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Smaller Hippocampal Volume Among Black and Latinx Youth Living in High-Stigma Contexts

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Objective: To determine whether structural and individual forms of stigma are associated with neurodevelopment in children.

Method: Stigma related to gender, race, and Latinx ethnicity was measured at the structural level using objective state-level indicators of social policies and prejudicial attitudes and at the individual level using self-reports of perceived discrimination. Respective associations of stigma with hippocampal volume and amygdala reactivity to threat were examined using data from the Adolescent Brain Cognitive Development (ABCD) Study (N = 11,534, mean age 9.9 years), the first multisite neuroimaging study that provided substantial variability in sociopolitical contexts and that included individual-level measures of stigma among youth.

Results: In a preregistered analysis, Black ($B = -58.26$, $p = .023$) and Latinx ($B = -40.10$, $p = .044$) youths in higher (vs lower) structural stigma contexts were found to have smaller hippocampal volume, controlling for total intracranial volume, demographics, and family socioeconomic status. This association was also observed at a trend-level among girls ($p = .082$). The magnitude of the difference in hippocampal volume between high and low structural stigma states was equivalent to the predicted impact of a $20,000 difference in annual family income in this sample. As hypothesized, structural stigma was not associated with hippocampal volume in nonstigmatized youths, providing evidence of specificity. Perceived discrimination was unrelated to hippocampal volume in stigmatized groups. No associations between perceived discrimination or structural stigma and amygdala reactivity to threat were observed.

Conclusion: This study provides novel evidence that an objective measure of structural stigma may be more strongly related to hippocampal volume than subjective perceptions of stigma, suggesting that contextual approaches to stigma could yield new insights into neurodevelopment among marginalized youth.

Key words: hippocampal volume, neurodevelopment, population neuroscience, stigma

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Stigma—defined as the co-occurrence of labeling, stereotyping, status loss, and discrimination in a context in which power is exercised[1]—contributes to adverse mental health outcomes for marginalized groups through its influence on processes across individual, interpersonal, and structural levels.[1–3] At the individual level, stigma manifests as psychological responses through which stigmatized individuals perceive and react to stigma, including identity concealment,[4] self-stigma,[5] and expectations of rejection.[6] Interpersonal forms of stigma refer to interactional processes that occur between the stigmatized person and nonstigmatized person, such as discriminatory treatment.[7] Although most research has focused on the mental health consequences of stigma at the individual and interpersonal levels,[7] growing evidence indicates that structural stigma—defined as "societal-level conditions, cultural norms and institutional policies and practices that constrain the opportunities, resources, and wellbeing of the stigmatized"[8]—represents an additional risk factor for psychopathology among people who are stigmatized.[3] For instance, observational studies have shown that people living in states with fewer legal protections for their stigmatized group (eg, restrictive immigration policies) have higher levels of psychological distress[9,10] and psychiatric disorders[11] than people living in states with greater protections. Further, quasi-experimental studies have demonstrated that rates of mental disorders[12] and psychological distress[13] increase among stigmatized populations following increases in structural stigma (eg, passage of laws denying services to same-sex couples).

Despite consistent evidence for the adverse mental health consequences of stigma, the biological mechanisms

through which stigma contributes to risk for psychopathology are only beginning to be understood.[3,14] Experimental and observational studies have documented a variety of physiological responses to stigma-related experiences, including changes in immune functioning, inflammatory processes, and regulation of the hypothalamic-pituitary-adrenal axis.[15,16] Surprisingly, although social factors such as rejection, exclusion, and early-life adversity (eg, childhood trauma) have been associated consistently with brain structure and function,[17–30] few studies have examined neurodevelopmental sequelae of stigma.

The current study begins to address this gap in the literature. Specifically, we examined whether individual and structural forms of stigma are associated with 2 neural outcomes: hippocampal volume and amygdala reactivity to threat. We chose these outcomes because they are associated with stress exposure,[19–22,24,29–31] consistent with social identity threat theories of stigma that conceptualize it as a chronic stressor.[7] Additionally, both neural outcomes are associated with multiple forms of psychopathology[32–38] and thus may serve as mechanisms linking stigma with mental health problems.[7,8] To address our research question, we required a unique data structure that not only included measures of stigma at the individual level, but also sampled respondents from a range of social environments that differed in structural stigma. This presented a methodological challenge, as most neuroimaging studies are conducted in one (or a small number) of communities. In such designs, respondents are similarly exposed to the same macrosocial context—known as a ubiquitous exposure[39]—precluding the possibility of linking contextual variation with neural outcomes. Fortunately, neuroimaging studies with meaningful variation in social context have recently become available. In this study, we used data from one of the first national, multisite neuroimaging studies with substantial variability in sociopolitical contexts: the Adolescent Brain Cognitive Development (ABCD) Study. This dataset measured brain structure and function in 11,534 youths sampled from 17 states, affording significant geographic variability in exposure to stigmatizing contexts among youth.

We examined 3 stigmatized groups—female, racial (Black), and ethnic (Latinx) minority youth (mean age 9.9 years)—informed by the developmental literature on identity awareness, formation, and responsivity to identity-based stressors, which indicates that gender,[40] racial,[41] and ethnic[42] identities emerge during early childhood. Female, Black, and Latinx youth report identity awareness and constancy as well as perceptions of group-based stereotypes by age 9–10 years, the age of the baseline ABCD sample. We tested 2 preregistered hypotheses. First, we predicted that greater exposure to individual and structural stigma would be associated with smaller hippocampal volume and elevated amygdala reactivity to threat cues (ie, fearful relative to neutral faces) among female, Black, and Latinx youth, controlling for demographics and family socioeconomic status (SES). Second, we hypothesized that structural stigma would be unrelated to hippocampal volume or amygdala reactivity in the nonstigmatized comparison groups: male, White, and non-Hispanic White youth. This analysis serves as a negative control approach,[43] in that we tested whether there is an association among the groups where we would not theoretically expect it.

METHOD

Sample

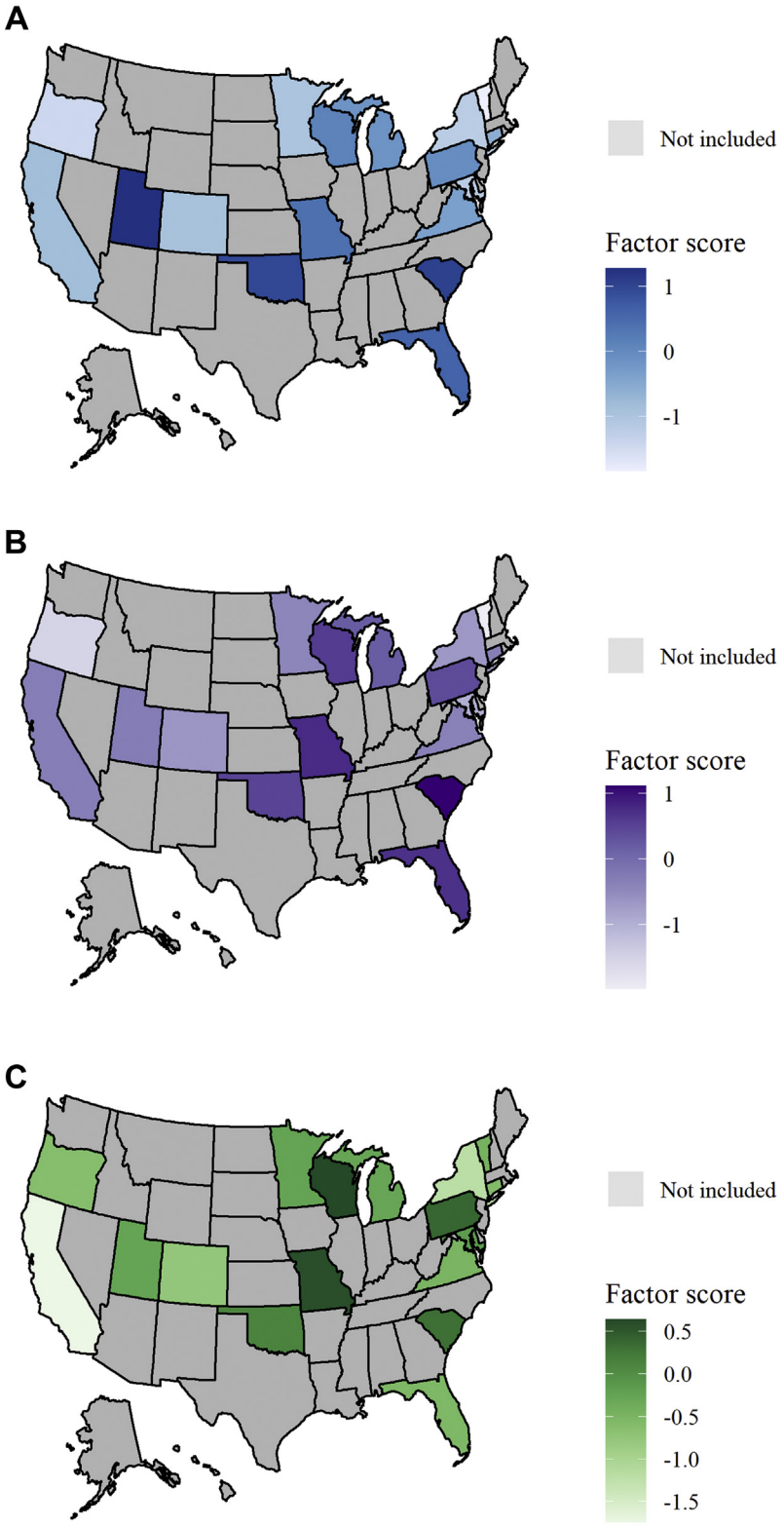
Data come from the ABCD Study, the largest study of brain development in the United States (https://abcdstudy.org). We drew data from the Year 1 assessment (ABCD 2.0) of 11,534 youths. Twenty-one study sites were included from across the United States. From these sites, a stratified probability sample of schools within the catchment areas for each site were selected, and eligible youths were recruited from each school. The ABCD study approximates a multistage probability sample but is not nationally representative.[44] The imaging procedures were harmonized across sites.[45] The study protocol received ethics approval from the Harvard University Institutional Review Board.

Measures

Structural Stigma. Consistent with conceptualizations of structural stigma[8] and prior research on this topic,[3] we selected items that captured societal-level conditions, social/cultural norms, and/or institutional policies to create proxy measures of the social climate relevant to the 3 groups of interest (female, Black, and Latinx youth). We compiled items from publicly available data sources used in prior work to assess structural forms of stigma related to gender,[46–48] race,[49–52] and Latinx ethnicity.[10] We modeled these items as indicators in a factor analysis (described below), with the final factor score determining the structural stigma score for each state for each domain of stigma (Figure 1). We chose a factor analytic approach because it recognizes that different dimensions of structural stigma (eg, norms, policies) are highly correlated; improves construct validity; and captures shared variance, thereby reducing measurement error.

Because we used a data-driven technique, the final factor scores included different components across the 3 groups. For instance, while the index of structural stigma related to Latinx ethnicity included both state laws and aggregated social norms, the index of structural stigma related to race included only aggregated norms. We

FIGURE 1 State-Level Structural Stigma Across 3 Stigmatized Groups



Note: *The figure shows the distribution of the 3 measures of structural stigma related to sex/gender (A), race (B), and Latinx ethnicity (C) across the 17 states in the Adolescent Brain Cognitive Development (ABCD) Study sample. Darker colors represent states with higher levels of structural stigma for each domain of stigma (ie, sex/gender, race, and Latinx ethnicity).*

nevertheless refer to all of these indicators as structural, in that they represent factors at the contextual rather than individual/interpersonal level. This approach is consistent with conceptualizations of individual attitudes shaping structural factors (eg, laws and policies) in ways that subsequently influence the attitudes of individuals within a particular social context; as such, aggregated attitudes represent more than individual bias because they not only reflect but also shape broader social structures.[53,54] We describe the items and sources of data for each group below; further details are in Supplement 1 and Tables S1 and S2, available online.

The measure of structural stigma related to gender comprised 18 items. Twelve of these indicators assessed aggregated implicit and explicit attitudes, which were obtained from 2 sources: Project Implicit (pooled across years 2003–2018) and the General Social Survey (pooled across years 1974–2014). The explicit indicators directly queried gender role attitudes and sexist beliefs. The implicit indicators were obtained through the Implicit Association Test (IAT) and examined to what extent respondents associate gender with career and scientific domains. The other 6 items were taken from previous state-level composite indicators of women's social status,[46,47] including economic (eg, ratio of men's to women's earnings), political (eg, women's representation in elected office), social and economic autonomy (eg, women's business ownership), and reproductive factors (eg, percentage of women who live in a county without an abortion provider). These items were obtained from several sources, including the Bureau of Labor Statistics, Current Population Survey, and Center for American Women in Politics.

The measure of structural stigma related to race comprised 31 items, all of which assessed aggregated attitudes related to race and racial prejudice, which were obtained from 3 sources: Project Implicit (pooled across years 2002–2017), the General Social Survey (pooled across years 1973–2014), and the American National Election Survey (pooled across years 1992–2016). Collectively, these items assessed several different components of racial prejudice, including general attitudes toward Black people, the impact of discrimination on the lives of Black people, the existence of racial prejudice, and endorsement of racial stereotypes. A similar aggregate measure of explicit racial bias has demonstrated strong retest reliability and convergent/discriminant validity.[53]

For structural stigma related to Latinx ethnicity, we used the following 3 indicators: a feeling thermometer of explicit attitudes of immigrants (obtained from the American National Election Survey), a composite index of state-level policies related to immigration (eg, whether immigrants were granted access to health services), and a feeling thermometer of explicit attitudes of Hispanics (obtained from the American National Election Survey). We included attitudes and policies related to immigration, despite the obvious fact that not all Latinx people are immigrants, because of the conflation of immigration with Latinx ethnicity in the United States; the mixed status nature of many Latinx households; the concealability of immigration status, which makes people targets regardless of citizenship; and the salience of immigration policy to Latinx individuals in the United States.[55]

We created a factor score for each state for each structural stigma measure by using exploratory factor analysis with a factor loading cutoff of 0.40; we reran the factor analysis iteratively and excluded variables until all retained items met the 0.40 threshold (Table S1, available online). For each measure, a 1-factor solution emerged, indicating that these items load onto a single construct of structural stigma, providing some evidence of construct validity. Cronbach α was calculated to assess reliability.[56] The measures of structural stigma indicated high reliability for gender ($\alpha = 0.94$) and race ($\alpha = 0.97$), but lower reliability for Latinx ethnicity ($\alpha = 0.57$). Because Cronbach α is influenced by the number of items that comprise a scale, the low α for Latinx structural stigma likely reflects the small number of items contributing to the factor ($n = 3$) rather than poor reliability.

Perceived Discrimination. Respondents were asked a series of questions about their perceptions of discrimination, unfair treatment, and perceived acceptance based on their identity (see Table S3, available online). After preregistering our analysis plan, we discovered that the perceived discrimination measure was first administered in the year after the baseline neuroimaging assessment (wave 1). The measure was then readministered during a follow-up assessment (wave 2), in which neuroimaging data were collected a second time. Currently, the ABCD Study has released only half of the data on the wave 2 sample. Because there are strengths and limitations associated with each assessment (eg, reduced power at wave 2 but temporal concurrence, increased power at wave 1 but lacking in temporal precedence), we present results for wave 1 in the main text and wave 2 in Supplement 2, available online; both produce similar conclusions.

Brain Structure and Function. Hippocampal volume was obtained from the structural data release. Quality control measures were applied to structural magnetic resonance imaging data, including visual inspection of structural volumes, inspection of outliers of segmented volumes for potential segmentation problems, and exclusion of data that did not meet the quality control standards in the public data release. Volume measures of left and right hippocampus,

obtained using automatic segmentation in FreeSurfer 5.3 (https://surfer.nmr.mgh.harvard.edu/), were summed to produce a measure of total hippocampal volume.

Amygdala activation to threat was measured by contrasting amygdala response to fearful faces relative to neutral faces during an emotional n-back working memory task.[45] The task includes 2 runs of 8 blocks each. On every trial, participants respond as to whether the picture was a "Match" or "No Match." Within each block, stimuli were all fearful faces, all neutral faces, all happy faces, or all places. Individual-level estimates of task-related blood oxygen level–dependent signal were computed using a general linear model implemented in AFNI 3dDeconvolve (https://afni.nimh.nih.gov/pub/dist/doc/program_help/3dDeconvolve.html). Hemodynamic response functions were modeled for cues (approximately 3 seconds) and trial blocks (approximately 24 seconds) as square waves convolved with a gamma variate basis function plus its temporal derivative using the AFNI SPMG option within 3dDeconvolve. The contrast of interest was activation during the fearful face blocks vs activation during the neutral face blocks within an amygdala region of interest defined using automatic segmentation by Freesurfer 5.3. The region-of-interest coefficients for this contrast from this task were obtained from the ABCD Study's curated data release. Analyses were conducted separately for right and left amygdala because the associations of social stressors (eg, childhood trauma) with amygdala reactivity to threat often exhibit hemispheric specificity.[19,21,22] For both outcomes, ABCD Study guidelines were followed with regard to exclusion of participants based on data quality, motion, or inattention (see Supplement 3, available online, for details).

Analytic Strategy

We preregistered our hypotheses and analyses (https://osf.io/9axqr). We focused on 3 groups of stigmatized youth in the ABCD Study sample: female, Black, and Latinx youth. (In our preregistration, we hypothesized null effects among sexual minorities at baseline because sexual identities emerge later in development[57]; see Supplement 2, available online, for those results.) Analyses were conducted using generalized mixed-effects models with lme4 in R.[58] Random effects included site and family. Fixed effects included age, sex (in analyses not focused on gender), family SES (family income), parental marital status, and race and ethnicity (in analyses not focused on race and Latinx ethnicity, respectively). Analyses examining hippocampal volume additionally controlled for total intracranial volume.

After preregistering our analysis plan, we discovered substantial missing data on family income (approximately 9%). Multiple imputation (100 imputations) was used to handle these missing data. Given difficulties in imputing in 3-level multilevel models and models with small (eg, 2 siblings) cluster sizes,[59] we imputed based on 2-level structure with a random intercept of site, but not family, using the pan and mitml packages in R.[60,61] We also conducted supplementary analyses that controlled for an alternate measure of SES—family education—which had substantially lower missingness (0.7%) and was strongly correlated with family income ($r = 0.64$). The direction, magnitude, and significance of associations were unchanged with this alternative measure (see Supplement 4, available online).

A preregistered power analysis indicated that within female participants and in all control analyses, we had adequate sample size to detect an effect size of $r = 0.1$ with close to 100% power. Within Black and Latinx participants, we had sample size to detect an effect size of $r = 0.1$ with 99% power.

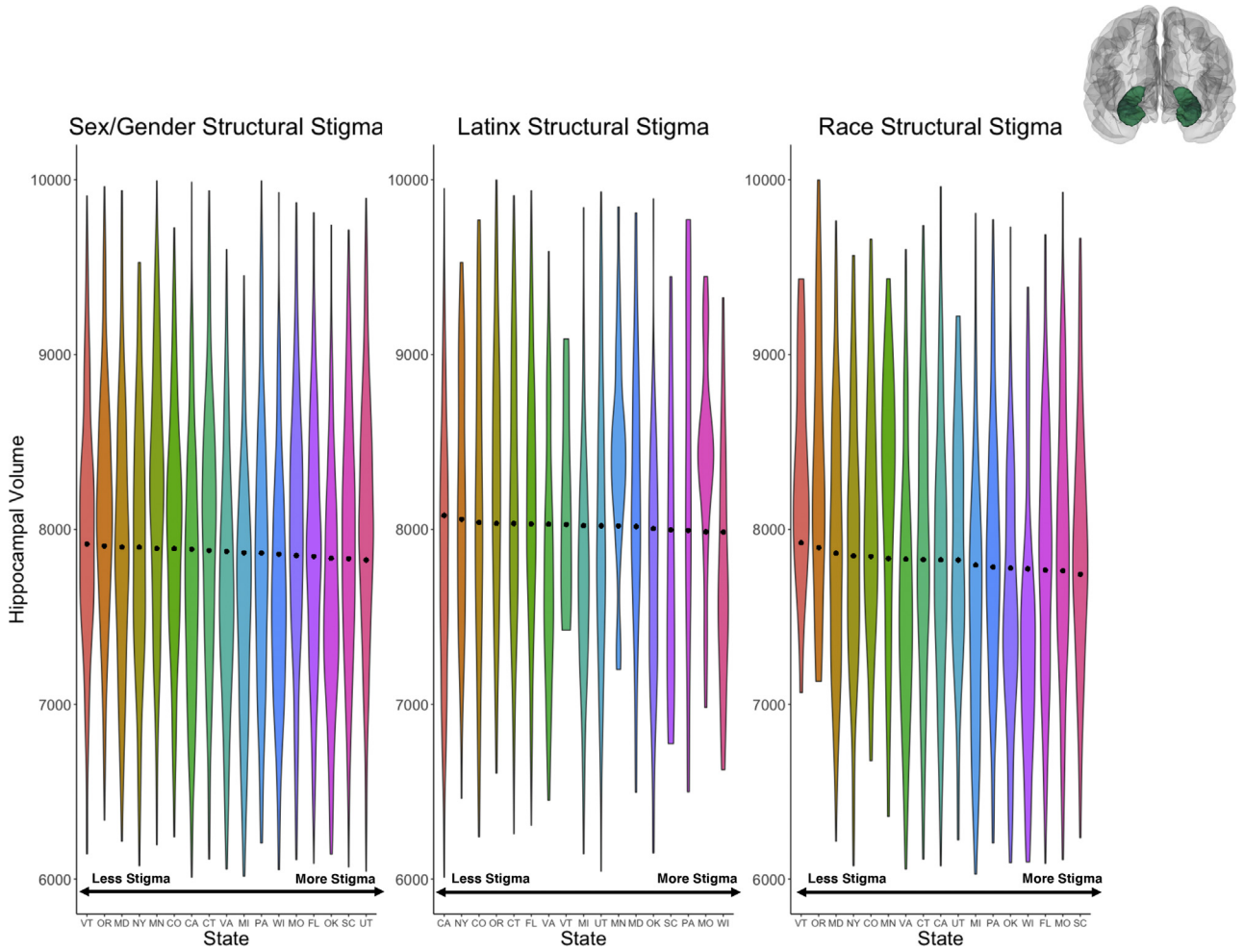
RESULTS

To test our predictions, we linked the 3 indicators of structural stigma to the ABCD Study dataset via the Federal Information Processing Standards (FIPS) code of the state where each ABCD Study site is located (n = 21 sites) to determine their association with neural outcomes (see Table S4, available online). Because our independent variable (structural stigma) is a contextual factor coded at the site level, the degrees of freedom for the p values presented below are based on the site ($df = 19$), rather than on the total sample size of youths (eg, n = 5,489 girls) included in each analysis, which should be considered when interpreting the statistical and practical significance of the β estimates.

Structural Stigma and Hippocampal Volume

Figure 2 shows the results for hippocampal volume. Higher structural stigma related to gender was associated with smaller hippocampal volume among girls ($n = 5{,}489$, $B = -29.50$, SE = 16.96), although this was not statistically significant after controlling for covariates ($p = .082$). Higher structural stigma related to race was associated with smaller hippocampal volume among Black youths (n = 2,421, $B = -58.26$, SE = 25.70, $p = .023$). A 1-unit increase in racial structural stigma was associated with a decrease in hippocampal volume of 58 mm^3 among Black youths. Higher structural stigma related to Latinx ethnicity was associated with smaller hippocampal volume among Latinx youths (n = 2,346, $B = -40.10$, SE = 19.90, $p = .044$). A 1-unit increase in Latinx structural stigma was associated with a decrease in hippocampal volume of 40 mm^3 among Latinx youths.

FIGURE 2 Plot of Hippocampal Volume Among Female, Latinx, and Black Youth by State



Note: *States are ordered from left to right in each plot based on their structural stigma factor scores. Violin plots depict the density distribution of hippocampal volume in that state. Black points represent the hippocampal volume predicted based on each state's structural stigma score when all other covariates in the multilevel models of the relation between structural stigma and hippocampal volume are at their mean.*

A non-preregistered analysis indicated that the magnitude of associations between structural stigma and hippocampal volume was similar for the right and left hippocampus among all 3 stigmatized groups (see Supplement 5, Table S5, available online). As hypothesized, structural stigma was unrelated to hippocampal volume in the nonstigmatized comparison groups: boys (n = 6,037, $B = -12.8$, $p = .486$), non-Latinx White youths (n = 6,887, $B = 6.27$, $p = 0.780$), and White youths (n = 8,594, $B = -21.56$, $p = .231$).

Structural Stigma and Amygdala Reactivity to Threat

There was no association between structural stigma and amygdala activation to fearful relative to neutral faces for any of the 3 stigmatized groups or for the nonstigmatized comparison groups (see Supplement 2, available online).

Perceived Discrimination and Neural Outcomes

Perceived discrimination (measured continuously) was not associated with hippocampal volume among female ($B = -13.1$, SE = 21.5, $p = .541$), Black ($B = 16.0$, SE = 22.5, $p = .478$), or Latinx ($B = -41.9$, SE = 25.5, $p = .101$) youths. Similar results were obtained with the dichotomous indicators of perceived discrimination (see Supplement 2, available online). Further, no association between perceived discrimination and amygdala reactivity was observed (see Supplement 2, available online).

DISCUSSION

Capitalizing on an innovative data structure, we were in the unique position to simultaneously measure stigma at both individual and structural levels and to determine their relative associations with neural outcomes in youth. We provide novel evidence that structural stigma is associated with brain structure in children, such that youths living in higher structural stigma contexts had smaller hippocampal volume when they had an identity that was a target of that structural stigma compared with youths living in lower stigma contexts. This association was observed consistently across 3 stigmatized groups (although it reached statistical significance only for Black and Latinx youths), suggesting that this relation is generalizable across diverse types of stigmatized identities and statuses. In contrast, perceived discrimination was not associated with hippocampal volume among stigmatized youths. Thus, findings suggest that an objective measure of stigma at the structural level may be more strongly related to hippocampal volume than subjective perceptions of stigma measured at the individual level.

The associations of structural stigma with hippocampal volume build on a substantial literature documenting reduced hippocampal volume in children who have experienced trauma, who are raised in families with lower SES, and who have low levels of parental support and nurturance.[29,62–64] We extend this work beyond individual-level experiences by demonstrating that being raised in a social context characterized by higher levels of stigma toward members of one's group also influences hippocampal volume. The effect sizes for the association between structural stigma and hippocampal volume, while relatively modest in magnitude, are similar to those observed for relatively extreme stressors—such as childhood trauma—that are established correlates of reduced hippocampal volume. For instance, Black youths in the highest structural stigma states had a hippocampus that was 177 mm^3 smaller than youths in the lowest structural stigma states, equivalent to approximately 2.3% of the average hippocampal volume among Black youths in the ABCD Study sample. A recent study, by comparison, found that the reduction in hippocampal volume attributable to childhood experiences of interpersonal violence was 364 mm^3,[65] approximately 3.8% of the average volume in that sample. To further contextualize this finding, the magnitude of the observed difference in hippocampal size between high and low structural stigma states was equivalent to the predicted impact of a $20,000 difference in annual family income in this sample (based on the linear association observed in these analyses). Statistically small effects can have societally important consequences if they apply to many people, or if they apply repeatedly to the same person.[66] These findings therefore suggest that structural stigma may be meaningfully associated with brain development in youth.

Our measure of state-level structural stigma related to gender, race, and ethnicity is a proxy for the social environment, which is hypothesized to influence a variety of intermediary variables that in turn may shape brain structure and function. Further research is needed to identify the specific environmental and neurobiological mechanisms linking structural stigma to reduced hippocampal volume. Animal and human studies have documented lasting reductions in hippocampal volume following exposure to chronic stress[24,27–30,67,68] and resulting from low levels of support and nurturance in early life.[63,64] These effects are mediated by excessive production of corticotropin-releasing hormone in animal models,[24] although the precise neurobiological mechanisms contributing to these volume reductions in humans are unknown. The association of structural stigma with hippocampal volume may be due, in part, to exposure to chronic stress or to a lack of social support associated with living in a stigmatizing context. Stressors resulting from structural stigma are conceptualized as chronic because they are related to fairly stable underlying social structures.[3] Support for a developmental pathway from structural stigma to hippocampal volume via experiences of chronic stress or low levels of support should be considered provisional, however, until it can be tested directly with longitudinal data that incorporates measures of stigma-related chronic stressors,[69] which will be possible in future waves of the ABCD Study.

In contrast to the results for hippocampal volume, we did not observe an association between structural stigma and amygdala reactivity to fearful faces. Future research is needed to determine whether the divergent association of structural stigma with hippocampal volume and amygdala reactivity replicates and, if so, the reasons for this divergence. One possibility, supported by meta-analysis, is that task demands reduce amygdala response to salient cues.[70] Because amygdala activation was assessed during a working memory task in the ABCD Study, it may have constrained variability in amygdala reactivity in our sample. The incorporation of additional tasks in future work may help to reveal whether this contributed to the divergent neural patterns observed herein.

We note several study limitations. First, these were cross-sectional analyses. However, issues of temporality are less of a concern for causal inference in our study, given that hippocampal volume cannot cause state-level structural stigma. Second, although the ABCD Study is one of the largest of its kind, the 21 study sites are located in only 17 states. This resulted in a restricted range of structural stigma

for each of our groups, with more than half of the sites located in states below the mean structural stigma scores (given the possible range from all 50 states). This restricted range reduced our statistical power, which means that our estimates are likely conservative. At the same time, the restricted range limits generalizability to other social contexts.

Third, we measured structural stigma at the state level. Our focus on distal environments offers a conservative test, given that more proximal environments are likely to exert stronger effects.[71] However, this approach does not incorporate within-state heterogeneity, particularly with respect to local social environments that may differ from those at the state level. Exploring associations between structural stigma and hippocampal volume at more proximal levels of analysis (eg, counties) represents an important area for future inquiry.

Fourth, we measured structural stigma using an empirically derived approach (ie, factor analysis) that combined multiple indicators of societal-level conditions, social attitudes, and public policies to create a comprehensive index. This approach has several advantages, including providing evidence of construct validity (ie, showing that multiple items related to structural stigma load onto a single factor) and reducing measurement error (ie, tapping into shared variance). However, our approach likely missed other important dimensions of structural stigma. For instance, racial disparities in incarceration, which have been used in previous studies as indicators of structural racism,[49] did not load highly onto our factor. In addition, the internal consistency of the Latinx structural stigma measure was low. Although this likely reflected the small number of items comprising that scale, further research is needed to determine whether these results are generalizable across different operationalizations of this construct.

Fifth, although the indicators of structural stigma were obtained across a range of years, we aggregated all responses to the state level regardless of year queried, which allowed for all states to have a sizable number of respondents, regardless of yearly sampling variation, thereby reducing measurement error. One potential limitation is that this approach does not capture changes in temporal trends in structural stigma. However, while structural sexism and structural racism have declined nationally over time, the relative levels of structural stigma in individual states (ie, rankings relative to other states) have remained highly stable,[48,72] suggesting that a time-invariant measure represents a valid approach to operationalizing this construct. Further, supplementary analyses showed that our structural stigma measures were highly correlated ($rs = 0.84$–0.99) with an alternative measure that was restricted to the years following the birth of youth in the ABCD Study sample.

Sixth, there was low endorsement of perceived discrimination across stigmatized groups, which may have biased us toward the null. Additionally, while both Black and Latinx youth were significantly more likely to perceive discrimination than White and White non-Latinx youth, respectively, perceived discrimination was not higher among female than male youth, raising questions of construct validity for this group. Thus, future research is needed to confirm these results with measures of perceived discrimination that have demonstrated reliability and validity.

Seventh, because this is an observational study, we cannot definitively rule out alternative explanations. For instance, it is possible that other contextual factors influence both the level of structural stigma and smaller hippocampal volume among youths. In addition, structural stigma is confounded with site and scanner effects, and there are not enough degrees of freedom to control for scanner effects with interpretable results. However, there are 2 reasons why it is implausible that observed associations between structural stigma and hippocampal volume are due to scanner effects. First, if results were attributable to scanner effects, we would expect associations to be present among both the stigmatized and the nonstigmatized youths. Yet, our negative control analyses showed no association between structural stigma and hippocampal volume for any of the nonstigmatized comparison groups. Second, if certain scanners systematically underestimated or overestimated hippocampal volume among members of a particular ethnic, racial, or gender group, we would expect to see an interaction between scanner type and that identity; however, a non-preregistered analysis revealed no significant interactions between scanner type and female sex, Black racial identity, or Latinx ethnicity in relation to hippocampal volume.

Finally, in observational studies of contextual factors, one concern is whether the results are due to social selection, whereby individuals with the observed outcome (ie, lower hippocampal volume) sort into the exposure status (ie, structural stigma). Yet, in studies of children, issues of social selection are less plausible, given that children are rarely responsible for moves into and out of certain environments. Although it is possible that the selection of parents into high structural stigma environments may contribute to the observed patterns (given strong associations between family SES and hippocampal volume in children), we observed no meaningful association between structural stigma and parental SES for any group ($rs < 0.16$). Thus, there is minimal evidence for differential selection of low-income parents into high structural stigma states.

Despite the limitations of this study, the results not only expand our understanding of the multilevel consequences of stigma, but also suggest a potential neural mechanism underlying the established association between structural stigma and psychopathology.[3] Examining whether hippocampal volume mediates the structural stigma–mental health association will be possible in future waves of the ABCD Study dataset as the youth age into the developmental period of risk for depression and posttraumatic stress disorder, both of which have been consistently linked with hippocampal volume.[32–35] Additionally, our results suggest that macrolevel features of the social context are associated with brain structure in youth, which has implications for broadening the range of potential explanatory variables in cognitive neuroscience to include contextual influences. Collectively, these findings set the stage for future studies to identify additional contextual correlates of neurodevelopment among youth and to uncover the environmental and neurobiological mechanisms underlying these relations.

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Funding acquisition: Barch, McLaughlin
Investigation: Barch
Methodology: Barch
Supervision: Hatzenbuehler, Barch, McLaughlin
Visualization: Weissman
Writing — original draft: Hatzenbuehler
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