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EMPIRICAL RESEARCH

Effects of Indirect Exposure to Homicide Events on Children's Mental Health: Evidence from Urban Settings in Colombia

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Abstract

Exposure to neighborhood violence is an important risk factor for the social and emotional development of children and youth. Previous work recognizes that violence may affect children indirectly via secondhand exposure; yet, few studies have aimed to identify and quantify these effects, especially in settings like Colombia where youth is chronically exposed to violence. To address this gap in the literature, this article implements an empirical strategy where geographically specific and time-stamped data are leveraged to identify the effect of indirect exposure to homicides on fifth grade children's social and emotional outcomes. Sample participants (N = 5801) represent the fifth-grade population of boys and girls (50.7%) in two major urban areas in the country (*M*age = 11.01, SD = 0.75). We hypothesize that the effects of exposure to neighborhood violence on children's social and emotional skills will be consistent and negative. The findings indicate a consistent negative effect of indirect exposure to homicides on children's emotional functioning (i.e., emotional regulation and empathy), as well as on the prevalence of avoidance behaviors. However, contrary to theoretical expectations, the results do not support effects on children's levels of aggressive behavior, nor on the beliefs and attitudes that justify the use of aggression in interpersonal relationships. The findings are discussed in light of predictions from social cognitive models and their implications for developmentally and trauma-informed interventions for youth.

Keywords Exposure to violence · Urban elementary-school children · Mental health · Social and emotional development

Introduction

Exposure to community and neighborhood violence is an important risk factor for child and youth development. Violence affects academic, social, and emotional outcomes through a sequence of short-term physiological, cognitive, emotional, and behavioral mechanisms (Sharkey et al. 2014). Exposure to violence triggers a set of individual stress responses that include the activation of neuroendocrine, attentional, and neurocognitive systems (Pechtel and Pizzagalli 2011), which in turn interfere with cognitive and emotional functioning through the development of biased and less accurate attentional and appraisal processes of social and emotional stimuli (Dodge 2006). These patterns of social cognition constitute a set of micro-level processes that are associated with the development of inappropriate coping mechanisms (Buka et al. 2001), emotional appraisal patterns, and behaviors such as early vigilance, recognition of fear (Henrich and Shahar 2013), and behavioral suppression (Fowler et al. 2009). Taken together, these effects of exposure are posited to translate into symptomatology linked to internalizing and externalizing behavior in school settings (Wilson et al., 2009).

Whereas direct victimization may lead to bodily harm or even death, and is frequently regarded as a public health problem (Zimmerman and Posick 2016), indirect exposure -i.e. learning via secondhand accounts of neighborhood violence- also has important detrimental effects on children (Fleckman et al. 2016). According to McCoy et al. (2013, 2015a), children who learn about violent events occurring nearby their schools exhibit a behavioral profile that is consistent with suppression coping strategies and eventually can lead to psychopathology (Mrug and Windle 2010).

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Similarly, McCoy et al. (2015b) present evidence indicating an important association between indirect exposure to violence and the ability of children to attend selectively to negative valence emotional stimuli, and to produce biased interpretations of other's emotional states.

These previous results are consistent with the Social Cognitive Model proposed by Dodge, Bates and Pettit (1990), in which exposure to violence can impact child mental health and social behavior if it affects one or more of three mental processes: (a) the perception of threat and experience of irritation and fear; (b) the accessibility of negative behavioral responses in one's memorial repertoire; and (c) the evaluation that these responses will lead to desirable positive consequences. In light of this framework, indirect exposure to violent events occurring nearby school grounds can impair the ability of students to recognize and regulate their own emotional states, to empathize with those of others, justify their own actions, and to display symptoms of internalizing and externalizing problems. These short-term emotional, cognitive, and behavioral effects have developmentally shown to predict lower levels of educational attainment (Boylan et al. 2015), life earnings and labor market participation (Bowles et al. 2001), and higher rates of participation in criminal activities, and unhealthy behaviors later in life (Heckman and Kautz 2012).

Building from the Social Cognitive Model predictions, previous work has shown that indirect effects of violence could translate into biases in processes of emotional regulation (Kliever et al. 2004), contribute to the development of an hypersensitivity to negative stimuli (McCoy et al. 2015a, b), and eventually lead children to react without consideration of other´s emotional states (Schipper and Petermann 2013). Similarly, previous work indicated that indirect exposure to violence contributes to the formation of beliefs justifying the use of aggression in interpersonal relationships, an effect that has been evaluated in Colombia, whereby children exposed to community violence are more likely to support views justifying the use of interpersonal aggression (Molano et al. 2015). Finally, indirect exposure to violence could also modify the evaluation that children make of certain behavioral responses, and according to the literature, could increase the probability that individuals will enact behavioral patterns that are consistent with externalizing and internalizing symptomatology (Fowler et al. 2009).

Despite these theoretical expectations and previous results, unbiased evidence from applied settings supporting these claims has been hard to compile. Violence exposure is not a random process, and most of the time occurs alongside other important environmental stressors such as poverty, low-quality schools, and interparental violence (Foster and Brooks-Gunn 2009). Therefore, the usual empirical issues of reverse causality and confounding variables limit the capacity of observational studies to give unbiased and consistent impact estimates. To overcome these limitations, pioneer work conducted by Sharkey et al. (2012, 2014) and McCoy et al. (2013, 2015a, b), has taken advantage of geographically-located and time-stamped violence data to construct counterfactual scenarios within neighborhoods and street-blocks. In these analytical scenarios, the outcomes of children from very similar socio-economic and educational backgrounds are compared based on their observed level of exposure to violence within relatively small geographical and temporal windows. While these recent empirical strategies do not provide a developmental window into the indirect effects of violence, they do provide unbiased estimates of the effects on short-term outcomes that previous literature has linked with risky developmental trajectories (Masten and Cicchetti 2010). This article implements a variation of these analytical strategies to identify the effect of indirect exposure to violence on Colombian children's emotional, social, and cognitive functioning.

Colombia has been subject to decades of politically motivated armed conflict. While the areas most affected by the civil conflict display patterns of clustering around indicators of absence of governmental entities, poverty, and availability of natural and economic resources (Fernandez et al. 2014), the de-escalation of the conflict during the last 10 years, along with the announcement of peace talks and, agreement have modified the patterns of exposure across the country (Brodzinsky 2013). Although the deceleration of Colombia's political conflict has been accompanied by a decrease in kidnapping, terrorist attacks, and forced displacement, there has been an increase in urban criminality, such as homicides, personal injuries, and burglary (Ortega et al. 2015). The effects of these events on urban residents' human development are not fully understood.

Alongside these changes in the patterns of exposure to violence, the Colombian context has also evidenced valuable efforts to document how violence affects the development of children and adolescents. Previous work has shown how violence at the municipal level increases incentives to drop out of school and decreases incentives to strive for better academic results (Rodriguez and Sanchez 2012). These studies suggest diverse mechanisms for these negative effects, such as student stress, destruction of school infrastructure, teacher absenteeism, and increases in the opportunity cost of finishing school. However, the existing body of evidence has at least two important limitations. First, the use of indicators of violence at the municipal level as a measure of exposure to violence. Using these indicators ignores the immense variability in the incidence of crime and violence within municipalities. Without doubt, the assumption that all inhabitants of a municipality are exposed to the same level of violence (i.e., the municipal

average of homicides), can lead to bias in the estimators. Second, most of the previous work has focused on indicators of academic achievement, yet -to our knowledge-, no previous work has explored the social, emotional, and behavioral mechanisms that may intervene in these effects. The empirical strategy and the focus in social and emotional outcomes of this article attempt to overcome these important limitations of previous work.

The Current Study

This article seeks to identify what is the effect of indirect violence exposure on children's short-term social and emotional functioning in two large urban districts in Colombia. We contribute to previous research by focusing on short-term psychological indicators that represent different emotional, cognitive, and behavioral processes predicted by the Social Cognitive Model to be impaired by violence exposure, and at the same time are important predictors of positive human development (Masten and Cicchetti 2010). Additionally, the empirical approach proposed by Sharkey (2018) and McCoy et al. (2015a, b) is extended to Colombia, a middle-income country stricken by more than 50 years of civil violence (United Nations High Commissioner for Refugees 2014), and with urban homicide rates that are comparable to those reported for Baltimore in the U.S. (UNODC, 2011).

Attending to the literature informing this work, outcome measures are organized following the framework proposed by Dodge (2006). As indicators of *the experience of irritation and fear*, measures capturing the emotional regulation ability and the empathy of the child are included. A first hypothesis states that indirect exposure to homicides will impair children's ability to regulate their emotional states and to connect with other experiencing different emotional states. As indicators of the *accessibility of negative behavioral responses*, the article analyzes an outcome evaluating the extent to which children regard the use of violence, in their interpersonal relationships, as a possibility (Guerra et al. 2003). A second hypothesis of this article is that indirect exposure to nearby homicides will increase the probability that children accept and justify the use of violence as an adequate mean to achieve one's goals. Finally, as indicators of *potential behavioral outcomes*, measures of internalizing (i.e., avoidance of confrontation) and externalizing behavior (i.e., aggression) are considered. According to the meta-analytic work presented by Fowler et al. (2009), a third hypothesis states that higher levels of self-reported aggressive and avoidance behaviors are observed among our sample of urban youth exposed to violence.

In this article, the central predictor of these expected effects is indirect exposure to homicides occurring in the neighborhood where children attend school during a temporal window close to the dates of their social and emotional assessment. The main assumption behind this identification strategy is that, for children attending two different schools within the same neighborhood, the timing of a homicide in relation to the students' assessment date may reasonably be assumed as exogenous. To test these claims, the article draws from three important sources of information to create a unique dataset. First, it draws from data collected by the Colombian Institute of Educational Assessment as part of the biennial population-based academic evaluations called SABER, a national paper-based test, designed to monitor the quality of education and the development of children and youth in the country (Lopera et al. 2013). This article focuses on the social and emotional component of the test, where urban 5th grade students were asked to consider several scenarios and to reflect on their emotions, cognitions, and behaviors when facing conflictive situations. Second, the article employs demographic information identifying children and their schools. These child-level data were collected by the Colombian Institute of Educational Assessment, and include several questions inquiring about household- and school-level socio-economic conditions. The data were collected on 24 October 2012, at all elementary schools in Colombia, as part of that year's national standardized evaluation. Third, the article employs a dataset compiled by the National Police of all the homicides that took place in two major metropolitan areas between January 1st and 31 December 2012. In these data, during 2012 we observe 2867 homicides recorded with geographical location and time of occurrence.

After merging these sources of information, our dataset includes 2867 homicides and 674 public schools in the two urban districts during 2012. Of these schools, 624 (92.5%) were exposed to a homicide at any time during the entire year, yet only 111 schools (16.1%) were exposed on the seven days prior to the assessment. For these 111 schools we did not find statistically significant differences in the levels of violence exposure between 1 January and 15 September 2012, when comparing those exposed to homicides the week prior to the test with those who were not ($\hat{\beta} = 0.15$, $p = 0.826$). Neither did we find differences between these two sets of schools, in the average exposure to homicides in the 12 weeks encompassing the academic period in which students attended schools prior to the test ($\hat{\beta} = 0.99$, $p = 0.562$).

After evaluating the central hypothesis with these data, the article presents robustness checks of its main claims by: (i) using diverse model specifications varying the geographical and temporal windows that define exposure, (ii) providing a falsification test of estimated results, and (iii) employing personal assaults as an alternative measure of exposure to violence. Supporting evidence from these tests is used to assess the central exogeneity assumption of this

article. While all these data have been collected at a single point in time from our sample, together they represent several cognitive and emotional processes involved in the development of social, emotional, and behavioral skills (Jones and Bouffard 2012). Evidence supporting these expectations will provide an important test to recent models of social cognition in applied settings.

Methods

Participants

The analytical sample for this study comprises 5801 children, nested in 111 schools, within two large cities in Colombia. Nearly half of our participants are female (50.7%), and on average they are 11.01 years old (SD = 0.75 years). For about a half of the sample, their mothers have obtained at least a high-school diploma (53.1%). As reported above, on average schools attended by these children are exposed to 4.4 homicides during the 12 weeks elapsed since the start of the academic year (SD = 3.5), yet, by construction of the analytical sample, only 54 schools and 2649 children were exposed to homicides nearby their school grounds a week after the national test.

In the analytical sample, 57.3% of schools are public, and nearly a half provide services to children in the morning shift (from 7 am to 1 pm). Only 4.26% of schools in our analytical sample serve children in an extended shift, where school days run from 7 am to 3 pm. Table 1 summarizes this information for the analytical sample, distinguishing between those schools that were exposed to homicides the week prior to the SABER test and those that were not. Other relevant demographic information suggest that, among this analytical sample, 55% of children report living with two parents, 41.1% report that both parents have an income, and on average children report to live in arrangements where 2.96 people share a single room (SD = 1.36).

Central to the external validity of the results in this article, Table S1 (available in the appendix) compares these demographic indicators for our analytical sample, and the set of excluded cases. Excluded cases comprise the set of child reports that are observed in neighborhoods where: (i) there was only one school, (ii) all the schools were exposed to homicides the week before the test, or (iii) none of the schools were exposed to homicides the week before the test. As noted before, we excluded these cases to focus on the experience of children attending two different schools within the same neighborhood, for which the timing of a homicide in relation to the assessment date may reasonably be assumed as exogenous. While this exclusion comprises the external validity of findings, it constructs a valid counterfactual scenario to test our hypothesis.

Measures

Outcomes

This article considers five different child-reported social and emotional outcomes. All outcome variables are standardized to a mean of zero and a standard deviation of one, where higher values represent a higher prevalence of the indicated process. As noted above, these data were collected as part of the biennial population-based academic evaluations called SABER. All procedures for data collection were supervised and approved by the Ministry of Education in Colombia. The Institutional Review Board of Universidad de los Andes authorized all data-management and analytical procedures.

Emotional regulation Measured by six items asking children to report the degree to which they regulate and control their own emotions as a response to specific disturbing situations (e.g., *When you are angry, do you yell at other people?*). Children responded on a yes (coded with a value of 1)/no (coded with a value of 0) scale to each one of these items. A composite measure -averaging child responses and standardizing the estimated value- was created for this article. The original measure was developed by Daza and Mejia (unpublished) and reported by Chaux et al. (2009). Among our sample, internal consistency reliability was estimated at 0.65.

Empathy Measured by five items inquiring participants about the emotions they usually feel when something occurs to a classmate (e.g., *When a classmate is sad because she does not have someone to be with, do you feel bad?*). Participants answered on a three-point scale created by Chaux et al. (2009) ranging from: (0) I think it is funny, (1) I do not care, to (2) I feel bad, from which we estimated a standardized average score. In our sample, internal reliability coefficient, Cronbach's $\widehat{\alpha}$ is estimated at 0.86.

Normative beliefs about aggression Measured by six items asking about participant's own beliefs about the justifications for using aggression in particular interpersonal situations (e.g., *One has to fight so that others won't think you are a coward*). This measure, developed for the Colombian context by Chaux (2009), is adapted from the work of Slaby and Guerra (1988). Participants answered to these questions on a 4-point scale ranging from (0) Completely Disagree to (3) Completely agree. Results are presented on a standardized average score ($\hat{\alpha} = 0.77$).

Avoidance behavior Measured by six items asking children to report on their likely response to situations where they are teased or threatened by their peers (e.g., *If someone*

Table 1 Descriptive statistics for our analytical sample

	Control group		Exposed group		Total analytical sample	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Exposure	0	(0)	1	(0)	0.446	(0.497)
$\widehat{Exposure\ academic\ year}$	3.790	(3.263)	(5.14-1)	(3.662)	4.401	(3.511)
Exposure after the test	0.210	(0.412)	0.222	(0.413)	0.211	(0.412)
Individual characteristics[a]						
Age (*In years*)	10.97	(0.756)	11.05	(0.746)	11.01	(0.752)
Female	0.477	(0.500)	0.546	(0.498)	0.507	(0.500)
Mother finish high school	0.540	(0.498)	0.518	(0.500)	0.531	(0.499)
Family characteristics[b]						
House has floor	0.670	(0.470)	0.657	(0.475)	0.664	(0.472)
House has sanitary	0.992	(0.089)	0.989	(0.106)	0.991	(0.096)
Has older sibling	0.194	(0.359)	0.233	(0.423)	0.211	(0.408)
People living with you	1.603	(0.489)	1.635	(0.481)	1.617	(0.486)
Lives with two parents	0.554	(0.497)	0.546	(0.498)	0.550	(0.497)
Lives with no parents	0.147	(0.354)	0.152	(0.359)	0.150	(0.357)
Double income parents	0.409	(0.492)	0.413	(0.492)	0.411	(0.492)
Ratio: people to rooms	2.972	(1.352)	2.957	(1.386)	2.965	(1.367)
Assets (*In millions pesos*)	37.04	(12.90)	36.02	(13.15)	36.59	(13.02)
Family owns a car	0.205	(0.404)	0.202	(0.402)	0.204	(0.403)
School characteristics[c]						
Public school	0.581	(0.493)	0.563	(0.496)	0.573	(0.495)
Morning shift	0.329	(0.470)	0.627	(0.484)	0.465	(0.499)
Afternoon shift	0.639	(0.480)	0.318	(0.466)	0.492	(0.500)
Full shift	0.032	(0.176)	0.055	(0.228)	0.042	(0.202)
Geographical units						
Area of localities	N = 10 in treatment and control				6.462	(2.954)
Area of neighborhoods	N = 30 in treatment and control				1.581	(1.053)
Number of schools	57		54		111	
Number of children	3152		2649		5801	

[a]To control for baseline differences among individuals we include basic demographic characteristics: The age of the child, their gender, and the reported levels of mother's education as a proxy of the quality of their social interactions

[b]As Family characteristics, we include indicator variables that characterize the conditions of the home—as reported by students-. These indicators include whether the house has a floor made of material, as opposed to dirt, and whether it is connected to sanitary services. We also include a set of family characteristics indicators characterizing the composition of the family. These include whether the student lives with his/her parents, whether they are working, and a ratio of rooms in the house to number of people cohabitating the student

[c]Our vector of school characteristics includes: an indicator of whether the school is public or private, and three indicators that characterize whether students attend the school during the morning, the afternoon or during an extended shift where students spend at least 8 h a day on school grounds

says mean things about me, it is best to pretend he/she did not say anything). Participants answered to these questions on a 4-point scale, created by Daza and Mejia (unpublished), ranging from (0) Completely Disagree to (3) Completely Agree. ($\hat{\alpha} = 0.82$).

Aggressive behavior Measured with a single item asking children whether they had hit their classmates, at least once, during the past week (*During the last week have you hit, pushed, kicked or shoved any of your classmates*).

Main predictor

A dummy variable indicating whether a homicide was reported within a 500-m radius around a school attended by the 5th graders in our sample, on the week prior to the

SABER examination. This predictor has a value of one if at least one homicide was recorded in the specified geographical area during this temporal window and a value of zero otherwise. In the Colombian context, homicides are defined as any action that results in the loss of a life, by either negligence or bad intent, and are punishable with 13 to 25 years of imprisonment (Colombian Penal Law 2000). In this analytical sample, the most common cited cause were interpersonal conflicts (63.9%), personal or gang-related vendettas (22.0%), followed by those related to political conflict (7.46%), and those resulting from arm robberies (5.7%). The remaining 1% were recorded as resulting from accidents, police operatives, or sexual assaults. Only 4% of our sample schools were exposed to more than one homicide on the week prior to the test, for this reason we decided to recode these cases and create an indicator variable.

Control covariates

To account for plausible alternative explanations, all the estimated models introduced a set of school-, family-, and individual-level demographic variables. Attending to the literature, individual characteristics such as gender, age, and mother's educational level are included, as these might be associated with differences in the social and emotional performance of children (Ompad et al. 2007; Nagata et al. 2016). Estimated models also included indicators of the quality of schools in which 5th graders in the analytical sample were enrolled, and family economic and compositional characteristics that have been shown to be associated with both exposure to violence and indicators of child development (Lansford et al. 2016). All models were estimated accounting for these vectors of variables and fixed effects representing neighborhoods and municipalities. Descriptive statistics for these variables for control and exposed groups are presented in Table 1.

Analytical Strategy

To answer the proposed research question, the following model is fitted to the data:

$$\begin{aligned} Y_{ijnm} = {} & \beta_0 + \beta_1\left(EXPOSURE_{jnm}\right) \\ & + \beta_2\left(Exposure\,\widehat{Academic\,Year}_{jnm}\right) \\ & + \gamma\left(SCHOOL\,COVARIATES_{jnm}\right) \\ & + \delta\left(FAMILY\,CHARACTERISTICS_{ijnm}\right) \\ & + \psi\left(INDIVIDUAL\,DEMOGRAPHICS_{ijnm}\right) \\ & + \theta_{nm} + \theta_m + \varepsilon_{ijnm} \end{aligned}$$

In this equation, Y_{ijnm} stands for the estimated value of an outcome, for child i in school j, within neighborhood n and municipality m. In this model, the estimate associated with parameter β_1 was used to evaluate the hypotheses about the existence, sign and magnitude of the effects of exposure to violence on individual level outcomes, controlling for relevant individual, school, and family covariates. Additionally, to account for potential differences in exposure prior to the defined analytical window, the model includes the average weekly exposure to homicides around school grounds during the 12 weeks of the academic calendar of the year in which schools were in session. The estimated effect of this predictor was represented in the model by the coefficient associated with parameter β_2.To restrict estimation to average within-neighborhood comparisons, the model includes neighborhood (θ_{nm}) and municipality (θ_m) fixed effects. To address the clustering of children within schools, all models are estimated adjusting the standard errors.

Results are presented focusing on the impact estimates obtained from the definition of *Exposure* outlined above (i.e., Homicides occurring a week prior to the SABER test within a radius of 500 meters around school grounds) on standardized outcomes. The estimated *Exposure* parameter β_1 is interpreted as the standardized difference in each outcome as a result of a one-unit difference in exposure to violence. A summary of these results is presented below (Table 2), while Tables S2 to S6 (available in the appendix) present a taxonomy of estimated models in which sequentially controls are added to each outcome. Results obtained from alternative definitions of *Exposure* are presented as appendix tables and illustrated with Figures. Table S7 and Fig. 1 presents detailed results associated with variations in the temporal window; while Table S8 and Fig. 2 includes those associated with variations in the geographical window of exposure (both tables are available in the appendix). Table S9 presents robustness checks conducted using the count of personal assaults reported around school grounds on the week prior to the test. Table 3 presents results of the falsification test where homicides occurring a week after the assessment are employed as the main predictor.

Results

According to estimated results, shocks of violence (i.e., exposure to at least one homicide on the week prior to the test), generate lower standardized levels of *Emotional Regulation* ($\hat{\beta}_1 = -0.106$, [−0.203, −0.008]) and *Empathy* ($\hat{\beta}_1 = -0.114$, [−0.22, −0.009]) on average. Additionally, results indicate that these shocks of violence were related to differences in standardized child-reported forms of *Avoidance Behavior* ($\hat{\beta}_1 = 0.103$, [0.005, 0.18]) on average. Despite theoretical expectations, results do not support statistically significant effects of exposure to violence on the

Table 2 Estimated effect of homicides occurring on a radius of 500 meters from school grounds, 7 days before the test date

	Emotional regulation	Empathy	Normative beliefs about aggression	Avoidance behavior	Aggressive behavior
Exposure	−0.106*	−0.114*	−0.029	0.103*	−0.003
	(0.050)	(0.054)	(0.056)	(0.050)	(0.020)
Mean exposure over academic year	0.008	0.017	−0.005	0.004	−0.005
Female	(0.012)	(0.014)	(0.017)	(0.014)	(0.004)
Personal characteristics					
Age (In Months)	−0.149***	−0.160***	0.083*	−0.037	0.061***
Female	0.053	0.143**	−0.203***	0.057	−0.061***
Mother with HS	0.074	0.066	−0.012	0.023	0.014
Family characteristics					
House has floor	-0.003	0.031	−0.032	0.009	0.019
House has sanitary	0.533	−0.142	−0.379	0.201	0.050
Has old sibling	−0.111+	0.0040	0.164*	−0.021	0.053*
People living with you	0.014	0.034	−0.004	−0.024	−0.006
Lives with two parents	0.158*	0.118*	−0.144**	−0.003	−0.018
Lives with no parents	−0.089	0.190**	−0.001	0.016	0.031
Double income parents	−0.001	0.081	0.013	0.046	−0.011
Ratio: people to rooms	−0.011	−0.001	−0.005	0.011	−0.002
Assets (*In pesos*)	−4.e-08*	−6.e-08***	3.e-08+	−4.e-09	2.e-09
Family owns a car	−0.056	0.010	0.051	−0.025	0.005
School characteristics					
Public school	−0.001	0.008	0.051	0.062	−0.019
Morning shift	−0.439**	−0.227	0.283*	0.186*	0.102+
Afternoon shift	−0.428**	−0.222	0.269*	0.156+	0.076
Constant	1.756***	2.148***	−0.896+	0.152	−0.606**

Note: A full taxonomy of models estimated for each outcome are presented on Tables S1 to S5 in the appendix. Standard Errors are presented for on the main predictor in parenthesis

$+p<0.1$, $*p<0.05$, $**p<0.01$, $***p<0.001$

indicator of *Aggressive Behavior*, nor on the index of self-reported beliefs justifying the use of aggression as a means to solve interpersonal conflicts. It is worth noting that the measure of *Aggressive Behavior* includes a single item, and thus may be prone to an important amount of measurement error. These final fitted results are summarized in Table 2.

Along with these main results, differences associated with control covariates (individual, family, and school characteristics) are also found. In terms of individual characteristics, younger children reported lower levels of emotional regulation and empathy, but also reported higher levels of aggression and were more willing to justify the use of aggression. Additionally, female participants reported higher levels of empathy, but lower levels of beliefs and acts associated with aggression when compared to their male peers. Related to the characteristics of the families,

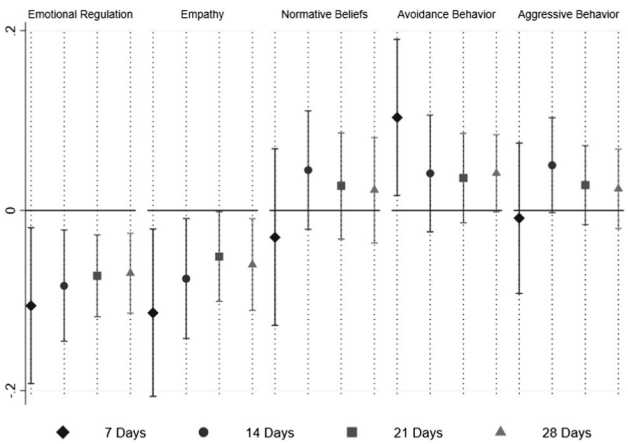

Fig. 1 Temporal sensitivity of findings. Each bar represents the estimated effect of *Exposure* on a 7, 14 and 21-day temporal window

scattered -but interesting- differences in our final fitted model are observed (See Table 2). Perhaps the most notable differences were those associated with homes with two heads of household. According to our results, children living in these conditions achieved higher levels of emotional regulation and empathy, and reported lower levels of aggression. Additionally, children who had an older sibling are also those who reported higher levels of aggression and the beliefs that justify its use. Children who reported that their households had fewer assets also reported higher levels, on average, of empathy. Similarly, children living with no parents at home also report higher levels of empathy. Regarding the school characteristics controlled for in the fitted models, no differences are found between public and private schools, yet interesting differences are observed associated with the time of the day in which students attend school (e.g., full day vs. morning shift vs. afternoon shift).

These endogenous differences became more salient when considering the results in the context of a taxonomy of estimations where different controls are added sequentially to the model (See tables S2 to S6, available in the appendix). While the sequential addition of groups of controls changed the statistical significance of some control covariates in the models -perhaps due to shared variance among them- for all outcomes, the main predictor only achieved statistical significance in the final fitted model. This behavior attests to the importance of restricting estimation to children living within the same neighborhood and differing only in their observed levels of exposure. Unrestricted estimations (Models 1 to 6 in tables S2 to S6) may be subject to omitted variable bias given that they are contrasting the potential outcomes of heterogeneous children exposed to environmental and social stressors anywhere across two large metropolitan areas in Colombia.

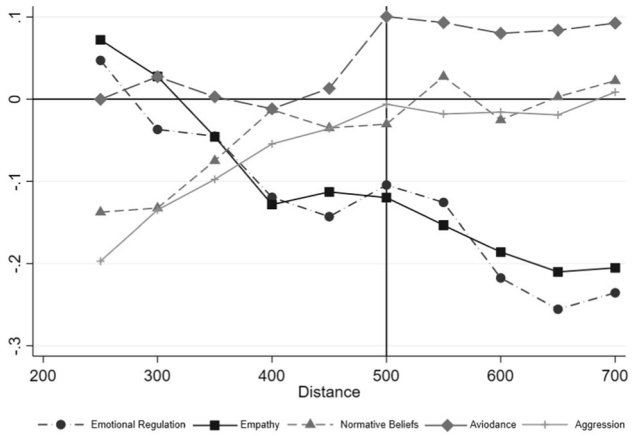

Fig. 2 Observed patterns of change in geographical sensitivity findings. Each line represents the estimated effect of *Exposure* for one of the our main outcomes according to different geographical radiuses around school grounds (from 250 to 700, on a 50-m interval)

Despite attempts to control for multiple confounding variables, and to restrict comparison to children attending schools within the same neighborhood, it is worth noting that the proportion of explained variance (R^2) for each outcome in the final fitted model ranges from 2.8% (*Avoidance Behavior*) to 7.3% (*Emotional Regulation*). This small proportion of explained variability suggests the existence of other unmeasured variables that may explain variability in child-outcomes. Despite this fact, the main findings indicate that between children attending schools in the same neighborhoods, and sharing similar demographic characteristics, indirect exposure to nearby homicides cause differences in their emotional and behavioral patterns that range from 0.103 to 0.114 points in a standardized metric.

As a reference point to this range of standardized effects, the results of two previous studies that use a similar empirical approach and outcome variables serve as a comparison point. First, Sharkey et al. (2012) estimate a negative impact that ranges between 0.33 and 0.83 in the standardized scores of two measures of self-regulation (attention and impulse control). Second, McCoy et al. (2015b) find that chronic neighborhood crime significantly predicts differences in three dimensions of emotional regulation, with regression coefficients that range between 0.08 and 0.12 in a standardized metric. Taken together, results presented in this article support the existence of a negative effect of indirect violence on *Emotional Regulation* and *Empathy* measures of Colombian children in 5th grade. Results also indicate that these negative emotional effects

Table 3 Falsification test—Estimated effect of homicides occurring on a radius of 500 meters from school grounds, 7 days after the test date

	Emotional regulation	Empathy	Normative beliefs about aggression	Avoidance behavior	Aggressive behavior
Falsification	−0.0278	0.0691	0.0967	0.117	0.0236
	[−0.219,0.164]	[−0.11,0.25]	[−0.106,0.299]	[−0.051,0.285]	[−0.059,0.107]
Constant	1.789**	2.057***	−1.025+	0.00158	−0.637**
	[0.648,2.929]	[0.972,3.143]	[−2.096,0.0452]	[−1.150,1.153]	[−1.033,−0.24]
R^2	0.073	0.066	0.051	0.029	0.052

Note: 95% confidence intervals in brackets. Model estimated with a full set of controls included on the our preferred specification (see Table 2)

$+p < 0.1$, $**p < 0.01$, $***p < 0.001$

are also made evident in the higher levels of *Avoidance Behavior* reported by exposed children. Contrary to our expectations, indirect exposure to violence does not appear to be related with levels of *Aggressive Behavior*, nor with personal *Beliefs* justifying the use of aggression in interpersonal relationships among this population.

Sensitivity Analyses

Building from this evidence, to analyze the sensitivity of findings to the ad-hoc definition of *Exposure* adopted here, the final analytical model was estimated using different specifications of this key predictor. On Fig. 1, estimated *Exposure* effects are plotted as a function of different temporal windows used to recode homicides occurring within 500 meters around the school grounds. Detailed results are presented in Table S7 (available online). As observed in this estimated plot, results present temporal consistency in *Exposure* estimates, especially in the case of their effect on *Empathy* ($\hat{\beta}_1$'s ranging from −0.114 to −0.05) and *Emotional Regulation* ($\hat{\beta}_1$'s ranging from −0.11 to −0.06). Variation in the temporal window of exposure did not appear to modify our null findings reported for *Aggressive Behavior* and *Normative Beliefs About Aggression*. Finally, on *Avoidance Behavior* sensitivity results indicate that only for the acute effect (experienced 7 days before the test) the null hypothesis associated with the *Exposure* estimate is rejected. Considering that in preliminary analyses differences in patterns of chronic violence exposure between our analytical groups are not found, this evidence is regarded as consistent with the assumption of exogeneity of the shocks occurring around these schools in the week prior to the SABER test. This evidence also highlights the arbitrariness involved in selecting seven days before the test as our temporal window. What was important about these violence shocks is their occurrence days before the test.

Following this same strategy, differences associated with the ad-hoc geographical window adopted in this article are evaluated modifying the radius within which homicides occur around school grounds. Different 50-meter intervals (from 250 to 700) in the radius within which homicides occurred the week prior to the test were tested. Findings from this test are displayed in Fig. 2. Detailed results are presented in Table S8 (available online). For this test, results indicate that increasing the spatial window is associated with an increase in the estimated negative effect of *Exposure* on *Emotional Regulation* and *Empathy* outcomes. Additionally, systematic effects of *Exposure* on *Avoidance Behavior* within radiuses above 500 meters are found. In contrast, while null effects on *Aggressive Behavior* and *Negative Beliefs About Aggression* are reported as main findings, this set of sensitivity analyses suggest statistically significant effects of homicides occurring 250 and 300 meters around school grounds. Paradoxically, these estimated effects are negative, suggesting that closer *Exposure* was associated with reductions in impact on cognition and behavior in the treated group. This evidence, while suggestive of a geographical gradient where effects on emotional processes and avoidance behavior become larger as distance from the event increases, should be considered with some caution. For this estimation, the analytical sample is not modified, and as the geographical window expands (shrinks), more (fewer) cases are included in the treated group. As such, these differences may be driven simply by the sample size available to estimate the difference between groups. For these reasons, the preferred geographical window reported in this article is that of 500 meters around school grounds.

Similarly, to evaluate the robustness of findings to the decision to select homicides as the measure of *Exposure*, the final fitted model is estimated using the number of personal assaults reported on the seven days prior to the SABER test, 500 meters around school grounds. Results of this estimation are presented on Table S9 (available online). Results previously reported for *Empathy* and *Avoidance Behavior* are robust to this change in *Exposure* measure. Findings previously reported for *Emotional Regulation*, while showing a similar negative sign, are not statistically significant in this specification. While this alternative measure of *Exposure* may be more prone to important sub-reporting biases when compared to homicides (e.g. given that reporting an assault depends on local access to police facilities, overcoming red tape around the reporting procedure, and overcoming fear from retaliation after the reporting), the similarities in the signs and magnitudes of the estimated results attest to the robustness of the main findings of this article, and open interesting windows for further investigations.

Finally, to analytically discount the existence of unobserved confounding variables that may bias main estimates, a falsification test is conducted. In this test, homicides occurring in the week *after* the test were used as the main predictor of the final fitted model. The rationale behind this test is the simple observation that the future should not predict the past, and that if a statistically significant effect is found, previously reported results are subject to omitted variable bias. In other words, failing to reject the null hypothesis embedded in this test will indicate that unobserved factors associated with the exposure to violence may be the driving mechanisms behind main results. As shown in Table 3, this is not the case and, consistent with expectations, results did not suggest differences in outcomes that are associated with future homicides. This evidence, alongside that presented for the temporal and spatial sensitivity of the main results, and the robustness to an alternative definition of *Exposure*, gives confidence about the reported main findings.

Discussion

While strong theoretical models link indirect exposure to violence and child outcomes (Dodge 2006), limited research has explored the effect of shocks of violence on indicators of child psychosocial functioning in Colombia, and Latin America. This article presents an empirical strategy where geographically and time-stamped homicide data is leveraged to identify its effect on children's social and emotional outcomes that are predicted to be affected by violence (Landsford et al. 2016), and are related to positive human development (Shinn and Yoshikawa, 2008). Main findings suggest important negative effects of this environmental stressor on urban children's standardized measures of emotional functioning (i.e., emotional regulation and empathy), as well as on the prevalence of avoidance behaviors. Results do not support effects on children's self-reported levels of aggressive behavior, nor on their beliefs and attitudes that support or justify the use of aggression in their interpersonal relationships.

These results are comparable to those reported by McCoy et al. (2013, 2015a, b), and summarized by Sharkey (2018) for urban populations in the U.S., and highlight the relevance of emotional regulation processes for the ability of individuals to cope and react to environmental stressors, such as exposure to violence. Unfortunately, as also recognized by Sharkey (2018), a frequent feature of these recent studies is the use of different metrics to describe the cognitive, social, and emotional development of children and adolescents exposed to these events. For example, while McCoy et al. (2015a, b) presents results from direct assessment conducted with children, Sharkey (2010) focused on standardized metrics of academic performance. This article, introduces different metrics that are aligned with expectations set forth by the Social Cognitive Model (Dodge 2006). While taken together these findings attest to the detrimental effects of indirect exposure to violence on children's emotional processes across multiple populations, future work should try to homogenize metrics and definitions of core emotional process in childhood and early adolescence (Jones and Bouffard, 2012).

Even though the existing literature supports an expectation of effects on emotional, cognitive, and behavioral indicators of social and emotional development, the pattern of findings reported in this article provides stronger evidence of the effects of violence on emotional processes. Estimated effects for *Empathy* and *Emotional Regulation* are the most stable among all findings, which strongly suggests that individual reactions to events of violence are mediated by an emotional appraisal process that, according to Sharkey (2018) and McCoy et al. (2015a, b), sits between the physiological reactions to environmental stressors and cognitive and behavioral reactions. These findings are also consistent with the predictions of the Social Cognitive Model (Dodge 2006), whereby these emotional micro-steps are one of the psychological links between exposure to violence and the development of mental health delays in exposed population. This body of literature suggests that indirect exposure to these acute events of violence may initially compromise emotional processes, perhaps contributing to the creation of stress, anxiety, and fear responses (Cooley-Stickland et al. 2001), and in turn may impact cognitive and behavioral functioning (Sharkey, 2018). Developmentally, these effects on emotional processes may also contribute to the emergence of internalizing and avoidance behavioral problems (Fowler et al. 2009), and may erode the opportunities of human capital formation (Boylan et al. 2015; Heckman and Kautz 2012).

Despite these important results, null findings on indicators of aggressive behavior and beliefs justifying the use of aggression are at odds with some of the predictions of psychological theories (Dodge 2006). Perhaps the definition of *Exposure* employed in this paper does not account for the intra-individual psychological processes that translate environmental stressors into deviant cognitions and behavior, and the predictions of these theories are more aligned with the effects of chronic exposures whereby repeated and constant events are the ones contributing to the long-term development of these outcomes. Surprisingly, according to sensitivity analyses, while shocks observed in a 500-m radius do not influence these outcomes, those occurring within a closer geographical window (250 to 300 m) produce counterintuitive results. As noted above, these effects may only be driven by a change in the composition of the treatment and control group, or simply due to measurement error embedded in our single-item measure of *Aggressive Behavior*. Despite these measurement limitations, an alternative explanation to this paradoxical finding, however, may stem from a "scare effect" (Lansford et al. 2016), whereby children who observe violent events closer to their school experience closely the negative effects of violence and temporarily modify their behavior and cognition to a position where the negative consequences are more salient. While this is a plausible explanation for this result, findings from this article do not provide direct evidence to support this hypothesis, and further research should explore more closely this unexpected results. Nonetheless, academic literature on this topic indicates that these effects are short-lived and may, in turn, lead to higher rates of the "scared-off" behavior (Petrosino 2013).

Along with these results, findings also indicate interesting patterns across sensitivity and falsification tests. First, a consistent result across all estimated models is that, even though demographic differences in social and emotional outcomes within our population are found, the effect of indirect exposure to homicides only achieves statistical

significance once the comparison group is restricted to children attending schools within the same neighborhood. This finding may be explained by the extensive socio-economic and demographic clustering of the Colombian population within geographical areas (Chaux et al. 2009). Events such as extreme poverty, unlawful urban development, and internal displacement explain this population clustering, which has persisted for decades.

Second, while restricting the variability of outcomes within neighborhoods, sensitivity analyses of time and exposure radius attest to the temporal stability of our findings and to important variability across space. To this point, it is worth noting that selected windows are arbitrary, and that the apparent stability of estimates across time may be only explained by gradients in the severity of the shock that are not analyzed in this paper. Similarly, changes in results observed as we modify the radius of exposure around schools may be driven by a change in the size of our exposed and control group within the same time-period. In other words, while time of exposure is held constant, variation in the radius may only imply a greater chance of contamination between analytical groups. Future research should attempt to address these biases by including a measure of exposure that is weighted for distance, time, and severity.

Third, while robustness analyses indicate the stability of some of the main findings to alternative measures (i.e. homicides versus personal assaults), it should be noted that the social patterns of geographical and temporal clustering of these events might respond to different causes within urban areas. For example, Stretesky et al. (2004) present evidence from 236 cities in the U.S., indicating that the spatial arrangement of a city explains an important amount of variation in homicide rates, yet this same pattern is not found for other forms of crime as robbery and personal assault. For this reason, further work should explore how different patterns of exposure generate different patterns of effects.

Finally, despite these potential sources of bias and their implications for these findings, this article fails to reject a null hypothesis of exposure when the latter is defined as those homicide events occurring the week *after* the test. This falsification result, alongside the lack of differences in the yearly exposure between groups, argues in favor of a central claim of our final fitted model: for children attending two different schools within the same urban neighborhood, the timing of a homicide event in relation to the students' assessment date may reasonably be assumed as exogenous.

In spite of all this evidence, one important issue remains unresolved: regardless of the empirical definition of violence exposure, this article assumes that the occurrence of a homicide or personal assault indirectly exposes children to this source of stress. Yet, from the available data, it is impossible to identify the children that in fact learned about these events. Therefore, reported effects of this article should be regarded as underestimated. Unbiased measures of direct or indirect exposure would produce a larger effect. Along these lines, Finkelhor et al. (2015) report than 25.3% of children in the U.S. had indirectly heard, witnessed or learned about violent acts in their homes, schools, and communities. Unfortunately, similar prevalence indicators are unavailable for Colombia. Nonetheless, assuming similar levels of those reported for the U.S., we should expect that the underestimation of the effects is non-negligible. Thus, further research should explore objective indicators of exposure to violence and subjective perceptions of insecurity, in order to study the simultaneous impact of these factors on child development.

Conclusion

This article evaluated the effect of indirect exposure to homicides on social and emotional outcomes among a population of children in urban areas of Colombia, a middle-income country stricken by more than five decades of civil war. This context provides an opportunity to learn about the effects of violence exposure, which this article achieves by analyzing unique geographically specific and time-stamped datasets. Aligned with theoretical expectations (Dodge 2006), the findings show a negative and robust effect of exposure to violence on indicators of children's emotional functioning. Specifically, children indirectly exposed to homicides are less likely to regulate their emotions in interpersonal relationships and are less likely to empathize the emotional states of others. These emotional reactions are accompanied by social behaviors that provide evidence of avoidance whereby children shy away from social interactions in the days after indirect exposure. Null findings were reported for aggressive behavior and the beliefs that justify its use in interpersonal relationships: children indirectly exposed to violence were neither more nor less likely to demonstrate more aggression nor to justify its use. Taken together, these findings question central tenants of theories suggesting the existence of a cycle of violence (Myers et al. 2018), according to which exposure to violence generates later aggressive behavior. This study's results suggest that analyses should further distinguish between emotional processes and subsequent behavioral patterns in the aftermath of community violence. This study revealed that acute shocks primarily affect children's emotional processes without necessarily amplifying aggressive or antisocial behaviors. Whether emotional processes in the aftermath of indirect violence exposure translate into aggressive behavioral patterns may relate to chronicity in exposure and the balance of other concomitant risk and

protective factors. Future research and interventions should build upon this distinction, and recognize that schools play a developmental role in promoting and protecting the emotional mental health of children and youth.

Authors' Contributions A.M. and A.H. conceptualized and designed the study, conducted initial analyses, drafted, reviewed and revised the manuscript. J.C.C. managed the data, coordinated and supervised data analysis, produced preliminary reports, and critically reviewed the manuscript. A.M. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

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Data Sharing Declaration The data sets generated and analyzed are not publically available. However, they are available from the corresponding author on a reasonable request. Requests for access will be review and evaluated in consultation with the Ministry of Education and National Police in Colombia.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This study was approved by the IRB offices at Ministry of Education and Universidad de los Andes. We complied with ethical standards for collecting anonymous data and analyzing it without any personal identification.

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