The Impact of Trauma and Early Life Adversity on Neural Structural Alterations during Development

By

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1. Introduction

Child maltreatment refers to physical and/or emotional ill-treatment, sexual abuse, neglect, and exploitation which result in actual or potential harm to children (World Health Organization, 2020). Childhood maltreatment is a widespread problem at the global level (Stoltenborgh, Marian, Lenneke, & Van Ijzendoorn, 2015). It is estimated that 50% or more of children in Africa, Asia, and Northern American have experienced violence (Hillis, Mercy, Amobi, & Kress, 2016). Studies with national samples indicate that the percentage of the populations who have been exposed to childhood maltreatment ranges from 40 to 80% (Copeland et al., 2018; Finkelhor, Ormrod, & Turner, 2009; McLaughlin et al., 2012). Childhood maltreatment is associated with long-term consequences including non-specific forms of psychopathology (Kessler et al., 2010), adverse physical health (Ehrlich, Miller, & Chen, 2016), and poor psychosocial functioning (Beal et al., 2019). These non-specific outcomes suggest that childhood maltreatment may increase adverse functioning through similar mechanisms.

One potential mechanism by which adverse events exert negative influence is their effect on brain development. Childhood is a sensitive period marked by high brain plasticity (Teicher, Samson, Anderson, & Ohashi, 2016). The developing brain undergoes substantial change during this time, including neuronal proliferation, pruning, and rewiring of existing neuronal connections (Johnston, 2004). Such malleability suggests the potential for chronic life stressors to have a substantial impact during this period. A growing body of literature suggests that childhood maltreatment is associated with aberrations in brain structures measured with volume and cortical thickness including the prefrontal cortex (Busso et al., 2017; Carrion et al., 2009;

Carrion & Wong, 2012; De Bellis et al., 1999; Gold et al., 2016; Van Harmelen et al., 2010), cingulate cortex (Baker et al., 2013; Dannlowski et al., 2012; Heim, Mayberg, Mletzko, Nemeroff, & Pruessner, 2013; Kelly et al., 2013; Thomaes et al., 2010), limbic structures (Bremner et al., 1997; Dannlowski et al., 2012; Gold et al., 2016; Lena Lim, Radua, & Rubia, 2014; Logue et al., 2018; McLaughlin et al., 2016; Riem, Alink, Out, Van Ijzendoorn, & Bakermans-Kranenburg, 2015; Thomaes et al., 2010; Whittle et al., 2013), and temporal lobe (Busso et al., 2017; S. A. De Brito et al., 2013; Gold et al., 2016; L. Lim et al., 2018; Lena Lim et al., 2014), which involve key areas for emotion regulation and executive functioning (Berens, Jensen, & Nelson, 2017; Bick & Nelson, 2016). Furthermore, these structural aberrations associated with childhood maltreatment have been shown to have mediating effects on mental illnesses in later stages (Callaghan & Tottenham, 2016; Luby, Barch, Whalen, Tillman, & Belden, 2017; Pagliaccio & Barch, 2016). Therefore, identifying the effect of childhood maltreatment on brain structures can increase our understanding of the risk factors associated with psychopathology.

Previous studies investigating the association between childhood maltreatment and brain structures are often limited by case-control designs in which individuals with a diagnosis of posttraumatic stress disorder (PTSD) or maltreatment exposure are compared to healthy controls (Bremner et al., 1997; Busso et al., 2017; Carrion et al., 2009; De Bellis et al., 1999; Logue et al., 2018; McLaughlin et al., 2016). Focusing on those with PTSD overlooks the large number of individuals who are exposed to early life maltreatment, yet do not go on to develop PTSD. Moreover, a binary approach in which individuals are categorized into an “exposed” group versus a “non-exposed” control group, does not capture the extent of severity of childhood maltreatment exposure. Given the high prevalence of childhood maltreatment, delineating the severity of childhood maltreatment on a continuum would be a better approach to capture the extent of potential neural aberrations associated with such maltreatment.

To quantify severity, the traditional approach has been to use a count variable in which the number of occurrences of different types of adversity is aggregated, known as a cumulative-risk approach (McLaughlin, Sheridan, Humphreys, Belsky, & Ellis, 2020). However, this approach oversimplifies the distinction between different types of adversities, assuming that all events have equal weights and can be additive. Such oversimplification may contribute to an increase in measurement error if an event that has poor correlations with other events is given equal weight. Moreover, the count approach does not take into account of the different types of adversity which may exert unique influences on the brain development.

Alternatively, a dimensional approach assumes that there is a core underlying dimension across different types of adversities with shared features (Humphreys & Zeanah, 2015; McLaughlin et al., 2020). Compared to a simple count variable, a dimensional model uses a latent variable which accounts for communalities and measurement error by weighting items based on how well they predict each other (Bollen, 2002). The noise introduced by items that do not predict other items will be minimized since that item will have a smaller weight than the more predictive items. Furthermore, dimensional models can delineate multidimensionality across different types of maltreatment, which enable us to identify common and specific factors of maltreatment. Specifically, a bifactor model hypothesizes that there is one general factor that accounts for the shared variances across all related variables and specific factors that account for unique variances after the shared variance is accounted by the general factor (Reise, Morizot, & Hays, 2007). Given the high co-occurrence of different types of childhood maltreatment, it is possible that childhood maltreatment is represented better by a hierarchical structure; that is, a general factor that accounts for potential commonalities across multiple types of maltreatment as well as specific factors, each with unique contributions.

The broader goal of this master's thesis is to investigate the association between childhood maltreatment and brain structure measured with cortical thickness and gray matter volume (GMV) using latent factors of childhood maltreatment. The current project utilized the first wave data of the Adolescent Brain Cognitive Development^{SM} Study (ABCD Study$^{®}$) (Volkow et al., 2018), which is the largest national study on children's brain development, following 11,875 children from ages 9-10 into young adulthood. The ABCD Study has a vast dataset including neuroimaging, youth self-report and parent self-report metrics on youths' experiences in various settings including family, school, and neighborhood. The ABCD Study also has a wide range of environmental risk measures which are derived from publicly available datasets based on participants' addresses. Using data from the ABCD Study, Study 1 aimed to investigate the association between childhood trauma and brain structures, to understand the effects of trauma exposure on brain development. Study 2 took a broader approach in defining childhood maltreatment by delineating a multidimensional structure of factors related to early life adversity using a bifactor model. Associations between the identified dimensional factors and brain structures were explored.

2. Study 1

Study 1 aimed to understand the effects of trauma exposure on brain structures in children. Extensive literature suggests that childhood maltreatment is associated with aberrations in brain structures measured with volume and cortical thickness in a wide range of regions, mostly with thinner cortices and/or smaller volume (Busso et al., 2017; Dannlowski et al., 2012;

Gold et al., 2016; Heim et al., 2013; Kelly et al., 2013; Lena Lim et al., 2014; Logue et al., 2018; McLaughlin et al., 2016; Thomaes et al., 2010; Van Harmelen et al., 2010), whereas some found thicker cortices and/or larger volume (Carrion et al., 2009; Corbo et al., 2014; L. Lim et al., 2018; Whittle et al., 2013). To disentangle the contribution of trauma exposure, Study 1 used a latent variable of trauma exposure. The latent variable of trauma exposure was derived based on the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5*) traumatic events which measures exposure to a greater number of traumatic events while accounting for measurement error. It was hypothesized that the latent trauma variable would be associated with smaller volumes and thinner cortices. Furthermore, measures of socioeconomic status (SES) were included to control for potential confounding effects since SES is known to have associations with the development of brain structures (Brito & Noble, 2014) as well as rates of childhood maltreatment (Paxson & Waldfogel, 2003).

2.1 Methods

2.1.1 Participants

The present study used data from Wave 1 of the ABCD Study (release 2.0.1) which includes de-identified data from 11,875 children between the ages of 9 and 10 years (Volkow et al., 2018). The use of this dataset was approved by the institutional review board at Vanderbilt University. The ABCD Study group was responsible for obtaining parental consent and child assent. The initial sample was collected at 21 sites distributed across the United States (Garavan et al., 2018). Post-stratification weights were applied to adjust the sample to be more representative of the US population (Heeringa & Berglund, 2020). The final sample size for Study 1 was N = 9,270, following the exclusion of missing data and participants failing to pass quality assurance measures for MRI data (see Supplementary Material 1). A summary of the demographics based on the final sample can be found in Supplementary Material 2.

2.1.2 Trauma Measure

Trauma exposure was assessed based on the posttraumatic stress disorder criterion A traumatic events checklist from the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS) (Kaufman et al., 1997). One of the primary caregivers of the child responded to 17 items assessing the occurrence of traumatic events (e.g., “A family member threatened to kill your child,” “A car accident in which your child or another person in the car was hurt bad enough to require medical attention”). Factor analysis was used to derive a latent variable that represents the degree of lifetime trauma exposure. Prior to factor analysis, items that had low endorsement were excluded based on the following criteria: 1) traumatic events that were endorsed by less that .5% of the sample, or 2) traumatic events that were endorsed by less than 1% of the sample and it was not possible to obtain polychoric correlations with the other items due to empty cells. As a result, four items were eliminated, leaving 13 items to define a latent trauma exposure variable (see Figure 1). The full list of K-SADS traumatic events checklist can be found in Supplementary Material 3. Parallel analysis (Horn, 1965) with Glorfeld correction (Glorfeld, 1995) indicated that a single factor could be extracted; a scree plot revealed an “elbow” after extraction of a single factor (see Figure 1).

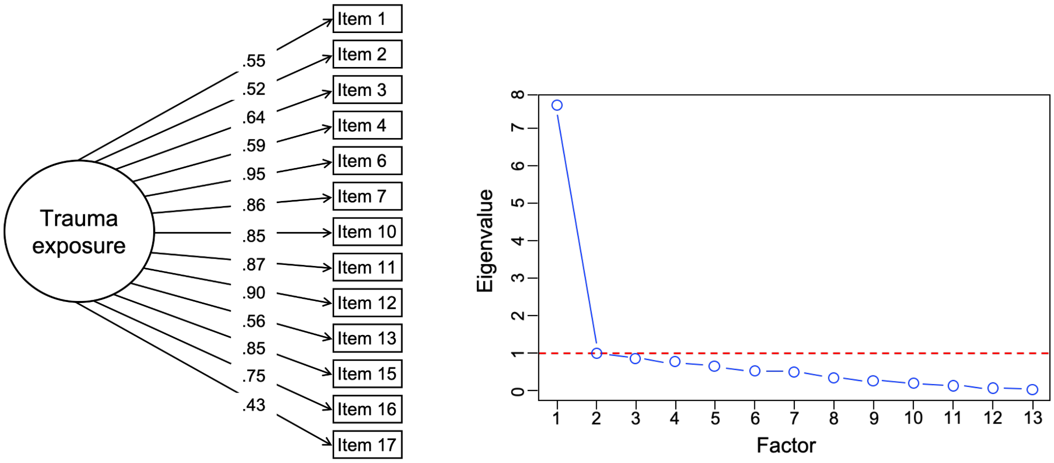

Fig. 1 Exploratory factor analysis identifies a single latent factor of trauma exposure

2.1.3 Image Acquisition, Quality Assurance, and Processing

The description of the image acquisition, quality assurance, and processing procedures for the ABCD Study is detailed elsewhere (Hagler et al., 2019). The ABCD Data Analysis and Informatics Center (DAIC) and the ABCD Imaging Acquisition Workgroup developed an imaging protocol to harmonize collection across multiple 3 tesla scanner platforms (Siemens Prisma, General Electrics (GE) 750, and Phillips) across 21 data collection sites. 3D T1- and T2-weighted images of brain structure were collected. For imaging data processing and analysis, DAIC used the Multi-Modal Processing Stream, which is a software package to employ centralized processing and analysis of imaging data collected across sites. All processing of imaging data was performed by DAIC.

2.1.4 Statistical Analyses

Structural equation modeling was performed in Mplus version 8.4. The WLSMV estimator was applied which uses pairwise deletion for missing data (Muthén & Muthén, 2017). A unidimensional item-factor analysis (Wirth & Edwards, 2007) was conducted to derive a single latent variable from 13 dichotomous yes/no items about whether the child experienced various traumatic events. The single latent factor derived from these items was defined as "trauma exposure." The latent factor score represents a weighted sum of these variables, with higher scores indicating exposure to a greater number of traumatic events. Post-stratification weights based on propensity scores for age, sex, race/ethnicity, family income, family type and parent employment, household size, and region of the US participants come from, were applied to all analyses to account for the stratification of the sample in data collection sites. Since the ABCD Study includes some participants who are twins or siblings, all analyses took into account clustering within families, with families being modeled with a random intercept.

Analyses were conducted to determine which regions were associated with our latent measure of trauma exposure. Cortical thickness analyses were performed with 68 cortical structures (34 in each hemisphere) based on the Desikan-Killiany atlas (Desikan et al., 2006). GMV analyses were performed with 68 cortical structures based on the same atlas as well as an additional 19 subcortical structures (Fischl et al., 2002). The demographic factors including age, sex, and race/ethnicity were included as covariates. Additionally, MRI scanner model was included as a covariate to account for differences between scanners. Lastly, average cortical thickness and total cortical and subcortical GMV were included as covariates in cortical thickness and volume analyses, respectively, to control for global differences in thickness or volume. As a result, the model for testing the association between trauma exposure and brain structure was as follows: brain region$_i$ = β*age + β*sex + β*race/ethnicity + β*MRI scanner model + β*average cortical thickness or total GMV + β*latent trauma factor, where $i = 1...68$ (i.e., the number of brain regions) for cortical thickness and GMV and $i = 1...19$ for subcortical GMV analysis. The false discovery rate (FDR; $q < 0.05$) was controlled to account for multiple tests across brain regions. To further control for possible associations between low SES and brain structure, income and parent’s highest level of education were added as additional covariates in sensitivity analyses.

2.2 Results

Greater trauma exposure was associated with thinner cortices in bilateral superior frontal gyri and right caudal middle frontal gyrus (see Figure 2; Supplementary Material 4). Greater trauma exposure was also associated with thicker cortices in the left isthmus cingulate and left posterior cingulate (see Figure 2; Supplementary Material 4). In terms of GMV, no cortical regions were significantly associated with trauma exposure (Supplementary Material 5). For subcortical volume, greater trauma exposure was associated with smaller volumes in the right putamen and the right amygdala (Supplementary Material 6). Of note, there was a weak bilateral effect for these regions: the left putamen and left amygdala were significant at uncorrected levels; however, this did not survive FDR-correction (p_{fdr}-values = .057). The right hippocampus was also significant at uncorrected levels but did not survive correction ($p_{fdr} = .057$). No other subcortical regions were significantly associated with trauma exposure.

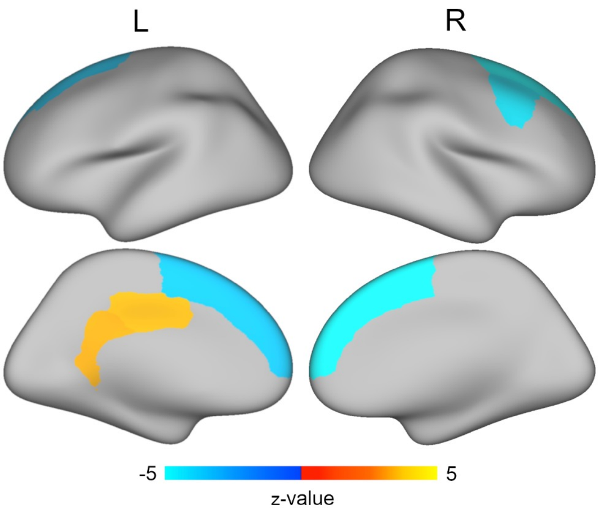

Fig. 2 Regions with significant associations between cortical thickness and latent trauma

Follow-up sensitivity analyses were performed with regional cortical thickness and volume to ensure the primary results were robust to possible confounds. For cortical thickness, the sensitivity findings were largely convergent with the primary results when controlling for family income and parent's highest level of education as additional covariates. Greater trauma exposure continued to be negatively associated with bilateral superior frontal gyri and right caudal middle frontal gyrus, and positively associated with the left posterior cingulate (Supplementary Material 7). While trauma exposure was associated with thicker cortices in the left isthmus cingulate at uncorrected levels, this did not survive FDR-correction during sensitivity analyses ($p_{fdr} = .068$). When controlling for family income and parent education for the volume sensitivity analyses, there was no significant association between subcortical volume and trauma exposure (Supplementary Material 8).

2.3 Discussion

The results of Study 1 demonstrated that trauma exposure was associated with variation in regional cortical thickness and subcortical GMV. Specifically, trauma exposure was associated with thinner cortices in the bilateral superior frontal gyri and right caudal middle frontal gyrus, and with thicker cortices found in the left posterior cingulate and left isthmus cingulate. Sensitivity analyses revealed that the cortical thickness associations remained largely consistent after controlling for income and parent education, while no volume results remained significant after controlling for SES measures. Overall, Study 1 indicates that trauma exposure during childhood may be a risk factor for structural aberrations in the developing brain.

The findings of thinner frontal cortices in Study 1 are consistent with prior work (Baker et al., 2013; Gold et al., 2016; Kelly et al., 2013; Lim et al., 2018; McLaughlin et al., 2014). The superior frontal gyrus is implicated in working memory and executive functioning (Boisgueheneuc et al., 2006), while the middle frontal gyrus is involved in attention modulation and control (Japee, Holiday, Satyshur, Mukai, & Ungerleider, 2015). In contrast to thinner frontal cortices, thicker cortices in the posterior and isthmus cingulate cortices were found. This finding is noteworthy given the prior finding of accelerated decreases in cortical thickness in the posterior and isthmus cortices at faster rates than the global average across ages (Grieve, Korgaonkar, Clark, & Williams, 2011). The posterior cingulate cortex is highly connected to a broad range of brain regions including frontal, parietal, and subcortical regions and is a key component of the default mode network, which modulates self-referential processing (Davey, Pujol, & Harrison, 2016; Leech & Sharp, 2014). Prior work has shown heightened connectivity with the default mode network in pediatric PTSD patients, which the authors suggest may underlie the persistence of trauma-related memory (Patriat, Birn, Keding, & Herringa, 2016).

The results of Study 1 build upon this prior work by demonstrating an association between trauma exposure and thicker posterior cingulate cortices in a large sample of children.

The volume results are also consistent with prior studies showing that childhood maltreatment is associated with smaller volumes in the amygdala, which is central for emotional processing (McCrory & Viding, 2015), and putamen, which is important for motor control and learning (Luo et al., 2020). The smaller volumes found in these regions may be the result of accelerated maturation or insufficient development as a result of exposure to chronic adversity (Grieve et al., 2011; Lemaitre et al., 2012; Teicher et al., 2016). However, the subcortical GMV results disappear after controlling for SES measures. These results indicate that the observed relationship between trauma exposure and GMV in subcortical regions may be accounted for by low SES, which is closely associated with a child's vulnerability to maltreatment (Paxson & Waldfogel, 2003).

While Study 1 reveals important structural aberrations associated with trauma exposure, it may be useful to broaden the definition of childhood adversity to include environmental stressors or different types of child adversity which may influence brain development in divergent ways. In particular, a bifactor model can be used to identify both common and unique factors representing different types of childhood adversity or environmental stress. To this end, Study 2 developed a bifactor model of childhood adversity/environmental stress and related these factors to brain structure.

3. Study 2

Study 2 aimed to delineate factors based on childhood adversity and environmental stressors using a dimensional approach. The high co-occurrences of early life stressors suggest a potential general factor underlying different types of adversities. As mentioned previously, a bifactor model can represent commonalities and specificities across multiple domains (Reise, 2012; Reise et al., 2007). In this case, the bifactor model hypothesizes that there is one general factor that accounts for the commonalities across all childhood adversity/environmental stressor variables. Akin to the “g” factor of general intelligence, our general factor will provide a measure of that which is common across our environmental variables. Additionally, the bifactor model will identify specific factors that represent the residual variance left over after the general factor has been extracted. The resulting subfactors now represent the unique effects of specific types of childhood adversity and environmental stressors, grouped together based on similarity. Using the bifactor model approach, Study 2 aimed to delineate common and specific factors of early life stressors and their association with brain structures in children.

3.1 Methods

3.1.1 Participants

Study 2 used data from Wave 1 of the ABCD Study (release 2.0.1) as in Study 1. 9,000 participants were randomly selected for an exploratory factor analysis and the remaining 2,875 participants were used for a confirmatory bifactor analysis. Three participants without post-stratification weights were excluded from the analyses. For the analyses with brain structures, participants with missing data and failing to pass quality assurance measures for MRI data were excluded (see Supplementary Material 9), leaving 9,706 participants for the structural analyses. A summary of demographics based on the final sample for each analysis can be found in Supplementary Material 2.

3.1.2 Stressor Measures

Items related to early life stressors from the ABCD Study were included. When the same measure was administered to both parents and youth, parental responses were selected due to the participants' young age in this sample. Items were excluded if they 1) had responses completed only by a subset of participants, 2) had responses with low endorsement rates (< .5%), and 3) it was not possible to estimate polychoric correlations with other items (i.e., the contingency tables with other items contained a cell with 0). For polytonomous items, responses with low endorsement (< .5%) were collapsed to preserve items. When items had high correlations with each other (r > .90), items were collapsed or only one item was retained. Continuous items with high skewness were log-transformed or outliers were removed based on the Rosner's test to correct for skewness. Continuous items with negative skewness were reverse scored before applying a log-transformation. Continuous items which were not skewed but had high variance were adjusted to lower the variance. After adjustments were made, an item cluster analysis (Revelle, 1978) was performed to identify "doublets," meaning two items clustering together. Items creating doublets were collapsed, or only one item was kept. After item selection and adjustment, 114 variables were included in the exploratory factor analysis. The description of measures in which selected items belong are presented below.

Diagnostic Interview for DSM-5 (KSADS) Traumatic Events. Occurrences of traumatic events during the child's lifetime was measured using the posttraumatic stress disorder criterion A traumatic events checklist from the K-SADS. Caregivers responded to items indicating the occurrence of traumatic events in children (e.g., "Beaten to the point of having bruises by a grown up in the home") based on a binary response.

Family Environment Scale – Family Conflict Subscale. Family conflict was measured by the Family Conflict Subscale from the Moos Family Environment Scale (Moos & Moos, 1994), which was modified from the PhenX toolkit (https://phenx.org) (Zucker et al., 2018). Parents responded to items assessing the presence of conflict within the family (e.g., "We fight a lot in our family") based on a binary response.

Demographics Survey – Family Experience. Financial difficulty experienced by the immediate family was assessed. Caregivers responded to items inquiring about instances of financial difficulty in the past 12 months (e.g., "Needed food but couldn't afford to buy it or couldn't afford to go out to get it") based on a binary response.

Family History Assessment. Family history of mental illness was assessed. Caregivers responded to the history of mental illness in any blood relative (e.g., biological father, biological mother, paternal/maternal grandfather, paternal/maternal grandmother, paternal/maternal uncle, paternal/maternal aunt, younger/older full sibling, younger/older half sibling, same age full sibling) of their child based on a binary response. Items assessed history of receiving psychiatric services or hospitalization, attempted or committed suicide, depression, mania, psychosis, nervous breakdowns, antisocial behaviors, and problems related to alcohol or drug use.

Child Report of Parental Behavioral Inventory. Youth's perceptions on caregiver's warmth, acceptance, and responsiveness were assessed. Youths responded to items describing the primary caregiver's behavior as warm or supportive (e.g., "First caregiver makes me feel better after talking over my worries with him/her") based on a three-point Likert scale.

Parent Diagnostic Interview for DSM-5 Background Items (KSADS-5). Items assessing the child's relationship with a caregiver, peer relationship, school performance, and placement in any special services were selected from the Diagnostic Interview for DSM-5 Background Items (K-SADS-5).

School Risk and Protective Factors Survey. Youth's connectedness to his or her school was assessed by items derived from the School Social Environment section in the PhenX Toolkit (Zucker et al., 2018). Items assessed the youth's interaction with their school teacher (e.g., "I get along with my teachers"), perception of the classroom environment (e.g., "I feel safe at my school"), involvement in school (e.g., "I like school because I do well in class"), and feelings of alienation from academic goals (e.g., "Usually, school bores me"), based on four-point Likert scale.

Peer Relationship. Youth's peer relationship was measured by assessing the number of friends and close friends that the child has. Both male and female friends were assessed separately.

Neighborhood Safety/Crime Survey. Parent's perception on neighborhood safety from crime was assessed by the Safety from Crime items from the PhenX Toolkit (Zucker et al., 2018). Caregivers responded to items assessing their perceptions on safety and presence of crime in their neighborhood (e.g., "My neighborhood is safe from crime"), based on a five-point Likert scale.

Community Risk and Protective Factors. Availability of substances in the community was assessed by items from the PhenX Community Risk and Protective Factors questionnaire (Lisdahl et al., 2018). Caregivers responded to items assessing how easily their child may access substances including alcohol, cigarettes, marijuana, and other drugs (e.g., "If your child wanted to get some beer, wine, or hard liquor, how easy would it be for her/him to get some?"), based on a four-point Likert scale.

Parental Monitoring Survey. Parental monitoring which indicates the parent's active effort to keep track of their child's whereabouts was assessed based on youth self-report (Zucker et al., 2018). The items assessed parental monitoring of the child's location, whom the child spends time with, parental monitoring via family dinner frequency, parent/child contact, and the child's disclosure to the parent based on a five-point Likert scale.

Elevation. The level of elevation, which is associated with greater exposure to air pollution due to the greater inhalation of carbon monoxide at the reduced oxygen concentrations (EPA, 1978), was retrieved from the Google maps.

Gross residential density. Gross residential density (i.e., housing units per acre) was obtained from the Environmental Protection Agency (EPA) based on the child's zip code. The resolution was at the census tract level.

Walkability. Walkability index scores were obtained from the EPA. These scores reflect the rank of each block relative to all other blocks in the United States. Walkability scores are influenced by the presence or absence and quality of sidewalks, pedestrian right-of-ways, traffic density, road conditions, building accessibility, etc. The resolution was at the census tract level.

Area Deprivation Index. The Area Deprivation Index (ADI) was calculated based on the Singh method (Kind et al., 2014; Singh, 2003) using data from the American Community Survey from 2011 to 2015. The ADI has 17 sub-scores and 1 national percentile score based on sub-scores ranging from 1 to 100, with the 100th percentile reflecting the most deprivation. The examples of sub-scores included are: median family income; median gross rent; home ownership rate; percentage of single-parent households with children younger than 18 years; percentage of population aged 25 years or older with at least a high school diploma; percentage of population below 138% of the poverty threshold; and percentage of households without a motor vehicle.

Population density. Population density was obtained from the National Aeronautics and Space Administration (NASA) Socioeconomic Data and Applications Center (SEDAC) based on the 2010 census tract.

Pollution measures. Satellite based pollution measures of fine particles (i.e., PM 2.5) and NO2 levels were obtained from NASA SEDAC based on three-year averages estimates from 2010 to 2013, with a resolution at 100 km^2. One-year annual average of daily PM 2.5 estimates from 2016 at a higher spatiotemporal resolution (i.e., 1 km^2) (Di et al., 2016) was also available for participants' primary, secondary, and tertiary addresses. The average across participants' current addresses was used for the daily PM 2.5 estimates at the higher resolution.

Estimated risk of lead exposure. The estimated risk of lead exposure was calculated based on the weighted sum of the age of homes and the rate of poverty. The scores ranged from 1 to 10, with a score of 10 indicating the highest risk. The resolution was at the census tract level. The scores were available for participants' primary, secondary, and tertiary addresses. The average across participants' current addresses was used.

Proximity to road. Proximity to major roads was calculated in meters.

Crime rate. Uniform crime reports were obtained from the Federal Bureau of Investigation, which was compiled by Inter-University Consortium for Political and Social Research, based on three-year average estimates from 2010 to 2012. The resolution was based on the county-level. The average across participants' current primary, secondary, and tertiary addresses was used.

Years of residence. The number of years lived at the current address was assessed.

3.1.3 Statistical Analyses

3.1.3.1 Exploratory Structural Equation Modeling

Exploratory Structural Equation Modeling (ESEM) (Asparouhov & Muthén, 2009) was performed with 9,000 randomly selected participants. Three participants were excluded for missing post-stratification weights, leaving 8,997 participants for the ESEM analysis. Parallel analysis with Glorfeld correction indicated that 4 factors could be extracted from the 114 variables (see Figure 3). ESEM with the WLSMV estimator and OBLIMIN rotation was conducted with 114 variables. Variables with a loading of ≥ 0.40 were retained for a confirmatory bifactor analysis.

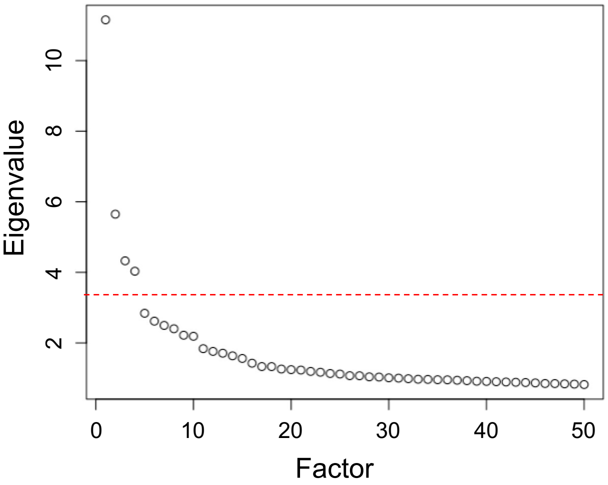

Fig. 3 Exploratory factor analysis identifies four factors of environmental stressors

3.1.3.2 Bifactor Modeling

A confirmatory bifactor analysis was performed with 2,875 hold-out participants based on the results of the ESEM. When a variable loaded on multiple factors with a loading ≥ 0.40, the variable was included in the factor with the higher loading. As required for the bifactor model, each item loaded on one general factor and one specific factor. All factors were specified to be orthogonal or uncorrelated (Reise, 2012).

3.1.3.3 Structural Equation Modeling

Structural equation modeling was performed to determine the association between brain regions and factors obtained from the bifactor analysis with 9,607 participants with brain data. Cortical thickness analyses were performed with 68 cortical structures based on the Desikan-Killiany atlas. GMV analyses were performed with 68 cortical structures based on the Desikan-Killiany atlas and 19 subcortical structures. The demographic factors (age, sex, race/ethnicity) and MRI scanner model were included as covariates. The false discovery rate (FDR; $q < 0.05$) was controlled to account for multiple tests across brain regions.

3.2 Results

3.2.1 ESEM

Factor loadings for the variables for each factor from the ESEM are presented in Supplementary Material 10. Four interpretable factors were extracted from the exploratory analyses. For Factor 1, all items from the Family History Assessment indicating history of mental illness in any blood relative of the child clustered together. Factor 1 also included items indicating traumatic events experienced by the child including physical abuse by a family or non-family member, sexual abuse by a non-family member or peer, and witnessing violence at home also loaded on Factor 1. Additionally, items assessing accessibility of substances including cigarettes, e-cigarettes, and marijuana, loaded onto Factor 1. Other items that clustered in Factor 1 included history of financial difficulty experienced by the immediate family such as not being able to pay for a doctor, hospital, or dentist. Finally, an item indicating a history of receiving mental health or substance abuse services by the child loaded onto Factor 1. In summary, the items that loaded most strongly onto Factor 1 focused on family risk for mental health issues, substance abuse, or behavioral problems. Therefore, Factor 1 was named “Familial Risk”.

In terms of Factor 2, items reflecting the child’s perception on his or her connectedness to school clustered together, such as relationship with school teachers, perception of the school environment, involvement in school, and alienation from academic goals. Additionally, the child’s perception of the primary caregiver’s warmth, acceptance, and responsiveness was grouped into Factor 2. Finally, items indicating the presence of conflict between family members also loaded onto Factor 2. Taken together, the items that loaded most strongly onto Factor 2 reflect the child’s interpersonal relationships both with family and in the community that the child belongs. Therefore, Factor 2 was named “Interpersonal Community”.

On Factor 3, items from the ADI clustered together which indicate the socioeconomic disadvantage of the neighborhood in which the child resides. Examples of the ADI items that loaded onto Factor 3 include median family income, the national percentile of ADI scores, the percentage of families living below or close to the poverty level, the median home value, the percentage of the population with at least a high school diploma, the percentage of single-parent households with children, and the unemployment rate. Additionally, items indicating the accessibility of alcohol to the child loaded on Factor 3. Lastly, items indicating financial difficulty experienced by the immediate family such as not being able to pay for food, rent, mortgage, telephone service, gas or electric service clustered onto Factor 3. Overall, the items that loaded most strongly onto Factor 3 reflected the deprivation of the child’s neighborhood environment. Accordingly, Factor 3 was named “Neighborhood Deprivation”.

Finally, Factor 4 was comprised of items indicating pollution levels, residential density, population density, walkability, lead exposure risk, crime rates, and parents' perception of neighborhood safety. Altogether, the items that loaded most strongly onto Factor 4 were associated with characteristics more commonly associated with urban settings such as crime and density. Therefore, Factor 4 was named "Urbanicity".

3.2.2 Bifactor Modeling

To extract a general factor that can account for commonalities across environmental stressors, bifactor modeling was performed with items obtained from the ESEM. Results of the bifactor model are presented in Supplementary Material 11. A schematic representation of the bifactor model with the identified factors is presented in Figure 4.

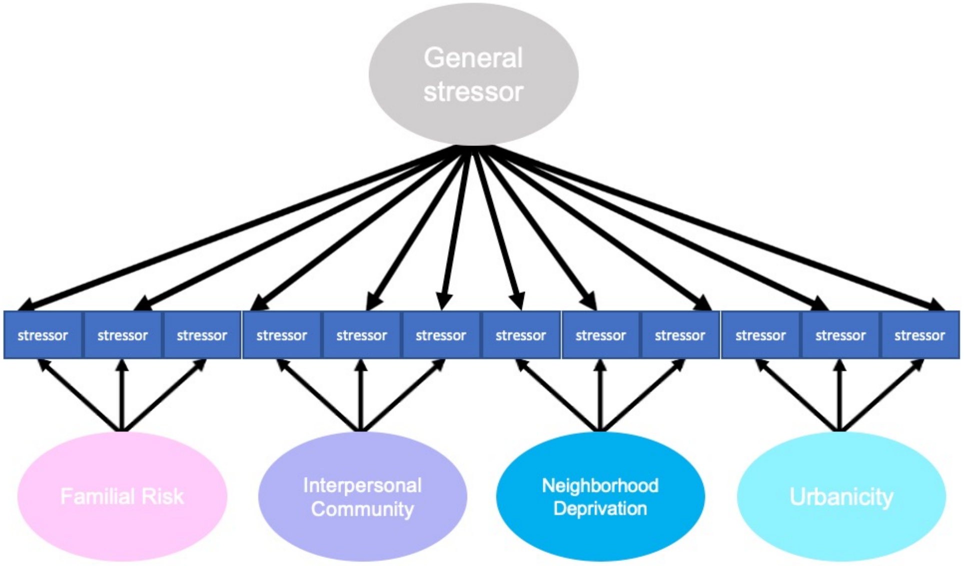

Fig. 4 A bifactor analysis delineates general and specific factors of environmental stressors

Two global fit indices were used to test model fit (Jackson, Gillaspy, & Purc-Stephenson, 2009; McDonald & Ho, 2002). The root mean square error of approximation (RMSEA) indicated a good fit (0.036; 90% CI: 0.035-0.037) whereas the comparative fit index (CFI) indicted an inadequate fit (0.830). However, Lai and Green (Lai & Green, 2016) have shown that disagreement between fit indices does not necessarily indicate problems with the model or data, as this inconsistency can arise because the two indices evaluate fit differently using arbitrary cutoffs. Furthermore, the inter-correlations in our model were relatively low, which could suggest the possibility that there is no general factor. However, previous studies suggest that even though the inter-factor correlations are low, the general factor might still be a valid metric when at least some items have strong loadings on the general factor and criterion validity can be demonstrated where the general factor predicts relevant outcomes (Moore, 2020). Therefore, analyses testing whether the general factor and specific factors are associated with brain structures were further examined.

3.2.3 Structural Equation Modeling

3.2.3.1 Cortical Thickness

After FDR correction for multiple comparisons, the general stressor factor was associated with cortical thinning across cortices (see Figure 5; Supplementary Material 12). Specifically, high general factor scores were associated with cortical thinning in bilateral parahippocampal gyri, lateral orbitofrontal cortices, cuneus cortices, pericalcarine cortices, lingual gyri, and lateral occipital cortices, and left precentral gyrus (p_{fdr}-values ≤ 0.042). The specific factor of neighborhood deprivation was associated with primarily with cortical thinning in frontal, parietal, and temporal regions (see Figure 6). Specifically, greater neighborhood deprivation was associated with cortical thinning in bilateral rostral middle frontal gyri, bilateral postcentral gyri, left caudal middle frontal gyrus, left superior frontal gyrus, left precentral gyrus, left paracentral lobule, left superior temporal gyrus, left superior parietal gyrus, left supramarginal gyrus, and right medial orbitofrontal gyrus (p_{fdr}-values ≤ 0.037). On the other hand, greater neighborhood deprivation was associated with thicker cortices in bilateral inferior parietal gyri (p_{fdr}-values = 0.023). Finally, the specific factor of urbanicity was associated primarily with thicker cortices in frontal and temporal cortices (see Figure 7). Specifically, greater urbanicity was associated with thicker cortices in bilateral rostral anterior cingulate cortices, bilateral insulae, right rostral middle frontal cortex, right lateral orbitofrontal cortex, right medial orbitofrontal cortex, and right entorhinal cortex (p_{fdr}-values ≤ 0.030). On the contrary, greater urbanicity was associated with thinner cortices in left supramarginal cortex (p_{fdr}-value < 0.001). No significant results were found for familial risk or interpersonal community in association with regional cortical thickness.

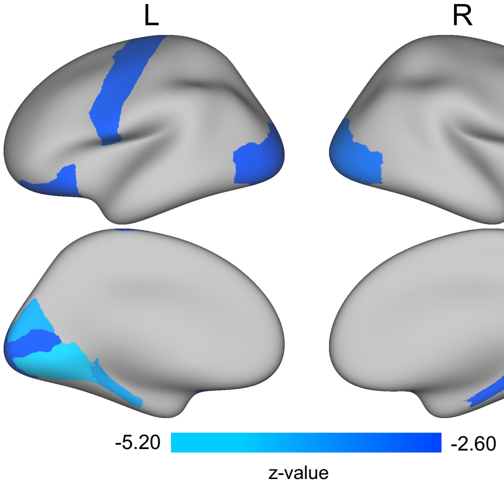

Fig. 5 Regions with significant associations between cortical thickness and the general factor

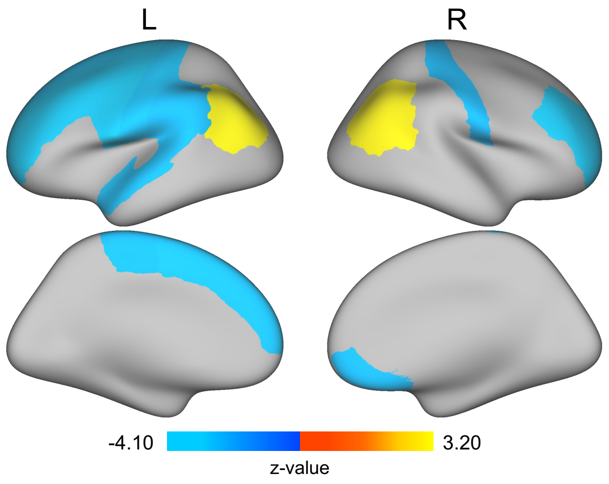

Fig. 6 Regions with significant associations between cortical thickness and neighborhood deprivation

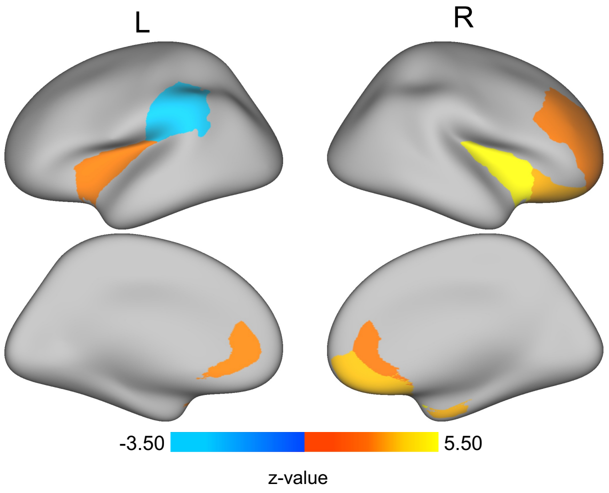

Fig. 7 Regions with significant associations between cortical thickness and urbanicity

3.2.3.2. Cortical and Subcortical GMV

After FDR correction for multiple comparisons, the general factor and urbanicity were associated with alterations in GMV across broad regions (Supplementary Material 13). For the general factor, the associations with cortical and subcortical GMV were global; out of 68 cortical regions tested, the general stressor factor was negatively associated with 66 cortical regions (p_{fdr}-value ≤ 0.012; Figure 8) and all subcortical GMV regions (p_{fdr}-values < 0.0001). For urbanicity, 42 out of 68 cortical GMV regions were positively associated with urbanicity (p_{fdr}-values ≤ 0.035; Figure 9), and 16 out of 19 subcortical GMV regions were positively associated with urbanicity (p_{fdr}-values ≤ 0.044). No significant results were found for familial risk, interpersonal community, or neighborhood deprivation in association with regional GMV.

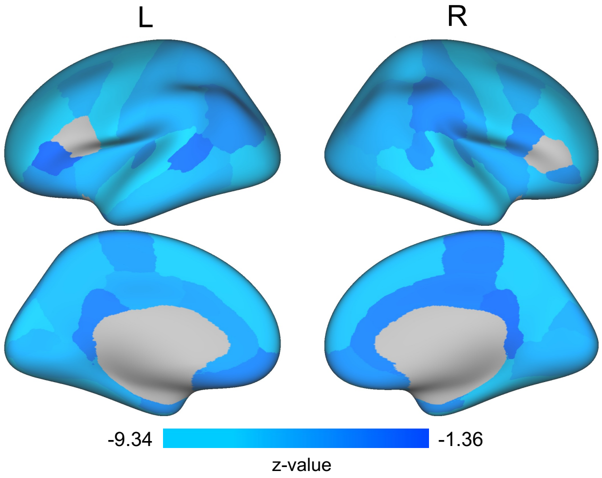

Fig. 8 Regions with significant associations between GMV and the general factor

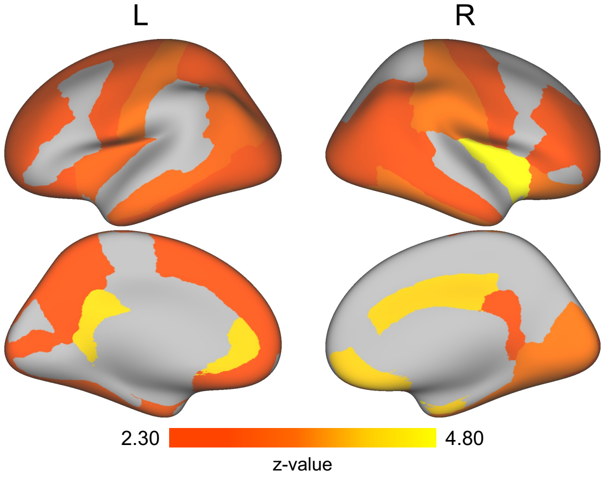

Fig. 9 Regions with significant associations between GMV and urbanicity

3.3 Discussion

The aim of Study 2 was to use a bifactor model to delineate general and specific factors associated with childhood adversity and environmental stressors in a large sample of children. An exploratory factor analysis revealed four factors that represent early life stressors at multiple levels: familial risk, interpersonal community, neighborhood deprivation, and urbanicity. Following this, a confirmatory bifactor analysis identified a general factor which represents the common variance across stressors as well as specific factors that reflect the unique variance after the common variance is accounted for by the general factor. Analyses with brain structures revealed that the general factor was associated with cortical thinning in several areas across the frontal, temporal, and occipital cortices. Additionally, the general factor was associated with globally smaller volume across cortical and subcortical structures. In terms of the specific factors, neighborhood deprivation was associated with cortical thinning in frontal, temporal, and parietal regions. Lastly, the specific factor of urbanicity was associated with thicker cortices in frontal and temporal regions as well as larger cortical and subcortical GMV in broad regions. Overall, the results suggest that environmental stressors are associated with aberrations in the developing brain.

Although adverse childhood experiences frequently co-occur (Dong et al., 2004), there has not been an attempt to identify a general factor that can explain the commonality across different stressors using a bifactor model. The identified general factor in the current study conceptually parallels the *p* factor, or the general factor of psychopathology, which represents an individual's predisposition or vulnerability to experience non-specific forms of psychopathology that go beyond the traditional categorical diagnoses (Caspi et al., 2014; Lahey et al., 2012). In previous studies, the general factor of psychopathology was associated with globally reduced cortical and subcortical GMV in the ABCD Study sample (Durham et al., 2021) and a large community sample of youths (Kaczkurkin et al., 2019). The similar global reduction in brain volume associated with the general factors of early life stressors and psychopathology suggests that early life adversity and environmental stressors are closely linked to psychopathology. However, it is unclear whether these two general factors are tapping into the same underlying mechanism or whether they independently predict similar brain development. One possibility is that early life adversity and environmental stressors may increase vulnerability to psychopathology through their impact on developing brain structures (Raymond, Marin, Majeur, & Lupien, 2018).

After accounting for the common variance measured by the general factor, greater neighborhood deprivation significantly predicted cortical thinning in frontal, parietal, and temporal regions, which are implicated in executive functioning (Collette, Hogge, Salmon, & Van der Linden, 2006) and language processing (Friederici, 2011). The current findings are consistent with studies showing that low SES is associated with deficits in language and executive functioning (Hackman & Farah, 2009; Noble, McCandliss, & Farah, 2007) as well as structural aberrations in these regions (Krishnadas et al., 2013). The current study builds upon prior work by using a large sample of children to show that structural aberrations associated with neighborhood deprivation manifest as early as 9-10 years.

In contrast to the general factor and neighborhood deprivation, urbanicity was associated with primarily thicker cortices and globally larger cortical and subcortical GMV. To understand these findings, it is important to keep in mind that urban living has both positive and negative effects. In terms of mental health, previous studies found that urban living is associated with an increased risk of psychopathology, especially psychosis (Krabbendam & Van Os, 2005; Myin-

Germeys, Delespaul, & Van Os, 2005; Van Os, Kenis, & Rutten, 2010). Moreover, prior work on brain structure has found that urban upbringing was associated with reduced GMV in males with psychotic disorders (Frissen, van Os, Peeters, Gronenschild, & Marcelis, 2018), although no association with cortical thickness was found (Frissen, Van Os, Habets, Gronenschild, & Marcelis, 2017). Additionally, exposure to air pollution is known to have detrimental effects on the developing brain (Calderón-Garcidueñas, Torres-Jardón, Kulesza, Park, & D'Angiulli, 2014; Tost, Champagne, & Meyer-Lindenberg, 2015). Conversely, living in an urban area also has benefits such as diverse cultural offerings, greater access to health care systems, and greater access to opportunities for social interaction (Dye, 2008; Krabbendam et al., 2020; Leyden, 2003; Rogers, Halstead, Gardner, & Carlson, 2011). Furthermore, the idea that "close neighbors are better than distant relatives" (close support of any kind is beneficial) is supported by research showing that neighborhood support may help mitigate mental health problems in urban dwellers (Zhang, Zhang, & Niu, 2021).

Given the positive and negative effects of urban living, we can better understand the results from Study 2. In interpreting a bifactor model, it is important to keep in mind that our urbanicity factor reflects the residual variance after the common variance associated with the general factor is removed. This leaves the "unique" variance that urbanicity explains above and beyond the general factor. Importantly, our general stressor factor includes some urbanicity items, such as residential density and safety of the neighborhood. Thus, the finding that the general factor is associated with smaller brain volumes is consistent with prior studies showing the detrimental effects of living in high density areas. In contrast, the urbanicity factor reflects the variance left over after removing the potential detrimental effects associated with the general factor. By doing so, we can now see that urbanicity is associated with larger brain volumes and greater cortical thickness, suggesting a positive effect that is consistent with the research showing the beneficial effects of neighborhood support associated with urban living. Together, this suggests that while some aspects of urban life can be detrimental to brain development (as reflected in the general factor), being around people can also be beneficial (as reflected in the urbanicity factor), possible due to greater levels of social support. The bifactor model is advantageous in this study because it allows us to move beyond the obvious relationships and provides us with more nuanced information about urbanicity's additional contribution above and beyond the general factor.

4. General Discussion

The current thesis aimed to investigate the association between trauma exposure and environmental stressors and brain structure by leveraging a large sample of children from ages 9 to 10 years. Study 1 focused on traumatic events by deriving a latent factor of trauma exposure, and found focal results in several regions for cortical thickness and subcortical GMV. Whereas cortical thickness results were largely convergent when controlling for SES, subcortical GMV results disappeared, indicating that low SES may account for the associations found for volume. Study 2 took a broader approach in defining childhood maltreatment by investigating factors associated with adverse childhood experiences ranging from interpersonal relationships with family, peers, and teachers, adverse family experiences including financial difficulty and history of mental illnesses, community and neighborhood characteristics including deprivation, safety, and availability of substances, and broader environmental characteristics such as pollution exposure, lead exposure, residential density, and crime rates. A bifactor analysis was used to identify a general factor that represents common variance across different stressors as well as specific factors of familial risk, interpersonal community, neighborhood deprivation, and urbanicity that represent unique effects. The general factor, neighborhood deprivation, and urbanicity were associated with distinct patterns of cortical thickness and GMV differences. Overall, the findings of the current thesis suggest that childhood trauma and environmental stressors may be risk factors for structural aberrations in the developing brain.

The current thesis results in important clinical implications. First, the findings illustrate that environmental stressors at the system-level such as neighborhoods with poor access to resources are associated with aberrations in broader brain regions than trauma exposure alone. These differences may reflect the chronic nature of environmental stressors as opposed to the potentially acute experiences of many traumatic events (Gur et al., 2019). However, chronic trauma exposure (which may not be apparent yet in this young sample) may eventually lead to greater changes in the developing brain over time. The potentially pervasive and chronic influences of systemic environmental stressors suggest that it may be useful for interventions to target systems at the community level. Second, convergent findings of globally smaller brain volumes associated with the general factor of stressors and the general factor of psychopathology in the same sample (Durham et al., 2021) substantiate a close relationship between environmental stressors and psychopathology. Addressing environmental contributors to abnormal brain development may reduce the subsequent development of psychopathology later in life. Thus, interventions would likely need to be implemented in utero or even before conception, such as better maternal nutrition and care, reduced exposure to environmental toxins, and greater support. Lastly, risk for psychopathology is often intergenerational (Bowers & Yehuda, 2016). The identified factors of familial risk, interpersonal relationship within family, neighborhood deprivation, and urbanicity are shared stressors between caregivers and children.

These shared environmental risk factors further highlight the necessity for systemic interventions that include the entire family.

Several limitations should be noted. First, all of the findings are cross-sectional in nature, so no implications about development over time can be made. Second, some of the measures were only available as parental report including the occurrence of traumatic events. Low parental endorsement of items in which a family member could have been a perpetrator of abuse may raise concerns of underreporting of those items and may underestimate of the impact of certain types of trauma on brain development. Lastly, Study 2 showed disagreement between model fit indices in the confirmatory bifactor analysis; however, this in itself does not preclude us from interpreting the results. Although analyses with brain structures indicate that the general and specific factors found in the current study are useful metrics in predicting aberrations of brain structures, further investigation of the discriminant validity is needed as well as replication using longitudinal datasets (Lahey, Moore, Kaczkurkin, & Zald, 2020).

Despite these limitations, the current thesis builds upon prior literature on the impact of early life stressors on structural aberrations in the developing brain and broadens our understanding by taking a novel approach to delineate the general and specific factors of childhood adversity and environmental stressors. The current findings on the potentially adverse effects of such stressors on brain development call for early intervention strategies at systemic levels.

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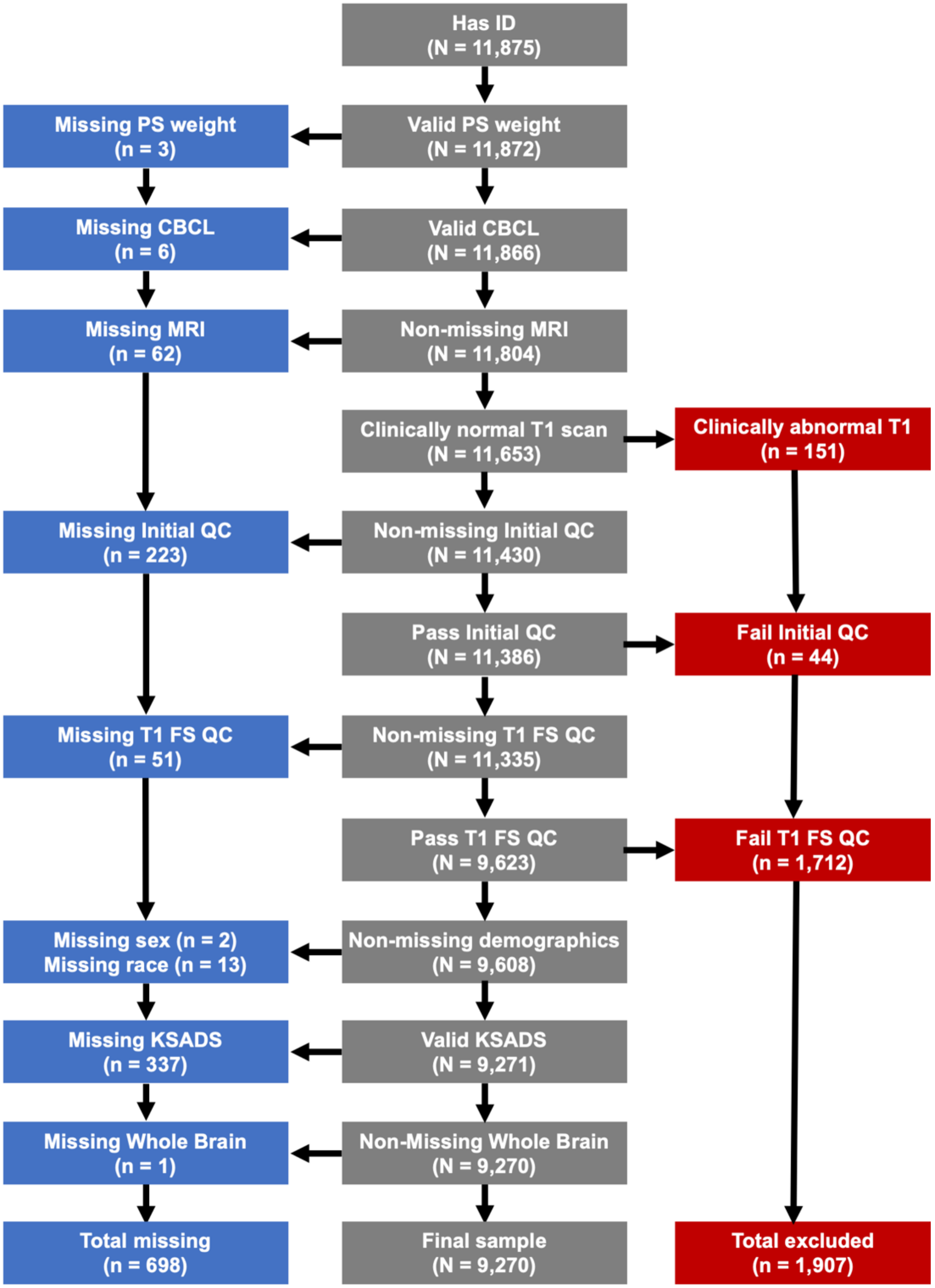
Appendix

Supplementary Material 1. Flowchart indicating exclusions for primary analyses with brain structure and trauma exposure in Study 1



Note. Missing: There were 3 participants excluded for missing propensity weight data (PS weight), 6 for missing Child Behavior Checklist data (CBCL), 62 for missing a variable indicating the normality/abnormality of the structural MRI images ("mrif_score"), 223 for missing data on an initial quality assurance variable ("iqc_t1_ok_ser"), 51 for missing data on an additional quality assurance variable ("fsqc_qc"), 2 for missing sex data, 13 for missing race-ethnicity data, 337 for missing items on the K-SADS trauma events checklist, and 1 for missing the whole brain variable (average cortical thickness or total GMV). Exclusion: There were 151 participants excluded for abnormal structural images, as indicated by an "mrif_score" value of 0 ("Image artifacts prevent radiology read") or 4 ("Consider immediate clinical referral"). There were 44 excluded for failing to pass initial quality control (QC) measures, as indicated by an "iqc_t1_ok_ser" value of 0. There were 1,712 excluded for failing to pass quality assurance variables based on FreeSurfer (FS) QC measures. Specifically, for QC score ("fsqc_qc"), responses of 0 ("reject") were excluded. For motion score ("fsqc_qu_motion"), pial overestimation score ("fsqc_qu_pialover"), white matter underestimation score ("fsqc_qu_wmunder"), and inhomogeneity (fsqc_qu_inhomogeneity), responses of >1 ("mild" to "severe") were excluded and only responses of 0 ("absent") were included.

Supplementary Material 2. Demographics of the sample

	Study 1 (*N* = 9270)		Study2					
			ESEM (*N* = 8,997)		Bifactor (*N* = 2,875)		SEM (*N* = 9,607)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age (months)	119.16	7.47	118.86	7.46	119.21	7.44	119.16	7.47
	N	%	*N*	%	*N*	%	*N*	%
Gender								
Female	4,519	48.75	4,312	47.93	1,368	47.58	4,686	48.78
Male	4,751	51.25	4,681	52.03	1,505	52.35	4,921	51.22
Race-Ethnicity								
White	4,956	53.46	4,637	51.54	1,536	53.43	5,127	53.37
Hispanic	1,860	20.06	1,815	20.17	592	20.59	1,961	20.41
African American	1,329	14.34	1,370	15.23	407	14.16	1,365	14.21
Other	1,125	12.14	1,161	12.9	336	11.69	1,154	12.01
Household Annual Income								
< $5,000	311	3.35	313	3.48	103	3.58	320	3.33
$5,000-$11,999	310	3.34	324	3.6	98	3.41	323	3.36
$12,000-$15,999	215	2.32	210	2.33	64	2.23	220	2.29
$16,000-$24,999	392	4.23	383	4.26	140	4.87	411	4.28
$25,000-$34,999	501	5.4	498	5.54	155	5.39	520	5.41
$35,000-$49,999	708	7.64	739	8.21	195	6.78	735	7.65
$50,000-$74,999	1,164	12.56	1,133	12.6	365	12.7	1,219	12.69
$75,000-$99,999	1,249	13.47	1,182	13.14	389	13.53	1,301	13.54
$100,000-$199,999	2,664	28.74	2,516	27.97	799	27.79	2,753	28.66
≥ $200,000	986	10.64	930	10.34	319	11.1	1,003	10.44

Missing	770	8.31	769	8.55	248	8.63	802	8.35
Parental Education								
No degree	453	4.89	444	4.94	159	5.53	468	4.87
Highschool degree/GED	1,104	11.91	1,103	12.26	337	11.72	1,147	11.94
Some college	1,499	16.17	1,477	16.42	473	16.45	1,572	16.36
Associate's degree	1,174	12.66	1,173	13.04	362	12.59	1,228	12.78
Bachelor's degree	2,626	28.33	2,514	27.94	815	28.35	2,721	28.32
Master's degree	1,824	19.68	1,737	19.31	544	18.92	1,867	19.43
Professional/ Doctoral degree	577	6.22	535	5.95	179	6.23	591	6.15
Missing	13	0.14	14	0.16	6	0.21	13	0.14

Note. The "Other" Race/Ethnicity category includes those who were identified by their parent as American Indian/Native American, Alaska Native, Native Hawaiian, Guamanian, Samoan, Other Pacific Islander, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian, or Other Race.

Supplementary Material 3. Traumatic event items from the K-SADS

	K-SADS Item
1	**A car accident in which your child or another person in the car was hurt bad enough to require medical attention**
2	**Another significant accident for which your child needed specialized and intensive medical treatment**
3	**Witnessed or caught in a fire that caused significant property damage or personal injury**
4	**Witnessed or caught in a natural disaster that caused significant property damage or personal injury**
5	Witnessed or present during an act of terrorism (e.g., Boston marathon bombing)
6	**Witnessed death or mass destruction in a war zone**
7	**Witnessed someone shot or stabbed in the community**
8	Shot, stabbed, or beaten brutally by a non-family member
9	Shot, stabbed, or beaten brutally by a grown-up in the home
10	**Beaten to the point of having bruises by a grown-up in the home**
11	**A non-family member threatened to kill your child**
12	**A family member threatened to kill your child**
13	**Witness the grown-ups in the home push, shove or hit one another**
14	A grown-up in the home touched your child in his or her privates, had your child touch their privates, or did other sexual things to your child
15	**An adult outside your family touched your child in his or her privates, had your child touch their privates or did other sexual things to your child**
16	**A peer forced your child to do something sexually**
17	**Learned about the sudden unexpected death of a loved one**

Note. Items in bold were used to derive a latent factor of trauma exposure. Items 5, 8, 9, and 14 were excluded from the factor analysis due to extremely low endorsement

Supplementary Material 4. Results examining the relationship between regional cortical thickness and trauma exposure

Brain region	Trauma			Brain region	Trauma		
	β	p_{fdr}	R^2		β	p_{fdr}	R^2
Left banks of superior temporal sulcus	-0.03	.306	.001	Right banks of superior temporal sulcus	0.01	.933	.000
Left caudal anterior cingulate	0.03	.337	.001	Right caudal anterior cingulate	-0.01	.933	.000
Left caudal middle frontal	-0.04	.085	.001	Right caudal middle frontal	**-0.07**	**.000**	.005
Left cuneus	0.00	.949	.000	Right cuneus	-0.01	.824	.000
Left entorhinal	0.03	.263	.001	Right entorhinal	0.02	.605	.000
Left fusiform	0.01	.824	.000	Right fusiform	-0.01	.726	.000
Left inferior parietal	-0.02	.496	.000	Right inferior parietal	0.00	.949	.000
Left inferior temporal	-0.01	.839	.000	Right inferior temporal	-0.01	.800	.000
Left isthmus cingulate	**0.06**	**.027**	.004	Right isthmus cingulate	0.03	.263	.001
Left lateral occipital	0.00	.951	.000	Right lateral occipital	-0.02	.334	.000
Left lateral orbitofrontal	0.03	.334	.001	Right lateral orbitofrontal	0.00	.949	.000
Left lingual	0.01	.800	.000	Right lingual	-0.02	.538	.000
Left medial orbitofrontal	0.00	.940	.000	Right medial orbitofrontal	-0.01	.933	.000
Left middle temporal	0.01	.933	.000	Right middle temporal	0.01	.696	.000
Left parahippocampal	0.03	.494	.001	Right parahippocampal	0.03	.495	.001
Left paracentral	0.00	.949	.000	Right paracentral	-0.01	.839	.000
Left pars opercularis	0.00	.949	.000	Right pars opercularis	0.03	.334	.001
Left pars orbitalis	0.01	.933	.000	Right pars orbitalis	0.02	.572	.000
Left pars triangularis	0.00	.994	.000	Right pars triangularis	0.00	.933	.000
Left pericalcarine	0.00	.994	.000	Right pericalcarine	-0.02	.495	.000
Left postcentral	-0.04	.085	.001	Right postcentral	-0.02	.572	.000
Left posterior cingulate	**0.06**	**.017**	.004	Right posterior cingulate	0.04	.263	.001
Left precentral	-0.02	.334	.000	Right precentral	-0.04	.143	.001
Left precuneus	0.02	.419	.001	Right precuneus	0.03	.263	.001

Left rostral anterior cingulate	-0.02	.499	.001	Right rostral anterior cingulate	0.01	.933	.000
Left rostral middle frontal	-0.02	.334	.000	Right rostral middle frontal	-0.03	.143	.001
Left superior frontal	**-0.04**	**.000**	.002	Right superior frontal	**-0.06**	**.000**	.004
Left superior parietal	-0.01	.933	.000	Right superior parietal	-0.01	.800	.000
Left superior temporal	-0.02	.495	.000	Right superior temporal	-0.02	.498	.000
Left supramarginal	-0.01	.933	.000	Right supramarginal	-0.03	.185	.001
Left frontal pole	-0.02	.538	.000	Right frontal pole	-0.01	.864	.000
Left temporal pole	0.03	.368	.001	Right temporal pole	0.00	.949	.000
Left transverse temporal	0.00	.949	.000	Right transverse temporal	-0.05	.068	.002
Left insula	0.03	.334	.001	Right insula	0.02	.538	.000

Note. N = 9,270. Coefficients in bold are significant after FDR correction (adopting a 5% false discovery rate) for 68 tests

Supplementary Material 5. Results examining the relationship between cortical regional GMV and trauma exposure

Brain region	Trauma			Brain region	Trauma		
	β	p_{fdr}	R^2		β	p_{fdr}	R^2
Left banks of superior temporal sulcus	0.01	.818	.000	Right banks of superior temporal sulcus	-0.01	.878	.000
Left caudal anterior cingulate	0.02	.803	.000	Right caudal anterior cingulate	-0.05	.204	.003
Left caudal middle frontal	-0.01	.837	.000	Right caudal middle frontal	0.00	.943	.000
Left cuneus	-0.01	.878	.000	Right cuneus	0.01	.878	.000
Left entorhinal	0.03	.782	.001	Right entorhinal	0.03	.763	.001
Left fusiform	-0.01	.800	.000	Right fusiform	0.04	.204	.002
Left inferior parietal	0.01	.837	.000	Right inferior parietal	0.02	.800	.000
Left inferior temporal	-0.01	.837	.000	Right inferior temporal	-0.01	.782	.000
Left isthmus cingulate	0.01	.878	.000	Right isthmus cingulate	0.04	.550	.001
Left lateral occipital	-0.01	.837	.000	Right lateral occipital	-0.02	.782	.000
Left lateral orbitofrontal	0.03	.258	.001	Right lateral orbitofrontal	0.02	.550	.000
Left lingual	0.00	.927	.000	Right lingual	-0.01	.837	.000
Left medial orbitofrontal	0.04	.204	.002	Right medial orbitofrontal	0.00	.957	.000
Left middle temporal	-0.01	.811	.000	Right middle temporal	-0.02	.550	.001
Left parahippocampal	-0.01	.811	.000	Right parahippocampal	-0.03	.550	.001
Left paracentral	0.04	.258	.002	Right paracentral	-0.01	.878	.000
Left pars opercularis	0.02	.782	.001	Right pars opercularis	0.02	.782	.000
Left pars orbitalis	0.01	.803	.000	Right pars orbitalis	0.01	.837	.000
Left pars triangularis	-0.01	.837	.000	Right pars triangularis	-0.01	.837	.000
Left pericalcarine	0.00	.957	.000	Right pericalcarine	0.00	.975	.000
Left postcentral	-0.02	.782	.000	Right postcentral	0.01	.811	.000
Left posterior cingulate	0.01	.837	.000	Right posterior cingulate	0.00	.943	.000
Left precentral	0.01	.803	.000	Right precentral	-0.03	.550	.001
Left precuneus	0.00	.957	.000	Right precuneus	-0.02	.782	.000

Left rostral anterior cingulate	0.02	.763	.000	Right rostral anterior cingulate	0.02	.782	.000
Left rostral middle frontal	-0.01	.782	.000	Right rostral middle frontal	0.01	.800	.000
Left superior frontal	0.00	.943	.000	Right superior frontal	0.02	.550	.000
Left superior parietal	0.02	.782	.000	Right superior parietal	-0.01	.878	.000
Left superior temporal	-0.02	.782	.000	Right superior temporal	-0.01	.837	.000
Left supramarginal	-0.01	.800	.000	Right supramarginal	-0.02	.782	.000
Left frontal pole	-0.01	.833	.000	Right frontal pole	0.00	.975	.000
Left temporal pole	-0.01	.878	.000	Right temporal pole	0.02	.800	.000
Left transverse temporal	-0.02	.782	.000	Right transverse temporal	-0.03	.763	.001
Left insula	0.00	.943	.000	Right insula	0.02	.782	.000

Note. N = 9,270

Supplementary Material 6. Results examining the relationship between subcortical regional GMV and trauma exposure

Brain region	Trauma			Brain region	Trauma		
	β	p_{fdr}	R^2		β	p_{fdr}	R^2
Left cerebellum cortex	0.02	.092	.000	Right cerebellum cortex	0.01	.283	.000
Left thalamus proper	-0.02	.480	.000	Right thalamus proper	-0.02	.278	.001
Left caudate	0.00	.914	.000	Right caudate	0.01	.707	.000
Left putamen	-0.04	.057	.001	Right putamen	**-0.05**	**.019**	.002
Left pallidum	-0.02	.480	.000	Right pallidum	0.00	.914	.000
Left hippocampus	-0.04	.092	.002	Right hippocampus	-0.04	.057	.002
Left amygdala	-0.05	.057	.002	Right amygdala	**-0.05**	**.048**	.002
Left accumbens area	-0.01	.707	.000	Right accumbens area	-0.01	.770	.000
Left ventral diencephalon	-0.01	.629	.000	Right ventral diencephalon	0.00	.953	.000
Brain stem	0.00	.914	.000				

Note. N = 9,270. Coefficients in bold are significant after FDR correction (adopting a 5% false discovery rate) for 19 tests.

Supplementary Material 7. Results examining the relationship between regional cortical thickness and trauma exposure with income and parent education as additional covariates

Brain region	Trauma			Brain region	Trauma		
	β	p_{fdr}	R^2		β	p_{fdr}	R^2
Left banks of superior temporal sulcus	-0.03	.245	.001	Right banks of superior temporal sulcus	0.01	.830	.000
Left caudal anterior cingulate	0.03	.392	.001	Right caudal anterior cingulate	-0.02	.572	.001
Left caudal middle frontal	-0.03	.216	.001	**Right caudal middle frontal**	**-0.07**	**.000**	.005
Left cuneus	0.01	.746	.000	Right cuneus	0.00	.961	.000
Left entorhinal	0.03	.307	.001	Right entorhinal	0.02	.556	.000
Left fusiform	0.01	.861	.000	Right fusiform	-0.01	.830	.000
Left inferior parietal	-0.03	.307	.001	Right inferior parietal	-0.01	.830	.000
Left inferior temporal	-0.01	.671	.000	Right inferior temporal	-0.02	.556	.000
Left isthmus cingulate	0.06	.068	.003	Right isthmus cingulate	0.03	.389	.001
Left lateral occipital	0.00	.961	.000	Right lateral occipital	-0.01	.572	.000
Left lateral orbitofrontal	0.04	.159	.002	Right lateral orbitofrontal	0.00	.987	.000
Left lingual	0.02	.389	.001	Right lingual	-0.01	.861	.000
Left medial orbitofrontal	0.00	.946	.000	Right medial orbitofrontal	-0.01	.746	.000
Left middle temporal	0.00	.938	.000	Right middle temporal	0.01	.830	.000
Left parahippocampal	0.04	.307	.001	Right parahippocampal	0.04	.307	.001
Left paracentral	0.00	.938	.000	Right paracentral	-0.01	.847	.000
Left pars opercularis	-0.01	.807	.000	Right pars opercularis	0.02	.389	.001
Left pars orbitalis	0.01	.912	.000	Right pars orbitalis	0.01	.861	.000
Left pars triangularis	-0.01	.847	.000	Right pars triangularis	0.00	.946	.000
Left pericalcarine	0.00	.945	.000	Right pericalcarine	-0.01	.840	.000
Left postcentral	-0.04	.163	.001	Right postcentral	-0.01	.746	.000
Left posterior cingulate	**0.06**	**.017**	.004	Right posterior cingulate	0.04	.255	.001
Left precentral	-0.02	.406	.000	Right precentral	-0.03	.245	.001

Left precuneus	0.02	.430	.000	Right precuneus	0.03	.307	.001
Left rostral anterior cingulate	-0.03	.307	.001	Right rostral anterior cingulate	0.00	.961	.000
Left rostral middle frontal	-0.03	.245	.001	Right rostral middle frontal	-0.03	.153	.001
Left superior frontal	**-0.05**	**.000**	.002	Right superior frontal	**-0.07**	**.000**	.004
Left superior parietal	-0.01	.830	.000	Right superior parietal	-0.02	.389	.000
Left superior temporal	-0.02	.556	.000	Right superior temporal	-0.01	.830	.000
Left supramarginal	-0.02	.584	.000	Right supramarginal	-0.03	.153	.001
Left frontal pole	-0.01	.746	.000	Right frontal pole	-0.01	.746	.000
Left temporal pole	0.03	.389	.001	Right temporal pole	0.01	.912	.000
Left transverse temporal	0.00	.946	.000	Right transverse temporal	-0.04	.153	.002
Left insula	0.04	.245	.001	Right insula	0.03	.307	.001

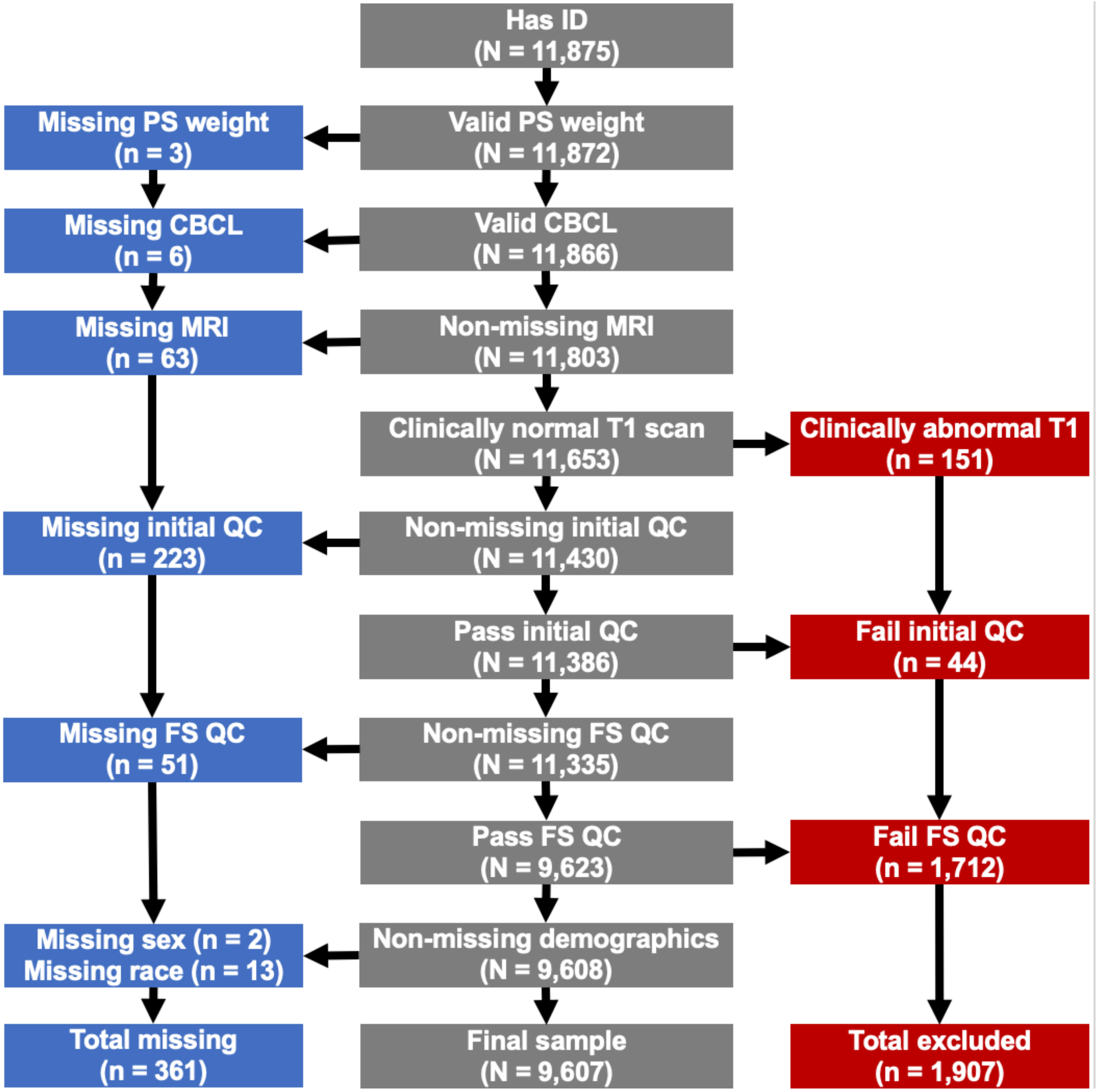
Note. N = 8,496. Coefficients in bold are significant after FDR correction (adopting a 5% false discovery rate) for 68 tests.

Supplementary Material 8. Results examining the relationship between subcortical regional GMV and trauma exposure with income and parent education as additional covariates

Brain region	Trauma			Brain region	Trauma		
	β	p_{fdr}	R^2		β	p_{fdr}	R^2
Left cerebellum cortex	0.01	.502	.000	Right cerebellum cortex	0.00	0.813	.000
Left thalamus proper	-0.01	.813	.000	Right thalamus proper	-0.02	0.625	.000
Left caudate	0.01	.813	.000	Right caudate	0.01	0.798	.000
Left putamen	-0.02	.502	.000	Right putamen	-0.04	0.152	.001
Left pallidum	-0.01	.798	.000	Right pallidum	0.00	0.951	.000
Left hippocampus	-0.03	.502	.001	Right hippocampus	-0.03	0.502	.001
Left amygdala	-0.04	.215	.002	Right amygdala	-0.05	0.152	.002
Left accumbens area	-0.01	.813	.000	Right accumbens area	0.00	0.979	.000
Left ventral diencephalon	-0.01	.813	.000	Right ventral diencephalon	0.01	0.813	.000
Brain stem	0.00	.950	.000				

Note. N = 8,496.

Supplementary Material 9. Flowchart indicating exclusions for primary analyses with brain structure and stressor factors in Study 2



Note. Missing: There were 3 participants excluded for missing propensity weight data (PS weight), 6 for missing Child Behavior Checklist data (CBCL), 62 for missing a variable indicating the normality/abnormality of the structural MRI images ("mrif_score"), 223 for missing data on an initial quality assurance variable ("iqc_t1_ok_ser"), 51 for missing data on an additional quality assurance variable ("fsqc_qc"), 2 for missing sex data, 13 for missing race-ethnicity data, and 1 for missing the whole brain variable (average cortical thickness or total GMV). Exclusion: There were 151 participants excluded for abnormal structural images, as indicated by an "mrif_score" value of 0 ("Image artifacts prevent radiology read") or 4 ("Consider immediate clinical referral"). There were 44 excluded for failing to pass initial quality control (QC) measures, as indicated by an “iqc_t1_ok_ser” value of 0. There were 1,712 excluded for failing to pass quality assurance variables based on FreeSurfer (FS) QC measures. Specifically, for QC score (“fsqc_qc”), responses of 0 (“reject”) were excluded. For motion score (“fsqc_qu_motion”), pial overestimation score (“fsqc_qu_pialover”), white matter underestimation score (“fsqc_qu_wmunder”), and inhomogeneity (fsqc_qu_inhomogeneity), responses of >1 (“mild” to “severe”) were excluded and only responses of 0 (“absent”) were included.

Supplementary Material 10. Exploratory factor analysis with 4 factors in ESEM

Item	Brief wording	Familial Risk	Interpersonal Community	Neighborhood Deprivation	Urbanicity
ksads754	Car accident	0.24	0.02	0.14	-0.05
ksads755	Significant accident	0.26	0.00	-0.02	-0.04
ksads756	Witnessed/caught in a fire	0.31	0.04	0.07	0.02
ksads757	Witnessed/caught in a natural disaster	0.18	0.04	0.12	-0.27
ksads760	Witnessed violence in the community	**0.40**	0.05	0.28	0.13
ksads763	Beaten by a grown up in the home	**0.51**	0.03	0.17	-0.03
ksads766	Witnessed violence in the home	**0.48**	-0.03	0.20	0.07
ksads768	An adult outside did sexual things	**0.47**	0.00	0.20	-0.10
ksads769	A peer did sexual things	**0.46**	-0.01	0.03	0.02
ksads770	Learned about sudden death of loved one	0.29	0.02	0.10	0.01
ksads764_765*	Threatened life by a non-family member/Threatened life by a family member	**0.43**	-0.02	0.18	-0.08
fes_q1	Family members fight a lot	0.10	**-0.45**	0.11	-0.06
fes_q2	Family member rarely become angry	0.05	-0.27	0.11	-0.01
fes_q3	Family members throw things	0.12	-0.35	0.18	-0.08
fes_q4	Family members hardly lose temper	0.08	-0.35	0.05	-0.02
fes_q5	Family members criticize each other	0.10	-0.39	0.07	-0.04
fes_q6	Family members hit each other	0.06	-0.36	0.13	-0.08
fes_q7	Family members try to smooth things when there is a disagreement	0.06	**-0.43**	0.05	-0.03
fes_q8	Family members try to outdo each other	0.05	-0.31	0.12	-0.06
fes_q9	Family members don't raise voice	0.01	-0.28	0.02	0.02
famexp1_2*	Needed food but couldn't afford/Could not afford telephone service	0.38	-0.03	**0.49**	0.09
famexp3_4*	Could not pay rent or mortgage/Evicted for not paying the rent or mortgage	0.38	-0.05	**0.41**	0.10
famexp5	Could not pay for gas or electric service	0.35	-0.04	**0.40**	0.05
famexp6	Could not afford to go to the hospital	**0.48**	-0.08	0.34	-0.08

famexp7	Could not afford to see a dentist	**0.40**	-0.05	**0.40**	-0.09
roster	Number of people living at the home	-0.01	-0.03	0.06	-0.10
fmhx4	Family history of alcohol-related problems	**0.59**	0.02	-0.07	-0.02
fmhx5	Family history of drug-related problems	**0.67**	-0.01	0.11	-0.01
fmhx6	Family history of depression	**0.76**	0.01	-0.13	-0.01
fmhx7	Family history of mania	**0.60**	0.02	-0.04	0.05
fmhx8	Family history of psychosis	**0.54**	0.00	0.05	0.09
fmhx9	Family history of antisocial problems	**0.65**	-0.01	0.16	-0.04
fmhx10	Family history of nerve problems	**0.65**	0.02	-0.05	0.04
fmhx11	Family history of receiving psychiatric service	**0.82**	0.03	-0.21	-0.03
fmhx12	Family history of hospitalization due to psychiatric problems	**0.75**	0.03	-0.06	0.01
fmhx13	Family history of suicide	**0.64**	-0.01	-0.04	0.01
cvg_acc1	Caregiver makes me feel better after talking over my worries	0.06	**0.59**	-0.01	0.06
cvg_acc2	Caregiver smiles at me very often	0.05	**0.52**	-0.10	0.03
cvg_acc3	Caregiver makes be feel better when I'm upset	0.08	**0.61**	0.00	0.02
cvg_acc4	Caregiver believes in showing love for me	0.08	**0.61**	-0.01	0.01
cvg_acc5	Caregiver is easy to talk to	0.03	**0.54**	-0.02	0.04
cvg_acc	There is a second adult who cares for me	-0.08	0.15	-0.14	-0.07
conflict	Caregiver and child get along	0.29	-0.16	-0.06	0.01
ftime_lv	Child lives with caregiver full time	-0.10	-0.04	0.07	0.05
school_g	Grades child gets on average	0.09	-0.19	0.26	0.07
grad_drp	Drop in child's grades	-0.08	0.19	-0.27	-0.05
service1	Child receives: Full-time emotional support	0.16	-0.18	0.29	0.08
service2	Child receives: Full-time learning support	-0.05	-0.09	0.35	0.09
service4	Child receives: Special education for specific subjects	0.15	-0.13	0.13	0.03
service5	Child receives: Part-time aide	0.15	-0.12	0.11	0.07

service6	Child receives: Resource room	0.26	-0.12	-0.01	0.00
service7	Child receives: Tutoring support	0.07	-0.08	0.18	-0.07
service8	Child receives: Gifted program service	-0.03	0.06	-0.16	-0.06
service9	Child receives: other special service	0.12	-0.08	0.03	-0.01
det_susp	Detention or suspension history	-0.24	0.19	-0.31	-0.08
bst_frnd	Child has a best friend	-0.04	0.17	0.08	-0.02
grp_frnd	Child has a group of friends	0.02	0.16	-0.22	-0.06
bully	Problems with bullying	0.35	-0.12	0.12	0.04
mh_srvc	Child has received mental health service	**0.46**	-0.14	-0.06	0.03
school2	Students have lots of chance to decide things in my school	0.00	0.37	0.08	0.06
school3	I get along with my teachers	-0.01	**0.62**	-0.02	-0.06
school4	My teachers notice when I'm doing good job	0.01	**0.50**	0.16	0.01
school5	There are many chances for students in get involved	0.04	0.33	0.01	0.02
school6	I feel safe at my school	0.01	**0.58**	-0.12	-0.06
school7	The school lets my parents know when I've done something well	0.03	**0.43**	0.11	0.00
school8	I like school because I do well	-0.01	**0.66**	0.15	-0.02
school9	I feel just as smart as other kids	0.03	**0.46**	0.06	-0.03
school10	There are many chances to be part of class	0.05	**0.54**	0.00	0.04
school12	I like school	-0.01	**0.75**	0.09	-0.01
school15	School bores me	0.04	**-0.65**	-0.03	0.02
school17	Getting good grads is not important to me	0.04	-0.29	-0.14	0.03
resil5a	The number of friends that are boys	0.00	-0.03	-0.03	-0.01
resil6a	The number of friends that are girls	-0.01	0.20	0.01	0.02
resil5b	The number of close friends that are boys	0.01	-0.04	-0.04	-0.01
resil6b	The number of close friends that are girls	-0.01	0.21	0.05	0.02
neighbr	Neighborhood is safe from crime (child)	-0.03	0.26	-0.26	-0.17
neighbr1	I feel safe walking in my neighborhood	-0.14	0.01	-0.33	**-0.46**
neighbr3	Neighborhood is safe from crime (parent)	-0.18	0.01	-0.33	**-0.52**

crpf1	Accessibility to alcohol	0.14	0.02	**-0.41**	-0.06
crpf2	Accessibility to cigarettes	**0.56**	-0.04	-0.03	0.02
crpf3	Accessibility to e-cigarettes	**0.55**	0.00	-0.08	0.05
crpf4	Accessibility to marijuana	**0.52**	-0.03	-0.09	0.12
crpf6	Medical marijuana legal in the state	0.06	0.05	0.21	-0.25
monitor1	How often parents know where I am	-0.01	**0.42**	-0.05	0.01
monitor2	How often parents know who I am with	0.03	0.32	-0.11	-0.01
monitor3	How often parents get in touch when they are not at home	0.03	0.29	-0.08	0.03
monitor4	How often I let parents about my plan	-0.01	**0.40**	0.06	0.03
monitor5	How often child and parents eat dinner together	-0.04	0.28	-0.13	0.00
rh_yr	Years of residence	-0.08	0.00	-0.17	0.05
rh_ele	Elevation level	0.32	0.05	-0.23	0.13
rh_dnst	Gross residential density	-0.08	0.01	0.14	0.72
rh_walk	Walkability scores	-0.03	0.01	0.06	**0.61**
rh_edu_h^	Percentage of populations with at least high school diploma	-0.15	-0.02	**0.74**	0.17
rh_work^	Percentage of populations with white collar occupations	-0.06	0.01	0.25	-0.30
rh_incom	Median family income	0.05	-0.01	**-0.93**	-0.04
rh_homev	Median home value	-0.11	-0.01	**-0.78**	0.34
rh_rent	Median gross rent	-0.16	-0.02	**-0.55**	0.14
rh_mortg	Median monthly mortgage	-0.09	-0.01	**-0.80**	0.27
rh_homeo^	Home ownership rate	-0.08	0.01	**0.52**	**0.46**
rh_crowd	Crowding in the home	-0.20	0.02	0.39	0.28
rh_unemp	Unemployment rate	-0.10	-0.02	**0.59**	0.23
rh_b138	Percentage of populations below or around the poverty level	-0.09	0.00	**0.81**	0.23
rh_sp	Percentage of single-parent household	-0.05	0.00	**0.71**	0.24

rh_ncar	Percentage of houses without a motor vehicle	0.00	0.01	**0.53**	**0.44**
rh_ntel	Percentage of houses without a telephone	-0.06	0.00	**0.42**	0.10
rh_nplmb	Percentage of houses without complete plumbing	-0.07	0.00	**0.43**	0.11
rh_adi_p	National percentile of ADI scores	0.04	0.00	**0.83**	-0.13
rh_ppden	Population density	-0.06	0.02	0.07	**0.69**
rh_no2	Pollution measure (NO2)	0.09	0.00	-0.27	**0.80**
rh_pm25	Pollution measure (PM2.5)	0.13	0.01	-0.06	0.32
rh_pxrd	Proximity to major roads	0.01	0.03	-0.12	-0.21
rh_lead	Lead exposure risk	0.12	0.00	0.16	**0.46**
rh_pm25a	Pollution measure (PM2.5) at high resolution	-0.04	0.01	0.18	0.37
rh_crime	Crime rates	0.23	0.03	-0.30	**0.45**

Note. *N* = 8,997. Standardized loadings ≥ 0.4 are in bold. * denotes composite of highly correlated items; ^ denotes items that are reverse coded before log transformation. Items with standardized loadings in bold were retained for the next round of a confirmatory factor analysis in the second random sample (*N* = 2,875).

Supplementary Material 11. Standardized factor loadings from the confirmatory bifactor model

Item	Brief wording	General	Familial Risk	Interpersonal Community	Neighborhood Deprivation	Urbanicity
ksads760	Witnessed violence in the community	**0.55**	0.31			
ksads763	Beaten by a grown up in the home	0.14	**0.60**			
ksads 766	Witnessed violence in the home	0.32	**0.47**			
ksads 768	An adult outside did sexual things	0.33	**0.43**			
ksads 769	A peer did sexual things	0.15	0.37			
famexp6	Could not afford to go to the hospital	**0.50**	0.28			
famexp7	Could not afford to see a dentist	**0.51**	0.22			
fmhx4	Family history of alcohol-related problems	0.01	**0.63**			
fmhx 5	Family history of drug-related problems	0.21	**0.71**			
fmhx 6	Family history of depression	-0.02	**0.76**			
fmhx 7	Family history of mania	0.09	**0.68**			
fmhx 8	Family history of psychosis	0.18	**0.63**			
fmhx 9	Family history of antisocial problems	0.24	**0.66**			
fmhx 10	Family history of nerve problems	0.08	**0.63**			
fmhx 11	Family history of receiving psychiatric service	-0.10	**0.80**			
fmhx 12	Family history of hospitalization due to psychiatric problems	0.10	**0.78**			
fmhx 13	Family history of suicide	0.07	**0.68**			
mh_srvc	Child has received mental health service	0.05	**0.41**			
crpf2	Accessibility to cigarettes	0.01	**0.53**			
crpf3	Accessibility to e-cigarettes	-0.04	**0.56**			
crpf4	Accessibility to marijuana	0.05	**0.43**			

ksads764_765*	Threatened life by a non-family member/Threatened life by a family member	0.19	**0.54**		
fes_q1	Family members fight a lot	0.13		-0.28	
fes_q7	Family members try to smooth things when there is a disagreement	0.15		-0.33	
cvg_acc1	Caregiver makes me feel better after talking over my worries	0.01		**0.65**	
cvg_acc2	Caregiver smiles at me very often	-0.10		**0.57**	
cvg_acc3	Caregiver makes be feel better when I'm upset	-0.02		**0.68**	
cvg_acc4	Caregiver believes in showing love for me	0.00		**0.71**	
cvg_acc5	Caregiver is easy to talk to	-0.06		**0.54**	
school3	I get along with my teachers	-0.10		**0.62**	
school4	My teachers notice when I'm doing good job	0.11		**0.53**	
school6	I feel safe at my school	-0.22		**0.52**	
school7	The school lets my parents know when I've done something well	0.06		**0.47**	
school8	I like school because I do well	0.09		**0.66**	
school9	I feel just as smart as other kids	0.05		**0.48**	
school10	There are many chances to be part of class	-0.03		**0.49**	
school12	I like school	-0.01		**0.78**	
school15	School bores me	0.06		**-0.65**	
monitor1	How often parents know where I am	-0.07		0.36	
monitor4	How often I let parents about my plan	0.06		0.37	
famexp5	Family members criticize each other	**0.53**			0.10
crpf1	Accessibility to alcohol	-0.34			-0.15
rh_edu_h^	Percentage of populations with at least high school diploma	**0.67**			0.34

rh_incom	Median family income	**-0.67**	**-0.64**	
rh_homv	Median home value	-0.23	**-0.89**	
rh_rent	Median gross rent	-0.25	**-0.58**	
rh_mortg	Median monthly mortgage	-0.31	**-0.87**	
rh_homeo^	Home ownership rate	**0.80**	0.05	
rh_unemp	Unemployment rate	**0.61**	0.22	
rh_b138	Percentage of populations below or around the poverty level	**0.81**	0.37	
rh_sp	Percentage of single-parent household	**0.72**	0.33	
rh_ncar	Percentage of houses without a motor vehicle	**0.71**	0.17	
rh_ntel	Percentage of houses without a telephone	**0.41**	0.20	
rh_nplmb	Percentage of houses without complete plumbing	**0.41**	0.19	
rh_adi_p	National percentile of ADI scores	**0.46**	**0.73**	
famexp_1_2*	Needed food but couldn't afford/Could not afford telephone service	**0.62**	0.09	
famexp_3_4*	Could not pay rent or mortgage/Evicted for not paying the rent or mortgage	**0.54**	0.07	
neighbr1	I feel safe walking in my neighborhood	**-0.54**		**-0.52**
neighbr3	Neighborhood is safe from crime	**-0.55**		**-0.56**
rh_dnst	Gross residential density	**0.42**		**0.57**
rh_walk	Walkability scores	0.28		**0.49**
rh_ppden	Population density	0.35		**0.56**
rh_no2	Pollution measure (NO2)	-0.01		**0.75**
rh_lead	Lead exposure risk	0.34		0.37
rh_crime	Crime rates	-0.11		**0.48**

Note. N = 2,875; Standardized loadings ≥ 0.4 are in bold. * denotes composite of two highly correlated items; ^ denotes items that are reverse coded before log transformation.

Supplementary Material 12. Results examining the relationship between regional cortical thickness and environmental stressors

Brain region	General			Familial Risk			Interpersonal Community			Neighborhood Deprivation			Urbanicity		
	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2
Left banks of superior temporal sulcus	-2.05	.147	.001	-0.17	.980	.000	-0.91	.644	.000	-1.46	.365	.000	-0.90	.588	.000
Left caudal anterior cingulate	-0.82	.700	.000	-1.72	.450	.000	-0.24	.840	.000	-0.26	.886	.000	1.94	.167	.001
Left caudal middle frontal	-1.04	.567	.000	0.06	.985	.000	-1.86	.260	.001	**-4.09**	**.000**	.002	0.56	.700	.000
Left cuneus	**-4.04**	**.000**	.002	2.32	.242	.001	-0.38	.829	.000	-0.37	.838	.000	-0.27	.837	.000
Left entorhinal	-0.17	.936	.000	-0.70	.753	.000	-0.70	.717	.000	0.17	.918	.000	2.56	.062	.001
Left fusiform	-0.69	.781	.000	0.52	.840	.000	-0.89	.644	.000	1.07	.535	.000	-0.33	.811	.000
Left inferior parietal	0.37	.843	.000	2.18	.242	.001	-2.47	.147	.001	**3.11**	**.023**	.001	-0.81	.594	.000
Left inferior temporal	-0.65	.793	.000	-0.01	.995	.000	-0.24	.840	.000	0.63	.725	.000	-1.12	.497	.000
Left isthmus cingulate	0.36	.843	.000	0.05	.985	.000	0.50	.777	.000	2.40	.064	.001	0.87	.588	.000
Left lateral occipital	**-2.63**	**.042**	.001	1.60	.499	.000	-0.61	.738	.000	0.84	.709	.000	1.39	.383	.000
Left lateral orbitofrontal	**-2.66**	**.042**	.001	1.89	.359	.001	-0.79	.693	.000	-0.29	.873	.000	1.34	.383	.000
Left lingual	**-4.95**	**.000**	.003	1.42	.547	.000	-0.34	.834	.000	-1.71	.278	.000	1.42	.374	.000
Left medial orbitofrontal	-0.90	.640	.000	-1.04	.648	.000	-1.85	.260	.001	0.57	.755	.000	2.58	.062	.001
Left middle temporal	-0.39	.843	.000	-0.25	.956	.000	-0.75	.697	.000	-2.52	.054	.001	-0.03	.976	.000
Left parahippocampal	**-4.05**	**.000**	.003	1.40	.547	.000	-0.78	.693	.000	-1.61	.306	.000	0.91	.588	.000
Left paracentral	-2.19	.116	.001	-0.71	.753	.000	0.65	.730	.000	**-2.74**	**.037**	.001	-0.70	.673	.000
Left pars opercularis	0.68	.781	.000	0.96	.692	.000	-0.88	.644	.000	-0.75	.725	.000	-1.89	.167	.001
Left pars orbitalis	0.29	.861	.000	2.36	.242	.001	-1.44	.428	.000	0.66	.725	.000	-0.60	.700	.000
Left pars triangularis	1.77	.238	.000	0.09	.985	.000	-1.19	.578	.000	-1.22	.470	.000	-0.66	.680	.000
Left pericalcarine	**-2.69**	**.042**	.001	1.18	.595	.000	0.47	.790	.000	-1.12	.509	.000	1.52	.322	.000
Left postcentral	-1.54	.302	.000	-0.47	.864	.000	0.00	.999	.000	**-2.86**	**.034**	.001	-1.92	.167	.000
Left posterior cingulate	-0.38	.843	.000	-1.47	.547	.000	0.97	.644	.000	-0.46	.817	.000	0.14	.917	.000
Left precentral	**-2.77**	**.042**	.001	0.24	.956	.000	-2.10	.199	.001	**-3.48**	**.000**	.001	-0.81	.594	.000
Left precuneus	-1.42	.349	.000	2.26	.242	.001	-0.25	.840	.000	-0.14	.929	.000	0.32	.812	.000
Left rostral anterior cingulate	-0.07	.972	.000	1.31	.561	.000	-0.83	.673	.000	1.27	.445	.000	**3.04**	**.023**	.002
Left rostral middle frontal	-0.43	.843	.000	0.75	.753	.000	-1.49	.408	.000	**-3.56**	**.000**	.001	0.04	.976	.000
Left superior frontal	-0.40	.843	.000	-0.71	.753	.000	-2.61	.122	.001	**-2.86**	**.034**	.001	1.01	.544	.000

Left superior parietal	-1.80	.230	.000	1.43	.547	.000	-1.48	.408	.000	0.52	.775	.000	0.82	.594	.000
Left superior temporal	-1.36	.370	.000	0.75	.753	.000	-1.29	.533	.000	**-2.79**	**.034**	.001	0.58	.700	.000
Left supramarginal	0.33	.857	.000	0.04	.985	.000	-2.17	.192	.001	**-2.71**	**.037**	.001	**-3.50**	**.000**	.002
Left frontal pole	-0.13	.953	.000	2.59	.242	.001	-2.24	.192	.001	-0.05	.962	.000	-1.02	.544	.000
Left temporal pole	-0.46	.843	.000	0.79	.753	.000	-1.18	.578	.000	-1.42	.368	.000	0.22	.861	.000
Left transverse temporal	-1.68	.258	.000	1.95	.347	.001	-1.09	.602	.000	0.41	.828	.000	0.37	.793	.000
Left insula	-1.72	.251	.000	1.65	.486	.000	-0.94	.644	.000	0.67	.725	.000	**2.97**	**.026**	.001
Right banks of superior temporal sulcus	-1.53	.302	.000	-0.68	.753	.000	0.34	.834	.000	-2.48	.055	.001	0.53	.700	.000
Right caudal anterior cingulate	-0.53	.843	.000	-0.71	.753	.000	-2.16	.192	.001	-0.24	.886	.000	2.41	.091	.001
Right caudal middle frontal	-0.90	.640	.000	-1.03	.648	.000	-3.30	.068	.002	-1.54	.337	.000	1.02	.544	.000
Right cuneus	**-4.11**	**.000**	.002	2.49	.242	.001	-0.22	.840	.000	-0.71	.725	.000	1.95	.167	.001
Right entorhinal	-0.21	.917	.000	-0.83	.753	.000	-1.20	.578	.000	0.73	.725	.000	**3.73**	**.000**	.002
Right fusiform	-2.21	.115	.001	-0.39	.864	.000	-0.74	.697	.000	0.83	.709	.000	1.90	.167	.001
Right inferior parietal	-0.45	.843	.000	2.17	.242	.001	-1.58	.391	.000	**3.04**	**.023**	.001	-0.44	.747	.000
Right inferior temporal	-1.52	.302	.000	1.11	.631	.000	-0.54	.756	.000	-0.40	.828	.000	-1.89	.167	.000
Right isthmus cingulate	0.52	.843	.000	0.19	.980	.000	0.22	.840	.000	0.81	.709	.000	0.64	.683	.000
Right lateral occipital	**-3.24**	**.009**	.001	1.29	.561	.000	-0.64	.730	.000	-1.20	.476	.000	2.28	.107	.001
Right lateral orbitofrontal	**-3.58**	**.000**	.002	2.15	.242	.001	-0.93	.644	.000	-0.87	.702	.000	**3.71**	**.000**	.002
Right lingual	**-3.52**	**.000**	.002	1.46	.547	.000	-0.64	.730	.000	-1.62	.306	.000	2.17	.128	.001
Right medial orbitofrontal	-0.06	.972	.000	0.58	.800	.000	-1.13	.602	.000	**-2.79**	**.034**	.001	**3.97**	**.000**	.002
Right middle temporal	-0.36	.843	.000	0.78	.753	.000	-1.07	.602	.000	0.05	.962	.000	-2.31	.107	.001
Right parahippocampal	**-2.70**	**.042**	.001	0.15	.982	.000	-1.64	.365	.000	-2.37	.068	.001	0.53	.700	.000
Right paracentral	-2.56	.053	.001	-0.66	.755	.000	0.30	.840	.000	-2.51	.054	.001	0.55	.700	.000
Right pars opercularis	0.05	.972	.000	1.26	.568	.000	-3.05	.068	.001	-1.70	.278	.000	1.70	.242	.000
Right pars orbitalis	0.62	.795	.000	0.11	.985	.000	-2.08	.199	.001	-0.05	.962	.000	0.48	.725	.000
Right pars triangularis	0.62	.795	.000	1.16	.595	.000	-1.89	.260	.000	-1.46	.365	.000	0.97	.561	.000
Right pericalcarine	**-5.13**	**.000**	.004	1.85	.368	.001	-0.44	.804	.000	-1.17	.484	.000	1.67	.246	.000
Right postcentral	-1.08	.546	.000	-0.23	.956	.000	0.38	.829	.000	**-2.72**	**.037**	.001	-1.36	.383	.000
Right posterior cingulate	0.00	1.000	.000	-0.39	.864	.000	-2.70	.119	.001	-0.39	.828	.000	-0.66	.680	.000
Right precentral	-2.33	.091	.001	-0.04	.985	.000	-2.39	.165	.001	-1.28	.445	.000	1.12	.497	.000
Right precuneus	-2.04	.147	.001	2.30	.242	.001	-0.94	.644	.000	0.70	.725	.000	-1.28	.412	.000
Right rostral anterior cingulate	0.30	.861	.000	1.23	.575	.000	-1.05	.602	.000	2.30	.075	.001	**2.85**	**.030**	.001

Right rostral middle frontal	-1.59	.296	.000	-0.41	.864	.000	-2.78	.113	.001	**-3.63**	**.000**	.002	**2.94**	**.026**	.001
Right superior frontal	-1.12	.530	.000	-1.32	.561	.000	-2.22	.192	.001	-2.20	.095	.001	1.19	.468	.000
Right superior parietal	-0.74	.760	.000	1.38	.547	.000	-1.09	.602	.000	0.78	.723	.000	-0.86	.588	.000
Right superior temporal	-1.67	.258	.000	0.40	.864	.000	-0.54	.756	.000	-1.42	.368	.000	-1.90	.167	.001
Right supramarginal	0.46	.843	.000	1.08	.635	.000	-0.23	.840	.000	-0.23	.886	.000	-2.22	.118	.001
Right frontal pole	0.94	.640	.000	0.64	.755	.000	1.75	.306	.000	0.63	.725	.000	-0.87	.588	.000
Right temporal pole	-1.41	.349	.000	0.78	.753	.000	-1.95	.253	.001	0.29	.873	.000	-1.37	.383	.000
Right transverse temporal	-1.12	.530	.000	0.44	.864	.000	-1.49	.408	.000	-0.54	.772	.000	-2.07	.156	.001
Right insula	-1.86	.211	.001	0.68	.753	.000	-0.56	.756	.000	0.62	.725	.000	**5.43**	**.000**	.004

Note. N = 9,607. Coefficients in bold are significant after FDR correction (adopting a 5% false discovery rate) for 68 tests

Supplementary Material 13. Results examining the relationship between cortical and subcortical regional GMV and environmental stressors

Brain region	General			Familial Risk			Interpersonal Community			Neighborhood Deprivation			Urbanicity		
	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2	β	p_{fdr}	R^2
Left banks of superior temporal sulcus	**-3.16**	**.002**	.002	-0.59	.921	.000	1.08	.763	.000	-1.29	.554	.000	2.12	.050	.001
Left caudal anterior cingulate	**-5.30**	**.000**	.004	0.28	.921	.000	1.30	.686	.000	-0.13	.924	.000	1.83	.092	.001
Left caudal middle frontal	**-6.09**	**.000**	.006	2.97	.174	.001	-0.05	.975	.000	-0.96	.684	.000	0.98	.360	.000
Left cuneus	**-6.95**	**.000**	.006	2.30	.239	.001	-0.03	.975	.000	-0.40	.818	.000	0.89	.405	.000
Left entorhinal	**-4.64**	**.000**	.003	-1.48	.554	.000	0.31	.970	.000	-2.46	.370	.001	**3.09**	**.006**	.001
Left fusiform	**-6.83**	**.000**	.007	0.56	.921	.000	2.30	.363	.001	-0.76	.732	.000	**3.09**	**.006**	.001
Left inferior parietal	**-4.58**	**.000**	.003	-1.29	.643	.000	1.28	.686	.000	-1.61	.490	.000	**3.25**	**.004**	.002
Left inferior temporal	**-6.16**	**.000**	.005	-0.59	.921	.000	0.94	.763	.000	-1.08	.605	.000	**2.90**	**.010**	.001
Left isthmus cingulate	**-3.76**	**.000**	.002	0.29	.921	.000	0.94	.763	.000	-1.45	.492	.000	**4.34**	**.000**	.003
Left lateral occipital	**-7.21**	**.000**	.007	1.73	.486	.000	-0.54	.899	.000	0.89	.704	.000	**2.74**	**.012**	.001
Left lateral orbitofrontal	**-5.35**	**.000**	.004	0.86	.891	.000	0.19	.975	.000	-0.41	.818	.000	**2.88**	**.010**	.001
Left lingual	**-6.11**	**.000**	.005	2.22	.251	.001	2.33	.363	.001	-0.78	.731	.000	**2.39**	**.027**	.001
Left medial orbitofrontal	**-4.04**	**.000**	.002	-0.68	.921	.000	-0.06	.975	.000	1.54	.492	.000	**2.66**	**.015**	.001
Left middle temporal	**-6.37**	**.000**	.006	0.53	.921	.000	1.42	.686	.000	-1.22	.554	.000	**3.26**	**.004**	.001
Left parahippocampal	**-6.04**	**.000**	.005	-2.07	.301	.001	1.49	.686	.000	-2.23	.370	.001	1.89	.083	.001
Left paracentral	**-4.85**	**.000**	.004	-0.23	.921	.000	1.50	.686	.000	0.12	.924	.000	1.12	.301	.000
Left pars opercularis	-1.92	.056	.001	1.28	.643	.000	0.15	.975	.000	0.72	.757	.000	1.08	.314	.000
Left pars orbitalis	**-5.21**	**.000**	.004	1.38	.605	.000	-0.19	.975	.000	-0.40	.818	.000	0.75	.470	.000
Left pars triangularis	**-2.53**	**.012**	.001	-0.28	.921	.000	0.99	.763	.000	0.34	.820	.000	1.14	.297	.000
Left pericalcarine	**-5.96**	**.000**	.005	1.83	.416	.001	1.31	.686	.000	-0.10	.933	.000	**2.83**	**.011**	.001
Left postcentral	**-5.98**	**.000**	.005	-0.94	.841	.000	1.43	.686	.000	-2.14	.370	.001	**3.46**	**.004**	.002
Left posterior cingulate	**-5.60**	**.000**	.005	-0.35	.921	.000	0.47	.899	.000	-1.51	.492	.000	**2.41**	**.026**	.001
Left precentral	**-8.55**	**.000**	.010	1.17	.643	.000	0.48	.899	.000	-1.20	.554	.000	**2.93**	**.008**	.001
Left precuneus	**-6.25**	**.000**	.005	1.41	.601	.000	1.22	.719	.000	-1.21	.554	.000	**2.57**	**.018**	.001
Left rostral anterior cingulate	**-5.31**	**.000**	.004	1.58	.496	.000	1.92	.582	.001	-0.21	.882	.000	**4.27**	**.000**	.003
Left rostral middle frontal	**-8.95**	**.000**	.011	-0.12	.950	.000	1.09	.763	.000	-0.96	.684	.000	**2.66**	**.015**	.001

Left superior frontal	**-6.87**	**.000**	.006	0.35	.921	.000	0.50	.899	.000	-0.44	.818	.000	**2.68**	**.014**	.001
Left superior parietal	**-5.77**	**.000**	.005	2.18	.261	.001	0.62	.899	.000	0.04	.969	.000	**2.72**	**.012**	.001
Left superior temporal	**-7.64**	**.000**	.008	0.12	.950	.000	0.40	.924	.000	-1.56	.492	.000	**2.34**	**.030**	.001
Left supramarginal	**-5.84**	**.000**	.005	-0.55	.921	.000	-0.25	.975	.000	-1.95	.370	.001	1.77	.102	.000
Left frontal pole	**-4.40**	**.000**	.003	1.18	.643	.000	-1.35	.686	.000	0.62	.772	.000	0.76	.470	.000
Left temporal pole	**-5.00**	**.000**	.004	-0.22	.921	.000	-0.67	.899	.000	-0.93	.684	.000	0.25	.810	.000
Left transverse temporal	**-4.98**	**.000**	.004	0.64	.921	.000	0.18	.975	.000	0.82	.717	.000	0.85	.421	.000
Left insula	**-6.07**	**.000**	.005	0.32	.921	.000	1.31	.686	.000	0.39	.818	.000	**3.20**	**.004**	.001
Right banks of superior temporal sulcus	**-4.63**	**.000**	.003	0.03	.985	.000	1.81	.582	.001	-1.36	.544	.000	**2.86**	**.010**	.001
Right caudal anterior cingulate	**-3.77**	**.000**	.002	-0.80	.921	.000	-0.04	.975	.000	-0.46	.818	.000	**3.86**	**.000**	.002
Right caudal middle frontal	**-5.95**	**.000**	.005	1.95	.361	.001	-0.06	.975	.000	1.78	.402	.000	1.70	.113	.000
Right cuneus	**-5.53**	**.000**	.004	2.67	.174	.001	0.29	.970	.000	-1.24	.554	.000	**3.05**	**.006**	.001
Right entorhinal	**-4.59**	**.000**	.003	-0.04	.985	.000	-0.05	.975	.000	-2.27	.370	.001	**3.90**	**.000**	.002
Right fusiform	**-7.21**	**.000**	.007	-0.35	.921	.000	1.72	.582	.000	-0.34	.820	.000	**2.98**	**.008**	.001
Right inferior parietal	**-5.94**	**.000**	.005	-0.67	.921	.000	0.64	.899	.000	-1.19	.554	.000	**2.27**	**.035**	.001
Right inferior temporal	**-6.60**	**.000**	.006	-0.30	.921	.000	0.66	.899	.000	0.29	.841	.000	**3.38**	**.004**	.002
Right isthmus cingulate	**-2.83**	**.005**	.001	1.59	.496	.000	0.82	.874	.000	-0.62	.772	.000	**2.36**	**.028**	.001
Right lateral occipital	**-6.20**	**.000**	.005	0.77	.921	.000	-0.47	.899	.000	0.35	.820	.000	**2.58**	**.018**	.001
Right lateral orbitofrontal	**-6.69**	**.000**	.006	1.49	.554	.000	0.43	.923	.000	-0.69	.766	.000	**3.42**	**.004**	.001
Right lingual	**-5.89**	**.000**	.005	2.82	.174	.001	0.07	.975	.000	-1.46	.492	.000	**3.13**	**.006**	.001
Right medial orbitofrontal	**-4.60**	**.000**	.003	-0.21	.921	.000	1.05	.763	.000	-0.79	.728	.000	**3.61**	**.000**	.002
Right middle temporal	**-7.56**	**.000**	.008	0.64	.921	.000	1.71	.582	.000	-1.98	.370	.001	**2.79**	**.011**	.001
Right parahippocampal	**-7.02**	**.000**	.007	-1.20	.643	.000	1.55	.686	.000	-1.69	.445	.000	1.12	.301	.000
Right paracentral	**-3.56**	**.000**	.002	-0.61	.921	.000	0.77	.886	.000	-1.48	.492	.000	1.82	.092	.001
Right pars opercularis	**-4.22**	**.000**	.003	1.67	.486	.000	-0.71	.899	.000	-0.30	.841	.000	0.09	.931	.000
Right pars orbitalis	**-4.90**	**.000**	.003	0.36	.921	.000	-0.55	.899	.000	-1.07	.609	.000	1.27	.249	.000
Right pars triangularis	-1.36	.175	.000	-0.41	.921	.000	0.76	.886	.000	-1.28	.554	.000	**2.55**	**.019**	.001
Right pericalcarine	**-5.85**	**.000**	.005	2.50	.209	.001	0.17	.975	.000	-1.96	.370	.001	**3.40**	**.004**	.002
Right postcentral	**-5.53**	**.000**	.005	-0.41	.921	.000	2.40	.363	.001	-1.88	.379	.001	**3.43**	**.004**	.002
Right posterior cingulate	**-3.72**	**.000**	.002	-1.68	.486	.000	0.25	.975	.000	-1.42	.503	.000	**3.67**	**.000**	.002
Right precentral	**-7.47**	**.000**	.008	-0.25	.921	.000	-0.14	.975	.000	-0.62	.772	.000	**2.56**	**.018**	.001
Right precuneus	**-6.77**	**.000**	.006	0.64	.921	.000	2.25	.363	.001	-0.42	.818	.000	2.05	.057	.001

Right rostral anterior cingulate	**-3.80**	**.000**	.002	1.61	.496	.000	0.62	.899	.000	0.28	.841	.000	1.73	.109	.000
Right rostral middle frontal	**-8.04**	**.000**	.009	1.20	.643	.000	-0.09	.975	.000	-0.69	.766	.000	**2.80**	**.011**	.001
Right superior frontal	**-6.61**	**.000**	.006	0.09	.963	.000	1.30	.686	.000	-0.84	.717	.000	1.51	.162	.000
Right superior parietal	**-6.60**	**.000**	.006	2.69	.174	.001	0.93	.763	.000	0.84	.717	.000	1.55	.153	.000
Right superior temporal	**-7.88**	**.000**	.009	0.47	.921	.000	0.77	.886	.000	-1.47	.492	.000	1.19	.281	.000
Right supramarginal	**-3.97**	**.000**	.002	-0.82	.917	.000	0.63	.899	.000	-0.46	.818	.000	**3.53**	**.000**	.002
Right frontal pole	**-4.78**	**.000**	.003	0.34	.921	.000	1.13	.763	.000	1.69	.445	.000	-1.54	.153	.000
Right temporal pole	**-4.39**	**.000**	.003	0.97	.830	.000	-1.27	.686	.000	-0.83	.717	.000	0.33	.760	.000
Right transverse temporal	**-5.10**	**.000**	.004	0.76	.921	.000	-0.13	.975	.000	-0.59	.780	.000	0.85	.421	.000
Right insula	**-5.53**	**.000**	.004	0.18	.931	.000	1.85	.582	.000	-0.38	.820	.000	**4.72**	**.000**	.003
Left cerebellum cortex	**-9.02**	**.000**	.010	-0.22	.921	.000	2.29	.363	.001	-2.11	.370	.001	**2.94**	**.008**	.001
Left thalamus proper	**-8.93**	**.000**	.010	0.64	.921	.000	1.11	.763	.000	0.44	.818	.000	**3.95**	**.000**	.002
Left caudate	**-7.12**	**.000**	.008	0.21	.921	.000	1.00	.763	.000	-1.81	.402	.001	**2.19**	**.044**	.001
Left putamen	**-7.13**	**.000**	.007	-1.27	.643	.000	0.47	.899	.000	-3.07	.087	.001	**4.02**	**.000**	.002
Left pallidum	**-4.56**	**.000**	.003	-1.93	.361	.001	1.77	.582	.000	-0.44	.818	.000	**2.92**	**.010**	.001
Left hippocampus	**-6.62**	**.000**	.006	-0.41	.921	.000	0.62	.899	.000	-0.61	.772	.000	**3.75**	**.000**	.002
Left amygdala	**-6.50**	**.000**	.006	-1.18	.643	.000	0.31	.970	.000	-1.31	.554	.000	**2.43**	**.025**	.001
Left accumbens area	**-6.87**	**.000**	.006	-0.92	.844	.000	0.30	.970	.000	-3.39	.087	.001	**3.36**	**.004**	.001
Left ventral diencephalon	**-4.74**	**.000**	.003	-0.47	.921	.000	1.94	.582	.000	-0.54	.802	.000	**2.49**	**.022**	.001
Right cerebellum cortex	**-6.91**	**.000**	.007	-0.45	.921	.000	-0.41	.923	.000	-1.17	.554	.000	**4.89**	**.000**	.003
Right thalamus proper	**-9.34**	**.000**	.011	0.00	.997	.000	2.30	.363	.001	-2.02	.370	.001	**2.72**	**.014**	.001
Right caudate	**-7.46**	**.000**	.007	1.11	.678	.000	0.23	.975	.000	0.14	.924	.000	**4.85**	**.000**	.003
Right putamen	**-6.72**	**.000**	.007	0.55	.921	.000	1.11	.763	.000	-1.12	.582	.000	1.73	.109	.000
Right pallidum	**-7.09**	**.000**	.007	-2.33	.239	.001	0.47	.899	.000	-1.88	.379	.001	2.09	.054	.001
Right hippocampus	**-5.69**	**.000**	.004	-0.37	.921	.000	0.50	.899	.000	-0.93	.684	.000	**4.78**	**.000**	.003
Right amygdala	**-8.15**	**.000**	.009	-2.29	.239	.001	0.97	.763	.000	-2.09	.370	.001	**2.76**	**.012**	.001
Right accumbens area	**-5.97**	**.000**	.004	-1.16	.643	.000	1.01	.763	.000	-1.18	.554	.000	1.02	.342	.000
Right ventral diencephalon	**-6.14**	**.000**	.005	-0.62	.921	.000	1.39	.686	.000	-0.66	.772	.000	**2.89**	**.010**	.001
Brain stem	**-7.51**	**.000**	.008	0.14	.950	.000	-0.58	.899	.000	-0.56	.795	.000	**4.28**	**.000**	.003

Note. N = 9,607. Coefficients in bold are significant after FDR correction (adopting a 5% false discovery rate) for 87 tests