



Invisible wounds: Community exposure to gun homicides and adolescents' mental health and behavioral outcomes

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ABSTRACT

Prior research has illustrated the importance of some types of local community crime for adolescents' outcomes. However, we have little knowledge about the extent to which gun homicides within adolescents' neighborhoods affect their mental health and behavioral outcomes. This is important because local gun homicide incidents may be uniquely harmful for adolescents and their association with adolescents' mental health and behavior may represent an underappreciated externality of the U.S.'s gun violence epidemic. In this study, we used data on the geocoded location of gun homicides linked with restricted Fragile Families and Child Wellbeing Study data to examine whether gun homicides incidents near adolescents' homes and/or schools were associated with their mental health and behavioral outcomes. We found that the occurrence of a gun homicide near an adolescent's home or school was associated with significantly worse symptoms of anxiety and depression for girls and, in some cases, with symptoms of anxiety for boys. We further found that these relationships varied depending on the distance of gun homicide incidents to homes and schools.

Introduction

In 2018, nearly half a million violent crime victimizations (7.4%) (Morgan & Oudekerk, 2019) and 75% of murders (Gramlich, 2019) involved firearms. Further, rates of violent crime victimization involving firearms have been increasing since 2015 (Morgan & Oudekerk, 2019). Prior research suggests that violent crime at the community level is detrimental for the mental health and development of adolescents who may hear about, witness, and/or be victimized by such crime (Fowler et al., 2009; Grinshteyn et al., 2018; Theall et al., 2017). Gun homicides are arguably an extreme version of violent crime, with larger potential than other acts of violence to be fatal and affect bystanders (Roth 1994; Weaver et al., 2004). This lethality has only increased with the proliferation of high-caliber firearms (Braga & Cook, 2018). As such, gun homicides may have especially important associations with mental health outcomes for adolescents living in communities affected by gun violence.

While data limitations have prevented thorough study of this hypothesis (Rajan et al., 2019), prior research offers some support for these expectations. Specifically, victimization with a gun is associated with greater mental health distress than victimization with other types of

weapons (Kagawa et al., 2020). The lethality of firearms may make firearm-inflicted violence especially traumatizing for bystanders as well, a possibility supported by qualitative research which found that residents of violent neighborhoods expressed fear about the randomness of gun violence and the possibility that loved ones could be caught in the crossfire (Opara 2020). Additionally, studies conducted in particular sites, often cities with above average rates of gun violence, have found that gun violence is associated with youths' behavioral and cognitive outcomes (Bergen-Cico et al., 2018; Bingenheimer et al., 2005; Sharkey 2010). It is therefore possible that local occurrences of gun homicides lead to mental health trauma and/or worse behavior outcomes among adolescent residents, though this research would be bolstered by examining these associations across a wider range of U.S. cities.

We also know little about whether the relationship between gun violence and adolescent mental health and behavior varies by the characteristics of the individual or the gun violence incident. Theory suggests that the associations between gun homicides and adolescent mental health and behavioral outcomes vary for girls relative to boys, the former being more likely to exhibit internalizing behaviors like anxiety and depression and the latter being more likely to engage in externalizing behaviors that are directed to the external environment,

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like aggression or disobedience (Eschenbeck et al., 2007; Maschi et al., 2008; Stiles et al., 2000). In addition, the proximity of the incident to adolescents' schools or homes could shape how immediate the threat feels and, as a result, adolescents' mental health and behavioral responses to gun violence.

To explore these gaps in the literature, we harnessed newly-available, geocoded data on the location of gun homicides linked to the home and school addresses of adolescents participating in the Fragile Families and Child Wellbeing Study (FFCWS). The FFCWS sample includes adolescents born in the late 1990s in 20 U.S. cities of 200,000 people or more. In this paper, we provide descriptive insights into the association between the occurrence of gun homicides near adolescents' homes or schools and externalizing behavior problems (such as aggression and peer problems), symptoms of anxiety, and symptoms of depression. We also examined whether these relationships varied by gender or the distance between adolescents' homes/schools and the gun homicide incident(s).

This study helps address several limitations in this nascent literature. First, we strengthen the generalizability of the findings on the effects of violence on mental health by using a sample of adolescents from large cities around the U.S. These rich data allowed us to account for a larger set of individual, household, and contextual covariates than many prior studies. Second, we build and reinforce evidence from prior studies on community violence by focusing on gun homicides, an extreme form of violence that is potentially more traumatizing (Rajan et al., 2019). Third, we examined gun violence proximate to school *and* home settings, both of which are meaningful for shaping adolescents' lived experiences and which have rarely been examined in tandem. Fourth, we used objective, geocoded reports of gun homicides from the Gun Violence Archive (GVA) and youth self-reports of mental health, which are arguably higher-quality measures of these constructs than those used in prior studies. Fifth, we examined whether the relationship between gun violence and mental health/behavior varies across adolescent gender, which has largely gone unexamined in the gun violence literature. The findings from this study are relevant for understanding the social determinants of mental health and behavior in adolescents and developing intervention models that support positive youth development.

Gun violence and adolescents' outcomes

A large body of literature has shown the long-term effects of adverse childhood experiences (ACEs) on health and wellbeing across the life course (Hughes et al., 2017). Exposure to violence in childhood and/or adolescence is considered to be one of the common ACEs (Hughes et al., 2017; Ports et al., 2016), but gun homicide exposure has largely not been previously considered. This is important because adolescents are exposed to gun violence with considerable frequency. In a nationally representative survey of adolescents, 5 percent reported that they had seen someone get shot and 10.6 percent had seen someone threatened with a gun, knife, or other weapon (Nofziger & Kurtz, 2005). Individuals who are low-income, Black or Latinx, or who reside in cities with higher violent crime rates are disproportionately likely to be exposed to gun violence and homicides (Hurt et al., 2001; Tracy et al., 2019). Based on GVA data (which this study uses), in Baltimore, Memphis, and New Orleans, 61 percent, 53 percent, and 48 percent of residents respectively lived in a neighborhood where a gun homicide occurred (Aufrecht et al., 2017). Direct exposure to gun homicides (witnessing homicides) and indirect exposure to gun homicides (hearing about or seeing the aftermath of homicides) may therefore be relatively prevalent and underappreciated ACEs shaping behavioral and mental health outcomes and disparities.

While little research has explored the impact of community gun homicides on adolescents' mental health and behavioral outcomes, we can gain insights concerning what we would expect to find from the literature on the effects of violent crime on adolescents. Prior research has found that being the victim of local violence, witnessing local

violence, and hearing about local violence are associated with behavior problems and PTSD among children and adolescents (Fowler et al., 2009; Turner et al., 2006; Zinzow et al., 2009). A number of other studies have asked youth about their experiences with different types of violence, including gun violence (Allwood & Bell, 2008; Hurt 2001; Nofziger & Kurtz, 2005; Zinzow et al., 2009). While these studies do not explore the potentially unique effect of gun violence, they illustrate that local gun violence, in tandem with other kinds of community violence, is associated with worse behavioral and mental health outcomes (Allwood & Bell, 2008; Cuartas & Leventhal, 2020; Nofziger & Kurtz, 2005; Zinzow et al., 2009).

In one of the few studies that has directly examined the association between gun violence exposure and adolescents' outcomes among adolescents in Chicago, being shot, shot at, or witnessing a shooting was associated with 2.5 times higher odds of self-reported perpetration of serious violence up to 2 years after gun violence exposure (Bingenheimer et al., 2005). Exposure to gun violence has also been found to be associated with mental health outcomes among children in Boston, Philadelphia, and Eastern Tennessee (Mitchell et al., 2019); among rural youth in Ohio (Slovak & Singer, 2001), and among adults in four U.S. cities (Smith et al., 2020). In another study, fatal school shootings were associated with a 21.4 percent increase in the usage of antidepressants among local adolescents (Rossin-Slater et al., 2019). These studies provide important insights into the associations between local gun violence exposure and youth outcomes. However, it would be valuable to study the impact of community gun homicides on adolescents' mental health and behavioral problems with a broader sample of youth across the U.S., including from cities that do not have above average homicide rates.

The role of distance and gender

In addition to having little information about the association between gun homicide incidents and adolescents' mental health and behavioral problems, we have little information on whether the context of the gun homicide or the characteristics of the individual shape the consequences of gun homicides. It may be the case that gun homicides occurring particularly close to adolescents' home or school addresses are especially impactful for their mental health and behavior. Prior research has found that more personalized experiences of violence—at home, in school, or towards a loved one—are associated with internalizing behavior problems such as depression and anxiety, while depersonalized experiences in one's community are more likely to promote aggressive, externalizing behaviors (Flannery et al., 2004; Lambert et al., 2012; Mrug & Windle, 2010). Because very local occurrences of gun homicides may feel more personal or be directed towards individuals that respondents know, especially nearby gun homicides may have stronger associations with mental health outcomes. In contrast, more geographically distant and therefore potentially more depersonalized occurrences could have stronger relationships with externalizing behaviors.

Further, community gun homicides may differentially impact outcomes for girls and boys because of gender differences in the prevalence of particular behavioral and mental health outcomes. Girls tend to be more prone to exhibiting internalizing behaviors such as anxiety and depression, including after witnessing or being the victims of violence, while boys are more likely to exhibit externalizing behaviors such as aggression and peer problems (Eschenbeck et al., 2007; Maschi et al., 2008; Stiles et al., 2000). Moreover, some prior literature finds that assault-related violence exposure is associated with greater symptoms of PTSD and mental health concerns for females relative to males (Breslau & Anthony, 2007; Kessler et al., 1995; Stein et al., 2000), though others do not find gender differences (Dunn et al., 2012; Iverson et al., 2013). Consequently, we may observe stronger associations between local gun homicides and girls' mental health outcomes. However, non-assault-related violence exposures (including witnessing violence) have largely not been found to be associated with substantial gender

differences in PTSD and mental health concerns (Breslau & Anthony, 2007; Stein et al., 2000). Given that we are examining local gun homicide incidents that are not likely to be directed towards respondents and which individuals may not directly witness, it is possible we will not observe gender differences. The extent to which the relationship between local gun homicides and mental health and behavioral outcomes varies by adolescent gender is therefore an open question.

Theory

Theories connecting community violence and adolescent mental health and behavioral problems help outline reasons for expecting that gun homicides have an especially dramatic impact on adolescents. Specifically, socialization theory posits that violence affects adolescents through processes of socialization, whereby adolescents adopt scripts that validate and support the use of violence (Anderson, 1999; Harding, 2009). This socialization process is more likely to occur among young males in low-resourced settings where opportunities for upward mobility are few and where youth are more likely to be socialized by older cohorts of young adults (Anderson, 1999; Harding, 2009). This literature illustrates why local gun homicides may be associated with externalizing behavior problems among youth, particularly boys. Further, individuals who live in neighborhoods where gun violence is present express a need to arm themselves for protection (Anderson, 1999; Watkins et al., 2008), a feeling that is likely heightened following a gun homicide. This suggests that gun homicides may promote and even seemingly necessitate the adoption of aggressive behaviors, relative to other forms of less lethal violence.

Additionally, social organization theory argues that local violence disrupts the formal and informal social connections that help maintain order within neighborhoods through, for example, neighbors looking out for one another (Sampson et al., 1997; Hipp et al., 2009; Morenoff et al., 2001). The importance of social ties and neighborhood cohesion for the mental health outcomes of adolescents (Dupere et al., 2012; Maimon et al., 2010) suggests that the disruptive influence of violence on local social connections could have spillover effects for youths' symptoms of anxiety and depression. Given that gun violence victimization has been found to be associated especially strongly with trauma (Kagawa et al., 2020) and that gun homicides are a particularly dramatic form of gun violence, it is likely that gun homicide exposure will be uniquely impactful for individuals' feelings of connectedness and mental health outcomes. Gun homicides that occur especially nearby may particularly disrupt social ties. These theories therefore help outline why we would expect to see a relationship between gun homicides and adolescents' behavior problems and mental health.

Data and methods

Sample

For this study, we used the FFCWS which began in 1998 when researchers started following 4898 children born in 20 randomly sampled U.S. cities with populations of 200,000 people or more. The FFCWS oversampled unmarried parents and is consequently not nationally representative without incorporating survey weights to address this sampling design. However, it captures a subset of the population that is especially likely to be impacted by gun homicides and is therefore uniquely valuable for our study. The FFCWS surveyed these children and their caregivers when the children turned 1, 3, 5, 9 and 15.

Our analysis used newly-available, restricted data on the precise location of gun homicide incidents collected by GVA and geocoded and linked by FFCWS to adolescents' home and school addresses in the Year 15 interview, which took place between 2014 and 2017 when adolescents were 15-years-old. As a result, we were able to observe *where* a gun homicide occurred relative to adolescents' home and school addresses (up to 1 mile away) and *when* a gun homicide occurred relative to the

interview date (up to 1 year before the date of adolescents' Year 15 interviews). These one-year and one-mile limits were imposed by FFCWS. GVA is an independent research group that collects daily data on gun homicides from law enforcement, media, government, and commercial sources (Gun Violence Archive, 2020). GVA data has been found to closely track CDC gun violence data, though it modestly undercounts gun homicides (Bendheim-Thoman Center for Research on Child Well-Being 2019). The linkage of the GVA data to FFCWS data represents one of the first opportunities to examine geocoded and validated gun homicides with individual-level data for a large sample that is not restricted to a single city and is linked with both home *and* school addresses.

We focused on the sample of respondents from Year 15 because this is the year we have information on local gun homicides. However, the longitudinal nature of the data allowed us to use data from Year 9 (the prior wave) for our multivariable analyses to capture the influence of prior characteristics and to better isolate the relationships between exposure to gun homicides and mental health/behavioral problems.

Our sample included a total of 2823 respondents of the original 4898 children. Some observations were lost to attrition. Online Appendix Table A illustrates that the families lost to follow-up were similar at baseline to the interviewed families, though families lost to follow-up were somewhat more likely to be Latinx, have less than a high school degree, and be in poverty than those who were not lost to follow-up. Notably, the total crime rate and the violent crime rate in the two groups were very similar. We also dropped observations that were missing the outcome measures (157 respondents), the covariates (529 respondents), or the gun homicide measures (71 respondents). While only 2–5% of observations were missing for most covariates, 10% of observations were missing for the Year 9 behavior problems measures (described below). The relationships reported below do not vary in any substantive way if the missing values on covariates are multiply imputed using Stata's *chained* command and imputing the data 10 times. For simplicity, we focus on the non-imputed results.

Outcomes

We utilized three outcome measures that help capture the multifaceted nature of adolescent mental health and behavior. First, externalizing behavior problems were measured with the externalizing behavior portion of the Child Behavior Checklist (CBCL), an index of behavior problems that is widely used in the literature on child behavior and development and which is constructed from the primary caregivers' responses to a variety of questions about their adolescents' behavior (Bendheim-Thoman Center for Research on Child Wellbeing 2018). These questions included whether the adolescent is "cruel, bullies, or shows meanness to others," "destroys things belonging to others," and "argues a lot," among other questions listed in Online Appendix Table B. Each question was summed into the component index and standardized to have a mean of 0 and a standard deviation of 1. Assessing the scale using Cronbach's alpha index of internal consistency indicates that this scale is reliable ($\alpha = 0.8949$). In supplementary analyses, we examined a standardized index that sums all of the questions included in the full CBCL, including internalizing and externalizing behaviors (full set of questions included in the CBCL are outlined in Online Appendix Table B).

Second, we examined the Brief Symptom Inventory (BSI-18), an index measure capturing adolescents' feelings of anxiety. The FFCWS BSI-18 index is a modified version of the original BSI-18 index that includes 6 anxiety-related questions, rather than the traditional 18 (Bendheim-Thoman Center for Research on Child Wellbeing 2018). This index was created from adolescents' levels of agreement with the following statements, "I feel nervous or shaky inside," "I feel fearful," "I have spells of terror or panic," "I feel tense or keyed up," "I get suddenly scared for no reason," and "I feel so restless I can't sit still." Because the question answers were ordered such that strongly agree received a value

of 0 and strongly disagree received a value of 4, we reverse-coded each measure, with higher values representing greater symptoms of anxiety. Each measure was summed into a component index and the index was standardized to have a mean of approximately 0 and a standard deviation around 1. The alpha index of internal consistency indicates that this scale is reliable ($\alpha = 0.760$).

Finally, we examined adolescents' scores on the Center for Epidemiologic Studies Depression Scale (CES-D), an index measure commonly used in the literature to assess symptoms of depression. FFCWS asked a subset of CES-D questions that have high reliability and consistency across cultural groups, including adolescents' level of agreement on the statements, "I feel depressed," "I feel I cannot shake off the blues, even with help," "I feel sad," "I feel happy," and "I feel life is not worth living" to arrive at a score indicating whether the adolescent exhibits depressive feelings (Bendheim-Thoman Center for Research on Child Wellbeing 2018). We reverse-coded each question (except "I feel happy") so that higher values represented greater symptoms of depression. Each measure was summed to create the depression index and the index was standardized to have a mean of 0 and a standard deviation of 1. The Cronbach alpha index of internal consistency indicates that this scale is reliable ($\alpha = 0.758$).

Focal independent variables

Our focal independent variables included a dichotomous measure representing whether at least one gun homicide occurred within 1 mile of an adolescent's home or school up to a year prior to the interview date ($1 = \text{at least one gun homicide occurred}$; $0 = \text{gun homicide did not occur}$). We did not separately examine gun homicides occurring proximate to one's home versus one's school because we found no substantive differences in the relationships across these two locations, likely because homes and schools tended to be geographically close for the FFCWS analytic sample (less than three-quarters of a mile distance on average).

In supplementary analyses, we examined the relationship between the average distance of all gun homicide incidents and adolescents' outcomes. To do this, we included a categorical measure with 0 (reference group) indicating that no gun homicide had occurred, 1 representing that gun homicide incidents within an adolescent's neighborhood occurred, on average, within half a mile of an adolescent's home or school address, and 2 representing that gun homicide incidents occurred, on average, over half a mile away from adolescents' homes or school but within one mile. In results available upon request we tested whether the *nearest* gun homicide incident occurred within one half mile of an adolescent's home or school. While the results are substantively very similar for these measures, we focus on the former, average measure of gun distance because 70 percent of respondents for whom a gun homicide occurred in their neighborhood had more than one gun homicide occur in their neighborhood. The extent to which homicides occur very close by, on average, is therefore likely to be especially impactful for adolescents' behavioral and mental health outcomes.

Covariates

There are a wide variety of individual, familial, and contextual characteristics that are likely to influence the relationship between local gun homicides and adolescents' mental health and behavioral problems, and that were available in the Fragile Families data. We utilized restricted Fragile Families data on county-level total and violent crime rates in Year 15 to account for broader patterns of crime. We also employed restricted data on city-level unemployment rates and tract-level poverty rates and logged incomes. Additionally, we included the city-level logged population size over 16-years-old because the age structure of the population may influence crime. We did not include the racial and educational composition of the city and tract because these covariates did not substantially impact our relationships and BIC and

AIC tests indicated that they reduced the fit of our models. These contextual characteristics are provided by Fragile Families from Census, Bureau of Labor Statistics, and Survey of Consumers data.

We also controlled for individual- and household-level covariates, including adolescents' race/ethnicity, whether adolescents' parents witnessed a shooting in Year 9 in their neighborhood (to help account for past local gun violence), and behavior problems and mental health status in Year 9 (the last wave prior to Year 15). The lagged measure of externalizing behavior problems was created from the same questions asked about externalizing behavior problems in Year 15, this measure therefore represents a lagged outcome. However, the anxiety and depression scales do not have equivalent counterparts in Year 9 because it is solely the caregiver who is asked about their child's mental health status in Year 9 and these questions are not drawn from the BSI-18 or CES-D. Instead, these measures are created from the internalizing behavior portion of the CBCL, the full set of questions are outlined in Online Appendix Table B. These measures were summed into a standardized index with an alpha score that indicated the scale was reliable ($\alpha = 0.713$). While these measures are not directly equivalent to the index measures for depression and anxiety, they capture similar symptoms and help account for prior symptoms of anxiety and depression.

We also adjusted for whether the primary caregiver was married or cohabiting with a partner (relative to not married/cohabiting), whether the adolescent's biological parents are married or cohabiting, and the primary caregiver's employment status and educational attainment. We accounted for the number of children in the household, logged household income, and whether the household is in poverty to help capture economic hardship.¹

Analytic strategy

We examined the associations between local gun homicides and adolescent mental health/behavior problems by utilizing linear mixed effects models with state-level random intercepts and robust standard errors clustered at the state level. Observations were therefore nested within states to help account for unobserved variation across states in the error terms. While this is a relatively high level of aggregation, too few individuals shared tracts to allow tracts to be used as a viable clustering category. However, almost 90 percent of respondents had not moved out of the state they resided in at baseline and our results did not differ if we nested observations within the 20 baseline cities originally selected by FFCWS (the only year for which city identifiers are available), offering suggestive evidence that our results would not substantially differ if we could nest observations at a finer level of aggregation.

For our main set of models and for our supplementary models examining the distance of gun homicides, we conduct separate models by child gender. This decision was based on the results of Chow tests which indicated that model effects were significantly different across gender to merit separately analyzing the relationship between gun homicide incidents and mental health and behavioral outcomes for girls and boys ($p < 0.000$ for each outcome).

As mentioned above, FFCWS is not nationally representative and, by Wave 6, some of the sample had been lost to attrition. To help account for this, in supplementary models we used FFCWS's weights that help

¹ We also considered including parents' symptoms of depression and anxiety in our models, as well as violence in the home. Parents' symptoms of anxiety and depression were measured by the primary caregiver's responses to the Composite International Diagnostic Interview – Short Form (CIDI-SF) on questions relating to major depressive episodes and generalized anxiety. Violence in the home was measured with a survey question asking if the youth had been hit by the primary caregiver or whether the parents had engaged in a physical fight in front of the youth in the past year. However, these questions exhibited considerable missingness and our results did not substantively differ when we included them in our models. We therefore do not include them here.

account for the sampling design, non-response at baseline, and attrition to produce a sample that is representative of all children born between 1998 and 2000 and living in cities with populations of 200,000 or more. The use of these weights resulted in a loss of observations. Further, FFCWS created replicate weights to account for the complex sampling design, which required the use of jackknife estimation of standard errors, which is not supported for mixed effects models (for more information on the construction of these weights, see [Fragile Families and Child Wellbeing Study, 2020](#)). As such, we re-estimated our results using the FFCWS replicate weights and linear OLS regression with our full suite of covariates.

Results

Descriptive statistics

We first present descriptive statistics for the outcomes, focal independent variables, and covariates by adolescent gender and whether a gun homicide occurred within 1 mile of their homes or schools within 1 year of their interview date ([Table 1](#)). About 62.7 percent of girls and 58.9 percent of boys in the sample had at least one gun homicide occur within one mile of their home or school in the prior year. Of those girls and boys for whom a gun homicide occurred proximate to their homes or schools, more than 20 percent had a firearm homicide occur, on average, within one-half mile of their home or school within the last year. Girls and boys for whom a gun homicide occurred in their neighborhood were more likely to be Black, socioeconomically disadvantaged, and to live in less-resourced communities than those for whom a gun homicide had not recently occurred.

Moreover, current scores on the behavior problem, anxiety, and depression indices were higher for those residing near a gun homicide incident, though Year 9 externalizing and internalizing behavior scores showed modestly smaller differences between these groups. Consistent with prior studies, girls exhibited higher average scores on the anxiety and depression indices, while boys exhibited higher average scores on the behavior problem index.

Behavior problems

In the bivariate models for externalizing behavior problems, the coefficient on the occurrence of a gun homicide was positive and statistically significant for both girls and boys, though the associations for boys only reached marginal significance (see [Table 2](#)). However, these relationships became non-significant once our covariates were included. We also did not observe significant differences in our associations based on the distance of the gun homicide incident ([Appendix Table A](#)).

The relationships did not substantively differ when we examined behavior problems using the full CBCL (including externalizing and internalizing behavior problems). Because our framing of gender differences in behavior problems more closely aligns with an understanding of externalizing behavior, we focused on the externalizing behavioral problems measure. We also focused on the anxiety and depression indices over the internalizing behavior portion of the CBCL because these indices are respondent-rather than parent-answered and therefore more likely to be reliable reflections of 15-year-olds' mental health.

Anxiety

In bivariate models, the occurrence of a gun homicide near one's home or school was positively and significantly associated with anxiety scores for girls and boys ([Table 2](#)). Once individual, familial, and contextual characteristics were included in the models, the coefficients attenuated, but remained significant for girls and became non-significant for boys. More specifically, anxiety scores were 16 percent of a standard deviation higher for girls for whom a gun homicide

Table 1

Descriptive statistics (means/SDs) by gender and occurrence of a gun homicide within 1 mile of home or school.

	Girls		Boys	
	No Gun Homicide	Gun Homicide	No Gun Homicide	Gun Homicide
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
<i>Outcomes</i>				
Behavior Scale, Year 15	-0.115 (0.445)	-0.034 (0.541)	-0.000 (0.569)	0.071 (0.654)
Anxiety Scale, Year 15	-0.004 (0.695)	0.104 (0.722)	-0.076 (0.616)	-0.015 (0.654)
Depression Scale, Year 15	-0.012 (0.735)	0.143 (0.782)	-0.132 (0.646)	-0.033 (0.689)
<i>Year 9 Behavior</i>				
Lagged Behavior Scale	-0.119 (0.393)	-0.043 (0.551)	0.014 (0.551)	0.084 (0.611)
Internalizing Behaviors	-0.015 (0.574)	-0.069 (0.553)	0.037 (0.601)	0.024 (0.607)
<i>Firearm Variables</i>				
Witnessed Shooting, Year 9	0.025 (0.157)	0.084 (0.278)	0.020 (0.141)	0.080 (0.271)
Homicide Within Half Mile on Avg.	N/A	0.218 (0.413)	N/A	0.205 (0.404)
More than One Gun Homicide	N/A	0.7321 (0.4432)	N/A	0.714 (0.452)
<i>Covariates</i>				
<i>Race/Ethnicity</i>				
White	0.396 (0.489)	0.095 (0.293)	0.362 (0.481)	0.112 (0.315)
Black	0.320 (0.467)	0.627 (0.484)	0.332 (0.471)	0.614 (0.487)
Latinx	0.242 (0.429)	0.256 (0.437)	0.259 (0.439)	0.245 (0.431)
Other	0.043 (0.203)	0.022 (0.147)	0.047 (0.212)	0.029 (0.169)
<i>PCG^a Education</i>				
Less than HS Degree	0.144 (0.352)	0.207 (0.406)	0.133 (0.340)	0.194 (0.398)
HS Degree	0.185 (0.388)	0.184 (0.388)	0.184 (0.387)	0.200 (0.392)
Some College	0.405 (0.491)	0.483 (0.500)	0.384 (0.487)	0.485 (0.500)
College+	0.265 (0.442)	0.126 (0.332)	0.300 (0.458)	0.121 (0.326)
PCG Employed	0.754 (0.431)	0.684 (0.465)	0.764 (0.425)	0.685 (0.465)
Logged HH ^b Income	10.749 (1.503)	10.200 (1.442)	10.927 (1.022)	10.285 (1.258)
HH in Poverty	0.209 (0.407)	0.392 (0.489)	0.178 (0.383)	0.394 (0.489)
PCG Married/Cohabit	0.657 (0.475)	0.475 (0.500)	0.677 (0.468)	0.515 (0.500)
Biological Parents Married	0.396 (0.489)	0.221 (0.415)	0.382 (0.486)	0.271 (0.445)
Number of Children in HH	1.372 (1.265)	1.515 (1.438)	1.365 (1.239)	1.548 (1.446)
Log Total Crime Rate, County	7.904 (0.478)	8.256 (0.356)	7.923 (0.482)	8.247 (0.350)
Log Violent Crime Rate, County	5.716 (0.759)	6.481 (0.552)	5.739 (0.771)	6.461 (0.558)
Unemployment Rate, City	0.074 (0.027)	0.075 (0.022)	0.074 (0.026)	0.075 (0.023)
	0.133	0.272	0.128	0.268

(continued on next page)

Table 1 (continued)

	Girls		Boys	
	No Gun Homicide	Gun Homicide	No Gun Homicide	Gun Homicide
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
% Below Poverty Level, Tract	(0.100)	(0.143)	(0.105)	(0.142)
Logged Income, Tract	11.011 (0.428)	10.518 (0.443)	11.008 (0.441)	10.522 (0.454)
Log Population Over 16, City	14.330	14.760	14.254	14.732
	(0.934)	(1.026)	(0.916)	(1.029)
N	513	864	594	852

Source: Authors' calculations with the Fragile Families and Child Wellbeing Study (FFCWS) Years 9 and 15 restricted data.

^a PCG = Primary caregiver.

^b HH = Household.

occurred near their homes or schools than for girls who did not have a gun homicide occur nearby, even after accounting for broader patterns of crime and household and contextual disadvantage.

Further, the relationship with anxiety was strongest when the average distance of a gun homicide incident was within half a mile of adolescents' home or school addresses (Appendix Table A). When a gun homicide occurred, on average, within half a mile of a girl's home or school, her anxiety score was over a quarter of a standard deviation higher than among girls for whom a gun homicide did not occur near their home or school. Likewise, for boys, the occurrence of a gun homicide was significantly associated with anxiety if the average distance of a gun homicide incident was within half a mile of their home or school, but not when the gun homicide was more distant.

Fully interacting our independent variables and covariates with gender yielded similar results, with gun homicides more strongly associated with anxiety for girls, though the gender interaction term did not reach statistical significance, we therefore cannot definitively conclude that gun homicides are more strongly associated with girls' than boys' anxiety outcomes.

Depression

The results for the depression index were similar to those for anxiety. In the bivariate models, the occurrence of a gun homicide was positively

Table 2

Mixed-effects regression models results predicting adolescent behavior problems as a function of local gun homicide incidents. Source: Authors' calculations with the FFCWS Years 9 and 15 restricted data.

	Behavior Problem Index		Anxiety Index		Depression Index	
	Bivariate	Multivariable ^a	Bivariate	Multivariable	Bivariate	Multivariable
<i>Girls</i>						
Gun Homicide = 1	0.081** (0.031)	0.012 (0.034)	0.117*** (0.028)	0.114** (0.042)	0.157*** (0.031)	0.178*** (0.034)
N	1377	1377	1377	1377	1377	1377
<i>Boys</i>						
Gun Homicide = 1	0.079 [^] (0.045)	-0.013 (0.037)	0.063* (0.028)	0.054 (0.033)	0.096 [^] (0.050)	0.035 (0.046)
N	1446	1446	1446	1446	1446	1446

Standard errors in parentheses.

[^] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

^a All multivariable models are adjusted for: the outcome lagged one wave (for behavior problems outcomes) and internalizing behavior problems in Wave 9 (for anxiety and depression outcomes), whether the child's parent witnessed a shooting in the neighborhood in Wave 9, race/ethnicity (White-ref, Black, Latinx, Other), mothers' highest level of education (less than high school-ref, high school degree, some college, college+), whether the mother is employed, logged total household income, whether the family is in poverty, whether the mother is married or cohabiting, whether the mother is married or cohabiting with the father of her child, the number of children in the household, the logged total crime rate in the county, the logged violent crime rate in the county, the city unemployment rate, the percentage of city residents who are 16+-years-old, the poverty rate of the Census tract, and logged income of the Census tract.

and significantly associated with symptoms of depression for girls and was marginally significantly associated with symptoms of depression for boys. Once our covariates were introduced, this relationship became non-significant for boys, though it remained significant for girls. In the fully-specified multivariable models, girls for whom a gun homicide occurred in their neighborhoods had depression scores that were 24 percent of a standard deviation higher than girls for whom a gun homicide had not occurred in their neighborhoods.

Unlike the findings for anxiety, the distance of a gun homicide incident did not meaningfully shape the relationship between local gun homicides and symptoms of depression (Appendix Table A). Interacting gender with the gun homicide indicator indicates that gun homicides are more strongly associated with girls' depression outcomes than boys' depression outcomes ($p < 0.05$) (results available upon request).

In supplementary analyses, we re-estimated our results with the FFCWS weights (Appendix Table A). Our results for girls were similar in magnitude and direction to our unweighted results, though they were not statistically significant, which may have resulted from the reduction in sample size and loss of power. In contrast, the results strengthened for boys and became significant for boys' symptoms of depression. Because of the larger sample size and the benefits of the unweighted mixed effects models, we had greater confidence in those results. Further, the unweighted sample captured a group of individuals who are disproportionately likely to be affected by gun violence and so are of especial interest to this study. Weighting the sample to be nationally representative may obscure the associations we observe if gun violence is especially impactful and prevalent for lower-income youth. On the other hand, weighting the sample helped address the unique sampling design and the possibility that those who attrit are unique relative to the general sample. Consequently, each model offers benefits, though together they highlight that gun violence has suggestive associations with mental health outcomes for youth, particularly when those incidences occur especially proximate to youths' homes and/or schools.

Discussion

Overall, our findings suggest that the acute trauma of gun homicides has important associations with mental health outcomes, particularly for adolescent girls. These findings are important given the prevalence of gun homicides within FFCWS adolescents' communities. Our null findings for behavioral problems are interesting and reflect the possibility that behavior is less likely to be disrupted by acute exposures to gun violence, which may not substantially alter socialization processes

already occurring.

Our findings offer important contributions to the literature on the determinants of adolescents' mental and behavioral health. We documented the associations between gun homicide incidents in adolescents' communities and their mental health and behavioral problems using a larger and more geographically diverse sample than most prior research. We also examined the associations between gun homicides occurring proximate to adolescents' homes and schools and their behavior and mental health outcomes, which prior studies have largely been unable to do. Additionally, we accounted for a multitude of individual, familial, and contextual characteristics that shape the relationship between gun homicide exposures and adolescents' outcomes. These contributions are enabled through the use of newly-available data linking geocoded gun homicides with individual-level data, one of the first large-scale datasets of its kind. Our analysis was also unique among studies in the literature on gun violence exposure for examining these associations across gender and the distance to the gun homicide incident. Prior literature largely finds gender differences in mental health responses to violence for individuals who experience assault (Breslau & Anthony, 2007; Kessler et al., 1995; Stein et al., 2000). Our findings build on this literature and suggest that we may also observe gender differences in individuals' mental health responses to local gun violence exposure, which may be more traumatizing than other forms of indirect violence exposure. By showing that gun homicides have unique associations with adolescents' mental health, we illustrate that this kind of violent crime may be an important, underappreciated ACE, even for those who have not necessarily witnessed gun homicides but who may have heard about these incidents or seen crime scenes. Such effects need to be included when considering the burden of gun violence in a community, especially because approximately 60% of children in our sample were exposed to at least one gun homicide in the prior year.

The relationships we observed are likely to have life-course implications as well. In many violent neighborhoods, children and adolescents express beliefs that they are not likely to live to adulthood, beliefs that could be exacerbated by local gun homicides and which can affect children's mental health, academic outcomes, aspirations for the future, and adult behaviors (McDade et al., 2012; Swisher & Warner, 2013). As such, our findings suggest that it is important to attend to the role of local gun homicides for shaping adolescents' short- and long-term mental health.

Limitations

Despite the importance of these findings, there are several limitations to consider. The FFCWS has a six-year gap between the Year 9 and 15 interviews. This gap misses formative years when adolescents' behavior and mental health issues may have emerged and evolved. While we accounted for Year 9 behaviors in our regressions, it would be valuable to have information about behavior and violence exposure in intervening years to better isolate the relationship between gun homicides and adolescents' outcomes.

Having additional data on prior behavior/mental health outcomes could also help illustrate how behavior and mental health evolve in the context of local environments. Behavioral problems may take years to develop and be resistant to acute changes. Further, youth exposed to gun homicides are likely to experience chronic life stressors, including possible exposure to gun homicides before our period of observation. The cortisol response to acute stress is blunted in individuals with greater early-life and lifetime stress (Bunea et al., 2017; Lam et al., 2019), which may alter the effects of acute exposure to gun homicides on youths' subsequent mental health. Thus, gun homicide occurrences may have cumulative impacts that we cannot capture here when examining homicides occurring in the last year and that may lead us to understate the relationship between gun homicide incidences and adolescents' mental health and behavior. It is also likely that at least some of our control group of adolescents who did not experience a gun homicide

in their neighborhood in the prior year were exposed to gun violence in earlier years or between the ages 9 and 15. As such, our relationships are likely to be biased towards 0.

There were also measurement limitations to some of our outcomes and covariates. For example, the behavior problem questions were parent-reported, whereas the anxiety and depression measures were youth-reported. We could observe different relationships if the behavior problem measures were also youth-generated. Additionally, it would be valuable to have tract-level crime rates to clearly assess whether instances of gun homicides or broader local crime are especially important for adolescent mental health.

Given that the FFCWS is not nationally representative and oversamples unmarried parents at the time of their children's birth, our results are largely generalizable to lower-income adolescents, particularly those born to unmarried parents, in larger cities, though married parents were sampled as well. While this is the population most likely to be exposed to gun violence, our results could be more conservative if we examined a wider range of households with more resources to cope with local gun homicides. At the same time, gun homicides may be more impactful for the mental health of adolescents from more well-resourced households who are less likely to have adapted to local violence and stressors (Lam et al., 2019). While we also estimated our models using weights to help account for the unique sampling design, the loss of statistical power from these weighted models makes us hesitant to draw conclusions from these results. The extent to which the effects of gun homicides vary across familial and neighborhood socioeconomic status is therefore an open, important question for future research. Finally, our methods were observational and the results should be interpreted as associations, not causal effects of community violence on adolescent mental health and behavior.

Conclusion

Much of the attention concerning the impact of gun homicides has, understandably, been directed towards the victims and perpetrators of gun-related incidents. Often lost from this discussion is the impact of gun homicides on community members who may hear about or witness these events and for whom gun violence may leave a lasting mark on their wellbeing. This study harnesses newly-available data on gun homicide incidents in adolescents' neighborhoods to begin to address this important gap in the literature. In doing so, we illustrate the broader societal costs associated with gun homicides for adolescents' mental health, particularly the mental health of adolescent girls. Our findings suggest that the impacts of the U.S. gun violence epidemic will be understated without acknowledging the victims who may not have visible wounds, but are hurt by the violence nonetheless.

CRedit authorship contribution statement

Christine Leibbrand: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing - review & editing. **Heather Hill:** Conceptualization, Writing - review & editing. **Ali Rowhani-Rahbar:** Conceptualization, Writing - review & editing, Funding acquisition. **Frederick Rivara:** Conceptualization, Writing - review & editing, Funding acquisition.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2020.100689>.

Appendix Table A: Mixed-effects regression model results predicting adolescent behavior problems and mental health outcomes as a function of community occurrences of gun homicides and the average distance of gun homicide incident(s)^a

	Unweighted					
	Girls			Boys		
	Behavior Problems	Anxiety	Depression	Behavior Problems	Anxiety	Depression
	<i>Average Distance of Gun Homicide Incident</i>			<i>Average Distance of Gun Homicide Incident</i>		
0 (No Gun Homicide)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1 (Gun Homicide(s) ≤0.5 Miles on Avg.)	-0.032 (0.038)	0.175** (0.054)	0.194*** (0.054)	0.041 (0.051)	0.122* (0.055)	0.088 (0.059)
2 (Gun Homicide(s) > 0.5 Miles on Avg.)	0.026 (0.034)	0.088 (0.045)	0.172*** (0.039)	-0.030 (0.040)	0.033 (0.036)	0.019 (0.049)
N	1377	1377	1377	1446	1446	1446
Weighted						
	Behavior Problems	Anxiety	Depression	Behavior Problems	Anxiety	Depression
	<i>Average Distance of Gun Homicide Incident</i>			<i>Average Distance of Gun Homicide Incident</i>		
0 (No Gun Homicide)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1 (Gun Homicide(s) ≤0.5 Miles on Avg.)	0.050 (0.145)	0.126 (0.473)	0.216 (0.387)	0.149 (0.117)	0.193 (0.119)	0.310* (0.114)
2 (Gun Homicide(s) > 0.5 Miles on Avg.)	0.041 (0.090)	0.040 (0.196)	0.153 (0.176)	0.101 (0.064)	-0.037 (0.107)	0.164** (0.057)
N	1002	1002	1002	1070	1070	1070

Source: Authors' calculations with the FFCWS Years 9 and 15 restricted data.

Standard errors in parentheses.

[^] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

^aFull suite of covariates included in the models.

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