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ABSTRACT

Objective: To examine whether at-risk male youth experience increases in anxiety, depressive symptoms, and aggression during years when they are exposed to gun violence, adjusting for relevant covariates.

Method: Participants were 1,216 male, justice-involved adolescents who were recently arrested for the first time for a moderate offense. They were interviewed 9 times over 5 years. Fixed effects (within-individual) regression models were used to estimate concurrent associations between exposure to gun violence and three outcomes: depressive symptoms, anxiety symptoms, and aggression (both overall and separately for proactive and reactive aggression). The reverse direction (anxiety, depressive symptoms, and aggression predicting gun violence exposure) was also modeled.

Results: After controlling for covariates, exposure to gun violence was significantly associated with increases in reactive aggression and, to a lesser extent, increases in proactive aggression. In addition, gun violence exposure was associated with increased anxiety but not depressive symptoms. We found no support for the reverse direction.

Conclusions: At-risk males experienced significant increases in anxiety and aggression (particularly reactive aggression) during years when they are exposed to gun violence, even after accounting for several potential confounding factors. The greater impact on reactive aggression suggests that exposure to gun violence may affect self-regulation and/or social information processing. The analyses shed light on the less-visible damage wrought by gun violence and underscore the importance of mental health screening and treatment for youth who have been exposed to violence – especially gun violence – both to assist individual youths and to disrupt cycles of violence.

Gun violence[1] is a tragic and costly public-health problem in the United States (DeLisi et al., 2010), one that disproportionately affects young men – especially young Black men living in socioeconomically disadvantaged communities (Lo et al., 2013; Papachristos et al., 2015). In 2017, over 417,000 criminal incidents involving the use of a firearm were recorded (Morgan & Truman, 2018). However, despite the prevalence of gun violence in the U.S., its psychological impact is not well-understood, particularly in the populations most likely to be exposed to it. This is in contrast to the consequences of community violence in general, which have been studied extensively (see Fowler et al., 2009). Given the prevalence of gun violence, it is critical to understand its impacts on adolescents and young adults, over and above other forms of community violence. Because of its lethality and unpredictability, it seems probable that exposure to gun violence may

have uniquely harmful psychological effects. Moreover, adolescents may be particularly vulnerable because they interact more with the community than younger children but have less developed self-regulatory capacities than adults (Heleniak et al., 2017). This report investigated whether, in a sample of youth with an elevated risk of exposure to violence, anxiety, depression, and aggression significantly increased during periods when they were exposed to gun violence.

Gun Violence Exposure During Adolescence

Studies of the prevalence of gun violence reveal the extent to which gun violence looms as a persistent threat for residents of many communities. For example, in a study of adolescents (ages 14–16) living in Chicago, IL, half of the participants had heard gunfire in the past year, 20% knew

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someone who had been shot, 11% had witnessed someone being shot at, 8% had witnessed someone being shot, and 2% had been shot at themselves (Kennedy & Ceballo, 2016). Similarly, in low income neighborhoods in New Haven, CT, 16% of young adults aged 18–34 reported being present when someone was shot at least once in their lifetime (Santilli et al., 2017).

Despite high rates of exposure to gun violence, few studies have examined the specific mental health and behavioral consequences of gun violence exposure. However, the large literature on exposure to community violence more generally suggests that it has an array of negative consequences, including mental health problems (Buka et al., 2001; Fowler et al., 2009; Gorman-Smith & Tolan, 1998; Lambert et al., 2012; Mrug & Windle, 2010) and externalizing problems (Fowler et al., 2009; Gorman-Smith et al., 2004; Gorman-Smith & Tolan, 1998; Lambert et al., 2012; Myers et al., 2018), which also includes the extensive research on the victim-offender overlap (for a review, see Berg & Mulford, 2020). Moreover, the impact is substantial: a meta-analysis of 114 studies (Fowler et al., 2009) estimated the associations between exposure to violence and internalizing symptoms ($d = .45$) and externalizing symptoms ($d = .63$) to be medium-to-strong in magnitude.

Many prior studies investigating the effects of community violence on internalizing problems have focused on symptoms of post-traumatic stress disorder (e.g., Fitzpatrick & Boldizar, 1993). Fewer have included as outcomes symptoms of depression or anxiety. Those that have yield mixed findings. Some find a significant association with depressive and/or anxiety symptoms (Gorman-Smith & Tolan, 1998; Heleniak et al., 2017; Lambert et al., 2012), even after adjustment for possible confounding variables, whereas others fail to do so (Bacchini et al., 2011; Mazza & Reynolds, 1999; Mrug & Windle, 2010). Notably, a longitudinal study by Mrug and Windle (2010) observed significant (albeit small) zero-order correlations between witnessing community violence and symptoms of both depression and anxiety; but these associations were reduced to non-significance in models that adjusted for prior risk factors and exposure to violence in other settings (home and school; Mrug & Windle, 2010).

For externalizing problems, the findings have been more consistent. For example, witnessing community violence is associated with criminal behavior in young adulthood, even after controlling for earlier delinquency (Eitle & Turner, 2002). Some research indicates that exposure to violence may affect reactive aggression (i.e., unplanned, impulsive acts in response to a real or perceived insult) more than proactive aggression (i.e., premeditated; S. Brown et al., 2017; Myers et al., 2018). It is also in line with models that

propose emotion dysregulation and cognitive biases (e.g., hostile attributions) as mechanisms linking exposure to violence with negative psychosocial outcomes (Heleniak et al., 2017; Phillips & Lochman, 2003). Taken together, prior research suggests that individuals exposed to gun violence may react by engaging in retaliatory or revenge aggression at a later time-point.

The mental health and behavioral impacts of exposure to gun violence, specifically, have received far less investigative attention. One exception is Bingenheimer et al. (2005), who found that adolescents – sampled from high crime areas of Chicago – exposed to gun violence were significantly more likely to engage in violent behavior subsequently, even after accounting for individual differences in propensity to be exposed to gun violence. Thus, exposure to gun violence may perpetuate later aggressive behavior. Unfortunately, this study did not consider mental health outcomes. However, studies of survivors of mass shootings consistently find that exposure to such events is associated with poorer mental health, especially among those with prior traumatic experiences, poorer self-regulation, and lower socioeconomic status (Lowe & Galea, 2017; Travers et al., 2018). The evidence to date, therefore, suggests that the psychological and behavioral consequences of gun violence exposure largely track with those of exposure to community violence more generally.

Several features might render gun violence more psychosocially harmful than exposure to other forms of violence. First, gun violence poses a greater mortal threat than other forms of violence. Indeed, firearm assaults are the second leading cause of death among American adolescents and the leading cause of death among Black American adolescents (Everytown for Gun Safety, 2019). Second, individuals are less able to defend themselves against gun violence than against other forms of violence. Third, gun violence may be less predictable than other forms of violence. Bullets often injure and kill individuals who are not the intended target, which means gun violence poses a threat even to members of the community who are not socially connected to the perpetrators. In short, we propose that the lethality and unpredictability of gun violence may render exposure to it uniquely harmful.

Specifically, we hypothesize that exposure to gun violence may be associated with increased violent and aggressive behavior, as well as increased anxiety and/or depression. Exposure to violence of any kind is detrimental, but we proffer that exposure gun violence makes individuals feel profoundly unsafe and will therefore have psychological and behavioral effects over and above other, experiences of adversity and trauma. Such a finding would have practical implications for methods to intervene in supportive ways and, hopefully, interfere with the perpetuation of violence among exposed youth.

In addition, to the extent that increased aggression is a response to gun violence exposure, it would be helpful to know, for both theory and practice, whether the resulting aggression is proactive or reactive.

Methodological Challenges of Studying Exposure to Gun Violence

The paucity of research on the consequences of gun violence is partly due to the challenges of studying relatively rare events. Although gun violence is far more prevalent in the U.S. than in other similarly developed countries, the base rate is still low. Witnessing a shooting is far more common than being shot (Kennedy & Ceballo, 2016; Santilli et al., 2017). One strategy for addressing the base-rate issue, is to combine different degrees of exposure (e.g., being shot *or* shot at *or* witnessing a shooting) for purposes of analysis. Of course, this comes at the cost of being able to differentiate the behavioral and psychological effects of being shot versus witnessing a shooting (Zimmerman & Posick, 2016). Another way to overcome the low base-rate problem is by using a sample of youth who have an elevated risk of exposure to gun violence (i.e., justice-system involved sample of adolescent and young adult men).

Another methodological challenge is that those exposed to gun violence also tend to be exposed to other adverse circumstances, such as poverty, food insecurity, family stress, lack of social support, environmental pollution, limited access to medical care, and non-gun-related violence (Buka et al., 2001; Finkelhor et al., 2011; Gorman-Smith & Tolan, 1998). The co-occurrence of multiple stressors makes it difficult to isolate the effects of any one form of adversity. A final challenge to studying the consequences of gun violence is the potential confounding effects of unobserved differences between individuals who are and are not exposed to gun violence (which also may be related to the outcome variables). To overcome this limitation, others have suggested using fixed effects models (Berg & Mulford, 2020) because these models can statistically account for measured and unmeasured time-invariant confounding factors.

Because we wanted to examine the unique consequences of exposure to gun violence, our models accounted for exposure to other forms of violence in each recall period, isolating the effect of gun violence exposure over and above exposure to other forms of violence (Finkelhor et al., 2011). To further isolate the associations between exposure to gun violence and our outcomes, we controlled in each model for the individual's level of the outcome at the prior interview. Third, we attempted, in our models, to rule out a host of third-variable confounds including two environmental variables (incarceration and neighborhood disorder) and

two social/behavioral variables (peer delinquency, gun carrying) (Beardslee et al., 2018; Bingenheimer et al., 2005; Carter et al., 2013; Ferguson et al., 2009; Leventhal & Brooks-Gunn, 2003; Shulman & Cauffman, 2011; Turanovic, 2019; Zimmerman & Messner, 2013, 2013). Finally, our models also accounted for bereavement (i.e., the death of someone close to the participant) because youths' experience of grief following the death of friends or family lead to elevated scores on our measured of anxiety, depression, and/or aggression (though scholars argue that grief is conceptually distinguishable from depression and PTSD; Spuij et al., 2012).

The Present Study

The primary aim of the present study was to estimate the consequences of exposure to gun violence with respect to anxiety symptoms, depression symptoms, and aggression in a sample of youth at increased risk of exposure to violence: justice-system-involved adolescent males (Braga, 2003; Sherman, 2001). Consistent with the recommendation from others (Berg & Mulford, 2020), we modeled within-person changes in the outcome variables observed at nine time points across five years, and then examined the extent to which they varied as a function of recent exposure to gun violence. By considering only within-individual fluctuations in anxiety, depression, and aggression as they relate to changes over time in exposure to gun violence, we were able to control for any unchanging characteristics of the individual (e.g., early-life adversity, family characteristics) and his environment that might be correlated with gun violence exposure and/or our outcome variables. The longitudinal study design, as well as the inclusion of several potential confounding variables (non-gun violence, incarceration, neighborhood disorder, peer delinquency, gun carrying, and bereavement), strengthens the case for inferring causality from the incremental association between gun violence exposure and our outcomes of symptoms of anxiety, symptoms of depression, and aggression.

Method

Participants

Participants were 1,216 male adolescents from the longitudinal Crossroads Study (http://sites.uci.edu/crossroadsinfo/; see 2021). Youth were eligible to participate in the Crossroads Study if they had recently been arrested for the first time for a moderate offense (i.e., misdemeanor), including vandalism (17.5%), theft (16.7%), and possession of marijuana for personal use (14.8%). In order to make the

findings more generalizable to the population of youth involved in juvenile justice systems in the United States, participants were sampled from three geographically-distinct sites: Philadelphia, Pennsylvania (N = 533); Jefferson Parish, Louisiana (N = 151); and Orange County, California (N =532). Consistent with the demographic composition of justice-system-involved youth in each jurisdiction, the sample included a disproportionate number of racial and ethnic minorities: Latino/Hispanic (46%), Black/African American (37%), White (15%), and self-identified other (2%). The sample was also of low socioeconomic status, as indicated by low rates of two-parent households (22%) and low maternal education (34% did not complete high school or the equivalent).

Procedures

The Institutional Review Boards at all three study sites approved the study procedures. Signed parental consent and youth assent were obtained before interviews were conducted with participants. Youth were informed of the nature of the study, were told there was no penalty for not participating, were told they could skip any question, and were given a detailed explanation of the Privacy Certificate obtained from the Department of Justice that protects participants' privacy by exempting both their identity and responses from subpoenas, court orders, and other types of involuntary disclosures. The youth were reminded of this certificate before sensitive and potentially incriminating questions, such as gun carrying, were asked.

Interviews with the youth ranged from 2 to 3 hours in length and were conducted using a secure, computer-assisted program. Youth completed their first interview (Time 1 or T1) after the disposition hearing for their first arrest, and were subsequently interviewed biannually for three years followed by two annual assessments (6, 12, 18, 24, 30, 36, 48, and 60 months after the T1 interview) for a total of nine waves of data. Youth were between 13 and 17 years of age (M_{age} = 15.29) at T1 and they were between 17 and 23 (M_{age} = 20.79) at the 60-month follow-up interview (T9). Retention for the eight follow up interviews was high: between 85% and 95% of the initial sample completed each of the follow up interviews. For each of the self-reported measures, we utilized a life event calendar approach to boost participant recall (Roberts & Horney, 2010). Youth were asked to report on events that occurred within the 6- or 12-month recall period (i.e., the period of time between current and previous interview; 6 months for the semi-annual assessments and 12 months for the annual assessments). Participants were financially compensated for each interview.

Measures

The models estimated included "key" variables: the predictor (gun ETV) and the outcome. In addition, seven covariates were modeled, one of which was the level of the outcome variable from the prior time point. For ease of interpretation, all continuous variables were standardized. Standardization was accomplished by using the grand mean and the average within-individual standard deviation. All dichotomous variables were coded as 0 or 1.

Key Variables

The key variables in the analyses were exposure to gun violence (the predictor of interest) and three outcome variables, modeled separately: symptoms of anxiety, symptoms of depression, and aggression.

Exposure to gun violence (Gun ETV). Four items from the self-reported Exposure to Violence inventory (ETV; Selner-O'Hagan et al., 1998) were used to measure exposure to gun violence. The selected items asked whether, during the recall period, the participant (1) was shot, (2) was shot at, (3) witnessed someone else get shot, or (4) witnessed someone else get shot at. The four items were combined to create a single binary variable indexing whether the participant was exposed to any gun-related violence during each recall period. If the participant experienced any of the four gun violence events, he received a score of 1; if he experienced none of the gun violence events, he received a score of 0.

Anxiety and depressive symptoms. Participants completed the Generalized Anxiety Disorder (GAD) and Major Depressive Disorder (MDD) subscales of the Revised Child Anxiety and Depression Scale (RCADS; Chorpita et al., 2005). The GAD subscale consists of six items that measure perseverative and general worries (e.g., *"I worry about what is going to happen."*). Youth reported the frequency with which they experienced each symptom on a scale that ranged from 0 (*Never*) to 3 (*Always*). The MMD subscale consists of ten items assessing depressive symptoms such as feelings of worthlessness, anhedonia, emptiness and sleep disturbances (e.g., *"Nothing is much fun anymore."*). Youth reported how often they experienced each item, on a scale from 0 (*"never"*) to 3 (*"always"*). Items were summed for each scale to create a total score for GAD and MMD. Scores were then standardized. Higher scores on each scale are indicative of greater symptoms. Internal consistency was high for both scales: mean α for anxiety symptoms = .84, range = .81 to .87; mean α for depressive symptoms = .85; range = .81 to .88.

Aggression. For most analyses, we used the total physical aggression subscale of The Peer Conflict Scale (PCS; Marsee et al., 2011) as our measure of aggression. The subscale comprises 20 items that assess both reactive and proactive physical aggression. Each item describes a potential behavioral response to a scenario, and youth used a 4-point response scale that ranged from 0 (*Not at all true*) to 3 (*Definitely true*) to indicate how well the response matched their typical behavioral style. Sample items for proactive physical aggression include items such as, "*I start fights to get what I want*" and "*I threaten others, even if they haven't done anything to me,*" and sample items for reactive physical aggression include items such as, "*When I am teased, I will hurt someone or break something*" and "*I threaten others when they do something wrong to me.*" Items were summed to create a total aggression score, with higher scores indicative of greater aggression, as well as separate subscales for reactive and proactive aggression. Scores were then standardized. Internal consistency for the total aggression scale was high: mean α = .88, range = .85 to .90, as well as for the proactive aggression and reactive aggression subscale (proactive aggression mean α = .79, range = .72 to .83; reactive aggression mean α = .85, range = .83 to .86).

Potential Confounds

In addition, to rule out potential confounds on the relation between gun ETV and our outcomes, our models included several covariates.

Exposure to non-gun-related violence (Non-gun ETV). Because we wanted to distinguish responses to gun violence exposure from responses to other forms of violence, we needed to adjust for youth's exposure to other forms of violence during the recall period. To do so, we used the ETV inventory (Selner-O'Hagan et al., 1998). A total of six items were used for this measure, three assessing direct non-gun-related violence ("*Been chased where you thought you might be seriously hurt,*" "*Been beaten up, mugged, or seriously threatened by another person,*" and "*Been raped, had someone attempt to rape you or been sexually attacked in some other way*") and three assessing if they had witnessed each of the three types of non-gun-related violence. A dichotomous variable was created to index whether participants experienced any non-gun related violent events during each recall period. The combined non-gun related violence variable was coded as "1" if the participant experienced any of the six items, and "0" if the participant endorsed none of the six items.

Incarceration. Because incarceration or institutionalization might affect levels of anxiety, depression, and/or aggression as well as opportunities for violence exposure, we included a binary variable that indexed whether participants were incarcerated or otherwise securely confined at all during each recall period. Any incarceration or institutionalization during the recall period resulted in a score of 1, with 0 indicating experiencing no form of secure confinement during the recall period.

Neighborhood disorder. An adapted version of the self-reported Neighborhood Conditions Measure (Sampson & Raudenbush, 1999) was used to assess participants' perceptions of the environment surrounding their home. The scale consisted of 21 items describing physical and social indicators of neighborhood disorder. The neighborhood disorder variable was calculated as the mean of the 21 items, with higher scores indicating greater neighborhood disorder (poorer conditions). Internal consistency was high: mean α = .96, range = .94 to .97.

Peer delinquency. Thirteen items from the Association with Deviant Peers scale were used to assess peer delinquency at each time point (Thornberry et al., 1994). For each of 13 illegal behaviors (e.g., stolen something worth more than 100 USD; been in a physical fight) youth were asked to report the proportion of their friends who had engaged in the behavior using a 5-point scale that ranged from 1 (*None of them*) to 5 (*All of them*). A total peer delinquency score was calculated as the mean of the 13 items, with higher scores indicating greater delinquency of the participant's peers (mean α = .91, range = .90 to .92).

Gun carrying. At each interview, a single item from the Self-Report of Offending scale (SRO; Huizinga et al., 1991) was utilized to assess whether the participant had "carried a gun" since the previous interview. This item was dichotomized to indicate whether the participant carried a gun at least once during each recall period (1 = carried a gun; 0 = did not carry a gun).

Bereavement. One binary item from the ETV inventory was used to create a variable indexing whether anyone close to the participant died during the recall period (Selner-O'Hagan et al., 1998). The bereaved item was coded as 1 if the participant experienced the death of someone close to him during the recall period and was coded as 0 if he did not.

Time-invariant "T1" Variables

For descriptive purposes, we examined the correlations between our time-varying variables and four variables assessed at the first time point (T1), see Table 2.

Plan of Analysis

Fixed effects regressions (within-individual change models) within a structural equation modeling framework were estimated to examine associations within individuals over time between variation in predictors and outcomes (Allison, 2009; Allison et al., 2017). Models were estimated in Mplus version 8 (see Figure 1 and supplemental material 2). Missing data were handled by the use of full information maximum likelihood estimation, which uses all available data to estimate model parameters. Overall goodness of fit for each model was evaluated with the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). All models fit the data well (statistics available upon request).

Examining the Relation between Gun ETV and Outcome Variables

A series of fixed effects regressions were specified to examine the covariance between exposure to gun violence during each recall period and levels of anxiety, depression, and aggression (see Figure 1 and Supplemental Material 2).

These models examined within-individual change exclusively. Thus, only factors that vary over time (e.g., exposure to gun violence, incarceration, peer delinquency) had the potential to explain variation over time in an outcome. *Unchanging* characteristics of the individual and his
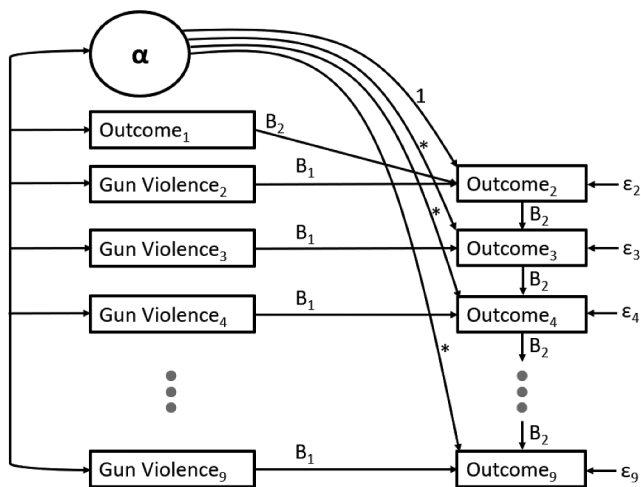

Figure 1. A simplified representation of the specification for the fixed effects models. Each outcome variable (anxiety symptoms, depressive symptoms, aggression) was modeled separately. In addition to the paths shown in figure, each model also included the following concurrent control variables: non-gun violence, incarceration, neighborhood disadvantage, peer delinquency, gun carrying, and bereavement. The nonrestrictive factor loadings between α and the outcomes at each time-point (*) indicate that time-trends in the dependent variables were freely estimated (the statistical equivalent of including a series of dummy coded variables – less one – to represent each time-point).

environment (e.g., race/ethnicity, early life experiences), which help to explain differences *between* individuals, could have no influence on the estimates in these models (Allison, 2009). In the primary models predicting anxiety, depressive symptoms, and aggression (separately), we entered independent variables in steps. Because gun ETV was consistently correlated with non-gun ETV (rs range from .27 to .37), the first step included these two predictors simultaneously, thereby estimating the unique associations between gun ETV and the outcomes, over and above any effects associated with non-gun ETV. The second step added the outcome variable at the prior time point (T-1), controlling for prior levels of the outcome variable. The third step added the remaining time-varying covariates: incarceration, neighborhood, peer delinquency, gun carrying, and bereavement. In the last step of the primary analysis, we tested the prediction that the association between gun violence and aggression would be mostly circumscribed to reactive forms of aggression. For this step, we conducted fixed effects models separately for proactive aggression and reactive aggression, controlling for all covariates form the previous models (including the lagged dependent variables).

Testing for Reverse Causality

Our study design does not conclusively rule out the possibility of reverse causation. However, we tested for evidence of reciprocal, incremental effects of anxiety, depressive symptoms, and/or aggression on gun ETV. To do so, we used fixed effects models similar to those in the main analyses, except with gun ETV as the outcome and anxiety, depressive symptoms, and aggression (modeled separately) as the predictors.

Results

Descriptive Statistics

In regard to gun violence, 7% to 13% of youth reported gun ETV during a given recall period (6 or 12 months; Table 1). Throughout the study, a total of 222 participants had exactly one recall period in which they reported exposure to gun violence, 113 had two such recall periods, and 134 had three or more recall periods in which they reported gun ETV. Four-hundred and sixty-nine participants were exposed to gun violence during at least one recall period. As expected, exposure to non-gun-related violence was more common (see Table 1).

Different patterns emerged in the means for the outcome variables over time. Anxiety symptoms followed a U-shaped pattern, depressive symptoms displayed a fairly flat pattern, and aggression peaked at T1 (soon after the arrest that made them eligible for the study)

Table 1. Descriptive statistics for unstandardized study variables.

	Time 1 N = 1,216	Time 2 N = 1,164	Time 3 N = 1,141	Time 4 N = 1,139	Time 5 N = 1,130	Time 6 N = 1,121	Time 7 N = 1,102	Time 8 N = 1,053	Time 9 N = 1026
Continuous variables[range], M/(SD)									
Anxiety symptoms [0–18]	5.25 (3.73)	4.72 (3.77)	4.65 (3.62)	4.48 (3.63)	4.46 (3.63)	4.42 (3.61)	4.29 (3.60)	4.66 (3.92)	4.75 (3.94)
Depressive symptoms [0–30]	5.80 (4.66)	5.24 (4.46)	5.34 (4.65)	5.16 (4.57)	5.09 (4.54)	5.09 (4.54)	5.09 (4.54)	5.44 (5.17)	5.44 (5.17)
Aggression [0–60]	6.88 (7.38)	5.97 (7.37)	5.48 (6.82)	4.93 (6.69)	4.38 (6.13)	4.38 (6.13)	4.38 (6.13)	3.72 (5.55)	3.72 (5.55)
Neighborhood [1–4]	2.07 (0.68)	2.02 (0.68)	2.01 (0.70)	1.98 (0.71)	1.95 (0.72)	1.95 (0.72)	1.95 (0.72)	1.98 (0.74)	1.98 (0.74)
Peer Delinquency [1–5]	1.75 (0.67)	1.66 (0.68)	1.62 (0.70)	1.57 (0.66)	1.52 (0.64)	1.52 (0.64)	1.52 (0.64)	1.51 (0.62)	1.51 (0.62)
Dichotomous variables %/N									
Gun ETV	11.68 142	12.89 150	10.78 123	9.83 112	8.15 92	7.40 83	8.34 92	10.92 115	10.23 105
Non-gun ETV	41.94 510	41.75 486	33.48 382	27.83 317	24.89 281	20.79 233	21.85 241	20.23 213	19.59 201
Incarceration	0.00 0	5.46 65	9.57 112	11.36 132	10.59 122	9.62 110	10.88 122	11.18 122	9.94 102
Bereavement	18.34 223	18.81 219	18.58 212	16.77 191	13.73 155	15.25 171	14.78 163	22.32 235	24.27 249
Gun carrying	4.36 53	5.25 61	5.17 59	3.95 45	5.23 59	4.28 48	5.44 60	6.27 66	7.50 77

Notes: ETV = exposure to violence. Gun ETV refers to exposure to gun violence; non-gun ETV refers to exposure to other forms of violence.

Table 2. Correlations among key study variables and covariates: Within-subjects correlations above the diagonal; between-subjects correlations below the diagonal.

		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Gun ETV	–	.32	.10	.14	.23	.37	.21	.09	.15	.30			
2.	Non-gun ETV	.46	–	.17	.20	.29	.21	.26	.07	.12	.39			
3.	Depressive symptoms	.16	.30	–	.67	.31	.12	.17	.09	.05	.30			
4.	Anxiety symptoms	.21	.33	.74	–	.31	.15	.17	.11	.08	.28			
5.	Aggression	.38	.42	.40	.40	–	.22	.23	.15	.09	.44			
6.	Gun carrying	.62	.39	.16	.22	.40	–	.15	.15	.08	.35			
7.	Neighborhood disorder	.34	.38	.20	.22	.29	.24	–	.14	.08	.28			
8.	Incarceration	.26	.20	.14	.15	.29	.31	.27	–	.02	.18			
9.	Bereavement	.32	.25	.10	.15	.17	.24	.15	.11	–	.11			
10.	Peer delinquency	.45	.58	.42	.38	.56	.53	.34	.30	.20	–			
11.	T1 offending	.30	.32	.27	.27	.36	.42	.18	.20	.15	.54	–		
12.	T1 ETV witness	.46	.47	.19	.24	.30	.35	.35	.16	.25	.38	.52	–	
13.	T1 ETV victim	.32	.43	.26	.28	.27	.30	.17	.08	.20	.36	.55	.59	–
14.	T1 age	−.02	.01	.03	.05	−.07	.01	−.05	−.13	−.01	.08	.20	.13	.13

Notes: Correlations in bold type are significant at $p < .001$; those that are underlined are significant at $p < .01$. ETV = exposure to violence, T1 = from initial interview, T1 offending = self-reported variety of offenses committed, T1 ETV witness = variety of violent events ever witnessed, T1 ETV victim = variety of violent victimization experiences ever. A single multilevel model was used to estimate within- and between-subjects correlations.

and declined over time. See Table 1 for additional information about variables used in the analysis. See Supplemental Material 3 for more descriptive information about the sample at Time 1.

Primary Results

The first set of fixed effects models (see Table 3) estimated the average within-subjects associations between gun ETV and non-gun ETV (separately) with each outcome, without controlling for the other potential confounding variables. In all six models, gun ETV and non-gun ETV were associated with significant elevations in anxiety, depressive symptoms, and aggression. For both gun and non-gun ETV, the coefficients were largest for

aggression, followed by anxiety symptoms, and then depressive symptoms.

Anxiety Symptoms

The second set of fixed effects models (again estimated separately for each psychological outcome) were carried out in three steps as described in the Plan of Analysis (for results, see Table 4).

On average, young men reported significantly more anxiety symptoms during recall periods when they were exposed to gun violence than when they were not exposed to gun violence, an association that remained statistically significant even after adjusting for all covariates. A similar result was obtained for non-gun ETV. In both cases, the addition of the time-

Table 3. Unconditional within-subjects effects of gun ETV and non-gun ETV (Modeled Separately) on anxiety, depression, and aggression.

	Predictor: Gun ETV			Predictor: Non-gun ETV		
Outcome	B	95% CI	p	B	95% CI	p
Anxiety symptoms	0.32	[0.23, 0.04]	<.001	0.24	[0.19, 0.30]	<.001
Depressive symptoms	0.20	[0.11, 0.28]	.002	0.21	[0.15, 0.26]	<.001
Aggression	0.47	[0.39, 0.54]	<.001	0.37	[0.32, 0.42]	<.001

Note: Gun ETV refers to exposure to gun violence; non-gun ETV refers to exposure to other forms of violence. Models present concurrent associations between gun and non-gun ETV and the outcomes. All outcome variables (anxiety symptoms, depressive symptoms, and aggression) were standardized using the overall mean and the average within-individual standard deviation. All models also controlled for time with dummy-coded time variables, centered at T1.

varying covariates in Step 3 reduced the magnitude of the gun and non-gun ETV regression coefficients (almost by half), though they remained significant.

Depressive Symptoms

Gun ETV was associated with increased depressive symptoms in Steps 1 and 2, however, this association was reduced to non-significance in Step 3, when additional covariates were added (see Model 3; Table 4). In contrast, non-gun ETV was associated with significant increases in depressive symptoms even after adjusting for all time-varying covariates (see Model 3; Table 4).

Aggression

Aggression was a relatively strong correlate of both gun ETV and non-gun ETV. The results from Models 2 and 3 in Table 4 indicate that, in recall periods when a young man experienced gun violence, his level of aggression increased (compared to his own average for other recall periods) by between .24 (Model 3) and .38 (Model 2) standard deviations, even after accounting for exposure to other forms of violence. The corresponding estimates for the increase in aggression associated with non-gun ETV were .19 (Model 3) and .30 (Model 2) standard deviations.

To better understand the nature of the relation between ETV and aggression, additional analysis were run with proactive and reactive aggression modeled separately. These models were identical to Model 3 in Table 4, except that reactive and proactive aggression were used as the outcomes. Results indicated that gun ETV and non-gun ETV were both significantly associated with proactive aggression as well as with reactive aggression (See Table 5). We further probed these findings by simultaneously estimating the impact of the predictors (e.g., gun ETV, non-gun ETV, all control variables) on proactive and reactive aggression to determine whether gun ETV (or non-gun ETV) had a stronger impact on proactive or reactive aggression. For these models, we used a χ^2 difference test that

Table 4. Models estimating the within-person effect of gun and non-gun ETV on symptoms of anxiety, depression, and aggression.

	Model 1			Model 2			Model 3		
	B	95% CI	p	B	95% CI	p	B	95% CI	p
Anxiety Symptoms									
Gun ETV	0.26	[0.16, 0.33]	<.001	0.23	[0.13, 0.32]	<.001	0.12	[0.01, 0.21]	.016
Non-gun ETV	0.20	[0.15, 0.27]	<.001	0.22	[0.17, 0.29]	<.001	0.14	[0.08, 0.21]	<.001
Prior anxiety				0.17	[0.15, 0.20]	<.001	0.16	[0.14, 0.19]	<.001
Incarceration							0.18	[0.08, 0.26]	<.001
Neighborhood							0.08	[0.06, 0.11]	<.001
Peer delinquency							0.09	[0.06, 0.11]	<.001
Gun carrying							0.21	[0.08, 0.34]	.002
Bereavement							0.05	[−0.01, 0.12]	.168
Depressive Symptoms									
Gun ETV	0.14	[0.05, 0.23]	.001	0.10	[0.01, 0.19]	.034	0.00	[−0.1, 0.09]	.951
Non-gun ETV	0.19	[0.13, 0.24]	<.001	0.18	[0.11, 0.24]	<.001	0.10	[0.04, 0.17]	.002
Prior depressive symptoms				0.17	[0.14, 0.19]	<.001	0.16	[0.13, 0.18]	<.001
Incarceration							0.08	[−0.02, 0.18]	.106
Neighborhood							0.08	[0.05, 0.1]	<.001
Peer delinquency							0.07	[0.05, 0.1]	<.001
Gun carrying							0.24	[0.11, 0.37]	<.001
Bereavement							0.03	[−0.04, 0.09]	.382
Aggression									
Gun ETV	0.37	[0.29, 0.45]	<.001	0.38	[0.29, 0.47]	<.001	0.24	[0.15, 0.32]	<.001
Non-gun ETV	0.32	[0.26, 0.37]	<.001	0.30	[0.24, 0.36]	<.001	0.19	[0.13, 0.25]	<.001
Prior aggression				0.20	[0.18, 0.23]	<.001	0.18	[0.16, 0.2]	<.001
Incarceration							0.12	[0.04, 0.21]	.006
Neighborhood							0.05	[0.03, 0.07]	<.001
Peer delinquency							0.17	[0.14, 0.19]	<.001
Gun carrying							0.15	[0.03, 0.26]	.015
Bereavement							0.09	[0.03, 0.15]	.003

Note: Gun ETV refers to exposure to gun violence; non-gun ETV refers to exposure to other forms of violence. All predictor variables were concurrent with outcomes except the lagged dependent variables. All outcome variables (anxiety, depression, and aggression) and continuous predictors (peer delinquency, neighborhood) were standardized using the overall mean and the average within-individual standard deviation. All models controlled for time with dummy-coded time variables, centered at T1.

Table 5. Fully adjusted models estimating the within-person effect of gun and non-gun ETV on symptoms of proactive aggression and reactive aggression.

	B	95% CI	p
Proactive Aggression			
Gun ETV	0.09	[0.00, 0.18]	.041
Non-gun ETV	0.11	[0.04, 0.17]	.001
Prior proactive aggression	0.18	[0.15, 0.20]	<.001
Incarceration	0.15	[0.06, 0.24]	.001
Neighborhood	0.04	[0.02, 0.06]	<.001
Peer delinquency	0.12	[0.10, 0.15]	<.001
Gun carrying	0.05	[−0.07, 0.17]	.395
Bereavement	0.05	[−0.01, 0.11]	.082
Reactive Aggression			
Gun ETV	0.27	[0.18, 0.36]	<.001
Non-gun ETV	0.20	[0.14, 0.26]	<.001
Prior reactive aggression	0.16	[0.13, 0.18]	<.001
Incarceration	0.08	[−0.01, 0.17]	.077
Neighborhood	0.05	[0.03, 0.07]	<.001
Peer delinquency	0.16	[0.14, 0.19]	<.001
Gun carrying	0.16	[0.04, 0.28]	.008
Bereavement	0.09	[0.03, 0.15]	.003

Note: Gun ETV refers to exposure to gun violence; non-gun ETV refers to exposure to other forms of violence. All predictor variables were concurrent with outcomes except the lagged dependent variables. All outcome variables (anxiety, depression, and aggression) and continuous predictors (peer delinquency, neighborhood) were standardized using the overall mean and the average within-individual standard deviation. All models controlled for time with dummy-coded time variables, centered at T1.

compared a freely estimated model to a model where the coefficients for gun ETV were constrained to be equal for proactive aggression and reactive aggression. We also examined a χ^2 difference test that compared a freely estimated model to a model where the coefficients for non-gun ETV were constrained to be equal for proactive aggression and reactive aggression. The χ^2 difference test for gun ETV was significant, suggesting that the magnitude of the coefficient for gun ETV was significantly stronger when predicting reactive aggression than when predicting proactive aggression ($\Delta \chi^2 = 18.37$, $\Delta df = 1$, $p < .001$). Similarly, the χ^2 difference test for non-gun ETV was also significant, suggesting that the association between non-gun ETV and reactive aggression was stronger than the association between non-gun ETV and proactive aggression ($\Delta \chi^2 = 7.21$, $\Delta df = 1$, $p = .007$).

Reciprocal Effects Models

To test for the possibility of reverse causality, models were re-run with gun ETV as the outcome and with anxiety, depression, and aggression as predictors. Consistent with the primary models, gun ETV from the prior time point was included as a covariate in each model. Thus, these models examined the incremental effects of anxiety, depression and aggression on exposure to gun violence, over and above prior gun ETV and the other covariates. In each model, the reciprocal effect of the focal predictor variable was non-significant (see Supplemental Table 1). Thus, these models yielded no evidence that heightened anxiety,

depressive symptoms, or aggression increased the chances of exposure to gun violence within a given recall period.

Discussion

Gun violence is an epidemic in the United States, one that disproportionately affects disadvantaged, under-resourced communities (Lo et al., 2013; Papachristos et al., 2015). Although the consequences of community violence has been studied extensively in prior work (e.g., Fowler et al., 2009), the psychological and behavioral ramifications of gun violence for individuals living in these communities has not received sufficient attention. The present analysis helps address this gap by characterizing some of the detrimental consequences of gun violence in a sample of at-risk youth followed for five years. Our findings indicate that, after adjusting for experiencing other forms of violence, exposure to gun violence is associated with increased levels of aggression, anxiety symptoms, and – to a lesser extent – depressive symptoms. With respect to aggression and anxiety, but not depressive symptoms, the findings hold even after adjusting for numerous potential confounds.

The finding that exposure to gun violence is associated with increased anxiety and aggression is consistent with prior research on the effects of exposure to neighborhood or community violence more generally (Fowler et al., 2009; Gorman-Smith et al., 2004; Gorman-Smith & Tolan, 1998; Lambert et al., 2012; Mrug & Windle, 2010; Myers et al., 2018). It is noteworthy that exposure to gun violence appears to be uniquely related to anxiety and aggression, over and above the effects of exposure to other forms of violence as well as additional factors that impact upon well-being and behavior, such as incarceration, neighborhood disorder, peer delinquency, gun carrying, and bereavement. In fact, aggression was about .24 standard deviations higher during periods when the young men were exposed to gun violence compared to periods during which they did not experience gun violence; and further analysis suggested that this was mostly driven by increases in reactive (as opposed to proactive) aggression.

The greater impact on reactive, compared to proactive, aggression is consistent with prior work with justice-system-involved and college samples (S. Brown et al., 2017; Myers et al., 2018). ETV may interfere with emotional regulation (Herts et al., 2012) and may increase the tendency to perceive ambiguous social interactions as hostile in intent (Dodge et al., 2003; Guerra et al., 2003), both of which are associated with reactive aggression (Phillips & Lochman, 2003). Further, ETV increases youths' fears of injury and of "the unknown" (Cooley-Quille et al., 2001). In short, adolescents may react to violence exposure by being more "on edge" and poised to fight. Heightened reactive aggression places a youth at greater risk of further exposure to violence

and/or trauma (Carliner et al., 2017; Odgers et al., 2008), as well as potential legal consequences if they do react aggressively and engage in violence.

Also consistent with our hypotheses, gun violence exposure was associated with heightened symptoms of anxiety, though the magnitude of this association was substantially smaller than that of gun violence on aggression. The similarity in the magnitudes of the adjusted effects of gun and non-gun ETV on anxiety could be construed as contradictory to our prediction that gun violence would be particularly anxiety-provoking due to its potentially lethal and unpredictable nature. Still, our models indicate that exposure to gun violence does elevate anxiety symptoms, independent of other factors.

Our failure to find unique associations between gun violence exposure and depressive symptoms in the fully adjusted models is consistent with the mixed findings in the literature on exposure to violence (Fowler et al., 2009). It may be that the inconsistent findings in the literature are due to differences across studies in the covariates considered. After all, we did find significant bivariate associations, but these did not survive adjustment for covariates – consistent with other prior work in this area (Bacchini et al., 2011; Mazza & Reynolds, 1999; Mrug & Windle, 2010).

The literature on exposure to violence already provides persuasive evidence of a range of negative effects including poorer mental health, social relations, and academic outcomes, as well as increased likelihood of perpetrating crime (Margolin & Gordis, 2000; Odgers et al., 2008). Our results provide support for this pattern, whereby youths' responses to violence exposure place them at increased risk of further victimization and/or perpetration of violence. Our reverse causality model found no evidence that increased aggression in a given recall period heightened the risk of gun violence exposure in that same period; however we did observe that gun violence exposure was substantially correlated within individuals with a greater likelihood of gun carrying ($r = .37$) and greater peer delinquency ($r = .30$) at that time point. These correlations were even stronger between individuals. That, is, across the whole study, youth who reported more exposure to gun violence also reported more gun carrying ($r = .62$) and more delinquent peers ($r = .45$). Taken together with the evidence that gun violence exposure is associated with increased reactive aggression, these results are consistent with the notion that gun violence begets more violence.

Limitations

While our longitudinal design provided an advance over many past cross-sectional studies, conclusions about causality cannot be made. However, the reverse-causality

models found no evidence that anxiety, depression, or aggression lead to gun violence exposure. However, lack of evidence for reciprocal effects is not proof that they do not exist, particularly given that externalizing symptoms have been found to be associated with ETV in other studies (Foster & Brooks-Gunn, 2009).

Another key limitation is that we do not know whether the patterns observed generalize beyond our sample of young, at-risk males involved with the justice system. For instance, some research suggests that girls and women are more likely to experience internalizing symptoms or post-traumatic stress disorder in connection to violence exposure than are boys and men (Giaconia et al., 1995; Moses, 1999; Pastore et al., 1996). Another limitation is that, despite the advantages of using a within-person analysis to isolate the impact of gun violence exposure on mental health, there are still limitations in how well this controls for preexisting factors. Whereas we are able to rule out the possibility that changes in mental health status are attributable to chronic factors that co-occur with increased risk of ETV, we are unable to affirm that heightened levels of anxiety and aggression in periods in which participants experienced gun violence were in fact precipitated by the exposure itself and not by other, unmeasured, time-varying factors that co-varied with these events. Inclusion in our models of time-varying covariates such as imprisonment, neighborhood disorder, peer delinquency, gun carrying, and death of a close associate helps to rule out some, but not all, potential confounds. Nonetheless, this limitation means that we must exercise caution in drawing causal inferences.

Furthermore, our analyses did not consider moderating factors, such as family environment, social support, and coping skills, that might mitigate or exacerbate the mental health consequences of experiencing violence (Foster & Brooks-Gunn, 2009). In addition, all of the constructs in the present study were obtained via youth self-report, and this shared method variance could have inflated the parameter estimates in the models.

Finally, by combining different degrees of exposure (being the target or victim of an attack versus a witness), we afforded our analysis more statistical power but at the cost of characterizing the differential effects of various forms of exposure. There is reason to suspect that the effects of being shot might be greater than those of being targeted or witnessing a shooting (Lowe & Galea, 2017; Montgomerie et al., 2015), but we lacked the statistical power to address these questions.

Clinical Significance

In addition to these methodological limitations, it is also important to consider the limitations inherent to within-

individual models with respect to interpreting effect sizes, which bear on clinical significance. For example, Model 2 in Table 4 shows that, after adjusting for prior levels of the outcome and exposure to non-gun-related violence, participants reported levels of anxiety that were, on average, .22 standard deviations greater for interviews in which they reported gun ETV than for interviews in which they did not experience gun-ETV. For aggression, the corresponding coefficient indicated that participants reported, on average, .38 standard deviations more aggression at times when they were exposed to gun violence than at times when they were not. However, interpretation of these magnitudes is not straightforward. The "standard deviation" units are the average within-individual SD across the nine time points. Consequently, they cannot be directly interpreted with respect to the original metrics of the anxiety and aggression scales.

On the other hand, this method of standardization provides estimates of effect size and facilitates interpretation of the relative effects of ETV on the three outcomes. However, the associations between gun ETV and anxiety and aggression are meaningful. First, this effect is found for a risk factor that occurs at a very low base rate (i.e., most adolescents in the sample were exposed to between 1 and 4 instances of gun violence), which often decreases the precision of the estimate because of the inflated standard errors associated with low base rate variables. Second, despite this low base rate, this effect size is similar to other single risk factors for aggression mental health problems in adolescents. For example, in our models the effect sizes for exposure to gun violence tended to be as large or larger than the effect sizes for exposure to non-gun related violence. Thus, these findings suggest that any single risk factor is not likely to produce very large effect sizes and that explaining and intervening to reduce gun violence likely requires a focus on multiple risk factors. Third, the increase in risk for anxiety and aggression attributable to exposure to gun violence remained, even when controlling for other risk factors, including exposure to non-gun related violence. These finding suggest that if the effects of gun violence exposure on youths' adjustment are not considered in interventions, they are not likely to be reduced.

As a result, we would argue that our findings point to the need to direct more resources toward youth involved with the justice system, particularly to provide trauma-informed interventions that could interrupt the pathway from violence exposure to violence perpetration (Butler et al., 2011; Reeves, 2015). One way this could be implemented would be to better fund mental health screening and treatment programs for youth who are involved in the justice system. Also, hospitals could implement routine mental health screenings and referrals to youth treated for gun-related or other traumatic injuries (Raja et al., 2015). Similarly, schools could play a pivotal role in preventing serious mental health problems by periodically screening youth for violence exposure and providing services or referrals when warranted (Ridgard et al., 2015). Screeners for violence should specifically inquire about gun violence exposure. Further, in light of evidence that legal authorities can disrupt the cycle of violence for youthful offenders (C. Brown et al., 2019), enhancing trust in legal authority, such as law enforcement, may be paramount in reducing the link between violence exposure and physical aggression. All these solutions, however, require that resources be funneled to the communities where gun violence and other traumatic experiences occur at relatively high rates. Finally, another recommendation based on our findings would be to implement laws and policies that more effectively limit youths' access to guns (Keil et al., 2020; Ngo et al., 2019). Strengthening and expanding background checks for gun sales and allocating more police resources to preventing gun trafficking would likely reduce gun violence and therefore youths' exposure to it.

Conclusion

The present report sheds light on the less-visible damage wrought by gun violence – heightened anxiety and aggression among those exposed. Youth in the justice system are disproportionately likely to have a history of violence exposure. Unfortunately, they are also disproportionately likely to have little or no access to mental health resources outside of the justice system. Consequently, the justice system is uniquely positioned to provide essential mental health services to this underserved population. Doing so has the potential not only to bolster the well-being of youth, but also to reduce recidivism by disrupting cycles of violence. Furthermore, to the extent that these findings extend to youth not involved in the justice system, the results strengthen the argument for policy makers to advocate for stronger gun laws and prioritize the provision of mental health services to youth in communities with high rates of violent crime.

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