indicators in influencing mental health. It is also possible interaction effects are evident cross-sectionally due to effects being present earlier in childhood but do not influence changes over time during early adolescence. Further, interactive effects

between different SES indicators on mental health trajectories may only become evident in later life stages. For instance, an adolescent from a low-income family might experience a protective effect from strong and supportive neighborhood connections, but such an effect may only become evident later in adolescence when they engage more with their neighborhoods – an important question to explore in future work.

Our study has several strengths, including the use of a large national sample and longitudinal data; however, findings must be considered in light of some limitations. First, some of the data of the ABCD study were collected during the COVID-19 pandemic. Therefore, while this study provides important insight into the role that SES played in the change of mental health symptoms during this period, it may not apply outside of the pandemic context. Second, given that SES tends to be higher in ABCD relative to the national population, we cannot be sure of the generalizability of these results to the broader population. Third, given that this study was interested in the total effect of SES on mental health trajectories, we are unable to comment on the specific biological and environmental mechanisms that may have driven these associations. For example, lower income-to-needs is associated with earlier pubertal timing (64) and brain structure and function (65–68). These factors may act as mechanisms linking SES with mental health. Further, due to the constrains placed on families, low income is associated with several proximal environmental factors, such as parenting style, childhood maltreatment, and school environment (69,70), which are in turn associated with pubertal and/or development of brain structure and function (71–79) - ultimately influencing mental health outcomes (80). Finally, there are several factors, including supportive parenting, that may promote resilience and protect against the development of mental health problems in the context of low SES (81). Understanding the interplay of these risk and protective environmental and biological factors in the association observed in the present study need to be further explored. Fourth, we are unable to determine whether these effects are transient or persistent, and future longitudinal work using ABCD data is needed.

Conclusion. High SES was associated with greater increases in mental health problems during early adolescence in a large sample of youth. Our findings may reflect that low-SES children were more resilient to the stresses and changes brought on by the COVID-19 pandemic. However, mental health problems are on

the rise and the landscape of risk for mental health is changing. More research is needed on how different risk factors may interact with SES in conferring risk and resilience for the emergence of adolescent psychopathology.

Key points

What's known: Low SES is associated with higher mental health problems during adolescence. However, our knowledge of how different indicators of socioeconomic status (SES) influence longitudinal trajectories of mental health is limited.

What's new: In a large sample of U.S. adolescents, higher SES across numerous indicators was associated with lower mental health problems cross-sectionally but greater *increases* in mental health problems from 10 to 13 years.

Implications: Mental health problems are on the rise and the landscape of risk for psychopathology is changing. The COVID-19 pandemic may have altered how SES influences the emergence of mental health problems during early adolescence.

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