



# The Effects of Maternal Disaster Exposure on Adolescent Mental Health 12 Years Later

Meghan Zacher<sup>1,2</sup> · Monica Arkin<sup>3</sup> · Jean Rhodes<sup>3</sup> · Sarah R. Lowe<sup>4</sup>

Accepted: 10 March 2022

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2022

## Abstract

Natural disasters adversely impact children's mental health, with increased parent or child exposure and subsequent parental distress predicting poorer outcomes. It remains unknown, however, whether the psychological consequences of disasters for children persist long-term, and if so, why and for whom. We therefore examined the effects of mothers' exposure to Hurricane Katrina on adolescent children's mental health 12 years later, distinguishing between direct effects of disaster exposure and effects mediated by maternal distress, and evaluating moderation by child age and gender. Data were from a 2003–2018 study of young, low-income, primarily African American mothers living in New Orleans when Hurricane Katrina occurred in 2005 ( $n = 328$ ). Mothers rated their mental health about one year pre-Katrina and one, four, and 12 years afterwards. They reported on an adolescent child's (ages 10–17, mean = 14.46) internalizing and externalizing symptoms 12 years post-Katrina using the Strengths and Difficulties Questionnaire. Path analytic models adjusting for mothers' pre-disaster distress showed that, whereas the *direct effects* of maternal hurricane exposures on child mental health were not significant, the *indirect effects* were. Specifically, mothers who experienced more Katrina-related stressors had higher distress thereafter, which predicted poorer child outcomes. Results did not differ significantly by child age. Gender differences are discussed. Findings suggest that disasters can affect child mental health for many years, even for those who were very young or not yet born at the time, due to parents' disaster-related distress. Addressing parents' mental health needs in the aftermath of disasters may improve child well-being long-term.

**Keywords** Adolescent mental health · Internalizing symptoms · Externalizing symptoms · Natural disaster · Maternal mental health

## Introduction

Natural disasters have been shown to adversely impact child well-being (Furr et al., 2010; Masten & Narayan, 2012; Rubens et al., 2018). Unfortunately, disasters are common occurrences. Disasters affected more than four billion people worldwide over the past two decades, and they are expected

to become more frequent and destructive as climate change progresses (CRED, 2020). It is thus increasingly urgent to understand disasters' effects on children so that interventions can be designed to mitigate their harmful consequences.

There are two key ways in which disasters can affect child mental health. First, children's well-being may be negatively impacted by the stress and disruption that they themselves endure during and after disaster. Consistent with this idea, studies have shown that children who experience major disaster-related stressors, such as perceiving their life to be at risk or losing a loved one, are at heightened risk of post-traumatic stress (PTS) (Lai et al., 2017). Similarly, a study of Hurricane Katrina survivors found that children who did not evacuate before the storm were more likely to experience PTS than evacuees (Scheeringa & Zeanah, 2008). Evacuated children were not spared entirely, however, as many were distressed at returning home to find their communities and possessions destroyed (Scheeringa & Zeanah, 2008).

✉ Meghan Zacher  
meghan\_zacher@brown.edu

<sup>1</sup> Population Studies and Training Center, Brown University, Providence, RI, USA

<sup>2</sup> Data Science Initiative, Brown University, Providence, RI, USA

<sup>3</sup> Department of Psychology, University of Massachusetts, Boston, MA, USA

<sup>4</sup> Department of Social and Behavioral Sciences, Yale School of Public Health, New Haven, CT, USA

Disaster-related destruction may also affect child well-being by requiring relocation, upending children's support networks or prompting them to change schools (Lowe et al., 2013).

Second, children's mental health in the aftermath of disaster may be influenced by their parents' reactions to their own disaster exposure. As Bronfenbrenner's (1979) ecological systems theory explains, child well-being is influenced by multiple layers of social context. One such context is the home environment, which may be impacted by parents' disaster-related experiences and resulting psychopathology, stress, and strain on familial relationships and parenting practices (Bonanno et al., 2010; Kelley et al., 2010). Indeed, previous research demonstrates robust associations between the post-disaster mental health of parents and their children (Cobham et al., 2016; Morris et al., 2012).

Additional evidence suggests that parent disaster exposure and subsequent mental health work together mechanistically to impact child outcomes. Increased exposure is associated with heightened distress among parents, which is in turn predictive of poorer child mental health (Polusny et al., 2011; Proctor et al., 2007). For example, one study found that mothers' distress the year after Hurricane Katrina mediated the relationship between their exposure to hurricane-related stressors and their children's internalizing and externalizing symptoms three years post-Katrina, when children were ages 8 to 13 (Lowe et al., 2013).

While prior research demonstrates that disasters harm child mental health and has begun to elucidate the mechanisms through which this effect occurs, limitations remain. First, only a handful of studies have extended 10 or more years post-disaster (Green et al., 1994; McFarlane & Van Hooff, 2009; Morgan et al., 2003). As a result, little is known about the long-term psychological consequences of disasters for those exposed as children. Although long-term studies of adults exposed to disaster are also scarce, the extant evidence suggests that disasters' mental health effects can linger for extended periods of time (Hull et al., 2002; Raker et al., 2020). For example, in a sample of low-income mothers who survived Hurricane Katrina, 17% reported elevated symptoms of PTSD more than a decade after the storm, with heightened symptomatology among those who experienced more disaster-related stressors (Raker et al., 2019). The direct effects of disaster exposure may endure long-term for children as well, as may the indirect effects of exposure that occur via prolonged elevations in parent psychopathology.

In addition, few studies have examined whether and how disasters affect children who were very young and may therefore not remember the experience, or who did not witness the disaster firsthand, including those who were not yet born at the time it occurred. The direct effects of disasters on very young and unborn children may be smaller than those on older children who were exposed

themselves and have memories of the experience. That said, disaster exposure during critical periods in infancy and early childhood may have direct and lasting impacts on brain development and associated cognitive, emotional, and behavioral outcomes (Nelson & Gabard-Durnam, 2020). Likewise, mothers' disaster exposure during or even prior to pregnancy may affect children's long-term outcomes through developmental and epigenetic mechanisms (Harville et al., 2021; King et al., 2012; Takahashi et al., 2021; Yehuda & Lehrner, 2018). Mothers' disaster exposure and distress during pregnancy, for example, are associated with birth outcomes as well as later emotional and behavioral difficulties in children (King et al., 2012; McLean et al., 2018). In addition, disasters may influence young and unborn as well as older children through the indirect pathway outlined above and implied by theoretical models (Bronfenbrenner, 1979; Harville et al., 2021) and prior research (Lowe et al., 2013; Raker et al., 2019). That is, parent disaster exposure may impact parent mental health and in turn affect child well-being, regardless of the child's personal disaster experience and their recollection thereof.

Lastly, although studies suggest that younger children and girls are more susceptible to mental health problems following disasters than older children and boys (Bokschanin, 2007; Bonanno et al., 2010; Furr et al., 2010; Lai et al., 2017), whether these patterns endure long-term remains unknown. The mechanisms underlying patterns by child age and gender, which may involve differences in either the direct or indirect effects of disaster exposure, have also been underexplored. Suggestive evidence can be drawn from research comparing relationships between parent and child post-disaster mental health by child age or gender. One such study found that the relationship between parent and child mental health two years after a dam collapse was strongest for younger children (Green et al., 1991), suggesting that differences in the indirect effects of parent exposure may explain the poorer post-disaster mental health of young children observed in other work. Another study found no difference by child gender in the relationship between parent PTSD and child distress three years after an earthquake in Indonesia (Juth et al., 2015), implying that differential links between parent-child mental health do not account for girls' poorer post-disaster well-being.

In sum, prior research confirms that disasters adversely impact children. However, little is known about disasters' long-term effects on child mental health, including the extent to which they result directly from disaster exposure among children or parents versus indirectly due to effects on parent psychopathology. Even less is known about how and why disasters' long-term effects differ by child age—particularly for those who were very young or not yet born at the time of the disaster—and by child gender.

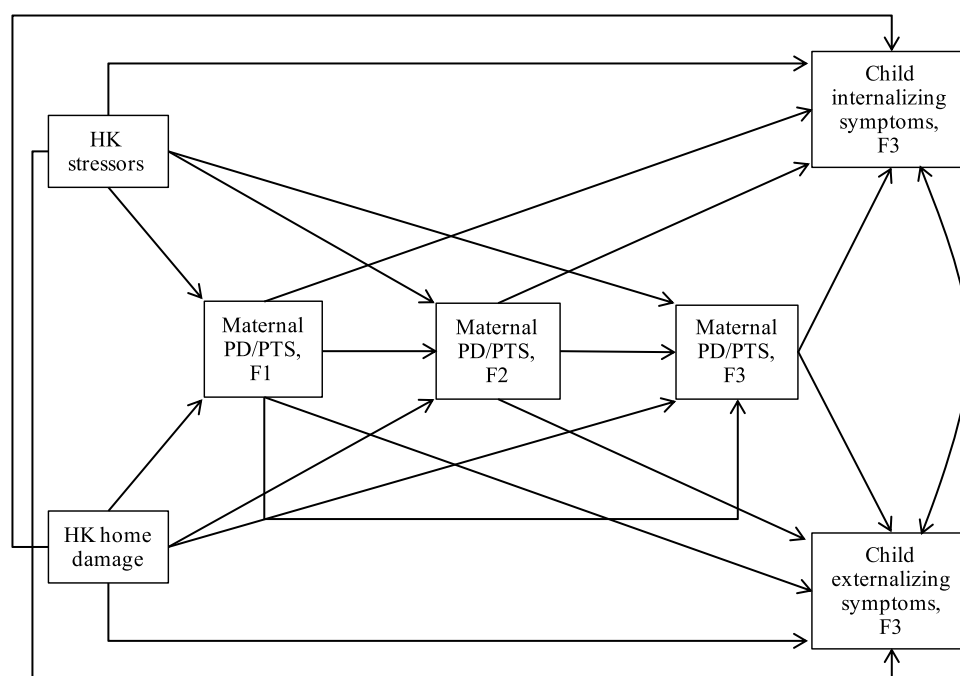
## The Current Study

The current study examined the relationship between mothers' exposure to Hurricane Katrina, a major disaster that caused almost 2,000 deaths and displaced about one million others (Knabb et al., 2005), and the mental health of their adolescent children approximately 12 years later. We used prospective panel data from a sample of young, low-income, primarily African American mothers who lived in New Orleans when Hurricane Katrina struck in 2005. Although not representative, our sample encompasses a sociodemographic group known to be vulnerable to natural disasters and resulting mental health adversity (Goldmann & Galea, 2014). It therefore reflects a priority population for disaster planning and mitigation.

The mothers in our sample were first surveyed between 2003 and 2005, on average one year prior to Hurricane Katrina. This enabled us to account for their prospectively measured pre-disaster characteristics, including mental health, in our analyses, unlike much prior research (Goldmann & Galea, 2014). In three post-Katrina surveys (approximately one, four, and 12 years post-disaster), mothers answered questions about their experiences with the hurricane and about their mental health. In the survey conducted 12 years post-Katrina, mothers also reported on an adolescent child's

internalizing and externalizing mental health symptoms. The children on whom mothers reported were ages 10–17 at the 12-year follow-up survey and ages 6 and younger when Katrina occurred, including some who were infants or not yet born. This study therefore presents a rare opportunity to compare disasters' long-term effects on children who were very young or unborn at the time to those who were older and are therefore more likely to remember the experience.

To examine the effects of maternal disaster exposure on adolescent mental health, we estimated the path analytic models in Fig. 1. We calculated the *direct effects* of maternal hurricane exposures on child internalizing and externalizing mental health symptoms and the *indirect effects* operating via maternal mental health, which we measured with non-specific psychological distress (PD) and Katrina-related PTS. We also assessed whether the direct and indirect effects of maternal hurricane exposures on child outcomes differed by child age or gender. We distinguished between two types of hurricane exposures—exposure to acute psychosocial stressors and to major home damage—as their effects on child outcomes may occur through distinct mechanisms. Psychosocial stressors such as perceived life threat and bereavement predict poorer mental health in adults for many years post-disaster, whereas the effects of home damage are comparatively short-lived (Raker et al., 2020). The effects of



**Fig. 1** Hypothesized path analytic model of child internalizing and externalizing symptoms. BL=Baseline; F=Follow-up; HK=Hurricane Katrina; PD=Psychological distress; PTS=Posttraumatic stress. Arrows indicate hypothesized causal pathways; all were expected to be positive in sign. All pathways controlled for mother characteristics at BL (age, race/ethnicity, number of children, marital

status, food stamp receipt, perceived social support, and PD). Pathways estimating child symptoms also controlled for child age and gender. BL was conducted November 2003–February 2005 (approximately one year pre-HK); F1 March 2006–March 2007 (one year post-HK); F2 March 2009–April 2010 (four years post-HK); and F3 November 2016–December 2018 (12 years post-HK)

maternal stressor exposure on child mental health may therefore operate partly indirectly via maternal psychopathology. The effects of home damage may instead result more directly from children's shock at seeing their homes and communities destroyed (Scheeringa & Zeanah, 2008) or from the ramifications of relocation, such as school transitions (Lowe et al., 2013).

## Methods

### Data and Sample

Data were from the Resilience in Survivors of Katrina (RISK) project, a prospective panel study of young, low-income parents who lived in New Orleans when Hurricane Katrina occurred (Waters, 2016). Respondents were originally recruited for a randomized controlled trial of an intervention to increase retention at community colleges, which began in 2003. Students from two colleges in New Orleans were eligible to participate if they were parents between the ages of 18 and 34 earning less than 200% of the federal poverty line. The resulting sample ( $n = 1,019$ ) was comprised primarily of African American mothers. Few fathers were recruited, and fathers were not resurveyed at the most recent follow-up. Eligibility for the current study was therefore limited to mothers ( $n = 942$ ).

The baseline (BL) survey took place before Hurricane Katrina, between November 2003 and February 2005; it was carried out using paper-and-pencil. Three follow-up surveys were conducted after the storm via telephone; the most recent follow-up could also be taken via web survey. Follow-up 1 occurred between March 2006 and March 2007 (F1, approximately one year post-Katrina,  $n = 711$  respondents), Follow-up 2 between March 2009 and April 2010 (F2, approximately four years post-Katrina,  $n = 752$ ), and Follow-up 3 between November 2016 and December 2018 (F3, approximately 12 years post-Katrina,  $n = 716$ ). At each follow-up, gift cards were offered as incentives to participate. Response rates were high, with around 70% of the original sample responding to each survey. Respondents provided informed consent at each wave. Written informed consent was collected at BL and for the most recent web-based survey; verbal informed consent was collected for all phone-based surveys. Respondents reported on their children's mental health; no data were collected directly from children. Therefore, children's assent was not solicited. The Institutional Review Board of Harvard University approved the RISK project.

At F3, mothers with children ages 10 to 17 in the household completed a series of questions about a randomly selected "focal" child, that is, whichever child had the most recent birthday. From the resulting sample of 430 mothers

who reported on a focal child, we dropped those missing information on mother's pre-Katrina sociodemographic characteristics ( $n = 56$ ) or hurricane exposures ( $n = 46$ ), as complete information on these variables was required to estimate the path analytic models. Our sample thus included data from 328 mothers who provided information on an adolescent child.

### Measures

**Child Mental Health** Mothers reported on child mental health using the Strengths and Difficulties Questionnaire (SDQ), a tool for mental health screening of children and adolescents. Validation studies have shown that high SDQ scores are predictive of psychiatric diagnoses and mental health service use, including in demographically diverse, population-based samples of U.S. adolescents (Bourdon et al., 2005; Goodman, 2001; He et al., 2013). Mothers in our sample were asked the extent to which each of 25 attributes described their child over the past six months (e.g., kind to younger children; often loses temper). Responses were recorded on a three-point Likert scale (0 = Not true; 1 = Somewhat true; 2 = Certainly true).

We constructed scores for SDQ subscales reflecting internalizing symptoms (e.g., emotional and peer problems) and externalizing symptoms (e.g., behavioral and hyperactivity problems). For each subscale, we summed responses to 10 relevant attributes after reverse-coding positively worded items. Both scores ranged from 0 to 20, with higher values indicating more symptoms. We utilized scores as continuous variables in analyses because increasing SDQ scores predict heightened risk of psychopathology across their entire range (Goodman & Goodman, 2009), and because to our knowledge, there are no validated cut-points for clinical levels of internalizing or externalizing symptoms. Cronbach's alpha reliabilities ( $\alpha$ ) for internalizing and externalizing symptom scores were 0.77 and 0.84, respectively.

**Maternal Hurricane Exposures** Our first measure of maternal hurricane exposure was an index of self-reported psychosocial stressors encountered during Hurricane Katrina or over the course of the following week. Specifically, we summed affirmative responses to the following nine items, which prior research found to be common experiences among Katrina survivors (Brodie et al., 2006): (1) lacked sufficient food; (2) lacked sufficient water; (3) lacked required medicines; (4) lacked required medical care; (5) relative lacked required medical care; (6) feared life was in danger; (7) child's safety unknown; (8) relative's safety unknown; and (9) relative or friend died. For 53% of respondents, all items were assessed at F1. For 31%, an abbreviated F1 survey instrument was used and only item (9) was assessed at

F1; items (1) through (8) were assessed at F2. The remaining 16% of respondents did not participate in F1 and answered all hurricane exposure questions at F2. Two-sample t-tests showed that the average number of stressors reported was similar whether assessed at F1 or primarily at F2 ( $p > 0.05$ ).

Our second measure of exposure was a binary variable indicating that the respondent's home experienced substantial or enormous damage due to Hurricane Katrina versus none, minimal, or moderate damage, as assessed via self-report at F1 (for 53% of respondents) or F2

**Maternal Mental Health** Maternal mental health was measured with PD and Katrina-related PTS. PD was assessed at all surveys with the Kessler-6 (K6) scale (Kessler et al., 2002). The K6 scale has been shown to discriminate strongly between adults with and without psychiatric disorders in population-based studies, supporting its convergent validity (Furukawa et al., 2003; Kessler et al., 2002, 2003). It was designed to measure symptom severity consistently across sociodemographic subgroups (Kessler et al., 2002) and has been used previously in racially and economically diverse U.S. samples (Krieger et al., 2011) and in studies of disaster survivors (Galea et al., 2007). Respondents were asked how often in the past 30 days they experienced six indicators of PD (e.g., hopeless). Answers were recorded on a five-point Likert scale ranging from 0 (none of the time) to 4 (all of the time). Responses were summed to create scores ranging from 0 to 24, with higher scores indicating worse mental health. Internal consistency was strong ( $\alpha = 0.74\text{--}0.81$ ).

PTS was evaluated at post-Katrina surveys using the revised Impact of Event Scale (IES-R), a 22-item scale evaluating event-specific distress (Weiss & Marmar, 1997). The IES-R is used frequently in studies of disaster survivors in the U.S. and elsewhere (Fitzpatrick, 2021). In support of its convergent validity, the IES-R has been shown to correlate highly with the PTSD checklist in community-based samples and to be sensitive to diagnosed PTSD (Creamer et al., 2003). Respondents were asked the extent to which they were bothered or distressed by difficulties related to Hurricane Katrina in the past seven days (e.g., In the past seven days, how distressing has Katrina been that other things kept making you think about it?). Responses were recorded on a five-point Likert scale from 0 (not at all) to 4 (extremely). Scores were computed as the mean of all items, with higher scores reflecting poorer mental health. Internal consistency in our sample was strong ( $\alpha = 0.94\text{--}0.97$ ).

**Characteristics of Mothers and Children** All equations estimated for our path analytic models controlled for mothers' BL characteristics that are known to be related to disaster exposure and subsequent mental health (Goldmann & Galea, 2014; Raker et al., 2019). These included age, self-reported race/ethnicity (non-Hispanic Black versus any other race),

number of children, marital status (married or cohabiting versus neither), food stamp receipt (yes versus no), perceived social support, and PD. Perceived social support was measured using the eight-item Social Provisions Scale (SPS) (Cutrona & Russell, 1987), for which respondents were asked whether they agreed with each item (e.g., I have a trustworthy person to turn to if I have problems), from strongly disagree (1) to strongly agree (4). Responses were reverse-coded where necessary so that higher values indicated stronger support, and then averaged. In our sample,  $\alpha = 0.78$ . PD at BL was measured using the K6 scale, as described earlier.

In equations predicting child symptoms, we also used as covariates the child's age in years at F3 and their gender (female versus male). Additionally, we estimated child age at the time of Hurricane Katrina to report as a descriptive statistic and to use in robustness tests. This measure was computed by subtracting the number of years that passed between Hurricane Katrina and the mother's F3 interview from the child's age at F3. Estimated child age at the time of Katrina was strongly correlated with child age at F3 ( $r = 0.91$ ,  $p < 0.001$ ).

## Analysis

Analyses were conducted in Stata 16.0 (StataCorp, 2019). We began by estimating descriptive statistics, including means and standard deviations for continuous variables and percentages for categorical variables. Using two-sample t-tests and chi-square tests, we also compared the BL characteristics and hurricane exposures of mothers in our sample ( $n = 328$ ) to those excluded due to survey or item non-response ( $n = 102$ ). Additionally, we computed a correlation matrix to enable a preliminary exploration of relationships among key variables. In these and all subsequent analyses, we considered two-tailed  $p$ -values below 0.05 to be statistically significant.

Next, we estimated the path analytic models shown in Fig. 1, disentangling the direct effects of maternal hurricane exposures (number of stressors and home damage) on child symptoms from the indirect effects that were mediated by maternal PD and, in a separate model, maternal PTS. We examined child internalizing and externalizing symptoms within the same models, allowing their error variances to covary. All pathways comprising the models—those to maternal mental health and those to child symptoms—controlled for mothers' BL sociodemographic and mental health characteristics, including age, race/ethnicity, number of children, marital status, food stamp receipt, perceived social support, and PD. Pathways predicting child symptoms also controlled for child age and gender. To make use of all available information and to account for deviations from



normality, we used the full information maximum likelihood estimation approach (FIML) with Huber-White robust standard errors. We report unstandardized effect estimates throughout.

Path models were judged to have acceptable fit if the Root Mean Square Error of Approximation (RMSEA) was less than 0.05 and the Comparative Fit Index (CFI) was greater than 0.95 (Hu & Bentler, 1999). We also inspected the Tucker-Lewis Index (TLI) and chi-square of model fit. We then examined the point estimates, 95% confidence intervals (CIs), and significance levels of all direct effects.

Next, we calculated the *total indirect effects* of each maternal hurricane exposure on child internalizing and externalizing symptoms through maternal mental health at F1, F2, and/or F3. To do so, we first computed indirect effects for each possible pathway, or *individual indirect effects*, as the product of the direct effects comprising them. Then, we summed the individual indirect effects to get the total indirect effect. In addition to the total indirect effect, individual indirect effects were examined to shed light on how maternal mental health in the short-, medium-, and long-term post-disaster periods combined to inform child outcomes. Indirect effects were statistically significant when their percentile-based 95% CIs, estimated across 2,000 bootstrapped samples, did not include 0 (Preacher & Hayes, 2008).

Finally, we assessed heterogeneity in the direct and total indirect effects of maternal hurricane exposures on child symptoms by SDQ subscale (internalizing versus externalizing), and, using multigroup models, by child age (ages 10–14 versus 15–17) and gender (female versus male). In robustness tests, we also ran multigroup models by estimated child age when Hurricane Katrina occurred (unborn-2 years old versus ages 3–6). We compared direct effects using chi-square difference tests. To compare indirect effects, we calculated percentile-based 95% CIs on effect differences across 2,000 bootstrapped samples (Preacher & Hayes, 2008).

## Results

### Descriptive Statistics

Table 1 provides descriptive statistics for mothers in our sample ( $n = 328$ ) and their children. Mothers were 24.03 years old (standard deviation [SD] = 4.12) at BL and 37.40 (SD = 4.15) at F3, on average. Most were non-Hispanic Black (84%), neither married nor cohabiting (75%), and received food stamps (68%) at BL. Mothers experienced an average of 3.27 (SD = 2.51) of the nine Katrina-related stressors assessed, and 64.0% reported that their home faced substantial or enormous damage due to Katrina. Mean maternal PD and PTS declined across

**Table 1** Descriptive statistics for mothers and children

	Mean	SD	%	N
<b>Mothers</b>				
Age, BL (years)	24.03	4.12		328
Age, F3 (years)	37.40	4.15		328
Non-Hispanic Black			84	328
Number of children, BL	1.81	1.06		328
Married or cohabiting, BL			25	328
Food stamp receipt, BL			68	328
Social support, BL (1–4)	3.20	0.45		328
PD, BL (0–24)	5.15	4.04		328
HK stressors (0–9)	3.27	2.51		328
HK home damage (substantial or enormous)			64	328
PD, F1 (0–24)	6.37	4.80		275
PD, F2 (0–24)	5.74	4.83		311
PD, F3 (0–24)	5.64	4.64		327
PTS, F1 (0–4)	1.41	0.98		273
PTS, F2 (0–4)	1.24	0.97		307
PTS, F3 (0–4)	0.66	0.85		324
<b>Children</b>				
Age, F3 (years)	14.46	1.82		328
10–14			45	328
15–17			55	328
Age, HK (years, estimated)	2.40	1.82		328
Unborn-2			51	328
3–6			49	328
Female			49	328
Internalizing symptoms, F3 (0–20)	4.09	3.68		322
Externalizing symptoms, F3 (0–20)	4.42	4.02		324

BL was conducted November 2003 – February 2005 (approximately one year pre-HK); F1 March 2006 – March 2007 (one year post-HK); F2 March 2009 – April 2010 (four years post-HK); and F3 November 2016 – December 2018 (12 years post-HK)

BL Baseline, F Follow-up, HK Hurricane Katrina, PD Psychological distress, PTS Posttraumatic stress, SD Standard deviation

post-Katrina follow-ups, although even at F3, PD remained elevated compared with BL and many continued to suffer from Katrina-related PTS symptoms. While just 5% of mothers had PD scores indicative of serious mental illness at BL (13 or higher) (Kessler et al., 2003), this increased to 11% at F1 and remained high at F2 (11%) and F3 (9%). The prevalence of elevated PTS (scores 1.5 or higher) (Creamer et al., 2003) declined more dramatically over time (F1: 45%; F2: 37%; F3: 18%), but PTS continued to burden a nontrivial percentage of mothers even 12 years after Katrina. Mothers in the sample and those excluded due to survey or item non-response did not differ significantly in terms of BL characteristics (including mental health) or hurricane exposures.

Respondents' children ranged in age from 10 to 17 at F3 (mean = 14.46, SD = 1.82). We estimated that they were 2.40

(SD = 1.82) years old, on average, when Hurricane Katrina occurred, with 51% ages 2 or younger and 7% not yet born. About half were female (49%). Average internalizing and externalizing symptom scores were 4.09 (SD = 3.68) and 4.42 (SD = 4.02), respectively. To our knowledge, there are no established cut-points for clinically elevated levels of internalizing and externalizing symptoms. However, normative bandings have been developed for total SDQ scores (the sum of internalizing and externalizing scores) among U.S. children and adolescents (Bourdon et al., 2005). Using these bandings, 73% of respondents' children had low social and emotional difficulties (scores 0–11 out of 40); 12% had medium difficulties (scores 12–15); and 15% had high difficulties (scores 16–40).

Table 2 presents correlations for key measures. Maternal exposure to Katrina-related stressors was significantly correlated with poorer maternal mental health at post-Katrina surveys, as well as with more internalizing symptoms in children at F3. Home damage was also related to maternal mental health, although its correlations with child internalizing and externalizing symptoms at F3 were non-significant. Maternal PD and PTS at F1, F2, and F3 were significantly correlated with internalizing symptoms in children, and externalizing symptoms demonstrated significant correlations with maternal PD at F2 and F3 and with maternal PTS at F3.

## Path Analytic Models

**Effects via Maternal PD** The hypothesized path analytic model investigating the effects of maternal hurricane exposures on child symptoms via maternal PD demonstrated good fit (RMSEA = 0.03; CFI > 0.99; TLI = 0.95;  $\chi^2(6) = 7.79$ ,

$p = 0.254$ ). Equation-level model fit ( $R^2$ ) statistics showed that 20% and 19% of the variance in child internalizing and externalizing symptoms, respectively, was explained by the independent variables in the model, including maternal hurricane exposures, maternal PD at F1, F2, and F3, and several mother and child characteristics.

Direct effects from the fitted model are presented in Fig. 2. Several hypothesized direct effects were not statistically significant. Most importantly, the direct effects of maternal hurricane exposures on child internalizing (Hurricane Katrina [HK] stressors: -0.01, CI = -0.17, 0.16; HK home damage: 0.71, CI = -0.10, 1.52) and externalizing (HK stressors: 0.02, CI = -0.17, 0.21; HK home damage: 0.29, CI = -0.55, 1.13) symptoms were non-significant. Also non-significant were the direct effects of home damage on maternal PD at F1, F2, and F3. However, the effects of maternal stressor exposure on maternal PD at F1 and F2 (but not F3) were significant, such that additional Katrina-related stressors predicted poorer maternal mental health. Maternal PD at F1 and F2, in turn, predicted higher subsequent PD. Finally, maternal PD at F2 and F3 (but not F1) predicted significantly more internalizing symptoms in children, and maternal PD at F3 (but not F1 or F2) predicted significantly more externalizing symptoms.

Table 3 presents the estimated effects of maternal hurricane exposures on child internalizing and externalizing symptoms, including the direct effects described above and the total indirect effects via maternal PD at F1, F2, and/or F3. The total indirect effects of maternal stressor exposure on child symptoms were statistically significant, with additional stressors predicting more internalizing (0.14, CI = 0.05, 0.25) and externalizing (0.11, CI = 0.03, 0.22) problems in children through maternal PD. For internalizing

**Table 2** Correlation matrix for key variables

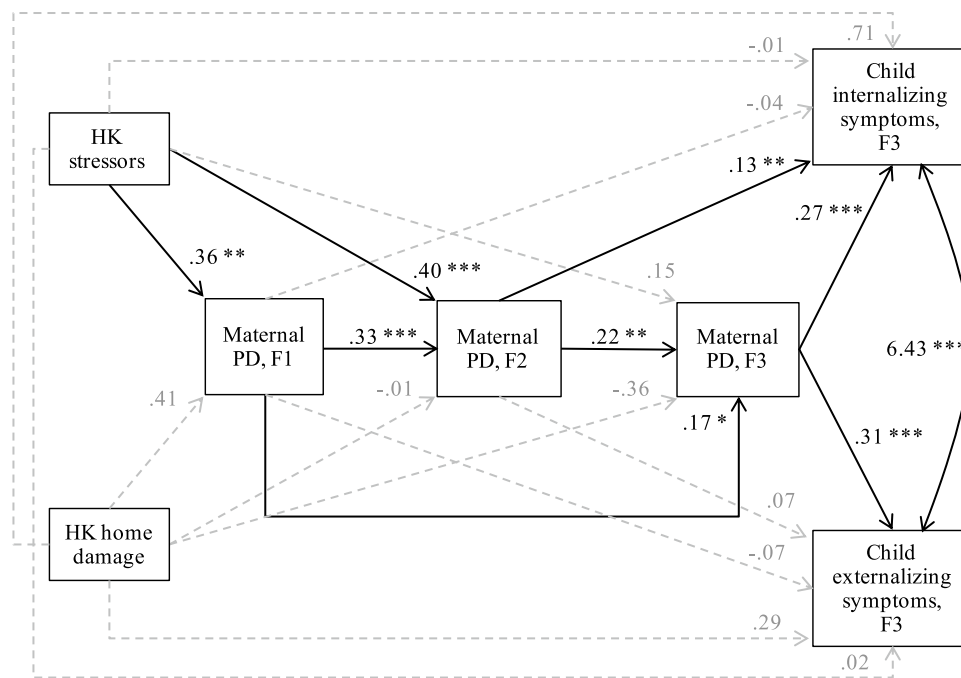
	1	2 <sup>a</sup>	3	4	5	6	7	8	9
1 HK stressors	–								
2 HK home damage <sup>a</sup>	0.36 ***	–							
3 Maternal PD, F1	0.26 ***	0.11	–						
4 Maternal PD, F2	0.31 ***	0.15 *	0.44 ***	–					
5 Maternal PD, F3	0.17 **	0.02	0.33 ***	0.34 ***	–				
6 Maternal PTS, F1	0.39 ***	0.18 *	0.47 ***	0.31 ***	0.20 ***	–			
7 Maternal PTS, F2	0.41 ***	0.32 ***	0.29 ***	0.33 ***	0.17 **	0.58 ***	–		
8 Maternal PTS, F3	0.30 ***	0.20 **	0.22 ***	0.26 ***	0.37 ***	0.40 ***	0.48 ***	–	
9 Child internalizing symptoms, F3	0.12 *	0.14	0.16 **	0.29 ***	0.38 ***	0.12 *	0.12 *	0.27 ***	–
10 Child externalizing symptoms, F3	0.06	0.06	0.06	0.14 *	0.34 ***	0.04	0.06	0.19 ***	0.57 ***

F1 was conducted March 2006 – March 2007 (approximately one year post-HK); F2 March 2009 – April 2010 (four years post-HK); and F3 November 2016 – December 2018 (12 years post-HK)

N 328, F Follow-up, HK Hurricane Katrina, PD Psychological distress, PTS Posttraumatic stress

\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

<sup>a</sup>Polyserial correlations



**Fig. 2** Direct effects (unstandardized) from the path analytic model of child internalizing and externalizing symptoms via maternal PD.  $N=328$ . BL=Baseline; F=Follow-up; HK=Hurricane Katrina; PD=Psychological distress. Dashed grey arrows indicate pathways that were not statistically significant ( $p>0.05$ ). All pathways controlled for mother characteristics at BL (age, race/ethnicity, number of children, marital status, food stamp receipt, perceived social support,

and PD). Pathways estimating child symptoms also controlled for child age and gender. BL was conducted November 2003–February 2005 (approximately one year pre-HK); F1 March 2006–March 2007 (one year post-HK); F2 March 2009–April 2010 (four years post-HK); and F3 November 2016–December 2018 (12 years post-HK). \*\*\*  $p<0.001$ ; \*\*  $p<0.01$ ; \*  $p<0.05$

symptoms, the indirect effect of maternal stressor exposure comprised more than 100% of its total effect (direct + indirect), as the direct effect was in the opposite direction. For externalizing symptoms, the indirect effect of maternal stressor exposure comprised 85% of its total effect. As shown in Table S1 (Online Resource), the indirect effects

of maternal stressor exposure on child symptoms were significant primarily for individual pathways including more recent or long-term measures of maternal distress. Meanwhile, the total indirect effect of Katrina-related home damage via maternal PD was non-significant for both internalizing ( $-0.07$ ,  $CI=-0.46, 0.29$ ) and externalizing

**Table 3** Direct and total indirect effects (unstandardized) of maternal hurricane exposures on child internalizing and externalizing symptoms

	Internalizing symptoms		Externalizing symptoms	
	<i>Est</i>	<i>95% CI</i>	<i>Est</i>	<i>95% CI</i>
<b>Models with maternal PD</b>				
Direct effect of HK stressors	-0.01	-0.17, 0.16	0.02	-0.17, 0.21
Direct effect of HK home damage	0.71	-0.10, 1.52	0.29	-0.55, 1.13
Indirect effect of HK stressors	0.14 *	0.05, 0.25	0.11 *	0.03, 0.22
Indirect effect of HK home damage	-0.07	-0.46, 0.29	-0.10	-0.50, 0.26
<b>Models with maternal PTS</b>				
Direct effect of HK stressors	0.05	-0.13, 0.24	0.07	-0.15, 0.29
Direct effect of HK home damage	0.63	-0.22, 1.47	0.16	-0.74, 1.07
Indirect effect of HK stressors	0.08	-0.01, 0.19	0.06	-0.03, 0.17
Indirect effect of HK home damage	0.01	-0.25, 0.24	0.01	-0.24, 0.21

$N=328$ , *CI* Confidence interval, *Est* Estimate, *HK* Hurricane Katrina, *PD* Psychological distress, *PTS* Post-traumatic stress

\*  $p<0.05$



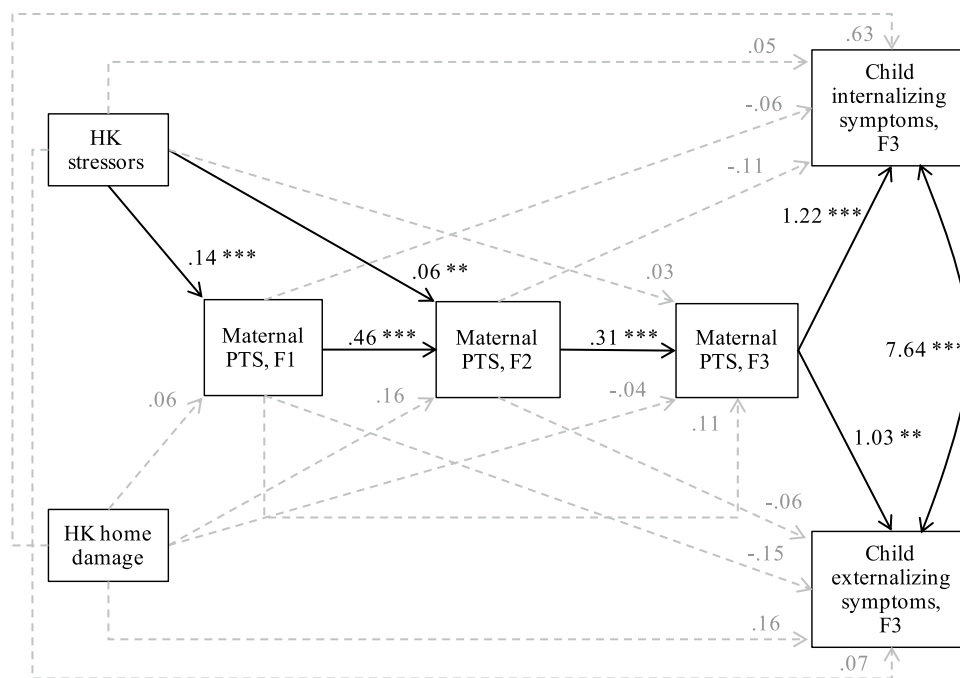
(-0.10, CI = -0.50, 0.26) symptoms in children, and no individual indirect effect of home damage was statistically significant.

The direct effects of maternal hurricane exposures on child outcomes did not differ significantly across internalizing and externalizing subscales (HK stressors:  $\Delta X^2(1) = 0.09$ ,  $p = 0.762$ ; HK home damage:  $\Delta X^2(1) = 0.94$ ,  $p = 0.332$ ). Similarly, there were no differences across SDQ subscales in the total indirect effects of maternal hurricane exposures (HK stressors: difference CI = -0.03, 0.10; HK home damage: difference CI = -0.13, 0.18).

**Effects via Maternal PTS** In general, results from the path model using PTS to measure maternal mental health mirrored those using PD. The hypothesized model demonstrated good fit (RMSEA = 0.01; CFI > 0.99; TLI = > 0.99;  $X^2(6) = 6.18$ ,  $p = 0.404$ ). Equation-level  $R^2$  statistics showed that 12% and 9% of the variance in child internalizing and externalizing symptoms, respectively, was explained by the independent variables in the model, including maternal hurricane exposures, maternal PTS at F1, F2, and F3, and characteristics of mothers and children.

Critically, the direct effects of maternal hurricane exposures on child internalizing (HK stressors: 0.05, CI = -0.13, 0.24; HK home damage: 0.63, CI = -0.22, 1.47) and externalizing (HK stressors: 0.07, CI = -0.15, 0.29; HK home damage: 0.16, CI = -0.74, 1.07) symptoms were non-significant (Fig. 3, Table 3). Furthermore, Katrina-related home damage was not significantly associated with maternal PTS at F1, F2, or F3. Maternal exposure to Katrina-related stressors, however, predicted significantly higher maternal PTS at F1 and F2 (but not F3). Maternal PTS at F1 predicted significantly higher maternal PTS at F2 (but not F3), and maternal PTS at F2 was associated with significantly higher PTS at F3. Finally, the effects of maternal PTS at F3 (but not F1 or F2) on child symptoms were significant, such that poorer maternal mental health predicted more internalizing and externalizing problems in children.

The total indirect effects of maternal stressor exposure on child outcomes via maternal PTS at F1, F2, and/or F3 were positive but non-significant (internalizing: 0.08, CI = -0.01, 0.19; externalizing: 0.06, CI = -0.03, 0.17) (Table 3). Several individual indirect effects were significant, however (Table S2). For example, maternal exposure



**Fig. 3** Direct effects (unstandardized) from the path analytic model of child internalizing and externalizing symptoms via maternal PTS.  $N = 328$ . BL = Baseline; F = Follow-up; HK = Hurricane Katrina; PTS = Posttraumatic stress. Dashed grey arrows indicate pathways that were not statistically significant ( $p > 0.05$ ). All pathways controlled for mother characteristics at BL (age, race/ethnicity, number of children, marital status, food stamp receipt, perceived social support,

and PD). Pathways estimating child symptoms also controlled for child age and gender. BL was conducted November 2003–February 2005 (approximately one year pre-HK); F1 March 2006–March 2007 (one year post-HK); F2 March 2009–April 2010 (four years post-HK); and F3 November 2016–December 2018 (12 years post-HK). \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$

to Katrina-related stressors predicted significantly poorer child outcomes at F3 indirectly through its impacts on maternal PTS at all post-Katrina surveys (F1, F2, and F3), or by prompting long-term elevations in maternal PTS. The total indirect effects of maternal stressor exposure comprised 59% and 44% of its total effects (direct + indirect) on child internalizing and externalizing symptoms, respectively. Regarding home damage, indirect effects on child outcomes were not significant when considering total indirect effects (internalizing: 0.01, CI = -0.25, 0.24; externalizing: 0.01, CI = -0.24, 0.21) or any of the individual pathways comprising them.

There were no differences between internalizing and externalizing symptoms in either the direct (HK stressors:  $\Delta X^2(1) = 0.04$ ,  $p = 0.847$ ; HK home damage:  $\Delta X^2(1) = 1.13$ ,  $p = 0.287$ ) or total indirect (HK stressors: difference CI = -0.06, 0.10; HK home damage: difference CI = -0.13, 0.14) effects of maternal hurricane exposures.

**Variation by Child Age and Gender** We found no significant differences in the direct and total indirect effects of maternal hurricane exposures on child symptoms by child age at F3, whether examining mediation by maternal PD or PTS (Table S3). Similar results were obtained in robustness tests stratifying respondents' children according to their estimated age when Hurricane Katrina occurred (Table S4). That is, the direct and total indirect effects of maternal hurricane exposures on children ages 2 or younger at the time of Katrina, some of whom were not yet born, were not statistically different from effects on children ages 3 to 6. Indeed, when evaluating mediation by maternal PD, the total indirect

effect of maternal stressor exposure on internalizing symptoms was significant and of similar magnitude for children in both age groups.

Two patterns from multigroup models by child gender warrant mention (Table 4). First, the direct effects of home damage on externalizing symptoms differed significantly by child gender in models utilizing either maternal PD ( $\Delta X^2(1) = 4.52$ ,  $p = 0.034$ ) or PTS ( $\Delta X^2(1) = 4.33$ ,  $p = 0.037$ ) as mediating variables. Home damage predicted significantly worse externalizing problems for boys, whereas for girls, its effects were non-significant and opposite in sign. Similar patterns were obtained for internalizing symptoms, with significant deleterious effects of home damage for boys but not for girls, although gender differences in these effects were not significant.

Second, the total indirect effects of maternal stressor exposure on child symptoms were larger for girls than for boys across models, and significantly so when evaluating mediation by maternal PD (internalizing: difference CI = 0.01, 0.48; externalizing: difference CI = 0.02, 0.45). Additional stressors predicted significantly more internalizing and externalizing symptoms via maternal PD for girls, whereas for boys, the indirect effects of maternal stressor exposure via maternal PD were close to 0 and non-significant. This result may be explained by gender differences in the direct effects of post-Katrina maternal mental health on child outcomes (not shown). These effects were generally larger for girls than for boys, and significantly so when considering the effect of maternal PD at F3 on internalizing symptoms ( $\Delta X^2(1) = 11.99$ ,  $p < 0.001$ ).

**Table 4** Direct and total indirect effects (unstandardized) of maternal hurricane exposures on child internalizing and externalizing symptoms by child gender

	Internalizing symptoms				Externalizing symptoms			
	Female		Male		Female		Male	
	<i>Est</i>	<i>95% CI</i>	<i>Est</i>	<i>95% CI</i>	<i>Est</i>	<i>95% CI</i>	<i>Est</i>	<i>95% CI</i>
<b>Models with maternal PD</b>								
Direct effect of HK stressors	0.04	-0.22, 0.30	-0.10	-0.29, 0.08	0.04	-0.26, 0.35	-0.01	-0.24, 0.22
Direct effect of HK home damage	0.25	-1.00, 1.51	1.32 *	0.45, 2.18	-0.61 <sup>a</sup>	-1.95, 0.72	1.35 *	0.41, 2.29
Indirect effect of HK stressors	0.25 <sup>a</sup>	0.07, 0.50	0.04	-0.04, 0.14	0.21 <sup>a</sup>	0.05, 0.42	+0.00	-0.11, 0.11
Indirect effect of HK home damage	-0.20	-1.05, 0.70	-0.00	-0.32, 0.25	-0.20	-0.99, 0.60	0.06	-0.34, 0.48
<b>Models with maternal PTS</b>								
Direct effect of HK stressors	0.16	-0.14, 0.46	-0.09	-0.29, 0.11	0.15	-0.20, 0.51	0.01	-0.23, 0.26
Direct effect of HK home damage	0.02	-1.39, 1.43	1.29 *	0.42, 2.17	-0.83 <sup>a</sup>	-2.35, 0.69	1.25 *	0.27, 2.22
Indirect effect of HK stressors	0.13	-0.03, 0.30	0.02	-0.09, 0.13	0.10	-0.04, 0.28	-0.03	-0.15, 0.09
Indirect effect of HK home damage	+0.00	-0.62, 0.64	+0.00	-0.29, 0.25	-0.01	-0.65, 0.59	0.12	-0.23, 0.45

*N* 328, *CI* Confidence interval, *Est* Estimate, *F* Follow-up, *HK* Hurricane Katrina, *PD* Psychological distress, *PTS* Posttraumatic stress

\*  $p < 0.05$

<sup>a</sup>Differs from the estimated effect for males at  $p < 0.05$

## Discussion

Prior research shows that natural disasters adversely impact child well-being, likely through some combination of stress, disruption, and parental distress (Bonanno et al., 2010; Furr et al., 2010; Lai et al., 2017; Masten & Narayan, 2012; Rubens et al., 2018). Yet few studies have examined the long-term psychological consequences of disasters for children, including the mechanisms through which they occur and whether they vary in magnitude by child age—particularly for those very young or not yet born when disaster struck—and gender. We sought to fill these gaps in the literature using a 2003–2018 study of young, low-income, and primarily African American mothers who were affected by Hurricane Katrina in 2005. Specifically, we examined relationships between mothers' disaster exposure and the well-being of their adolescent children 12 years post-Katrina.

We found that, whereas the *direct* effects of mothers' exposure to Katrina-related stressors and home damage on child internalizing and externalizing mental health symptoms were non-significant, there were significant *indirect* effects of maternal stressor exposure on child well-being. Mothers who experienced more psychosocial stressors during Katrina had poorer mental health thereafter, which in turn predicted poorer child outcomes. As a result, maternal stressor exposure had statistically significant indirect effects on internalizing and externalizing symptoms in children through maternal mental health in the years following Katrina. Additional findings suggest that the indirect effects of mothers' exposure to Katrina-related stressors were driven by long-term maternal mental health adversity, rather than poor maternal mental health in the short-term aftermath of Katrina alone. These results hint at the toll disasters can take beyond those directly impacted as their effects on well-being linger and ripple through households. Future research could build on these findings using analytic strategies appropriate for examining trajectories of parent psychopathology and their effects on child well-being, such as latent class growth analysis.

Critically, we found no significant differences in either the direct or total indirect effects of maternal hurricane exposures on child outcomes by child age at follow-up (10–14 versus 15–17) or their estimated age when Hurricane Katrina occurred (unborn–2 versus ages 3–6). Indeed, our analyses uncovered statistically significant indirect effects of maternal stressor exposure on child internalizing symptoms through maternal PD both for children ages 2 and younger when Katrina occurred, some of whom were not yet born, and those ages 3–6. In line with prior work on the intergenerational transmission of mental health and trauma (Harville et al., 2021; Johnston et al., 2013;

Yehuda & Lehrner, 2018), these results suggest that disasters' effects on well-being can span generations, impacting young survivors as well as those born post-disaster if the mental health needs of parents are left unaddressed. Further research is needed on the mechanisms underlying these patterns, which may involve economic strain, social support and community ties, family dynamics and parenting practices, or epigenetic moderation, for example (Bonanno et al., 2010; Cobham et al., 2016; Dashorst et al., 2019; Harville et al., 2021; Lai et al., 2018).

Our results regarding child age are distinct from prior work, which often found that disasters themselves and parents' related psychopathology have larger impacts on younger children (Boksaczanin, 2007; Bonanno et al., 2010; Green et al., 1991). Our unique conclusions may be explained by the long-term nature of our study or by the fact that respondents' children were all rather young when Katrina occurred. Our results may also stem in part from limited statistical power to detect moderation by child age, given our relatively small sample. Future research should evaluate whether lasting effects of disasters depend on developmental stage at exposure in larger samples of children ranging more widely in age.

Unlike age, child gender was found to moderate the effects of maternal hurricane exposures on adolescent outcomes. Home damage due to Katrina had larger direct effects on mental health symptoms for boys than for girls. This is a novel finding, as prior research has generally found larger effects of disasters on girls (Boksaczanin, 2007; Bonanno et al., 2010; Furr et al., 2010; Lai et al., 2017). Further research is warranted to explore the impacts on boys of home damage and its consequences, including displacement, disrupted social networks, and school transitions. Meanwhile, the indirect effects of maternal stressor exposure on child symptoms, as mediated by maternal mental health, were larger for girls than for boys. This result is consistent with prior research showing stronger relationships between mothers' and daughters' mental health than between mothers' and sons' in general (Goodman et al., 2011). It differs, however, from a study of parent–child mental health following an earthquake in Indonesia (Juth et al., 2015), which found no evidence of moderation by child gender among elementary-aged children. One possible explanation is that girls become particularly sensitive to maternal mental health in adolescence (Goodman et al., 2011).

Several limitations to the current study must be noted. Our sample is unique, composed of young, low-income, and primarily African American mothers who were enrolled in community colleges in New Orleans in 2003. Results may not generalize to all survivors of Hurricane Katrina or to survivors of other disasters. However, our sample reflects a priority population for disaster research, given the greater

vulnerability of women in general and young mothers in particular, those with low incomes, and ethnoracial minorities to disaster trauma or disruption and subsequent mental health challenges (Goldmann & Galea, 2014).

In addition, we were unable to investigate the effects of a child's own exposure to Hurricane Katrina on their mental health, as only mothers' exposure was evaluated. Research shows that parent-child reports of disaster-related experiences are often misaligned (Lai et al., 2015). This may explain why we found non-significant direct effects of maternal hurricane exposures on child mental health, even among older children who were more likely to have been exposed themselves and to remember the experience. Among the younger children, however, null direct effects are unlikely to be explained by discrepancies in parent-child exposures. Instead, for younger children, results suggest that the intergenerational transmission of mental health adversity following disasters may more often stem from lingering effects on parent well-being than from direct effects on child development. Still, future research with larger samples of children old enough to recollect their experience should evaluate the effects of both parent and child exposures on child outcomes. Likewise, studies should examine the effects of fathers' exposure and related psychopathology on child well-being, in addition to mothers'. To lessen concerns about recall bias, future studies should also strive to collect information on exposure as soon as possible post-disaster.

Relatedly, our analyses relied on mothers' reports of their mental health and that of their children, introducing risk of bias (Briggs-Gowan et al., 1996). A study of children ages 3–6 found that associations between maternal depression and child well-being were stronger when relying exclusively on maternal reports than when children reported on their own mental health or when fathers reported on maternal mental health (Ringoot et al., 2015). That said, mother-reported measures of child mental health have been validated (Goodman et al., 2001) and are commonly used (Cobham et al., 2016). Additionally, studies with adolescent children suggest that the bias introduced by relying on maternal reports may be relatively small (van der Toorn et al., 2010; Garstein et al., 2009). Nonetheless, future disaster studies should collect and utilize measures of child mental health from additional informants, such as teachers or children themselves, to address this source of bias. Future research should also examine bidirectional relationships between maternal and child mental health over time, which we were unable to explore because child mental health was only assessed once.

Finally, while our analyses controlled for maternal PD at BL to account for pre-existing mental health adversity, we were unable to control directly for genetic vulnerability. This is potentially problematic as vulnerability to mental illness may be shared by parents and children. Future research

should explore the role of genetic risk using within-family designs or by controlling for relevant polygenic scores, which were unavailable in our data.

The current study has two major strengths. The first is its long-term post-disaster follow-up, with the latest survey conducted approximately 12 years post-Katrina. The second is its prospective nature, which enabled us to account for mothers' pre-disaster mental health and other characteristics when estimating the effects of disaster exposure on maternal and child outcomes. Longitudinal, prospective data are uncommon in disaster research due to the unique challenges of predicting when and where disasters will occur and identifying and contacting survivors in the aftermath (Cobham et al., 2016; Goldmann & Galea, 2014).

The evidence for disasters' long-term and potentially intergenerational effects on child well-being uncovered in the current study is cause for concern. In contrast to a recent meta-analysis that found stronger effects of disasters on children's internalizing symptoms (Rubens et al., 2018), we found that the indirect effects of maternal exposures to Hurricane Katrina were significant and of similar magnitude for both internalizing and externalizing symptoms in adolescents. Both emotional and behavioral difficulties that emerge early in the life course may persist or transform into other forms of mental health adversity in adulthood (Johnson et al., 2018). Moreover, internalizing and externalizing symptoms in childhood and adolescence are associated with a range of long-term social and academic difficulties (Evensen et al., 2016; Masten et al., 2005; Obradovic et al., 2010; Sourander et al., 2007). The results of the current study thus suggest that supporting the mental health of disaster-affected parents both shortly after disaster strikes and over the following years and decades is likely to have meaningful impacts on child outcomes, both psychological and non-psychological, that are critical for their successful transition to adulthood.

Several clinical implications emerge from our findings. Children whose families were impacted by disaster may require long-term mental health support. Even children who were very young or born post-disaster are at risk of adverse consequences due to the residual effects of disaster-related adversity experienced by parents, which research shows can endure for more than a decade (Raker et al., 2019). In the immediate aftermath of disaster, efforts must be made to increase access to care for children, particularly among the marginalized groups most vulnerable to disaster-related trauma, disruption, and psychopathology (Goldmann & Galea, 2014). Family-based counseling in the aftermath of disaster may be especially beneficial, as it can identify unmet needs of each family member and establish connections to mental health professionals and other service providers for follow-up. Beyond the immediate post-disaster setting, clinicians working with children



and adolescents should inquire about family trauma history, including parental exposure to natural disasters, in addition to personal trauma history. Identifying child and “second generation” disaster survivors may aid in creating more holistic case formulations. Finally, while the current study is concerned primarily with children, our results underscore that child well-being is intricately linked with parents’ well-being, and likely that of the broader family and community at large. Universal access to mental health services, post-disaster and otherwise, is likely to enhance the well-being of adolescents, young children, and the next generation.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s10802-022-00917-1>.

**Acknowledgements** We are grateful to Ethan Raker, Sydney Johnson, Mariana Arcaya, and Mary Waters for helpful comments.

**Authors’ Contributions** All authors contributed to the study design. M. Zacher conducted the analysis. M. Zacher and M. Arkin drafted the initial manuscript. J. Rhodes and S. R. Lowe advised the study. All authors provided critical feedback and approved the final version of the manuscript.

**Funding** This work was supported by the Eunice Kennedy Shriver National Institute of Child Health and Human Development under Grants P01HD082032, R01HD057599, and R01HD046162; the National Science Foundation under Grant BCS-0555240; the MacArthur Foundation under Grant 04–80775-000-HCD; the Robert Wood Johnson Foundation under Grant 23029; the Center for Economic Policy Studies at Princeton University; and the Harvard Center for Population and Development Studies. General support was provided by the Population Studies and Training Center at Brown University (Grant P2CHD041020). S.R.L. was supported by an Early-Career Research Fellowship from the Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine.

**Availability of Data and Material/Code Availability** This study used a dataset that, at the time of writing, was not publicly available.

## Compliance with Ethical Standards

**Ethics Approval** The Institutional Review Board of Harvard University approved the Resilience in Survivors of Katrina (RISK) project (protocol #13067).

**Consent to Participate** Informed consent was obtained from all participants at each wave of data collection.

**Conflicts of Interest/Competing Interests** The authors have no conflicts of interest to report.

## References

- Bokszczanin, A. (2007). PTSD symptoms in children and adolescents 28 months after a flood: Age and gender differences. *Journal of Traumatic Stress, 20*(3), 347–351. <https://doi.org/10.1002/jts.20220>
- Bonanno, G. A., Brewin, C. R., Kaniasty, K., & La Greca, A. M. (2010). Weighing the costs of disaster: Consequences, risks, and resilience in individuals, families, and communities. *Psychological Science in the Public Interest, 11*(1), 1–49. <https://doi.org/10.1177/1529100610387086>
- Bourdon, K. H., Goodman, R., Rae, D. S., Simpson, G., & Koretz, D. S. (2005). The Strengths and Difficulties Questionnaire: U.S. normative data and psychometric properties. *Journal of the American Academy of Child and Adolescent Psychiatry, 44*(6), 557–564. <https://doi.org/10.1097/01.chi.0000159157.57075.c8>
- Briggs-Gowan, M. J., Carter, A. S., & Schwab-Stone, M. (1996). Discrepancies among mother, child, and teacher reports: Examining the contributions of maternal depression and anxiety. *Journal of Abnormal Child Psychology, 24*(6), 749–765. <https://doi.org/10.1007/BF01664738>
- Brodie, M., Weltzien, E., Altman, D., Blendon, R. J., & Benson, J. M. (2006). Experiences of Hurricane Katrina evacuees in Houston shelters: Implications for future planning. *American Journal of Public Health, 96*(8), 1402–1408. <https://doi.org/10.2105/AJPH.2005.084475>
- Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.
- Centre for Research on the Epidemiology of Disasters. (CRED). (2020). *The human cost of disasters: An overview of the last 20 Years, 2000–2019*. The United Nations Office for Disaster Risk Reduction. <https://reliefweb.int/report/world/human-cost-disasters-overview-last-20-years-2000-2019>
- Cobham, V. E., McDermott, B., Haslam, D., & Sanders, M. R. (2016). The role of parents, parenting and the family environment in children’s post-disaster mental health. *Current Psychiatry Reports, 18*(6), 53. <https://doi.org/10.1007/s11920-016-0691-4>
- Creamer, M., Bell, R., & Failla, S. (2003). Psychometric properties of the Impact of Event Scale—Revised. *Behaviour Research and Therapy, 41*(12), 1489–1496. <https://doi.org/10.1016/j.brat.2003.07.010>
- Cutrona, C. E., & Russell, D. W. (1987). The provisions of social relationships and adaptation to stress. In W. H. Jones & D. Perlman (Eds.), *Advances in personal relationships* (Vol. 1, pp. 36–67). JAI Press.
- Dashorst, P., Mooren, T. M., Kleber, R. J., de Jong, P. J., & Huntjens, R. J. C. (2019). Intergenerational consequences of the Holocaust on offspring mental health: A systematic review of associated factors and mechanisms. *European Journal of Psychotraumatology, 10*(1), 1654065. <https://doi.org/10.1080/20008198.2019.1654065>
- Evensen, M., Lyngstad, T. H., Melkevik, O., & Mykletun, A. (2016). The role of internalizing and externalizing problems in adolescence for adult educational attainment: Evidence from sibling comparisons using data from the Young HUNT Study. *European Sociological Review, 32*(5), 552–566. <https://doi.org/10.1093/esr/jcw001>
- Fitzpatrick, K. M. (2021). Post-traumatic stress symptomatology and displacement among Hurricane Harvey survivors. *Social Science & Medicine, 270*, 113634. <https://doi.org/10.1016/j.socscimed.2020.113634>
- Furr, J. M., Comer, J. S., Edmunds, J. M., & Kendall, P. C. (2010). Disasters and youth: A meta-analytic examination of posttraumatic stress. *Journal of Consulting and Clinical Psychology, 78*(6), 765–780. <https://doi.org/10.1037/a0021482>



- Furukawa, T. A., Kessler, R. C., Slade, T., & Andrews, G. (2003). The performance of the K6 and K10 screening scales for psychological distress in the Australian National Survey of Mental Health and Well-Being. *Psychological Medicine*, 33(2), 357–362. <https://doi.org/10.1017/S0033291702006700>
- Galea, S., Brewin, C. R., Gruber, M., Jones, R. T., King, D. W., King, L. A., McNally, R. J., Ursano, R. J., Petukhova, M., & Kessler, R. C. (2007). Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. *Archives of General Psychiatry*, 64(12), 1427–1434. <https://doi.org/10.1001/archpsyc.64.12.1427>
- Garstein, M. A., Bridgett, D. J., Dishion, T. J., & Kaufman, N. K. (2009). Depressed mood and maternal report of child behavior problems: Another look at the depression-distortion hypothesis. *Journal of Applied Developmental Psychology*, 30(2), 149–160. <https://doi.org/10.1016/j.appdev.2008.12.001>
- Goldmann, E., & Galea, S. (2014). Mental health consequences of disasters. *Annual Review of Public Health*, 35, 169–183. <https://doi.org/10.1146/annurev-publhealth-032013-182435>
- Goodman, A., & Goodman, R. (2009). Strengths and difficulties questionnaire as a dimensional measure of child mental health. *Journal of the American Academy of Child & Adolescent Psychiatry*, 48(4), 400–403. <https://doi.org/10.1097/CHI.0b013e3181985068>
- Goodman, R. (2001). Psychometric properties of the strengths and difficulties questionnaire. *Journal of the American Academy of Child & Adolescent Psychiatry*, 40(11), 1337–1345. <https://doi.org/10.1097/00004583-200111000-00015>
- Goodman, S. H., Rouse, M. H., Connell, A. M., Broth, M. R., Hall, C. M., & Heyward, D. (2011). Maternal depression and child psychopathology: A meta-analytic review. *Clinical Child and Family Psychology Review*, 14(1), 1–27. <https://doi.org/10.1007/s10567-010-0080-1>
- Green, B. L., Grace, M. C., Vary, M. G., Kramer, T. L., Gleser, G. C., & Leonard, A. C. (1994). Children of disaster in the second decade: A 17-year follow-up of Buffalo Creek survivors. *Journal of the American Academy of Child & Adolescent Psychiatry*, 33(1), 71–79. <https://doi.org/10.1097/00004583-199401000-00011>
- Green, B. L., Korol, M., Grace, M. C., Vary, M. G., Leonard, A. C., Gleser, G. C., & Smitson-cohen, S. (1991). Children and disaster: Age, gender, and parental effects on PTSD symptoms. *Journal of the American Academy of Child & Adolescent Psychiatry*, 30(6), 945–951. <https://doi.org/10.1097/00004583-199111000-00012>
- Harville, E. W., Beitsch, L., Uejio, C. K., Sherchan, S., & Lichtveld, M. Y. (2021). Assessing the effects of disasters and their aftermath on pregnancy and infant outcomes: A conceptual model. *International Journal of Disaster Risk Reduction*, 62, 102415. <https://doi.org/10.1016/j.ijdrr.2021.102415>
- He, J.-P., Burstein, M., Schmitz, A., & Merikangas, K. R. (2013). The Strengths and Difficulties Questionnaire (SDQ): The factor structure and scale validation in U.S. adolescents. *Journal of Abnormal Child Psychology*, 41(4), 583–595. <https://doi.org/10.1007/s10802-012-9696-6>
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Hull, A. M., Alexander, D. A., & Klein, S. (2002). Survivors of the Piper Alpha oil platform disaster: Long-term follow-up study. *The British Journal of Psychiatry: The Journal of Mental Science*, 181, 433–438. <https://doi.org/10.1192/bjp.181.5.433>
- Johnson, D., Dupuis, G., Piche, J., Clayborne, Z., & Colman, I. (2018). Adult mental health outcomes of adolescent depression: A systematic review. *Depression and Anxiety*, 35(8), 700–716. <https://doi.org/10.1002/da.22777>
- Johnston, D. W., Schurer, S., & Shields, M. A. (2013). Exploring the intergenerational persistence of mental health: Evidence from three generations. *Journal of Health Economics*, 32(6), 1077–1089. <https://doi.org/10.1016/j.jhealeco.2013.09.001>
- Juth, V., Silver, R. C., Seyle, D. C., Widyatmoko, C. S., & Tan, E. T. (2015). Post-disaster mental health among parent–child dyads after a major earthquake in Indonesia. *Journal of Abnormal Child Psychology*, 43(7), 1309–1318. <https://doi.org/10.1007/s10802-015-0009-8>
- Kelley, M. L., Self-Brown, S., Le, B., Bosson, J. V., Hernandez, B. C., & Gordon, A. T. (2010). Predicting posttraumatic stress symptoms in children following Hurricane Katrina: A prospective analysis of the effect of parental distress and parenting practices. *Journal of Traumatic Stress*, 23(5), 582–590. <https://doi.org/10.1002/jts.20573>
- Kessler, R. C., Andrews, G., Colpe, L. J., Hiripi, E., Mroczek, D. K., Normand, S.-L. T., Walters, E. E., & Zaslavsky, A. M. (2002). Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychological Medicine*, 32(6), 959–976. <https://doi.org/10.1017/s0033291702006074>
- Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Gfroerer, J. C., Hiripi, E., Howes, M. J., Normand, S.-L. T., Manderscheid, R. W., Walters, E. E., & Zaslavsky, A. M. (2003). Screening for serious mental illness in the general population. *Archives of General Psychiatry*, 60(2), 184–189. <https://doi.org/10.1001/archpsyc.60.2.184>
- King, S., Dancause, K., Turcotte-Tremblay, A.-M., Veru, F., & Laplante, D. P. (2012). Using natural disasters to study the effects of prenatal maternal stress on child health and development. *Birth Defects Research. Part C, Embryo Today: Reviews*, 96(4), 273–288. <https://doi.org/10.1002/bdrc.21026>
- Knabb, R. D., Rhome, J. R., & Brown, D. P. (2005). *Tropical cyclone report, Hurricane Katrina, 23–30 August, 2005*. National Hurricane Center.
- Krieger, N., Kosheleva, A., Waterman, P. D., Chen, J. T., & Koenen, K. (2011). Racial discrimination, psychological distress, and self-rated health among US-born and foreign-born Black Americans. *American Journal of Public Health*, 101(9), 1704–1713. <https://doi.org/10.2105/AJPH.2011.300168>
- Lai, B. S., Beaulieu, B., Ogokeh, C. E., Self-Brown, S., & Kelley, M. L. (2015). Mother and child reports of hurricane related stressors: Data from a sample of families exposed to Hurricane Katrina. *Child & Youth Care Forum*, 44(4), 549–565. <https://doi.org/10.1007/s10566-014-9289-3>
- Lai, B. S., Lewis, R., Livings, M. S., La Greca, A. M., & Esnard, A.-M. (2017). Posttraumatic stress symptom trajectories among children after disaster exposure: A review. *Journal of Traumatic Stress*, 30(6), 571–582. <https://doi.org/10.1002/jts.22242>
- Lai, B. S., Osborne, M. C., Piscitello, J., Self-Brown, S., & Kelley, M. L. (2018). The relationship between social support and posttraumatic stress symptoms among youth exposed to a natural disaster. *European Journal of Psychotraumatology*, 9, 1450042. <https://doi.org/10.1080/2008198.2018.1450042>
- Lowe, S. R., Godoy, L., Rhodes, J. E., & Carter, A. S. (2013). Predicting mothers' reports of children's mental health three years after Hurricane Katrina. *Journal of Applied Developmental Psychology*, 34(1), 17–27. <https://doi.org/10.1016/j.appdev.2012.09.002>
- Masten, A. S., & Narayan, A. J. (2012). Child development in the context of disaster, war, and terrorism: Pathways of risk and resilience. *Annual Review of Psychology*, 63, 227–257. <https://doi.org/10.1146/annurev-psych-120710-100356>
- Masten, A. S., Roisman, G. I., Long, J. D., Burt, K. B., Obradović, J., Riley, J. R., Boelcke-Stennes, K., & Tellegen, A. (2005). Developmental cascades: Linking academic achievement and externalizing and internalizing symptoms over 20 years. *Developmental Psychology*, 41(5), 733–746. <https://doi.org/10.1037/0012-1649.41.5.733>

- McFarlane, A. C., & Van Hooff, M. (2009). Impact of childhood exposure to a natural disaster on adult mental health: 20-year longitudinal follow-up study. *The British Journal of Psychiatry: The Journal of Mental Science*, 195(2), 142–148. <https://doi.org/10.1192/bjp.bp.108.054270>
- McLean, M. A., Cobham, V. E., Simcock, G., Elgbeili, G., Kildea, S., & King, S. (2018). The role of prenatal maternal stress in the development of childhood anxiety symptomatology: The QF2011 Queensland Flood Study. *Development and Psychopathology*, 30(3), 995–1007. <https://doi.org/10.1017/S0954579418000408>
- Morgan, L., Scourfield, J., Williams, D., Jasper, A., & Lewis, G. (2003). The Aberfan disaster: 33-year follow-up of survivors. *The British Journal of Psychiatry: The Journal of Mental Science*, 182, 532–536. <https://doi.org/10.1192/bjp.182.6.532>
- Morris, A., Gabert-Quillen, C., & Delahanty, D. (2012). The association between parent PTSD/depression symptoms and child PTSD symptoms: A meta-analysis. *Journal of Pediatric Psychology*, 37(10), 1076–1088. <https://doi.org/10.1093/jpepsy/jss091>
- Nelson, C. A., & Gabard-Durnam, L. J. (2020). Early adversity and critical periods: Neurodevelopmental consequences of violating the expectable environment. *Trends in Neurosciences*, 43(3), 133–143. <https://doi.org/10.1016/j.tins.2020.01.002>
- Obradovic, J., Burt, K. B., & Masten, A. S. (2010). Testing a dual cascade model linking competence and symptoms over 20 years from childhood to adulthood. *Journal of Clinical Child & Adolescent Psychology*, 39(1), 90–102. <https://doi.org/10.1080/15374410903401120>
- Polusny, M. A., Ries, B. J., Meis, L. A., DeGarmo, D., McCormick-Deaton, C. M., Thuras, P., & Erbes, C. R. (2011). Effects of parents' experiential avoidance and PTSD on adolescent disaster-related posttraumatic stress symptomatology. *Journal of Family Psychology*, 25(2), 220–229. <https://doi.org/10.1037/a0022945>
- Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40(3), 879–891. <https://doi.org/10.3758/BRM.40.3.879>
- Proctor, L. J., Fauchier, A., Oliver, P. H., Ramos, M. C., Rios, M. A., & Margolin, G. (2007). Family context and young children's responses to earthquake. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 48(9), 941–949. <https://doi.org/10.1111/j.1469-7610.2007.01771.x>
- Raker, E. J., Lowe, S. R., Arcaya, M. C., Johnson, S. T., Rhodes, J., & Waters, M. C. (2019). Twelve years later: The long-term mental health consequences of Hurricane Katrina. *Social Science & Medicine*, 242, 112610. <https://doi.org/10.1016/j.socscimed.2019.112610>
- Raker, E. J., Zacher, M., & Lowe, S. R. (2020). Lessons from Hurricane Katrina for predicting the indirect health consequences of the COVID-19 pandemic. *Proceedings of the National Academy of Sciences*, 117(23), 12595–12597. <https://doi.org/10.1073/pnas.2006706117>
- Ringoot, A. P., Tiemeier, H., Jaddoe, V. W. V., So, P., Hofman, A., Verhulst, F. C., & Jansen, P. W. (2015). Parental depression and child well-being: Young children's self-reports helped addressing biases in parent reports. *Journal of Clinical Epidemiology*, 68, 928–938. <https://doi.org/10.1016/j.jclinepi.2015.03.009>
- Rubens, S. L., Felix, E. D., & Hambrick, E. P. (2018). A meta-analysis of the impact of natural disasters on internalizing and externalizing problems in youth. *Journal of Traumatic Stress*, 31(3), 332–341. <https://doi.org/10.1002/jts.22292>
- Scheeringa, M. S., & Zeanah, C. H. (2008). Reconsideration of harm's way: Onsets and comorbidity patterns of disorders in preschool children and their caregivers following Hurricane Katrina. *Journal of Clinical Child & Adolescent Psychology*, 37(3), 508–518. <https://doi.org/10.1080/15374410802148178>
- Sourander, A., Jensen, P., Davies, M., Niemelä, S., Elonheimo, H., Ristkari, T., Helenius, H., Sillanmäki, L., Piha, J., Kumpulainen, K., Tamminen, T., Moilanen, I., & Almqvist, F. (2007). Who is at greatest risk of adverse long-term outcomes? The Finnish From a Boy to a Man Study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 46(9), 1148–1161. <https://doi.org/10.1097/chi.0b013e31809861e9>
- StataCorp. (2019). *Stata statistical software: Release 16*. StataCorp LLC.
- Takahashi, S., Arima, H., Nakano, M., Ohki, T., Morita, J., Tabata, K., Takayama, Y., Tanno, K., & Yamamoto, T. (2021). Telomere shortening as a stress-related biomarker in children exposed to maternal chronic stress in utero measured 7 years after the Great East Japan Earthquake. *Psychiatry Research*, 295, 113565. <https://doi.org/10.1016/j.psychres.2020.113565>
- van der Toorn, S. L. M., Huizink, A. C., Utens, E. M. W. J., Verhulst, F. C., Ormel, J., & Ferdinand, R. F. (2010). Maternal depressive symptoms, and not anxiety symptoms, are associated with positive mother-child reporting discrepancies of internalizing problems in children: A report on the TRAILS study. *European Child & Adolescent Psychiatry*, 19(4), 379–388. <https://doi.org/10.1007/s00787-009-0062-3>
- Waters, M. C. (2016). Life after Hurricane Katrina: The Resilience in Survivors of Katrina (RISK) project. *Sociological Forum*, 31(S1), 750–769. <https://doi.org/10.1111/sof.12271>
- Weiss, D., & Marmar, C. (1997). The Impact of Event Scale—Revised. In J. P. Wilson & T. M. Keane (Eds.), *Assessing psychological trauma and PTSD* (pp. 399–411). Guilford Press.
- Yehuda, R., & Lehrner, A. (2018). Intergenerational transmission of trauma effects: Putative role of epigenetic mechanisms. *World Psychiatry*, 17(3), 243–257. <https://doi.org/10.1002/wps.20568>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.