

Neighborhood crime risk and resting respiratory sinus arrhythmia in middle childhood: Evidence of gender differences

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Abstract

Although there is a robust link between resting respiratory sinus arrhythmia (RSA), a biological marker of emotion regulation, and risk for psychopathology, the factors that may be associated with aberrant RSA development remain unclear. The goal of the current study was to examine the relation between children's resting levels of RSA and neighborhood crime, a macro-level environmental stressor associated with increased risk for multiple forms of psychopathology in youth. The levels of neighborhood crime were obtained using a geocoded neighborhood crime exposure database, allowing for the objective assessment of the likelihood of crime occurring in the child's community. The results indicated that the relation between neighborhood crime and resting RSA differed for girls and boys such that living in a neighborhood with higher risk of exposure to violent crimes was associated with lower RSA for girls, but not boys. These results suggest that living in a higher crime neighborhood is associated with an objective, biologically-based marker of emotion regulation and highlight how neighborhood crime may be specifically associated with risk for girls.

KEYWORDS

crime, residence characteristics, respiratory sinus arrhythmia, sex differences

1 | INTRODUCTION

Deficits in emotion regulation are observed across multiple forms of psychopathology, including both internalizing and externalizing disorders (for a review, see Aldao, Nolen-Hoeksema, & Schweizer, 2010). Respiratory sinus arrhythmia (RSA), indexed by high-frequency heart rate variability, is a peripheral measure of parasympathetic regulatory influence on the heart, and is believed to reflect one's ability to flexibly respond and adapt to environmental demands (Berntson et al., 1997; Porges, 2007). Resting RSA has been proposed to be a biological marker of emotion regulation (Appelhans & Luecken, 2006; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). Specifically, given evidence that resting RSA may be a peripheral marker of prefrontal cortex (PFC) function, such that lower levels of RSA are associated with diminished recruitment of the PFC in the regulation of limbic structures (Beauchaine, 2015; Thayer et al., 2012), lower resting RSA

is believed to reflect decreased ability to successfully engage in top-down self-regulation. Supporting this, lower resting RSA is associated with decreased executive functioning (for a review, see Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Additionally, despite some mixed findings regarding the relation between self-reported emotion regulation and resting RSA (e.g., Bunford et al., 2017; De Witte, Sutterlin, Braet, & Mueller, 2016; Gentzler, Santucci, Kovacs, & Fox, 2009; Vasilev, Crowell, Beauchaine, Mead, & Gatzke-Kopp, 2009; Williams et al., 2015), a recent meta-analysis indicated that resting RSA is associated with both behaviorally observed and self-reported indices of top-down self-regulation (Holzman & Bridgett, 2017). Taken altogether, although resting RSA may not be a marker of specific emotion regulation strategies, there is clear evidence that low resting RSA is a promising biomarker of global emotion regulation capacity. Indeed, lower resting RSA is a transdiagnostic marker of risk for both internalizing and externalizing disorders characterized

by deficits in emotion regulation (Beauchaine, 2015; Beauchaine & Thayer, 2015). Although main effects of resting RSA are not always observed, several studies have shown that low resting RSA exacerbates the impact of adverse environments on risk for psychopathology (e.g., El-Sheikh, Harger, & Whitson, 2001; McLaughlin, Rith-Najarian, Dirks, & Sheridan, 2015; Mezulis, Crystal, Ahles, & Crowell, 2015). Given these associations between resting RSA, emotion regulation capacity, and risk for psychopathology, an important next step is to determine factors that may contribute to the development of low resting RSA.

Research on developmental trajectories of RSA suggests that resting RSA increases across infancy and childhood (Bar-Haim, Marshall, & Fox, 2000; Gatzke-Kopp & Ram, 2018), stabilizes temporarily in middle childhood (El-Sheikh, 2005; Hinnant, Elmore-Staton, & El-Sheikh, 2011), and then decreases again during adolescence (Hollenstein, McNeely, Eastabrook, Mackey, & Flynn, 2012) and adulthood (Pfeifer et al., 1983). Additionally, there is evidence that environmental stress may impact these trajectories (Del Giudice, Ellis, & Shirtcliff, 2011; Propper & Holochwost, 2013). Specifically, lower RSA levels have been observed in youth who have experienced multiple forms of environmental stress including negative family relationships (Del Giudice, Hinnant, Ellis, & El-Sheikh, 2012), exposure to domestic violence (Rigterink, Katz, & Hessler, 2010), and adverse life events (Allegrini, Evans, de Rooij, Greaves-Lord, & Huizink, 2017). Although these specific environmental stressors have been linked to lower RSA in youth, less is known about how broader, community-level environmental contexts may impact RSA. Because resting RSA is a promising biomarker of emotion regulation capacity, a clearer understanding of potential macro-level influences on normal versus atypical trajectories of RSA may help to better understand the development of emotion regulation in youth and why some communities may be at greater risk for psychopathology than others. Furthermore, as early childhood environments are proposed to play vital role in calibrating individuals' stress response systems, including resting RSA (Del Giudice et al., 2011), and this initial calibration of resting RSA that "sets the stage" for later development appears to stabilize around middle childhood (El-Sheikh, 2005; Hinnant et al., 2011), research during this developmental window could elucidate points of intervention to better support adaptive emotion regulation development in children.

One broader environmental risk factor that may be associated with resting RSA in children is community violence, which approximately 38% of youth report having witnessed in their lifetime (Zinzow et al., 2009). Indeed, exposure to direct community violence is associated with teacher-reported emotion dysregulation in children (Schwartz & Proctor, 2000), which indicates that living in a high-crime area may have a significant impact on youth's emotion regulation abilities. To date, two studies have examined the relation between neighborhood crime (i.e., community violence) and resting RSA, and both either failed to find a relation (Scarpa, Fikretoglu, & Luscher, 2000), or only saw an effect of crime on RSA within the context of complex gene \times gene \times crime or gene \times gene \times crime \times maltreatment interactions (Lynch, Manly, & Cicchetti, 2015). However,

several factors may have contributed to these null results. First, Scarpa and colleagues examined the relation between community violence and RSA in a sample of adults. Given evidence that resting RSA appears to peak by middle childhood (El-Sheikh, 2005; Hinnant et al., 2011), the impact of community violence on resting RSA should be stronger in children than adults. Therefore, it is important to consider the developmental timing of violence exposure. A second reason why the effect of community violence on resting RSA may not have been observed in these previous studies is that the effects may differ for girls and boys. Researchers have highlighted the importance of examining gender as a moderator when examining physiological indices given that important biological differences between males and females may otherwise obscure relations with physiological markers (Gatzke-Kopp, 2016). This may be particularly important when considering the impact of neighborhood crime on child resting RSA, given gender differences in both community violence impact and RSA developmental trajectories.

Although exposure to community violence is associated with both internalizing and externalizing symptoms in youth (for a review, see Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Balthes, 2009), there are gender differences in this risk, with evidence that the association between community violence and internalizing symptoms is stronger for girls than for boys (Buckner, Beardslee, & Bassuk, 2004; Moses, 1999; White, Bruce, Farrell, & Kliever, 1998). This said, however, some studies have failed to detect these gender differences (Schwab-Stone et al., 1999; Wilson, Rosenthal, & Battle, 2007). These mixed findings may be due to a lack of differentiation between direct and indirect community violence exposure, as direct exposure to community violence is similarly associated with internalizing symptoms for boys and girls, whereas the relation between indirect exposure (i.e., witnessing or hearing about community violence) and internalizing symptoms is stronger for girls than boys (Foster, Kuperminc, & Price, 2004; Javdani, Abdul-Adil, Suarez, Nichols, & Farmer, 2014). This suggests that although males and females may be similarly impacted by community violence directly experienced at the individual level, females may be more significantly impacted by community violence assessed at the macro-level (e.g., overall levels of neighborhood community violence). Furthermore, this is in line with research on gender differences in stress reactivity more broadly, which suggests that girls may be more reactive to environmental stress, particularly interpersonal stress, than boys (Hankin, Mermelstein, & Roesch, 2007).

There may also be gender differences in overall levels of children's resting RSA as well as in the relation between RSA and emotion regulation capacity. Specifically, there is some evidence that boys may exhibit higher levels of resting RSA than girls (Allegrini et al., 2017; El-Sheikh, 2005; Salomon, 2005; but see also Bobkowski et al., 2017; Hinnant et al., 2011). Furthermore, in adults, the relation between resting RSA and emotion regulation appears to be stronger for women than men, such that lower RSA is associated with greater deficits in emotion regulation for women than men (Williams et al., in press).

The goal of the current study, therefore, was to examine the impact of a broader environmental context, neighborhood crime, on a biological index of children's emotion regulation, as indexed by

resting RSA. Importantly, the current study did not examine children's actual experiences with crime, but rather the impact of living within the context of a high crime area on children's RSA. In doing so, we specifically examined the potential moderating role of child gender to determine whether the impact may differ for boys versus girls. Given evidence that girls show greater reactivity to indirect exposure to neighborhood violent crime compared to boys (Foster et al., 2004; Javdani et al., 2014), potentially signifying greater susceptibility to macro-level influences, we hypothesized that the relation between neighborhood crime and lower RSA would be stronger for girls than boys. By capitalizing on the use of a recently developed geocoded neighborhood crime exposure database (Applied Geographic Solutions, 2015), the current study used state-of-the-science technology to objectively assess community crime in the areas where participants resided, rather than relying on self-report, which may be subject to recall or response bias. In addition to examining the impact of total crime risk indices on child resting RSA, we also examined the impact of violent and nonviolent crime risk separately in a series of exploratory analyses. These exploratory analyses are in line with previous research that has differentiated between the impact of violent and nonviolent (i.e., property) crimes on child risk for psychopathology (McCoy, Roy, & Raver, 2016). Furthermore, it is important to differentiate between violent and nonviolent crime risk, given robust evidence that exposure to community violence is associated with risk for psychopathology in youth (Fowler et al., 2009). Indeed, one recent study found that neighborhood violent crime, but not nonviolent property crime, was associated with children's attentional biases for negative stimuli (McCoy et al., 2016). Therefore, we hypothesized that any associations between neighborhood crime and children's RSA would be stronger for personal crime, which captures violent crimes against persons, than property crime, which captures nonviolent crimes. Finally, because living in a higher crime area is also associated with other potentially confounding risk factors, such as lower socioeconomic status (SES) (Baum, Garofalo, & Yali, 1999), we examined whether any observed significant relations would be maintained when we statistically controlled multiple demographic variables associated with SES.

2 | METHOD

2.1 | Participants

Participants included 284 children between the ages of 7 and 11 years old recruited from the community as part of a larger study examining the NIMH Research Domain Criteria (National Institute of Mental Health, 2008) Negative Valence Systems in children (for details, see James, Woody, Feurer, Kudinova, & Gibb, 2017; Woody, Feurer, Sosoo, Hastings, & Gibb, 2016). Only one child per family was included for the current study. If more than one child from a family was available, one child was chosen at random for inclusion. The only exclusion criterion was the presence of a learning or developmental disability that would interfere with the child's ability to participate in the study (per parent report). Children's average age was

9.46 ($SD = 1.52$), and 51.4% were female. In terms of children's race/ethnicity, 66.5% were Caucasian, 15.5% were African American, 16.5% were multiracial, and the remainder were from other racial/ethnic groups. The median family income was \$30,001–\$35,000 (Range = \$0–\$5,000 to more than \$115,000), 43% of children's caregivers had achieved a degree in higher education (associates degree or higher), and 38.7% of children lived in single parent households. The demographic characteristics of the sample parallel those of the county from which they were recruited.

2.2 | Measures

Neighborhood crime exposure indices were obtained from CrimeRisk (Applied Geographic Solutions, 2015), which is a database containing geocoded information about crime risk indices for multiple types of crime including property (i.e., burglary, larceny, motor vehicle theft) and personal (i.e., murder, rape, robbery, assault) crime rates for each zip code within the target county. Crime risk indices, reflecting the relative risk of a crime occurring in an area compared to the national average, were calculated from a thorough analysis of crime reports in the target county across a 7-year period. It is important to note that the total crime, personal crime, and property crime indices do not reflect the actual number of reported crimes within an area, but rather reflect the risk that the specified form of crime will occur within each geocoded area, based off previous crime reports. However, previous studies have found that geocoded indices of neighborhood crime are associated with individual's actual exposure to community violence (Curry, Latkin, & Davey-Rothwell, 2008). A score of "100" was the equivalent of the national average for each crime statistic. Within the current study, total crime indices ranged from 13 to 143, personal crime indices ranged from 9 to 81, and property crime indices ranged from 13 to 154. For each participant, neighborhood crime rates were obtained by examining the indices for total crime, personal crime, and property crime for the zip code of their current address at the time of the study. Seventeen different zip codes within the target country were examined for the current study, and participants' crime risk scores were normally distributed.

Children's resting RSA was calculated from a 2-min rest period during which they watched a nature video featuring landscape scenes from Olympic National Park in the laboratory as part of a larger physiological protocol examining parent-child physiological coordination during a discussion paradigm. During this rest period, electrocardiogram (ECG) data were obtained using Biopac BioNomadix wireless systems and recorded with Acqknowledge v4.2 software. ECG was recorded via a standard 3-electrode (lead II) set-up and ECG data were sampled at 1,000 Hz. MindWare HRV 3.0.12 was used to inspect, transform, and analyze the ECG signal. ECG data were visually inspected for artifacts (e.g., temporary loss of signal, large movements, or an unusual R-R interval) and artifacts were corrected manually. Consistent with previous research (e.g., Woody et al., 2016), epochs with more than 10% artifacts (i.e., 10% of R-waves estimated within an epoch) were excluded, and resting RSA was only calculated for participants with at least 50% usable epochs. To calculate RSA, spectral

power analyses were performed with a fast Fourier transformation. Consistent with recommendations by the Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (Camm et al., 1996), RSA was defined as power density in the 0.12–1.00 Hz frequency band and was calculated by averaging across the 30-s epochs of the 2-min rest period.

2.3 | Procedure

Participants were recruited from the community through a variety of means including newspaper ads, television ads, and Facebook ads. At the initial assessment, assent and consent were obtained from the child participants and their legal guardians. Following consent, parents and children completed self-report questionnaires. Finally, children's resting RSA was collected during a 2-min rest period. As part of the larger study, participant's parents were paid \$80 for their participation, and children were given a \$10 gift card to a store of their choosing. All study procedures were approved by the university Institutional Review Board.

2.4 | Analytic plan

We used linear regressions to examine the impact of neighborhood crime risk indices on children's resting RSA. First, to examine the main effect of crime risk on children's resting RSA, RSA was entered as the outcome variable and total crime risk was entered as the predictor variable. Second, to examine whether child gender moderates the impact of crime risk on resting RSA, children's gender and the Crime \times Gender interaction were entered in the second step of the regression. Additionally, in a series of exploratory analyses mimicking those described above, analyses were conducted separately for personal and property crime risk. Finally, a series of tests of robustness were conducted to examine whether any observed relations between neighborhood crime and resting RSA were maintained after statistically controlling for the influence of other variables associated with socioeconomic status (SES). Specifically, a number of SES-related variables (i.e., family income, child race [Caucasian: yes vs. no], caregiver education, whether the child was living in a single-parent home [yes vs. no]) and child age were entered as covariates in separate analyses to determine if the relation between neighborhood crime and resting RSA was maintained. Finally, exploratory analyses were conducted to determine whether any of these variables moderated the relation between neighborhood crime and resting RSA. SPSS version 25 was used for all analyses.

3 | RESULTS

An initial inspection of the data indicated that three participants had missing data for family income and five participants had missing data for parent education. Little's missing completely at random test, for which the null hypothesis is that the data are missing at random, was nonsignificant, $\chi^2(15) = 17.30, p = .30$. Therefore, maximum

likelihood estimates of missing data were created and used for all analyses. Correlations among all study variables are presented in Table 1 along with their descriptive statistics. Preliminary analyses were conducted to determine whether children's demographic variables were associated with their resting RSA. As shown in Table 1, children's resting RSA was not significantly related to child age, gender, race (Caucasian: yes vs. no), family income, caregiver education, or living in a single-parent home (lowest $p = .42$). Additionally, as seen in Table 1, boys and girls did not differ in terms of total crime, personal crime, property crime, or any demographic variables (lowest $p = .11$).

Focusing first on total crime risk, results indicated that the main effect of total crime risk on children's resting RSA was not significant, $t(282) = -0.58, p = .56, \beta = -0.04, r_{\text{effect size}} = -0.03$. However, we found that Total Crime \times Gender interaction was significant, $t(280) = -2.00, p = .05, \beta = -0.33, r_{\text{effect size}} = -0.12$. To examine the form of the Total Crime \times Gender interaction, we examined the main effect of total crime on children's RSA separately for boys and girls. The main effect of total crime on resting RSA was significant for girls, $t(144) = -1.94, p = .05, \beta = -0.16, r_{\text{effect size}} = -0.16$, such that higher levels of neighborhood crime were associated with lower resting RSA. In contrast, the total crime index was not significantly associated with resting RSA for boys, $t(136) = 0.93, p = .35, \beta = 0.08, r_{\text{effect size}} = 0.08$.

Next, in a series of exploratory analyses we examined the relation between neighborhood crime and children's RSA separately for personal and property crime. The main effect of crime on children's resting RSA was not significant for either personal, $t(282) = -0.22, p = .83, \beta = -0.01, r_{\text{effect size}} = -0.01$, or property, $t(282) = -0.60, p = .55, \beta = -0.04, r_{\text{effect size}} = -0.04$, crime. Adding children's gender and the Crime \times Gender interactions in the second step of the regressions, we found that the Crime \times Gender interaction was significant for personal crime, $t(280) = -2.78, p = .006, \beta = -0.41, r_{\text{effect size}} = -0.16$, but was a nonsignificant trend for property crime, $t(280) = -1.92, p = .06, \beta = -0.32, r_{\text{effect size}} = -0.11$. Again, to examine the form of Personal Crime \times Gender interaction, we examined the main effect of personal crime on children's RSA separately for boys and girls. Consistent with the results for total crime risk, the main effect of personal crime on resting RSA was significant for girls, $t(144) = -2.25, p = .03, \beta = -0.18, r_{\text{effect size}} = -0.18$, but not boys, $t(136) = 1.72, p = .09, \beta = 0.15, r_{\text{effect size}} = 0.15$.

Finally, given the links observed in previous research between living in an area with a high crime index and other demographic variables associated with SES (Baum et al., 1999), we conducted a series of analyses to determine whether our results were at least partially independent of other potentially confounding demographic variables. Focusing first on total crime risk, the link between total crime and lower RSA in females was statistically maintained when we statistically controlled for the influence of child race (Caucasian: yes vs. no), whether the child was living in a single-parent home (yes vs. no), and child age (all $ps = 0.05$). However, the relation between total crime and RSA in girls was not maintained when statistically controlling for the influence of family income, $t(143) = -1.82, p = .07, \beta = -0.16, r_{\text{effect size}} = -0.15$, or caregiver education, $t(143) = -1.86,$

TABLE 1 Correlations and descriptive statistics for study variables

	1	2	3	4	5	6	7	8	9	10
1. RSA	-									
2. Total Crime Index	-0.04	-								
3. Personal Crime Index	-0.01	0.89**	-							
4. Property Crime Index	-0.04	0.99**	0.87**	-						
5. Child Gender (% Female)	-0.04	0.01	-0.004	0.02	-					
6. Child Age	0.03	0.06	0.09	0.06	-0.09	-				
7. Child Race (% Caucasian)	-0.02	-0.38**	-0.42**	-0.37**	-0.05	0.003	-			
8. Family Income (Median)	0.01	-0.33**	-0.38**	-0.32**	0.09	0.06	0.37**	-		
9. Parent Education (% Higher Education Degree)	0.05	-0.23**	-0.27**	-0.22**	0.03	0.01	0.31**	0.63**	-	
10. Family Structure (% Single-Parent Homes)	0.004	0.17**	0.21**	0.16**	-0.06	0.01	-0.22**	-0.48**	-0.26**	-
Mean (SD)	7.67 (1.21)	80.02 (32.99)	46.65 (22.78)	84.81 (34.77)	51.4%	9.46 (1.52)	66.5%	\$30,001–\$35,000	43.0%	38.7%

Abbreviation: RSA = Respiratory Sinus Arrhythmia.

** $p < .001$.

$p = .07$, $\beta = -0.16$, $r_{\text{effect size}} = 0.15$. Focusing next on personal crime risk, the relation between personal crime and lower RSA in females was maintained when we statistically controlled for the influence of family income, child race (Caucasian: yes vs. no), caregiver education, whether the child was living in a single-parent home (yes vs. no), and child age (highest $p = .03$). Finally, none of these demographic variables moderated any of the relations between gender, crime, or their interaction and child resting RSA (lowest $p = .18$).

4 | DISCUSSION

The goal of this study was to examine whether living within the context of a high-crime area was associated with resting levels of RSA in youth. Consistent with previous studies (Lynch et al., 2015; Scarpa et al., 2000), there was not a significant main effect of neighborhood crime on children's RSA. However, in line with our prediction, this relation was moderated by child gender. Specifically, whereas high crime risk was associated with lower resting RSA for girls, it was not associated with resting RSA for boys. In addition, the findings were specific to personal, but not property, crime, which is consistent with studies that have focused on the impact of *violent* crime on negative outcomes in youth (for a review, see Fowler et al., 2009). Finally, it is important to note that results were maintained when controlling for the potential influence of family income and other demographic variables associated with SES, suggesting that that there may be a unique effect of neighborhood violent crime on resting RSA in girls that is not attributable to SES more broadly. A key strength of this study is that it is one of the first to measure neighborhood crime using an innovative geocoded database that allows for the objective assessment of the risk for crime to occur within the area in which the child resides. In combination with a biologically based index of emotion regulation (i.e., RSA), this approach provides a more objective snapshot of how broader environmental contexts, such as neighborhood crime, may impact resting RSA during childhood.

Our finding that living in a neighborhood with higher violent crime was associated with lower RSA for girls is consistent with two lines of research which show, first, that the impact of indirect crime exposure and other forms of stress on internalizing symptoms is stronger for girls than boys (Foster et al., 2004; Hankin et al., 2007; Javdani et al., 2014), and second, that girls and boys may differ in their resting RSA developmental trajectory (Allegrini et al., 2017; El-Sheikh, 2005; Salomon, 2005). Given the cross-sectional design of the current study, conclusions cannot be drawn about whether the differential impact of neighborhood crime on child RSA is indicative of diverging risk for psychopathology for girls. Future studies, therefore, should examine whether RSA development mediates the relation between neighborhood crime exposure and future risk for psychopathology in females.

As noted above, one of the strengths of the current study was that it focused on an objective index of neighborhood crime by utilizing geocoded crime risk scores mapped on to children's current addresses at the time of the study. However, it is important to note

that this approach only accounts for macro-level influences of neighborhood crime and not children's individual direct or indirect experiences with crime. In the broader literature on community violence, the importance of differentiating between direct victimization of and witnessing community violence has been emphasized (Trickett, Durán, & Horn, 2003). This may be particularly important when examining gender differences in risk, as being a direct victim of community violence is associated with risk for psychological distress for both boys and girls, whereas witnessing or hearing about violence is a risk factor specifically for girls (Foster et al., 2004; Javdani et al., 2014). As it is unlikely that the majority of youth in our sample had been a direct victim of community violence, this is consistent with our findings that the community-level environmental context of living in a higher crime area is associated with lower RSA for girls, but not boys. However, it remains unclear whether direct victimization is also associated with resting RSA for boys. Future studies examining the impact of neighborhood crime on resting RSA for boys and girls should examine youth's specific direct and indirect experiences with community crime exposure and victimization.

Although the design of the current study does not allow for an examination of the precise mechanisms through which the macro-level context of living in a neighborhood with higher rates of crime may contribute to lower resting RSA in girls, it is possible that hypervigilance to danger in one's environment may play a role. Indeed, results indicated that the relation between neighborhood violent crime and girls' RSA was at least partially independent of other variables associated with low SES, suggesting that the violent crime rate may be a specific aspect of girls' communities that is associated with resting RSA. Furthermore, according to the adaptive calibration model, the development of lower levels of resting RSA may actually be adaptive within high-stress and dangerous environments where it is important to quickly detect and respond to threats (Del Giudice et al., 2011). Future studies are needed to examine the precise mechanisms through which community violent crime may contribute to girls' resting RSA.

It is also important to note that when utilizing a geocoding approach to index neighborhood crime, there is likely variability in the risk of crime occurring within zip codes and, therefore, the crime risk index may not reflect the risk for all youth in a given zip code. Alternatively, however, examining crime risk indices in smaller areas, such as census tracts or block groups, may be too restrictive. That said, because children do not simply exist on the streets on which they live, but actively go out in their communities to go to school, the store, or spend time with friends, the decision was made to utilize crime risk indices at the zip code level in an attempt to capture the likelihood of a crime occurring overall in the community in which the child lives and interacts.

There are a number of strengths in the current study including a large sample size, an objective measurement of emotion regulation capacity (RSA), and the utilization of geocoded crime risk statistics as an index of neighborhood crime and a broader environmental context. However, despite these strengths, there are some limitations that should be acknowledged. First, the range of personal crime risk in this area examined was below that of the national average.

Therefore, although our findings may generalize to smaller cities with lower crime rates, the generalizability of our findings may not extend to larger cities with higher rates of violent crime. Future studies should examine whether gender moderates the association between crime exposure and child RSA in a larger city with community crime rates at or above the national average. Second, children's exposure to neighborhood crime was assessed by geocoding children's current addresses. However, we did not assess how long the children had lived in this neighborhood, although a previous study found that participants who moved out of their neighborhood were likely to move to a community with similar crime rates (Gorman-Smith, Henry, & Tolan, 2004). As resting RSA peaks and temporarily stabilizes in middle childhood (El-Sheikh, 2005; Hinnant et al., 2011), thereby setting the stage for later RSA development during adolescence, environmental influences should be stronger among even younger children. Therefore, to the extent that children in the current sample lived in neighborhoods with significantly different crime levels (higher or lower) when they were younger, the current results may underestimate the true relation between neighborhood crime and RSA. More in-depth assessment of youth's address history, particularly in early childhood, is necessary in future replication studies to examine the developmental timing of neighborhood crime exposure. Finally, although neighborhood crime was associated with levels of resting RSA for girls, the cross-sectional design of the study prevents any causal conclusions. Therefore, longitudinal studies are needed to determine whether variations in neighborhood crime predict different trajectories of RSA development between children.

In summary, the current study highlights the association between neighborhood crime and children's RSA for girls. Furthermore, these findings illustrate how living in a higher crime area may impact girls' regulatory ability at the physiological level, thereby highlighting the need for intervention services for these high-risk youth. If replicated and extended through longitudinal studies, these findings may provide important insight into how broader environmental contexts, such as community violence, impact the developmental trajectory of resting RSA in girls.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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