

Association of Drug and Alcohol Use With Adolescent Firearm Homicide at Individual, Family, and Neighborhood Levels

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IMPORTANCE Homicide is the third leading cause of death for adolescents in the United States and the leading cause of death for adolescents who are African American. Large cities have disproportionate homicide rates.

OBJECTIVE To determine the relationships between exposures to drugs and alcohol at the individual, family, and neighborhood levels and adolescent firearm homicide and to inform new approaches to preventing firearm violence.

DESIGN, SETTING, AND PARTICIPANTS Population-based case-control study from January 2010 to December 2012 of all 13- to 20-year-olds who were homicide victims in Philadelphia during the study period matched to randomly selected 13- to 20-year-old controls from the general population.

EXPOSURES Individual drug and alcohol use at the time of injury, history of drug and alcohol use, caregiver drug and alcohol use, and neighborhood availability of alcohol and illegal drugs. We also controlled for age, race, school suspensions, arrests, and neighborhood ethnicity.

MAIN OUTCOMES AND MEASURES Adolescent firearm homicide identified from police and medical examiner's reports.

RESULTS We enrolled 161 adolescent homicide cases, including 157 (97.5%) firearm homicide cases and 172 matched controls, including 166 (96.5%) firearm homicide controls. Adolescents with a history of alcohol use (adjusted odds ratio [AOR], 4.1; 95% CI, 1.2-14.0) or drug use (AOR, 4.4; 95% CI, 1.7-11.6) had increased odds of firearm homicide. Adolescents whose caregiver had a history of drug use had increased odds of firearm homicide (AOR, 11.7; 95% CI, 2.8-48.0). Adolescents in neighborhoods with high densities of alcohol outlets (AOR, 3.2; 95% CI, 1.1-9.1) and moderate or high drug availability had increased odds of firearm homicide (AOR, 3.4; 95% CI, 1.1-10.3 vs AOR, 7.5; 95% CI, 2.2-25.8).

CONCLUSIONS AND RELEVANCE Almost all adolescent homicides in Philadelphia between 2010 and 2012 were committed with a firearm. Substance use at the individual, family, and neighborhood levels was associated with increased odds of adolescent firearm homicide; drug use was associated at all 3 levels and alcohol at the individual and neighborhood levels. Expanding violence prevention efforts to target drug and alcohol use at multiple levels may help to reduce the firearm violence that disproportionately affects adolescents in minority populations in large US cities.

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Homicide is the third leading cause of death for adolescents in the United States and the leading cause of death for African-American adolescents,¹ with young men of color dying at rates more than 20 times their white counterparts.² Large cities have disproportionate rates of homicide compared with other areas of the country.³

Adolescents engage in behaviors every day that increase their risk for violent injury such as fighting, carrying guns, and drug and alcohol use.⁴⁻⁶ Drugs and alcohol create substantial problems owing to their accessibility and effects on youth during critical periods of development.^{7,8} In the United States, adolescents use and abuse substances at relatively high rates with lifetime prevalence estimates showing 60% have had the opportunity to use illicit drugs, 24% have used illicit drugs, 60% have used alcohol, and 25% regularly use alcohol.⁹

Research in adults indicates that there is an elevated risk of becoming a victim of homicide associated with drug and alcohol use as well as a substantial homicide risk for those living with substance users.¹⁰⁻¹⁴ Thus, many adolescents may be at risk simply by being in a family or a neighborhood environment where alcohol and drugs are present, regardless of personal consumption. In Philadelphia, where almost all adolescent homicides are firearm homicides, we conducted a citywide population-based case-control study to determine alcohol and drug-related risk factors for becoming a homicide victim at the individual, family, and neighborhood levels.

Methods

Institutional review boards at the University of Pennsylvania and the Philadelphia Department of Public Health approved the study. Interviewers obtained verbal consent for participation from control respondents 18 years and older and verbal consent from a parent or guardian and assent from those aged 13 to 17 years. After completion of the interview, control participants were mailed a \$20 gift card as compensation for their participation.

Participant Identification and Matching

We rapidly ascertained cases of adolescent homicide and randomly selected adolescent controls. Cases were adolescents, ages 13 to 20 years, residing in Philadelphia County who died following an intentional assault in the county between January 2010 and December 2012. Based on daily monitoring of reports from the Philadelphia Medical Examiner's Office and Police Department, we identified new, fatally injured adolescents. Data coordinators forwarded relevant information (homicide date and time, victim age and sex, and resident status) to an independent survey research firm, DataStat, Inc, which then initiated recruitment of matched controls. This identification and matching process allowed quick identification of controls from a risk set at the time each case was fatally injured.

The control group included residents of Philadelphia County, ages 13 to 20 years, recruited through random digit dialing.¹⁵ We used incidence density sampling with a caliper match of 3 hours prior to and after the index case's time of in-

Key Points

Question Is there a relationship between alcohol- and drug-related factors and adolescent firearm homicide at the individual, family, and neighborhood levels?

Findings In a population-based, case-control study of 13- to 20-year-old residents of Philadelphia, Pennsylvania, we found that almost all adolescent homicides were firearm homicides. Drug use at all 3 levels and alcohol at the individual and neighborhood levels were associated with increased odds of adolescent firearm homicide.

Meaning Expanding violence prevention efforts to target substance use at multiple levels within society may help to reduce the firearm violence that disproportionately affects minority populations in large US cities.

jury to control for potential temporal and seasonal confounders. Controls were pair-matched to cases based on sex and indoor/outdoor location at the time of each index case's fatal injury. Matching criteria were selected based on prior research to avoid the likelihood of mismatches and very small numbers within any matching strata.¹⁶

Case to control recruitment at a 1:1 sampling ratio was based on prior power calculations and sample size estimations. For timely identification of controls, multiple interviewers simultaneously completed control interviews; 12 homicide case participants had more than 1 matched control. All were retained in the final analysis.

Data and Measures

We obtained detailed case information from the Philadelphia Child Death Review Team Case Reporting System in the Medical Examiner's Office. This database contains information from an interdisciplinary team of professionals representing several municipal departments and hospitals that jointly compile records pertaining to all deaths of Philadelphia children (0-21 years).¹⁷ Child death review data included information on the decedent, their family, and other contextual characteristics, such as history of drug or alcohol abuse and family drug or alcohol use (1 or more caregivers having a history of drug or alcohol abuse). The Medical Examiner's office provided the results of toxicology tests that identified case alcohol and drug use (such as cocaine, marijuana, methamphetamine, and opiates). The Police Department provided data on the address and circumstances of each homicide as well as decedent characteristics, including prior arrests.

Participants in the control group were interviewed by phone using a structured questionnaire containing information on individual and household demographics, education, employment, and delinquency. They were asked questions about drug and alcohol consumption and access (if they had used any alcohol or drugs not prescribed for them around the time of each case incident, whether they drank alcohol at any time before or during the time of case incident), history of drug use (the last time they used drugs that were not prescribed for them or not purchased at a store), history of alcohol abuse (indicated by a yes response to 2 of the 4 CAGE screening ques-

tions for alcoholism: Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers),¹⁸ and family drug and alcohol use (1 or more caregivers drinking alcohol every day, 1 or more caregivers ever using drugs that were not prescribed to them or purchased at a store).

Interviewers had those in the control group acknowledge that they were in a safe place and could have uninterrupted interview time. Interviewers used prompts to help participants accurately recall information about their address location, activities, and exposures at the time of their matched case's index injury. Interviews were conducted within a median time of 11 days of their match's index injury. DataStat used multiple recruitment strategies to maximize participation and reduce bias.^{16,19} Based on formula put forward by the American Association for Public Opinion Research²⁰ to standardize the calculation of response and cooperation rates in random sample surveys, the cooperation rate for control participants was 73.4% and the response rate was 52.3%. After completion of the interview, control participants were mailed a \$20 gift card.

Neighborhood data pertaining to alcohol and illicit drug sales markets came from multiple sources. The Police Department provided address location of crime incidents for narcotics manufacture, possession, and sales. The Pennsylvania Liquor Control Board provided access to a list of licenses for retail sales of alcohol in Philadelphia, including information such as business name, address, and type of business. We used 2010 to 2012 alcohol outlet data and crime data to create a kernel density summary variable of alcohol outlets per square mile, as well as a variable for narcotics sales incidents per square mile.²¹⁻²³ We created 3 equal groups for narcotic crime densities: low (0-21.93 per square mile), moderate (21.94-54.06 per square mile), and high (54.37-320.40 per square mile) and alcohol outlet densities: low (0-16.96 per square mile), moderate (17.27-30.58 per square mile), and high (30.59-442.33 per square mile). Alcohol sales (visible bars, taverns, beer stores, and corner stores) and advertisements were also assessed using a series of 360-degree, high-resolution panorama field photographs of the immediate environments of our cases and controls. The protocols used to create and code these photographs were part of a related study,²⁴ which examined the association between environmental neighborhood features, such as streets, buildings, and natural surroundings, and adolescent homicide. That study used a subsample of the same youth in the current study but focused on the data collected through photographs of the outdoor locations of case and controls.

We used 2010 US Census tract and block group data to calculate inverse distance weighted neighborhood metrics of household income, unemployment, race, and ethnicity for case and control address locations at the time of the case incident.

Statistical Analyses

Data were summarized using mean and median for continuous variables and frequency percentages for nominal variables. Bivariate comparisons were made between cases and controls for baseline characteristics using *t* tests, Wilcoxon rank sum tests, and χ^2 tests, as appropriate.

We modeled the associations between separate individual-level, family-level, and neighborhood-level alcohol and drug exposures and adolescent homicide. We produced odds ratios (ORs) using conditional logistic regression that accounted for case to control pair-matching. Adjusted ORs (AORs) accounted for individual (age in years, race, school suspensions, history of prior arrest) and neighborhood characteristics (percent of the population that was Hispanic).

We tested all models for collinearity and variance inflation factors were less than 5 in all instances. A 2-sided *P* value less than .05 was considered statistically significant. All analyses were performed with STATA statistical software (version 14, STATA Corp).²⁵

Results

We enrolled 161 adolescent homicide cases, including 157 (97.5%) firearm homicides, and 172 controls, including 166 (96.5%) firearm homicide controls. Firearm homicide cases and controls showed no significant differences in sex or whether they were indoors or outdoors at the time of the homicides. On average, compared with the controls, cases were older, more often identified as black, had more suspensions in their last year of school, and had more arrests (Table 1). Cases and controls had similar unemployment and school absences and were geographically represented in every major section of Philadelphia (Figure).

Individual and Family-Level Exposures

Table 2 shows individual, family, and neighborhood level drug and alcohol exposures for all adolescent homicides and for firearm homicides. Because analyses ran with all homicide cases and those restricted to firearm homicides showed no meaningful differences (data not shown) we present results for firearm homicide cases and controls.

Table 3 shows unadjusted and adjusted ORs for firearm homicide and alcohol and drug exposure at the individual, family, and neighborhood levels. Adolescents who had been using drugs at the time of the event had an increased odds of firearm homicide (OR, 3.8; 95% CI, 1.6-8.7). After adjustment, this association was no longer significant. We found no significant associations between alcohol use at the time of the event and firearm homicide in either unadjusted or adjusted analyses. Adolescents having a history of prior drug use (AOR, 4.4; 95% CI, 1.7-11.6) or alcohol abuse (AOR, 4.1; 95% CI, 1.2-14.0) had increased odds of firearm homicide.

In the unadjusted model, having a caregiver who frequently used alcohol was associated with increased odds of firearm homicide (OR, 3.4; 95% CI, 1.4-8.6); after adjusting for covariates, this relationship was no longer significant. Adolescents with a caregiver who had a history of reported drug use had increased odds of firearm homicide (AOR, 11.7; 95% CI, 2.8-48.0).

Neighborhood-Level Exposure

The overall density of alcohol outlet licensees and the odds of firearm homicide were associated (Table 3). Compared with

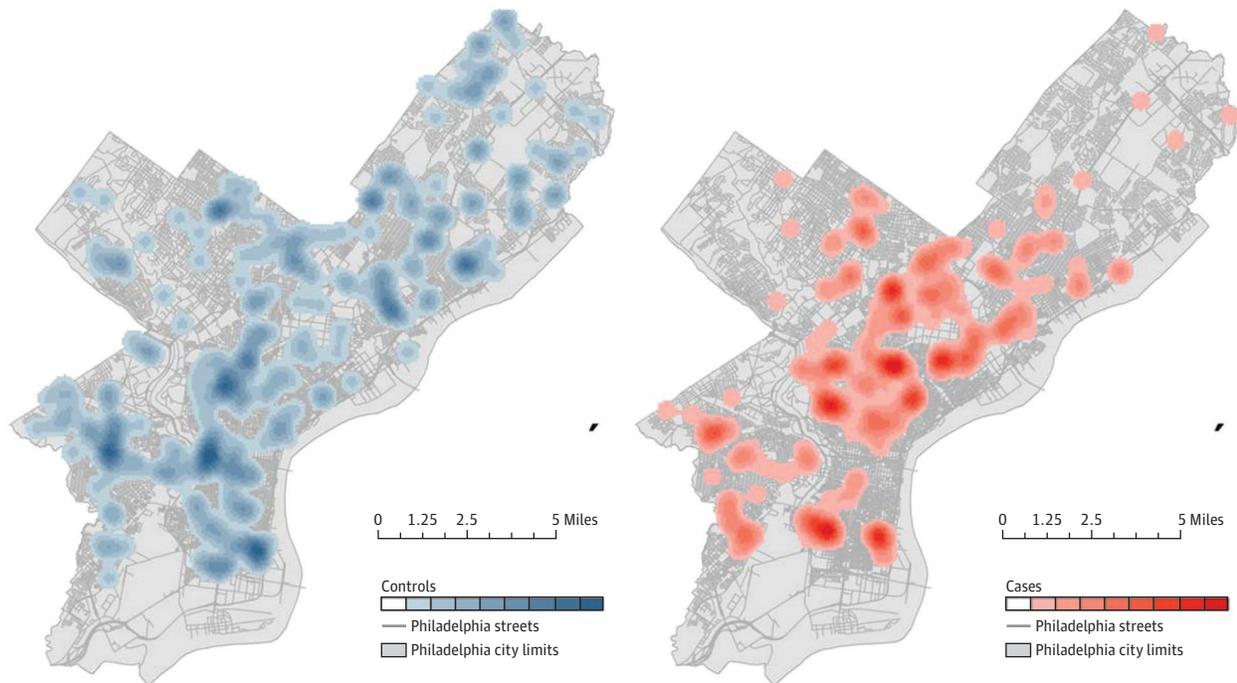
Table 1. Characteristics of the 157 Firearm Homicide Cases and 166 Controls Included in the Study

Characteristic	Participants		P Value ^a
	Cases (n = 157)	Controls (n = 166)	
Individual			
Age, mean (SD), y	18.5 (1.4)	17.2 (2.1)	<.001
Male, No. (%)	150 (95.5)	158 (95.2)	.88
Black, No. (%)	141 (89.8)	95 (57.2)	<.001
Hispanic/Latino, No. (%)	16 (10.2)	26 (15.7)	.13
Unemployed, No. (%)	99 (63.1)	104 (62.7)	.07
School absences in last year attended, mean (SD), d	19.1 (23.2)	16.6 (28.3)	.60
School suspensions, mean (SD)	10.1 (9.0)	4.4 (15.6)	<.001
Ever arrested, No. (%)	123 (65.0)	27 (16.3)	<.001
Outdoor, No. (%)	140 (89.1)	147 (88.6)	.86
Neighborhood, median (IQR)			
Household income, \$	34 601 (26 691-47 438)	36 289 (29 594-46 430)	.36
Unemployment, %	2.8 (2.2-4.0)	3.2 (2.3-4.5)	.23
Residents, %			
Black	52.6 (2.05-78.8)	52.7 (25.2-80.2)	.97
Hispanic	5.2 (3.6-7.6)	5.8 (3.6-13.9)	.08

Abbreviation: IQR, interquartile range.

^a Calculated using Wilcoxon rank-sum test for median household income, unemployment percentage, percentage of that population who are black, percentage of the population who are Hispanic, using t test for age, absences, suspensions, and using χ^2 test for sex, race, ethnicity, employment, history of arrest, and location.

Figure. Location of Adolescent Homicide Cases (Red) and Matched Controls (Blue), Philadelphia, Pennsylvania, 2010-2012



low-density locations, the unadjusted odds of firearm homicide was 2.8 (95% CI, 1.5-5.1) in locations with moderate density of alcohol outlets and 3.0 (95% CI, 1.6-5.5) in locations with high density. In adjusted analyses, the odds of firearm homicide was 3.2 (95% CI, 1.1-9.1) in locations with high density of alcohol outlets and the relationship was no longer significant in locations with moderate density. The trend for increasing density was not significant. In the unadjusted but not the adjusted models, firearm homicide was associated with loca-

tions where beer stores and corner stores were visible, as indicated by the photograph coding of each location. Visible bars or taverns and alcohol advertisements were not associated with firearm homicide risk.

The density of narcotics sales and the odds of firearm homicide were also associated (Table 3). Compared with locations with low levels of narcotic sales, in unadjusted analyses the odds of firearm homicide was 4.0 (95% CI, 2.0-8.1) in locations with moderate levels of sales and 8.8 (95% CI,

Table 2. Individual-, Family-, and Neighborhood-Level Drug and Alcohol Exposures for All Adolescent Homicides and Adolescent Firearm Homicides

Characteristic	Homicides, No. (%)			
	All Adolescent		Adolescent Firearm	
	Case (n = 161)	Control (n = 172)	Case (n = 157)	Control (n = 166)
Individual-Level Substance Use				
Using alcohol at the time	14 (8.7)	10 (5.8)	13 (8.3)	10 (6.0)
Using drugs at the time	26 (16.2)	8 (4.7)	26 (16.6)	8 (4.8)
History of alcohol abuse	47 (29.2)	10 (5.8)	47 (29.9)	10 (6.0)
History of drug use	98 (60.9)	39 (22.7)	98 (62.4)	39 (23.5)
Family-Level Substance Use				
Caregiver history of frequent alcohol use	21 (13.0)	10 (5.8)	21 (13.4)	10 (6.0)
Caregiver history of drug use	46 (28.6)	11 (6.4)	45 (28.7)	11 (6.6)
Neighborhood-Level Substance Use				
Alcohol outlet licenses (density/square mile)				
Low	36 (22.4)	72 (41.9)	36 (22.9)	70 (42.2)
Moderate	61 (37.9)	46 (26.7)	59 (37.6)	44 (26.5)
High	64 (39.8)	46 (27.7)	62 (39.5)	8 (4.8)
Bars and taverns visible	12 (7.5)	7 (4.1)	12 (7.6)	6 (3.6)
Beer stores and corner stores visible	46 (28.6)	31 (18.0)	46 (39.3)	29 (17.5)
Alcohol advertisements visible	28 (17.4)	19 (11.1)	28 (17.8)	17 (10.2)
Narcotics sales (density/square mile)				
Low	25 (15.5)	85 (49.4)	25 (15.9)	82 (49.4)
Moderate	59 (36.7)	51 (29.7)	50 (30.1)	50 (30.1)
High	77 (47.8)	34 (19.8)	32 (19.3)	32 (19.3)

4.2-18.6) in locations with high levels of sales. In adjusted analyses, these associations remained significant: moderate sales (AOR, 3.4; 95% CI, 1.1-10.3) and high sales (AOR, 7.5; 95% CI, 2.2-25.8). The trend for increasing density was not significant.

Discussion

Between January 2010 and December 2012, 97.5% of all adolescent homicides in Philadelphia were committed with a firearm, compared with 86% of adolescent homicides nationally during the same period.²⁶ We found increased odds of adolescent firearm homicide associated with substance use at the individual, family, and neighborhood levels: drug exposures were associated at all 3 levels and alcohol exposures were associated at the individual and neighborhood levels.

Substance use may be linked to an increased risk of adolescent homicide through: (1) difficulty identifying social cues or risky people and places owing to cognitive impairment; (2) an inability to defend or remove oneself from risky situations; and (3) being identified as an easy target for predators. However, we found no relationship between alcohol or drug consumption at the time of the incident and adolescent homicide. Although it is possible that a larger study with more cases and controls might have found significant associations, our findings are consistent with the findings of case-control studies of adult shooting victims.^{16,27} Our findings suggest that prevention efforts for

adolescent firearm homicide may need to expand their focus to include broader social and contextual factors that are external to the individual.

Our findings also suggest that drug use by a caregiver should be considered an important risk factor for an adolescent to become a victim of a firearm homicide. Parental substance use has been directly associated with negative outcomes for youth in both the short and long term. Parental substance abuse is significantly associated with child maltreatment,^{28,29} and exposure to parental substance use disorders in adolescence has been shown to increase the risk of a substance use disorder in the adolescent.^{30,31}

Family factors that are predictive of violence against adolescents include parental problem behavior, adolescent social isolation from the family, limited parental monitoring, and possibly prior parental victimization.³² Absence of adolescent-adult connections³³ and poor-quality relationships with parents or peers have been shown to increase risks for violent injury.^{34,35} Caregiver substance use might increase adolescent homicide owing to lack of supervision, poorly modeled behavior, or a disruptive family environment. The presence of caregivers who do not use illicit drugs may be important for protecting adolescents from intentional and unintentional injuries, including serious forms of violence, during this critical period when they develop autonomy.

Prior research has shown that the association between alcohol use and becoming a victim of violence varies by neighborhood social and physical context,³⁶ and specific characteristics of neighborhood environments, such as disorder (eg, the presence of vacant or vandalized properties), where adoles-

Table 3. Drug and Alcohol Exposures and Adolescent Firearm Homicide, Unadjusted and Adjusted Odds Ratios

Characteristic	OR ^a (95% CI)	AOR ^b (95% CI)
Individual-Level Substance Use		
Using alcohol at the time	1.5 (0.6-3.5)	0.9 (0.2-3.8)
Using drugs at the time	3.8 (1.6-8.7)	3.4 (0.8-13.5)
History of alcohol abuse	7.4 (3.1-17.4)	4.1 (1.2-14.0)
History of drug use	6.6 (3.5-12.6)	4.4 (1.7-11.6)
Family-Level Substance Use		
Caregiver history of frequent alcohol use	3.4 (1.4-8.6)	1.6 (0.4-6.3)
Caregiver history of drug use	13.9 (4.3-45.3)	11.7 (2.8-48.0)
Neighborhood-Level Substance Use		
Alcohol outlet licenses (density/square mile)		
Low	1 [Reference]	1 [Reference]
Moderate	2.8 (1.5-5.1)	1.4 (0.6-3.5)
High	3.0 (1.6-5.5)	3.2 (1.1-9.1)
Bars and taverns visible	2.1 (0.7-6.2)	5.2 (0.8-33.5)
Beer stores and corner stores visible	1.9 (1.1-3.2)	1.1 (0.5-2.4)
Alcohol advertisements visible	1.8 (0.9-3.4)	2.2 (0.8-5.6)
Narcotics sales (density/square mile)		
Low	1 [Reference]	1 [Reference]
Moderate	4.0 (2.0-8.1)	3.4 (1.1-10.3)
High	8.8 (4.2-18.6)	7.5 (2.2-25.8)

Abbreviations: AOR, adjusted odds ratio; OR, odds ratio.

^a Odds ratio from conditional logistic regression matched on sex, hour of the day, and indoor/outdoor status.

^b AORs adjusted for individual age in years, race, school suspensions, history of prior arrest, and percent of the neighborhood population that was Hispanic.

cents spend time can increase their risk for violent injury.^{24,37} Previous research has also demonstrated a relationship between alcohol outlet density and violence in adults^{16,38,39} as well as youth.⁴⁰ This relationship may reflect increased alcohol consumption owing to greater availability, poor recognition of intoxicated individuals by people who are serving alcohol, and consumption of alcohol in outdoor spaces where consumption is prohibited by law.¹⁶ Goldstein⁴¹ theorized 3 pathways through which illegal drugs and violence might be related: psychopharmacological, economic compulsive, and systemic. Our findings related to illegal drug activity at the neighborhood level may be explained by the systemic pathway, whereby violent patterns of behavior emerge owing to the broad illegality of the drug trade and the absence of a legal system to monitor and resolve disputes.

Limitations

The limitations of our study should be noted. Our cooperation and response rates for control participants are similar to other representative, random sample surveys conducted during the same period⁴²⁻⁴⁴ and suggest enrollment of a reasonably representative sample of Philadelphia youth; still selection bias is possible. Case-control studies are more feasible and efficient when studying rare outcomes such as adolescent homicide. However, case-control studies are prone to bias, confounding, and issues of reverse causation. We adjusted for multiple covariates in an effort to limit confounding.⁴⁵ Still, differences between cases and controls may persist in other, unmeasured factors that we could not include. Studies using measures collected through interviews are prone to recall bias. We sought to reduce this bias by selecting and interviewing controls within a short time period and using prompts to promote and anchor recall. Exposures may have been classified differently between cases and controls. Adolescents may have responded in a socially desirable way when questioned about substance use behaviors or had limited knowledge about household substance use. We minimized the potential for such misclassifications by creating a safe interview structure with interview techniques to promote honest and complete responses. Finally, our findings might not generalize to nonurban areas whose adolescent injury risks can be substantially different.^{46,47}

Conclusions

Our findings suggest that public health approaches to prevent firearm homicides among adolescents should address risk factors for violence at multiple levels.⁴⁸ The oldest and most tested approaches to reducing youth violence focus on changing individual behavior and family environments.⁴⁹ Efforts are under way to encourage the integration of substance use disorder treatment with general medical care for adults^{50,51}; perhaps creating opportunities to also address youth violence in families. Recent violence reduction initiatives are focused on changing the physical and social characteristics of neighborhood (eg, improving physical infrastructure or building youth engagement).^{52,53} Interventions targeting drug and alcohol exposures at the neighborhood level could expand these efforts. Multi-level approaches should form the basis for future research and interventions to reduce the burden of firearm violence that disproportionately affects adolescents in minority populations in large US cities.

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Invited Commentary

FIREARM VIOLENCE

The Roles of Alcohol and Drugs in Firearm Violence

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Alcohol and drugs play substantial roles in firearm violence in the United States, including both homicide and suicide. As evidenced by the case-control study by Hohl and colleagues¹ in this issue of *JAMA Internal Medicine*, the relationship occurs on multiple levels. The study found that measures of individual, family, and neighborhood substance use—particularly for illicit drugs—increased the risk of becoming a victim of firearm homicide among Philadelphia adolescents. These findings contribute to a larger body of research suggesting that there are multiple direct and indirect pathways by which alcohol and drugs can increase the risk of firearm homicide and suicide. Delineation of such pathways is crucial for interventions to prevent firearm violence.

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Hohl et al¹ studied adolescents in Philadelphia aged 13 to 20 years. Compared with other age groups, adolescents and young adults are at highest risk of both misusing substances and perpetrating and becoming victims of firearm homicide. In 2014, 44% of adolescents and young adults aged 12 to 25 years reported binge drinking and 31% reported using an illicit drug in the past month, compared with 23% and 8% of those aged 26 years or older.² In the same year, there were 4254 firearm homicides among those younger than 26 years, accounting for 39% of all firearm homicides in the US. About 70% of all homicides in the US are committed with firearms, and the proportion is higher among youth. During Hohl et al's¹ 2010 to 2012 study period, 98% of Philadelphia homicide victims ages 13 to 20 years were killed with a firearm, compared with 86% nationwide for that age range.¹ The higher proportion of firearm homicides among adolescents in Philadelphia may be owing to a lower minimum age for legal handgun possession in Pennsylvania (18 vs 21 in some states). In addition, the city's high rate of violent crime may prompt more youth at high risk to carry guns.

Prevalence studies show a clear correlation between substance use and perpetrating and becoming a victim of firearm violence. Between 20% to 30% of federal and state prisoners report being under the influence of alcohol or drugs at the time of the violent crime for which they are incarcerated. Toxicology studies show frequent alcohol and drug use among firearm homicide and suicide decedents as well.^{3,4} Beyond correlation, the causal relationships between alcohol, drugs, and firearm homicide and suicide are complex. The best available

evidence suggests that (1) alcohol misuse increases the risks for firearm homicide perpetration and suicide, and (2) involvement in illegal drug sales increases the risks of firearm homicide perpetration and victimization. But consistent with the findings of Hohl et al,¹ the evidence does not support a causal relationship between acute alcohol or drug intoxication and increased risk of becoming a victim of firearm homicide.^{3,5}

The pharmacological effects of alcohol intoxication can decrease inhibitions, impair judgment, and lead to impulsive and violent behavior.^{4,5} The consequences of alcohol misuse can be deadly when there is ready access to a firearm. The strongest support for this claim is research linking alcohol misuse with a heightened risk of perpetration of intimate partner firearm homicide and with firearm suicide.⁴ Firearm owners are more likely than non-gun-owners to report high-risk alcohol use, underscoring the importance of reducing the access of individuals who misuse alcohol to firearms.⁴

In contrast, the evidence does not clearly support a pharmacological pathway between any illegal drug use and perpetration of firearm violence. A recent review,³ of which one of us was an author, found no association between individuals' use of any illegal drug and firearm homicide or suicide in prospective studies that controlled for concurrent alcohol use. Psychophysiological effects vary across different types of drugs, however. Use of cannabis and opiates—the most frequently used recreational drugs in the United States—tends to inhibit rather than increase violent behavior, though opiate withdrawal can increase risk of violence.³ The few studies examining drugs more likely to increase violent behavior, such as methamphetamine and cocaine, are hindered by small sample sizes.³ The weight of the evidence indicates that selling illegal drugs or participating in gangs that sell drugs heightens the risk of firearm homicide.³

Substance use also influences the risk of firearm violence through indirect pathways. Substance misuse can negatively affect educational attainment, employment and income, and facilitate association with delinquent peer groups, all of which increase the risk of firearm homicide.^{3,4} These socioeconomic and social factors also operate as shared risk factors that independently increase the risk of both substance misuse and firearm homicide along other pathways. For example, association with peers who misuse substances or perpetrate violence increase adolescents' risk of engaging in the same