

# The consequences of community exposure to firearm homicide for adolescent substance use<sup>☆</sup>

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## ARTICLE INFO

### Keywords:

Adolescent health  
Community violence  
Firearm violence  
Neighborhood disadvantage  
Race and ethnicity  
Substance use

## ABSTRACT

In areas with high levels of violence, not just the individuals involved but entire communities experience harm. Acts of violence in the community that a young person did not witness or experience directly can still have consequences for their health behaviors. Using survey data from the Future of Families and Child Wellbeing Study merged with the Gun Violence Archive ( $N = 3042$ ), we investigate associations between community exposure to firearm homicide and adolescent substance use. Results indicate that exposure to a local firearm homicide in the past 180 days is associated with 1.56 higher odds of adolescent marijuana use, and exposure to multiple incidents nearly doubles the odds of use. There is no significant association between exposure and either alcohol or cigarette use. Moderation analyses show a positive association between firearm homicide exposure and marijuana use among Black and low-income adolescents and adolescents living in disadvantaged neighborhoods. These results suggest that health and healing-centered prevention and intervention strategies aimed at reducing exposure to firearm violence and mitigating subsequent harm, including substance use, are particularly important for those most impacted by co-occurring stressors linked to structural disadvantage.

## 1. Introduction

Adolescents (ages 10–19) in the United States (US) experience high rates of violence exposure, including victimization and witnessed violence in their homes and communities (Finkelhor et al., 2015). Studies have shown that violence exposure contributes to the development of poor health and health behaviors among adolescents, including mental health challenges, externalizing behaviors, and substance use (Lynch, 2003). Evidence linking exposure to violence with detrimental health outcomes has understandably emphasized violence that is witnessed or personally experienced. To be sure, the impacts of violence tend to be felt most strongly by direct victims and their families, but the conceptualization and consequences of exposure to violence—particularly that which occurs in public spaces and in the context of daily life—do not stop there. Acts of violence in the community that a young person did not witness or experience personally can still have

consequential impacts on their health and wellbeing via changes in the social, physical, and economic environments in which they live, learn, and grow. There is mounting evidence that in places with high levels of violence, entire communities can experience the ripple effects of violence and harm (Pinderhughes et al., 2015; Sharkey, 2018).

Adopting this broader perspective on “community exposure to violence,” this study investigates the impact of arguably the most severe form of violence: lethal interpersonal violence involving firearms. Specifically, we investigate the association between community exposure to firearm homicide and adolescent substance use, which is a risk factor for future violence involvement and other health and social problems during the transition to adulthood and beyond (Meier et al., 2012; Tapert et al., 2001; Volkow et al., 2014). Adolescents may turn to substance use as a strategy for coping with the aftermath of violent incidents in their communities and/or the strain that violence places on family and community resources, relationships, and connections (Simantov et al.,

<sup>☆</sup> All procedures were performed in compliance with relevant laws and institutional guidelines. This research was deemed exempt from human subjects review by the Institutional Review Boards at Gonzaga University and the University of California Davis because only secondary, deidentified data were used.

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<https://doi.org/10.1016/j.ssmph.2025.101799>

Received 28 January 2025; Received in revised form 17 March 2025; Accepted 3 April 2025

Available online 4 April 2025

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2000).

The current study extends our understanding of exposure to violence and its implications for adolescent health and wellbeing by examining two research questions. First, is community exposure to firearm homicide associated with adolescent marijuana, alcohol, or cigarette use? Second, is there variation across subgroups of adolescents in the association between community exposure to firearm homicide and adolescent substance use? To examine these questions, we use data from the Future of Families and Child Wellbeing Study (FFCWS), a longitudinal cohort study of children born primarily to parents with low incomes and living in urban areas, which has been linked to the Gun Violence Archive (GVA), an open-source database of incidents of firearm violence in the US. The GVA's fine-grained (temporally and spatially resolved) statistics provide objective measures of firearm homicide exposure and thus opportunities to examine the consequences of a broader spectrum of exposure. The rich, longitudinal data in the FFCWS allow for the inclusion of comprehensive individual, familial, and neighborhood characteristics that likely contribute to systematic differences in adolescents' risk of community exposure to firearm homicide. This is important because firearm violence exposure is not randomly distributed across the population; rather, patterns of exposure reflect macro-level social, economic, and political decisions that produce inequitable access to resources, opportunities, and wellbeing (Sampson et al., 2005), with low-income Black and Latinx youth disproportionately residing in communities that experience conditions associated with violence (James et al., 2021; Kravitz-Wirtz et al., 2022). We consider whether factors that shape adolescents' risk of community exposure to firearm homicide also shape the impacts of such exposure. A better understanding of the extent of, and factors associated with, differential vulnerability or resilience to community exposure to firearm violence can help inform more precise strategies for preventing subsequent firearm violence-related harm, including unhealthy substance use behavior.

### 1.1. Adolescent substance use and exposure to violence

Substance use among adolescents is widespread. The 2019 Youth Risk Behavior Survey found that 29 % of high school students had used alcohol in the past 30 days, while 22 % had used marijuana, and 6 % had used cigarettes (Creamer et al., 2020; Jones et al., 2020). Adolescents report using substances because it is "fun" and because it helps them relieve stress and temporarily forget their problems (Harrison et al., 1997; Simantov et al., 2000). At the same time, substance use poses both short- and long-term risks to health and wellbeing. Adolescence is a time of significant brain development, making the adolescent brain particularly vulnerable to the toxic effects of substances (Meier et al., 2012). Additionally, substance use often co-occurs with other health-risk behaviors, such as unprotected sex, dangerous driving, and violence involvement (Schulte & Hser, 2013). One study found that alcohol use in adolescence was associated with 1.44 greater odds of violent behavior (e.g., physical assault) in young adulthood (Maldonado-Molina et al., 2011); another showed that alcohol use before age 13 doubled the odds of carrying a weapon among 14-18-year-olds (Baiden et al., 2021). Over the long-term, substance use in adolescence can also increase the chances of continued use and problematic use in adulthood (Chambers et al., 2003; SAMHSA, 2010), as well as medical conditions, such as high blood pressure, that have been linked to adult substance misuse (Schulte & Hser, 2013).

A large body of research has sought to identify factors that heighten the risk of substance use in adolescence. Those highlighting violence exposure have focused mainly on primary exposure (i.e., victimization) and secondary exposure (i.e., witnessed violence) (Buka et al., 2001), with a growing number of studies emphasizing primary and secondary exposure that occurs in the community (i.e., outside adolescents' homes). This research demonstrates that adolescents who have been victimized in their neighborhoods (e.g., chased, attacked with a weapon,

shot at) are at greater risk of substance use than their comparable peers (Pinchevsky et al., 2014). There is also evidence that witnessing violence, specifically seeing someone shot or stabbed (Schwab-Stone et al., 1995), is predictive of marijuana and alcohol use (Kilpatrick et al., 2000; Pinchevsky et al., 2014; Schwab-Stone et al., 1995; Sullivan et al., 2004). Fewer studies have examined the association between violence exposure and cigarette use (independent of other substances); although one study of rural adolescents showed that witnessing violence inflicted on a stranger was associated with the initiation of cigarette use (Sullivan et al., 2004).

Although several studies suggest that adolescents use substances in response to violence experienced or witnessed firsthand, the consequences of broader community exposure for adolescent substance use remains underexplored. It is well accepted that individual behavior is tied to the broader social environment in which individuals are embedded. The social ecological model views individuals in the context of interrelated social environments or ecological systems, including families, peer groups, neighborhoods, communities, and institutions, and contends that individuals cannot be studied without consideration of these multiple ecological systems (Bronfenbrenner, 1977). Decades of research bear out this claim, showing that not only proximal environments (e.g., families, peer groups) but also more distal environments (e.g., neighborhoods, communities) play an important role in young people's health and development (Brooks-Gunn et al., 1993; Ross & Mirowsky, 2009). Building on research emphasizing the importance of neighborhoods and communities, scholars have argued for an expanded empirical focus when studying violence exposure—a focus that extends beyond direct victimization and witnessing of violence to include violence in individuals' residential environments, regardless of whether an individual is personally involved or hears or sees the violence firsthand (Pinderhughes et al., 2015; Sharkey, 2018). In the context of the current study, which examines deadly firearm violence, we term this type of exposure: "community exposure to firearm homicide." The neighborhood and community settings in which youth are embedded may be particularly salient during adolescence when youth gain independence and spend more time in this broader social environment (e.g., school, work, peer groups) (Brooks-Gunn et al., 1993).

Community exposure to violence may influence adolescent substance use through multiple pathways, including their perceptions of community safety and stability. Adolescents living in places impacted by violence may perceive their communities as unsafe, which can increase psychological distress, hyperarousal and hypervigilance and the use of substances as a coping mechanism (Schwab-Stone et al., 1995; Smith et al., 2019). Living every day with the threat of violence can also lead to feelings of mistrust and powerlessness that diminish mental health (Ross & Mirowsky, 2009). More broadly, community violence can alter the ways in which residents (youth and adults alike) selectively engage with (or disengage from) others living in the neighborhood and community activities (McCoy & Bowen, 2015); this disengagement can weaken social ties, increase anomie, and lessen adult monitoring of youth behavior. Acts of violence in the community can also have consequential impacts on physical and economic environments in the immediate and long-term—e.g., greater police presence in the neighborhood, metal detectors at schools, shuttered businesses and other disinvestments in the local economy (Pinderhughes et al., 2015; Sharkey, 2018). Such environmental changes can diminish the availability and adequacy of community resources, reduce economic opportunities for youth and their families, and lead to feelings of being "over-policed and under-protected" (Phelps et al., 2020), all of which can increase the risk of poor mental health and substance use (Arkes, 2007; Esposito et al., 2021).

### 1.2. Variation across subgroups

Social-structural inequalities shaping where people live, as well as resultant access to resources and opportunities, thrust the greatest burden of violence onto low-income communities of color and the youth

living in those communities (Benms et al., 2020; James et al., 2021; Kravitz-Wirtz et al., 2022; Poulson et al., 2021). We posit that the consequences of adolescents' community exposure to firearm homicide may be contingent upon those same social-structural factors that shape their risk of exposure in the first place. Thus, we consider whether and how social advantage/disadvantage associated with race/ethnicity, household income, and neighborhood conditions shape the consequences of such exposure (James et al., 2021; Kravitz-Wirtz et al., 2022).

It is unclear how the impacts of community exposure to firearm homicide on substance use might differ for adolescents with varying levels of risk of exposure. Stressful exposures can be conceptualized across several dimensions, including the degree to which the stressor is acute or chronic and whether it is unanticipated or expected (Keyes et al., 2011). On the one hand, for adolescents with, on average, low risk of exposure (e.g., White adolescents, adolescents living in households with above-poverty incomes, adolescents living in low disadvantage neighborhoods), an incident of local firearm violence may have an especially strong influence on their substance use behaviors because of its acute and unexpected nature and the distinct influence this "unique" event has on the social and physical conditions in their neighborhood, at home, and at school. On the other hand, for adolescents with, on average, high risk of exposure (e.g., Black and Latinx adolescents, adolescents living in households with below-poverty incomes, adolescents living in high disadvantage neighborhoods), local firearm violence may be chronic and contribute to an accumulation of multiple co-occurring disadvantages that place them at increased risk for possible adverse outcomes, such as substance use (Denise, 2014; Jackson & Knight, 2006).

There is evidence to support the notion that co-occurring disadvantages elevate adolescents' risk of substance use. Buggs and colleagues (2022) found that community exposure to firearm homicide was associated with depression among Black adolescents from marginalized and underserved communities. Additionally, Fagan and colleagues (2014) found that the association between violent victimization and marijuana use was stronger for young people living in neighborhoods with higher levels of disadvantage, where risk of exposure to violence was high. Despite this evidence, other studies suggest that adolescents living in communities where violence is chronic can become desensitized to that violence, as indicated by lower baseline heart rates and lower than expected internalizing symptoms among adolescents exposed to high levels of community violence (Cooley-Quille et al., 2001; Gaylord-Harden et al., 2011). Mixed evidence regarding the impact of violence exposure points to a need for additional research examining not only the average effects of broader conceptualizations of violence exposure but also variation in the impact of community firearm violence on substance use behavior.

## 2. Materials and methods

### 2.1. Data

To investigate how community exposure to firearm homicide is associated with adolescent substance use, we use data from the FFCWS and GVA. The FFCWS is a birth cohort study following 4898 children born between 1998 and 2000 and sampled from hospitals in 20 US cities with populations over 200,000 (Reichman et al., 2001). Surveys were conducted when the children were born and around ages 1, 3, 5, 9, and 15. Year 15 (conducted between 2014 and 2017) serves as the primary data source for this analysis. Of the baseline sample 70 % of children responded to the Year 15 survey ( $n = 3444$ ). The GVA is a national database of incidents of firearm violence for years 2014 through the present. Incidents are identified by professional staff through automated

and manual research through over 7500 sources from law enforcement, media, and government. The GVA data were linked to the FFCWS based on the dates of children's Year 15 surveys and the latitude and longitude coordinates of both homes and schools,<sup>1</sup> providing information regarding the recency (up to 1 year before) and distance (up to 1 mile away) from a firearm homicide incident for each location. The GVA collects information on multiple forms of fatal and nonfatal firearm violence, but only fatal incidents (excluding incidents that involved only suicide)<sup>2</sup> were linked with the FFCWS.

The merged data present a unique opportunity to study adolescents' firearm homicide exposure. In addition to the comprehensive suite of individual-, family-, and neighborhood-level health and social indicators from the FFCWS, the GVA provides objective measures of adolescents' exposure to firearm homicide. Although adolescent's self-reports of community firearm violence represent their direct experiences with victimization or witnessing, they also have the potential to be endogenous to the negative psychological effects of exposure (McCoy, 2013). The FFCWS sample provides an additional advantage; it contains an oversample of unmarried parents (75 % unmarried, 25 % married) and thus an overrepresentation of low-income, Black, and Hispanic/Latinx children, which allows us to document the impact of community exposure to firearm homicide among highly vulnerable groups. Moreover, adolescents in the study who were not exposed to firearm homicide serve as a valuable comparison group because they too are socioeconomically disadvantaged relative to the US population and therefore at heightened risk of exposure even if they have not, in actuality, experienced firearm homicide in their communities.

The analytic sample for our study included 3042 of the 3444 adolescents who participated in the Year 15 survey. We excluded 402 adolescents missing information for key covariates (e.g., externalizing and internalizing behaviors) or substance use.<sup>3</sup> We retained all other observations by producing 30 imputed data sets with multiple imputation by chained equations (White et al., 2009) using the `-mi` impute-command in Stata 17. Prior to imputation, 27 % of adolescents were missing information for at least one variable included in our analyses. Nonetheless, each variable was missing information for 5 % or less of the sample, except for the multi-item scales for externalizing and internalizing behaviors (8 % and 10 % missing, respectively).<sup>4</sup>

### 2.2. Measures

**Outcomes.** Adolescent substance use was assessed with a series of questions asking adolescents to report how often they had used marijuana, alcohol, and cigarettes in the past 30 days. From these survey items we constructed three dichotomous measures: any marijuana use, any alcohol use, and any cigarette use (all coded 0 = no, 1 = yes).

**Exposure.** We combined data regarding homicide exposure near adolescents' homes and schools to create two measures of community exposure to firearm homicide: any exposure (dichotomous) and intensity of exposure (or dose; categorical: 0, 1, 2+), both of which measure firearm homicide incidents that occurred within 600 m of

<sup>1</sup> The data was linked by FFCWS staff and is available through a restricted use data contract with FFCWS.

<sup>2</sup> We refer to fatal firearm violence incidents as firearm homicide incidents. However, fatal incidents linked to the FFCWS may include unintentional and undetermined firearm deaths, which nationally, made up approximately 2.1 % of annual deaths from firearms, on average, during the Year 15 data collection period, 2014–2017 (Centers for Disease Control and Prevention, 2021).

<sup>3</sup> This includes 15 adolescents whose primary caregiver did not participate in the Year 15 survey and were therefore missing important family-level information, 355 adolescents whose primary caregiver did not submit the assessment of children's externalizing and internalizing behaviors, and 32 adolescents who were missing information regarding substance use.

<sup>4</sup> We considered externalizing or internalizing behaviors to be missing if any item on the corresponding behavior questionnaire was skipped.

either home or school addresses within the past 180 days. We chose 600 m to approximate the radius of a typical census block group (median = 620 m) (Donaldson, 2013) and the 180-day temporal buffer because of missing information for longer time frames.<sup>5</sup>

**Covariates.** Covariates were carefully selected based on their potential associations with the exposure and/or outcomes, based on theory and prior research. To account specifically for selection into exposure, we chose variables measured prior to exposure (primarily at Year 9, the most immediate prior survey) or variables considered stable characteristics (e.g., impulsivity). Individual-level covariates included adolescents' self-reported race/ethnicity, a FFCWS-constructed variable coded according to Census-recognized categories and collapsed to maximize within-group sample sizes (*White, non-Hispanic; Black, non-Hispanic; Hispanic/Latinx; Other, non-Hispanic*, which includes American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, and multi-racial). We also included gender ( $0 = \text{boy}$ ,  $1 = \text{girl}$ ), age,<sup>6</sup> and an indicator of whether adolescents' interviews occurred during the summer months (*June, July or August*) when risk of firearm violence exposure is elevated (Reeping & Hemenway, 2020). We also included adolescents' prior substance use, a composite measure that captures any previous marijuana, alcohol, or cigarette use reported by the youth. Impulsivity was assessed using an abbreviated form of Dickman's (1990) impulsivity scale. Adolescents' internalizing and externalizing behaviors were reported by their mothers using the Child Behavior Checklist (Achenbach, 1991). At the family-level, we included the ratio of household income to the Federal Poverty Level (FPL), whether adolescents lived in single mother-headed households, and maternal education (*less than high school, high school diploma or equivalent, some college, Bachelor's degree*). Maternal substance use problems measured whether adolescents' mothers reported that substance use interfered with their work. Maternal depression was assessed using the Composite International Diagnostic Interview-Short Form (Kessler et al., 1998). Contextual characteristics included county-level total crime rates (US Federal Bureau of Investigation, 2015) and neighborhood disadvantage, an index composed of the tract-level unemployment rate, poverty rate, the percentage of persons age 25 and older without a high school diploma, the percentage of persons age 25 and older with a bachelor's degree, the percentage of female-headed households, and the percentage of households receiving public assistance (US Census Bureau, 2015). We included interview year to account for potential temporal trends in exposure and/or outcome (e.g., legalization of marijuana).

### 2.3. Analytic strategy

In the first part of the analysis, six separate covariate-adjusted logistic regression models estimate the average associations between any exposure and intensity (dose) of exposure and marijuana, alcohol, and cigarette use. Models were estimated using robust standard errors (Huber, 1967; White, 1980). In the table displaying results, we present odds ratios and 95 % confidence intervals (CIs) from fully adjusted models. Table S1 in the Supplementary Material shows odds ratios from unadjusted models and models that add individual, family, and then contextual covariates. In the text we also discuss marginal effects, or predicted probabilities of substance use for adolescents exposed and not exposed to firearm homicide, as they are more easily interpretable than odds ratios. We used Stata's `-mimrgns-` command to estimate marginal effects.

In the second part of this analysis, we consider potential moderators

of the associations between community exposure to firearm homicide and substance use. We chose as moderators three markers of structural inequalities resulting from macro-level social, economic, and political decisions: race/ethnicity (*White, non-Hispanic; Black, non-Hispanic; Hispanic/Latinx; Other, non-Hispanic*), household poverty (*less than 100 % FPL, 100–199 % FPL, 200 % FPL or greater*), and neighborhood disadvantage (*low: median disadvantage and below, high: above median disadvantage*). Moderation is assessed by interacting each of these variables separately with the two measures of community exposure to firearm homicide in logistic regression models. To interpret these results, we estimate (and present) marginal effects, focusing on the difference in predicted probabilities of substance use for adolescents with and without community exposure to firearm homicide across each category of the moderating variables.

## 3. Results

### 3.1. Descriptive statistics

Table 1 shows descriptive statistics for the full analytic sample and by exposure. Three-quarters of the sample was either Black (50 %) or Hispanic/Latinx (25 %). The average income-to-needs ratio was two times the poverty level. More than one-third of adolescents' households were headed by a single mother, and 32 % of mothers had not received a high school diploma. Adolescents exposed to firearm homicide were more socioeconomically disadvantaged than unexposed adolescents, evidenced by indicators such as lower income-to-needs ratios (no exposure: 2.58; any exposure: 1.54) and higher neighborhood disadvantage (no exposure:  $-0.44$ ; any exposure: 1.44). Additionally, the exposed group contained more Black adolescents than the unexposed group (69 % vs. 43 %). Our analytic sample is similar to the original FFCWS sample but contains fewer Hispanic/Latinx youth and fewer households living in poverty (which could be attributed to increases in mothers' employment as children aged).

### 3.2. Average associations with substance use

The first set of logistic regressions shown in Table 2 investigates the average associations between any community exposure to firearm homicide and the three measures of substance use. Model 1 shows a significant positive association between any exposure and marijuana use. Specifically, for adolescents with community exposure to firearm homicide, the odds of using marijuana in the past 30 days is 1.56 times as large as the odds for adolescents without exposure. Calculation of marginal effects indicates that adolescents exposed to firearm homicide have a 3.20 percentage point higher probability of using marijuana than adolescents who were not exposed (not shown; exposure: 0.10 (95 % CI: 0.08, 0.12), no exposure: 0.07 (95 % CI: 0.06, 0.08)). Models 2 and 3, respectively, show no significant associations between community exposure to firearm homicide and either alcohol or cigarette use.

The second set of logistic regressions (Table 2), which examines intensity (dose) of community exposure to firearm homicide, indicates that the occurrence of two or more incidents near an adolescent's home or school conveys significantly higher risk of past-month marijuana use, whereas a single incident does not (Model 4). For adolescents exposed to multiple firearm homicide incidents (versus an adolescent exposed to no incidents), the odds of using marijuana are nearly two times as large. Calculation of marginal effects indicates that adolescents exposed to multiple firearm homicide incidents have a 5.10 percentage point higher probability of using marijuana (not shown; 2+ exposures: 0.12 (95 % CI: 0.08, 0.16), no exposure: 0.07 (95 % CI: 0.06, 0.08)). We find no significant associations between intensity of community exposure to firearm homicide and alcohol or cigarette use (Models 5 and 6).

<sup>5</sup> FFCWS provides information about firearm homicide incidents that occurred within 365 days of adolescents' interviews, but due to the timing of FFCWS interviews and the onset of GVA data collection, only 76 % of adolescents have 365 days of data (95 % of adolescents had 180 days of data).

<sup>6</sup> We adjust for age because the Year 15 survey was conducted when adolescents were approximately age 15 (range: 14–18).

**Table 1**  
Descriptive statistics of variables included in analyses.

Variable	Community Exposure to Firearm Homicide				
	Full Sample	No Exposure	Any Exposure	Exposure to 1 Incident	Exposure to 2 or more incidents
	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %
Substance use (past 30 days, y15)					
Marijuana use	7.78	6.59	11.21	9.46	14.64
Alcohol use	4.27	4.54	3.50	3.47	3.54
Cigarette use	1.94	2.02	1.71	1.82	1.49
Exposure to firearm homicide (y15)					
None	74.05				
Any	25.95				
1 incident	17.16		66.11		
2 or more incidents	8.79		33.89		
Race/ethnicity (y15)					
White, non-Hispanic	17.37	22.09	3.91	4.22	3.33
Black, non-Hispanic	49.98	43.23	69.25	65.36	76.83
Hispanic/Latinx	24.83	26.35	20.50	23.37	14.91
Other, non-Hispanic	7.81	8.33	6.34	7.05	4.95
Girl (b)	48.95	47.69	52.53	52.63	52.34
Age (y15)	15.50 (0.69)	15.48 (0.69)	15.57 (0.70)	15.49 (0.67)	15.74 (0.72)
Summer (y15)	32.81	32.61	33.36	35.66	28.87
Impulsivity (y15)	2.48 (0.69)	2.46 (0.69)	2.53 (0.70)	2.51 (0.71)	2.58 (0.67)
Prior substance use (y9)	4.59	4.63	4.48	4.76	3.91
Internalizing behaviors (y9)	5.01 (5.68)	4.88 (5.24)	5.39 (6.78)	5.26 (6.46)	5.64 (7.35)
Externalizing behaviors (y9)	6.22 (6.84)	5.94 (6.33)	7.02 (8.09)	6.76 (7.87)	7.54 (8.48)
Single mother household (y9)	36.94	34.20	44.78	42.40	49.43
Income-to-needs ratio (y15)	2.32 (2.51)	2.59 (2.65)	1.54 (1.83)	1.54 (1.55)	1.53 (2.27)
Maternal education (b)					
Less than high school	31.89	28.83	40.59	39.08	43.52
High school or equivalent	32.10	30.85	35.65	35.63	35.67
Some college	25.50	27.67	19.28	20.39	17.13
Bachelor's degree	10.53	12.64	4.48	4.90	3.67
Maternal substance problems (y9)	1.79	1.72	1.98	2.33	1.32
Maternal depression (y9)	17.15	16.89	17.89	17.68	18.30
Log crime rate (county) (y15)	8.12 (0.44)	8.06 (0.45)	8.28 (0.34)	8.28 (0.33)	8.29 (0.35)
Neighborhood disadvantage (y15)	0.04 (1.97)	-0.44 (1.81)	1.41 (1.76)	1.18 (1.81)	1.85 (1.57)
Interview year					

**Table 1 (continued)**

Variable	Community Exposure to Firearm Homicide				
	Full Sample	No Exposure	Any Exposure	Exposure to 1 Incident	Exposure to 2 or more incidents
	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %	Mean (SD) of %
2014	24.29	24.59	23.43	22.60	25.04
2015	65.52	65.46	65.67	67.89	61.35
2016	10.19	9.94	10.89	9.50	13.61
N	3042	2165–2265	777–877	514–532	257–280

Notes: b = measured at baseline survey; y9 = measured at Year 9 survey; y15 = measured at Year 15 survey. Number of adolescents in each exposure category varies by imputed dataset.

3.3. Moderation of associations with substance use

We next consider moderators of the associations between community exposure to firearm homicide and marijuana use, the outcome for which average associations were observed. Fig. 1 shows the difference in predicted probabilities of marijuana use for adolescents with and without any community exposure to firearm homicide by race/ethnicity, household poverty, and neighborhood disadvantage. Statistically significant differences ( $p < .05$ ) are indicated with a star. The first panel shows that Black adolescents exposed to firearm homicide incidents have a 4.37 percentage point higher probability of past-month marijuana use than Black adolescents who have not been exposed (exposure: 0.10 (95 % CI: 0.08, 0.13), no exposure: 0.06 (95 % CI: 0.05, 0.08)). For White adolescents, we also observe a large difference in predicted probabilities for those exposed and not exposed to firearm homicide; however, this difference is not statistically significant, likely due to the small number of White adolescents with community exposure to firearm homicide ( $n \approx 31$ , varies by imputed dataset). Differences are also not statistically significant for Hispanic/Latinx adolescents and for adolescents from other racial/ethnic groups.

We also observe variation across levels of household poverty. For adolescents living in households with incomes below the FPL, community exposure to firearm homicide increases the probability of marijuana use by 4.31 percentage points (exposure: 0.11 (95 % CI: 0.07, 0.14), no exposure: 0.06 (95 % CI: 0.05, 0.08)). Among adolescents living in households with incomes above the FPL, predicted probabilities of marijuana use are not significantly different between those with and without community exposure to firearm homicide. Similarly, for adolescents living in neighborhoods experiencing high levels of disadvantage, the predicted probability of marijuana use is 3.04 percentage points higher for exposed versus not exposed adolescents (exposure: 0.09 (95 % CI: 0.07, 0.11), no exposure: 0.06 (95 % CI: 0.04, 0.07)). However, for adolescents living in less disadvantaged neighborhoods, there is no significant difference in marijuana use for exposed and not exposed youth.

Fig. 2 shows the difference in the predicted probabilities of past-month marijuana use for adolescents exposed to one firearm homicide incident (versus none) and two or more incidents (versus none). Results are shown for only two of the moderators, household poverty and neighborhood disadvantage, because there were too few White adolescents with two or more firearm homicide exposures ( $n \approx 10$ , varies by imputed dataset) to accurately estimate moderation by race/ethnicity. The results from models estimating moderation by household poverty indicate that for adolescents living in households with incomes below the FPL, community exposure to two or more firearm homicide incidents increases the probability of past-month marijuana use by 8.84 percentage points (2+ exposures: 0.15 (95 % CI: 0.09, 0.21), no exposure: 0.06 (95 % CI: 0.05, 0.08)). Similarly, for adolescents living in highly disadvantaged neighborhoods, the predicted probability of past-month

**Table 2**

Regression estimates of the average associations between community exposure to firearm homicide and substance use.

Variable	Any Exposure to Firearm Homicide			Intensity/Dose of Exposure to Firearm Homicide		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Marijuana Use	Alcohol Use	Cigarette Use	Marijuana Use	Alcohol Use	Cigarette Use
Community exposure to firearm homicide						
Any (ref. none)	1.562* (1.099, 2.222)	0.852 (0.500, 1.453)	0.706 (0.304, 1.638)			
Intensity/Dose (ref. none)						
1 incident				1.389 (0.922, 2.093)	0.857 (0.470, 1.565)	0.823 (0.329, 2.061)
2 or more incidents				1.930** (1.200, 3.102)	0.836 (0.370, 1.887)	0.491 (0.129, 1.867)
Race/ethnicity (ref. White, non-Hispanic)						
Black, non-Hispanic	0.980 (0.589, 1.631)	0.418** (0.234, 0.747)	0.695 (0.271, 1.786)	0.983 (0.590, 1.640)	0.418** (0.234, 0.747)	0.693 (0.269, 1.784)
Hispanic/Latinx	1.184 (0.698, 2.007)	1.099 (0.649, 1.858)	0.759 (0.284, 2.032)	1.204 (0.708, 2.045)	1.098 (0.649, 1.856)	0.746 (0.277, 2.006)
Other, non-Hispanic	1.153 (0.591, 2.248)	1.209 (0.616, 2.373)	1.212 (0.353, 4.167)	1.173 (0.601, 2.289)	1.208 (0.615, 2.371)	1.191 (0.343, 4.134)
Girl	0.702* (0.527, 0.937)	0.957 (0.665, 1.376)	0.578 (0.329, 1.015)	0.703* (0.527, 0.938)	0.957 (0.666, 1.376)	0.577 (0.328, 1.015)
Age	1.989*** (1.607, 2.463)	2.038*** (1.565, 2.654)	2.555*** (1.747, 3.737)	1.969*** (1.587, 2.442)	2.038*** (1.566, 2.653)	2.588*** (1.771, 3.782)
Summer	0.997 (0.734, 1.355)	0.807 (0.535, 1.219)	0.862 (0.471, 1.576)	1.005 (0.739, 1.366)	0.807 (0.535, 1.217)	0.855 (0.467, 1.563)
Impulsivity	2.156*** (1.742, 2.669)	2.225*** (1.661, 2.981)	2.112** (1.362, 3.273)	2.158*** (1.742, 2.673)	2.225*** (1.661, 2.981)	2.120** (1.368, 3.283)
Prior substance use	1.059 (0.592, 1.895)	1.200 (0.534, 2.695)	0.498 (0.106, 2.344)	1.061 (0.592, 1.903)	1.201 (0.535, 2.696)	0.500 (0.106, 2.350)
Internalizing behaviors	0.934** (0.898, 0.972)	0.970 (0.924, 1.019)	0.947 (0.882, 1.016)	0.934*** (0.898, 0.972)	0.970 (0.923, 1.019)	0.947 (0.882, 1.016)
Externalizing behaviors	1.056*** (1.030, 1.083)	1.035* (1.005, 1.065)	1.074** (1.029, 1.121)	1.056** (1.030, 1.082)	1.035* (1.005, 1.065)	1.074** (1.029, 1.122)
Single mother household	1.038 (0.759, 1.419)	0.958 (0.637, 1.439)	0.424* (0.209, 0.860)	1.032 (0.754, 1.412)	0.958 (0.638, 1.439)	0.427* (0.210, 0.867)
Income-to-needs ratio	0.986 (0.915, 1.063)	0.978 (0.898, 1.065)	0.809* (0.656, 0.998)	0.984 (0.913, 1.061)	0.978 (0.898, 1.066)	0.811 (0.657, 1.001)
Maternal education (ref. no high school diploma)						
High school or equivalent	0.716* (0.512, 1.000)	1.679* (1.059, 2.663)	0.929 (0.495, 1.742)	0.719 (0.514, 1.005)	1.679* (1.057, 2.666)	0.920 (0.491, 1.725)
Some college	0.600* (0.397, 0.905)	1.177 (0.679, 2.040)	0.672 (0.283, 1.596)	0.602* (0.399, 0.908)	1.177 (0.679, 2.040)	0.665 (0.280, 1.581)
Bachelor's degree	0.699 (0.363, 1.343)	1.900 (0.976, 3.701)	0.497 (0.109, 2.267)	0.696 (0.363, 1.338)	1.901 (0.976, 3.702)	0.497 (0.109, 2.271)
Maternal substance problems	1.347 (0.518, 3.500)	1.240 (0.332, 4.630)	1.078 (0.151, 7.684)	1.388 (0.535, 3.600)	1.238 (0.331, 4.629)	1.057 (0.147, 7.608)
Maternal depression	1.446* (1.033, 2.024)	1.232 (0.76, 1.983)	1.401 (0.749, 2.619)	1.445* (1.032, 2.024)	1.232 (0.766, 1.982)	1.405 (0.749, 2.635)
Log crime rate (county)	1.453 (0.998, 2.116)	1.202 (0.766, 1.886)	0.790 (0.383, 1.629)	1.455* (1.001, 2.116)	1.202 (0.766, 1.887)	0.789 (0.382, 1.631)
Neighborhood disadvantage	0.959 (0.875, 1.051)	0.960 (0.850, 1.084)	0.987 (0.840, 1.161)	0.952 (0.867, 1.045)	0.960 (0.848, 1.087)	0.994 (0.847, 1.168)
Interview year (ref. 2014)						
2015	0.764 (0.553, 1.056)	0.628* (0.416, 0.948)	0.481* (0.269, 0.859)	0.769 (0.555, 1.066)	0.628* (0.416, 0.947)	0.478* (0.267, 0.854)
2016	0.578 (0.322, 1.039)	0.383* (0.181, 0.810)	0.232** (0.079, 0.679)	0.582 (0.323, 1.047)	0.383* (0.181, 0.810)	0.232** (0.079, 0.676)
N			3042			

Notes: Models estimated using logistic regression; odds ratios shown; 95 % confidence intervals in parentheses. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$  (two-tailed tests).

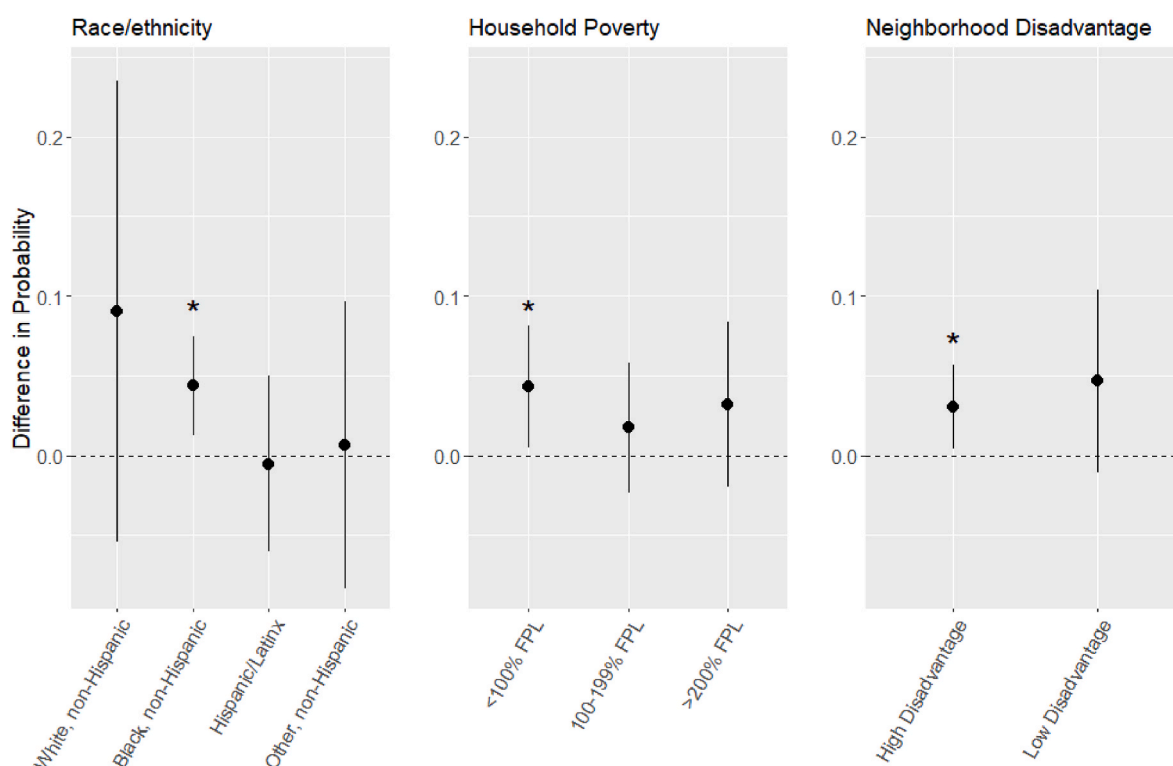
marijuana use is 4.70 percentage points higher for those with community exposure to multiple firearm homicide incidents compared to those not exposed at all (2+ exposures: 0.11 (95 % CI: 0.07, 0.14), no exposure: 0.06 (95 % CI: 0.04, 0.07)). We find no significant differences in marijuana use for adolescents exposed to only one incident (versus none), living in households with incomes above the FPL, and living in low disadvantage neighborhoods.

#### 4. Discussion

The first aim of this study was to assess whether community exposure to firearm homicide is associated with adolescent substance use. In contrast to many prior studies of violence exposure and substance use,

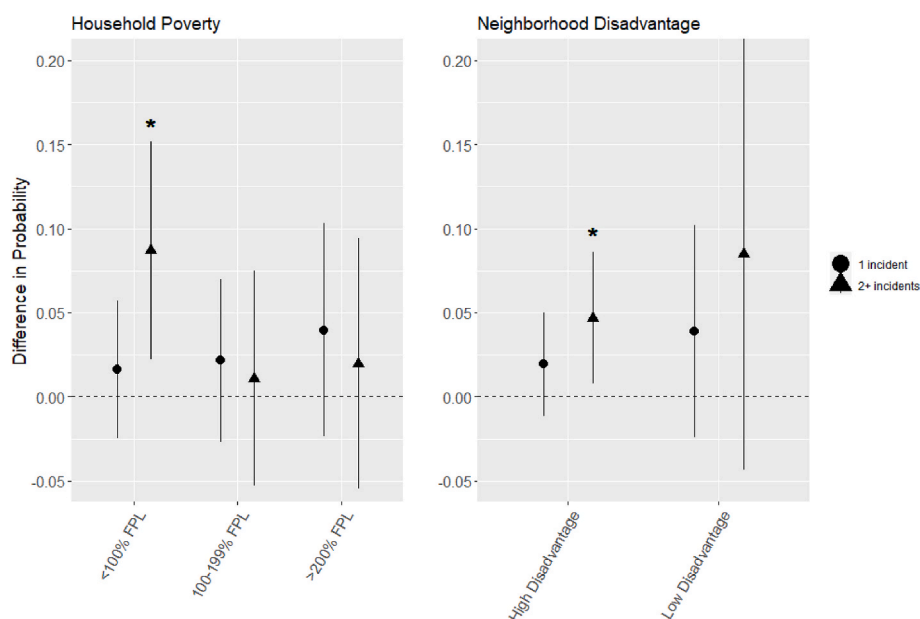
we focus on violence that occurs in adolescents' broader social environments, regardless of whether they were directly involved or witnessed the violence firsthand. We find that, on average, adolescents exposed to incidents of firearm homicide within 600 m of their homes or schools in the past 180 days have a greater risk of past-month marijuana use than adolescents who have not been exposed. Thus, local occurrences of firearm violence—even if not necessarily seen nor heard—do shape adolescents' substance use. Moreover, the results suggest that the intensity of exposure matters. Multiple community exposures to firearm homicide within the 180-day period convey the greatest risk, with exposure to two or more incidents nearly doubling the odds of using marijuana in the past month.

The second aim of this study was to assess whether associations



**Fig. 1.** Difference in Predicted Probability of Marijuana Use, Exposed to Firearm Homicide versus not Exposed to Firearm Homicide by Race/ethnicity, Household Poverty, and Neighborhood Disadvantage

*Note:* Estimates based on logistic regression models including all controls and an interaction between community exposure to firearm homicide and either adolescent race/ethnicity, household poverty, or neighborhood disadvantage; 95 % confidence intervals shown. FPL = Federal Poverty Level. Number of adolescents in each racial/ethnic, household poverty, and neighborhood disadvantage group varies by imputed dataset: White,  $n = 519$ – $535$ ; Black,  $n = 1509$ – $1533$ ; Hispanic/Latinx,  $n = 742$ – $766$ ; Other,  $n = 234$ – $243$ ; <100 % FPL,  $n = 960$ – $963$ ; 100–199 % FPL,  $n = 874$ – $877$ ; >200 % FPL,  $n = 1204$ – $1207$ ; high disadvantage,  $n = 1517$ – $1520$ ; low disadvantage,  $n = 1520$ – $1525$ . \* $p < .05$  (two-tailed tests).



**Fig. 2.** Difference in Predicted Probability of Marijuana Use, Exposed to 1 or 2+ Firearm Homicide Incidents versus not Exposed to Firearm Homicide by Household Poverty and Neighborhood Disadvantage

*Note:* Estimates based on logistic regression models including all controls and an interaction between intensity of community exposure to firearm homicide and either household poverty or neighborhood disadvantage; 95 % confidence intervals are shown. FPL = Federal Poverty Level. The number of adolescents in each household poverty and neighborhood disadvantage group varies by imputed dataset: <100 % FPL,  $n = 960$ – $963$ ; 100–199 % FPL,  $n = 874$ – $877$ ; >200 % FPL,  $n = 1204$ – $1207$ ; high disadvantage,  $n = 1517$ – $1520$ ; low disadvantage,  $n = 1520$ – $1525$ . \* $p < .05$  (two-tailed tests).

between community exposure to firearm homicide and substance use varied across subgroups. The moderation analyses show a positive and significant association between community exposure to firearm homicide and past-month marijuana use only among the most structurally disadvantaged adolescents: those who are Black, live in households with below-poverty incomes, or live in highly disadvantaged neighborhoods. These results suggest that those who face the greatest risk of community exposure to firearm homicide also face the greatest consequences of such exposure when it comes to substance use (James et al., 2021; Kravitz-Wirtz et al., 2022). This finding corroborates prior studies documenting the impact of firearm violence on the lives of adolescents in communities at highest risk (Bancalari et al., 2022; Buggs et al., 2022). That these associations were strongest when adolescents were exposed to multiple firearm homicide incidents suggests that chronic exposure may contribute to an accumulation of co-occurring stressors linked to structural disadvantage that place adolescents living in households and neighborhoods with limited socioeconomic resources at increased risk of marijuana use.

Although our study does not allow us to investigate adolescents' own explanations for substance use, the observed associations between firearm homicide exposure and marijuana use suggest that adolescents—particularly Black adolescents and those living in socioeconomically disadvantaged households and neighborhoods—may be using this substance in an attempt to counter distress and other negative emotions prompted by adverse community events (Harrison et al., 1997; Simantov et al., 2000). Although marijuana use may temporarily relieve stress, it is not without health and social risks. The adolescent brain is particularly vulnerable to addiction and the toxic effects of marijuana (Meier et al., 2012; Volkow et al., 2014). Marijuana use has also been linked with symptoms of chronic bronchitis (Volkow et al., 2014), and it may be an indicator of other health-risk behaviors or mental health problems (Tapert et al., 2001).

Although we hesitate to draw strong conclusions from null results, it is worth mentioning that we found no association between community exposure to firearm homicide and either cigarette or alcohol use. Marijuana is the most used substance among adolescents in our sample (see Table 1), and national data shows a declining use of cigarettes and alcohol among this population (Creamer et al., 2020; Jones et al., 2020). It is possible that marijuana has become the preferred or most accessible substance for responding to stress, and this may be especially true for marginalized youth (Jones et al., 2020). That said, as use of e-cigarettes becomes more prevalent among adolescents and surveys more consistently measure e-cigarette use (Cooper et al., 2022), a follow-up study may be warranted. Our study is not the only study to find a link between violence exposure and marijuana use but no other substances (Fagan et al., 2014; Wright et al., 2013); thus, accessibility and adolescent choice of substance is an important area for future research.

#### 4.1. Limitations

This study has some limitations. First, the results must be interpreted in the context of the FFCWS, which includes a sample of urban families who disproportionately experience economic and social disadvantage. Although the results are not generalizable to the US adolescent population, this sample does highlight the experiences of adolescents most likely to be exposed to gun violence. Second, the linkage between the FFCWS and GVA data pertains only to fatal interpersonal firearm violence incidents. Nonfatal firearm injuries occur up to four times as frequently as firearm homicide (Kaufman et al., 2021). Although we expect that our results are therefore underestimates of the full effects of community exposure to firearm violence, it is possible that the effects of nonfatal incidents may be different than those of fatal ones. Additionally, the data linkage does not include detailed information about each homicide incident, such as the victim count or whether a homicide occurred in a private (e.g., home) or public (e.g., on the street) space. Incidents involving more people injured or killed and incidents

occurring in public may amplify the mechanisms leading to marijuana use. Further examination of such variation may be a fruitful direction for future research.

The measures of substance use are also subject to limitations. These measures capture any use in the past 30 days, which conflates first-time use and single use with more frequent or problematic use. Additionally, because substance use was assessed over the past 30 days, and firearm homicide exposure was assessed over the past 180 days, it is possible that, for some adolescents, substance use occurred prior to exposure. We minimized the potential for temporal ordering issues by intentionally choosing a longer exposure period and a shorter outcome window (adolescents were also asked about substance use over the past year). We also tested the robustness of our results by identifying adolescents exposed to firearm homicide only within the past 30 days (14 % of those exposed within the past 180 days) and removing them from the analysis. We found the coefficients to be substantively unchanged.

A final limitation to note is omitted variable bias. Our models adjust for a wide range of potential confounders, but we cannot rule out the possibility that unmeasured variables that influence the risk of both firearm homicide exposure and marijuana use could result in a spurious relationship between the two.

## 5. Conclusion

Despite these limitations, the findings consistently point to the importance of considering firearm homicide occurring in adolescents' broader social environments when assessing the impacts of violence exposure on substance use. Our empirical focus on a broader definition of exposure to firearm violence—encompassing not only victims and witnesses but also those who live their daily lives in communities where firearm violence occurs—demonstrates the long reach of violence into the health behaviors of young people. This study also provides a better understanding of factors associated with differential vulnerability to the consequences of firearm violence exposure, suggesting that health and healing-centered prevention and intervention strategies aimed at both reducing exposure to firearm violence and mitigating subsequent firearm violence-related harm, including risky substance use behavior, are particularly important for Black and low-income adolescents facing co-occurring stressors linked to structural disadvantage.

## CRedit authorship contribution statement

**Angela Bruns:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Amanda J. Aibel:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Xiaoya Zhang:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **Shani A.L. Buggs:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Nicole Kravitz-Wirtz:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Conceptualization.

## Funding

This research was supported by the Centers for Disease Control and Prevention (CDC) National Center for Injury Prevention and Control (NCIPC) under Award No. R01CE003261. Funding for the Future of Families and Child Wellbeing Study (FFCWS) came from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) of the National Institutes of Health (NIH) under Award Nos. R01HD036916, R01HD039135, and R01HD040421, as well as a consortium of private foundations. The content is solely the responsibility of the authors and does not necessarily represent the official views of the CDC or NIH.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

Special thanks are owed to Sage Saplan for assistance with literature review.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2025.101799>.

## Data availability

The authors do not have permission to share data.

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