Witnessing a Violent Death and Smoking, Alcohol Consumption, and Marijuana Use among Adolescents

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ABSTRACT *Witnessing violence has been linked to maladaptive coping behaviors such as smoking, alcohol consumption, and marijuana use. However, more research is required to identify mechanisms in which witnessing violence leads to these behaviors. The objectives of this investigation were to examine the association between witnessing a violent death and smoking, alcohol consumption, and marijuana use among adolescents, to identify whether exhibiting depressive symptoms was a mediator within this relationship, and to determine if those who had adult support in school were less likely to engage in risky health behaviors. Data were collected from a sample of 1,878 urban students, from 18 public high schools participating in the 2008 Boston Youth Survey. In 2012, we used multilevel log-binomial regression models and propensity score matching to estimate the association between witnessing a violent death and smoking, alcohol consumption, and marijuana use. Analyses indicated that girls who witnessed a violent death were more likely to use marijuana (relative risk (RR)=1.09, 95 % confidence interval (CI)=1.02, 1.17), and tended towards a higher likelihood to smoke (RR=1.06, 95 % CI=1.00, 1.13) and consume alcohol (RR=1.07, 95 % CI=0.97, 1.18). Among boys, those who witnessed a violent death were significantly more likely to smoke (RR=1.20, 95 % CI=1.11, 1.29), consume alcohol (RR=1.30, 95 % CI=1.17, 1.45) and use marijuana (RR=1.33, 95 % CI=1.21, 1.46). When exhibiting depressive symptoms was included, estimates were not attenuated. However, among girls who witnessed a violent death, having an adult at school for support was protective against alcohol consumption. When we used propensity score matching, findings were consistent with the main analyses among boys only. This study adds insight into how witnessing violence can lead to adoption of adverse health behaviors.*

KEYWORDS *Adolescents, Violence, Coping, Smoking, Alcohol Consumption, Marijuana Use*

Abbreviations: SES – Socioeconomic Status

INTRODUCTION

Violence, including shootings, violent deaths, suicides, and family or domestic violence, often involves collateral effects, i.e., those who suffer the effects are not just those who are directly victimized, but also those who witness violent acts. These witnesses can include relatives of the victims as well as bystanders in the community.^{1,2} According to

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findings from a national survey among children aged 2 to 17 years, 1 in 3 had been a witness to violence or experienced another form of what is sometimes referred to as “indirect victimization.”³ In addition, more than one half of the children and youth had experienced a physical assault (i.e., direct victimization) themselves.³ Only 29 % reported no direct or indirect victimization of violence.³ The burden of witnessing violence in the community is often concentrated in disadvantaged and predominantly minority schools and communities, that are more likely to be racially and socioeconomically segregated in US society.^{4,5} Recent evidence has identified associations between witnessing violence and adverse outcomes such as persistent psychological distress.⁶ Additionally, witnessing violence has been linked to subsequent maladaptive coping behaviors such as smoking,^{7,8} alcohol consumption,⁷⁻⁹ and marijuana use.^{8,10-12} However, none of these studies looked at witnessing a violent death as a main risk factor for these adverse behaviors. Also, the identification of pathways leading from witnessing violence to smoking, alcohol consumption, and marijuana use, are needed.

Exhibiting depressive symptoms has also been shown to be a risk factor for smoking, alcohol consumption, and marijuana use.^{13,14} Depression may act as a mediator along the pathway between exposure to violence and adverse health behaviors. Risky health behaviors may act as coping responses to the psychological distress following exposure to violence. A recent longitudinal study among adolescents showed that those who had higher depressive symptoms reported faster increases than their peers in smoking, marijuana, and hard drug use across the high school years.¹⁵ These findings support the hypothesis that adolescents may smoke, consume alcohol, or use marijuana as a way to self-medicate and alleviate depressive symptoms.¹⁵⁻¹⁷

Not every instance of witnessing violence results in adverse health outcomes, a difference that may depend on the availability of coping resources such as social support. For example, researchers conducted a longitudinal study and observed a lack of perceived social support to be a predictor for depressive symptoms.¹⁸ Subsequently, exhibiting depressive symptoms has led to an increased risk for alcohol consumption.¹⁸ When traumatic events are witnessed, social support may serve as a stress buffer for adolescents, enabling them to avoid participation in harmful behaviors.

Low socioeconomic status (SES) has shown to be related to greater smoking behavior among adolescents.¹⁹ The findings are more mixed for the association between SES and alcohol consumption and marijuana use.¹⁹ According to the social determinants framework, the conditions in which people were born, grow, live, work, and age, play an important role in health and well-being.²⁰ Thus, several contextual characteristics of low SES neighborhoods might act as potential confounders between the relationship of witnessing a violent death and the three adverse behavioral outcomes. For example, neighborhood poverty has shown to be related to crime and violence, such as homicide.^{21,22} Rates of violence-related firearm deaths are highest in poor urban neighborhoods.²³ In turn, neighborhood poverty (independently of individual level SES) is associated with smoking,^{19,24} alcohol consumption,^{25,26} and marijuana use.²⁶ Some researchers have observed different results; i.e., students living in higher SES neighborhoods were significantly more likely to consume alcohol and use marijuana.²⁷ But regardless of the direction of associations, these findings point to the need to control for neighborhood SES as a potential confounder of the relationship between witnessing violence and health-related behaviors.

Additionally, the racial composition of an area has also been shown to be correlated with crime rates and violence,²⁸ and some evidence also links this neighborhood characteristic to smoking²⁹ and substance use.³⁰ In short, both neighborhood poverty and proportion of the neighborhood that is black are contextual indicators of socioeconomic status that can act as potential confounders. Therefore, researchers need to determine if the relationship between witnessing a violent death and participating in adverse behaviors is above and beyond the effects of these contextual characteristics.

Previous research has indicated that there are not only striking gender differences in the likelihood of being exposed to violence but in how adolescent boys and girls also react to violence. Several studies have identified that adolescent boys are more likely to witness a violent death.^{31,32} Furthermore, the effect of witnessing violence has proven to be more detrimental to adolescent girls.³¹ For example, researchers observed, in comparison to males, females were significantly more likely to develop PTSD when exposed to extreme violence.³³

Although a few studies among adolescents have identified the relationship between exposure to violence and adverse health behaviors, more investigation that attempts to understand the pathways involved is warranted. The primary objective of this study was to examine if witnessing violent deaths was associated with smoking, alcohol consumption, and marijuana use among a diverse sample of public high school students in Boston, MA. Secondly, we attempted to identify depressive symptoms as a possible mediator between witnessing a violent death and the behavioral outcomes. Thirdly, we sought to determine if having access to an adult at school for support acted as buffer between witnessing a violent death and the three negative health behaviors.

METHODS

Data for this investigation come from the 2008 Boston Youth Survey (BYS), a biennial survey of high school students (grades 9–12) in Boston public schools.^{34–36} A two-stage, stratified random sampling strategy was used and has been described elsewhere.^{35,36} The first stage consisted of inviting all 32 secondary schools in the Boston public schools system with non-specialty enrollments. Twenty-two of the eligible schools agreed to participate in the survey. Each participating school provided a unique list of classrooms stratified by grade, from which we randomly selected classrooms during the second stage. Classrooms were selected until the total number of enrolled students reached 100 to 125 per school. The final sample of students was representative of students in all schools in the Boston area in terms of race/ethnicity of the students, school drop-out rates, and other variables.³⁵

Data Collection

The BYS study staff developed the questionnaire, which included topics such as health behaviors, use of school and community resources, and indicators of positive youth development, with a particular emphasis on violence exposure using questions adapted from the My Exposure to Violence instrument developed by the Project on Human Development in Chicago Neighborhoods.³⁷ The paper-and-pencil survey was administered in classrooms in the spring of 2008. Passive consent was sought from students' parents prior to survey administration, and informed assent was given to and read aloud to students by survey administrators. Of the students selected ($n=2,725$), 69 % completed surveys ($n=1,878$). Of those who did not

complete a survey, $n=99$ chose not to participate, $n=24$ were not permitted by a parent or caregiver to take the survey, and the rest were absent the day of the survey ($n=724$). The Office of Human Research Administration at the Harvard School of Public Health approved all procedures for the BYS.

Study Variables

The three outcome variables were current smoking, alcohol consumption, and marijuana use. For each behavior, students were asked, "In the past 30 days, on how many days did you..." Response options included none, 1–2, 3–9, or 10 or more; and were dichotomized into none vs. yes.

The main exposure variable was whether adolescents reported they had witnessed a violent death in the past 12 months. Respondents were asked, "In the past 12 months, have you seen somebody get killed by violence like being shot, stabbed, or beaten to death?" Students were instructed to think only about real life and to not include things that may have been seen on TV, radio, the news, the Internet, a game, or in a movie. Response options were "yes" or "no."

Covariates included age, nativity (US born, foreign born arrived ≤ 4 years and foreign born arrived >4 years), and race/ethnicity (white, black, Asian, Hispanic, and other).

Since no individual level SES information was collected, i.e., household income, a neighborhood SES score was created using principal components analysis. Participants' home addresses were matched by zip code to the US Census. US Census indicators included proportion residents living below poverty level, proportion of households receiving public assistance, and proportion of families with a female head (Cronbach alpha=0.84). Quartiles of the neighborhood socioeconomic score were used to categorize neighborhood SES into very high, high, low, and very low.

The proportion of the residential neighborhood that is black was categorized into low ($<33\%$), medium ($33\text{--}66\%$), and high ($>66\%$) using US Census data.

The neighborhood socioeconomic score and proportion of the residential neighborhood that is black were moderately correlated (Pearson's $r=0.61$, $p<0.01$).

We used the Modified Depression Scale (MDS) to assess depressive symptoms.³⁸ Briefly, the MDS is a 5-item scale that is used to estimate the level of depressive symptoms in students. It has acceptable reliability (Cronbach's $\alpha=0.79$) and known-group validity (a form of construct validity).³⁸

We also tested to see if the association of witnessing a violent death on the three outcomes was moderated by whether or not the student had support from an adult at school. Students were asked to mark how much they agreed or disagreed with the statement "An adult at my school would help me if I had a problem or were upset." We dichotomized the responses into agree (agree or strongly agree) and disagree (disagree and strongly disagree).

STATISTICAL ANALYSIS

In 2012, data analysis was performed using Stata 12.0 (StataCorp, College Station, Texas). In the binomial regression analyses, we controlled for socio-demographic variables that could potentially confound the association between witnessing a violent death and smoking, alcohol consumption, and marijuana use. All multiple logistic regression analyses controlled for age, race/ethnicity, US nativity, neighborhood SES, and proportion of the neighborhood that is black. We conducted separate

analyses for girls and boys for each of the three outcomes since sex $\times$ witness to a violent death interaction terms were significant. The first model included the confounders. Then the mediator (depressive symptoms) was added followed by the addition of the interaction term: witnessed violence $\times$ receiving social support from an adult at school. We used the `xtmixed` command to account for the students being clustered within schools.

To determine whether depressive symptoms acted as a mediator between witnessing a violent death and smoking, alcohol consumption, and marijuana use, we applied the Baron and Kenny³⁹ method to test mediation of the following relationships: (1) witnessing a violent death and each of the health behavioral outcomes, (2) witnessing a violent death and depressive symptoms, and (3) depressive symptoms and the health behavioral outcomes.

Of the 1,878 participants, complete information was available for 729 girls and 553 boys (68.3 % of the sample). Those excluded due to missing data were more likely to be Black (odds ratio (OR)=2.00, 95 % CI=1.37, 2.91), immigrated to the US less than 4 years ago (OR=2.20, 95 % CI=1.62, 3.00), immigrated to the US more than 4 years ago (OR=1.30, 95 % CI=1.02, 1.66), and living in a neighborhood with a high proportion of Blacks (OR=1.82, 95 % CI=1.36, 2.45). Those excluded were less likely to be female and more likely to be from very low SES neighborhoods.

Propensity Score Matching

We used propensity score matching as an alternative method for addressing confounding.⁴⁰ In observational studies, researchers have no control over the treatment assignment, which may result in large differences on observed covariates in the two groups. This can lead to biased estimates of treatment effects.⁴⁰ Traditional multivariate analyses may not be sufficient to eliminate this bias. As a sensitivity analysis, we evaluated the treatment effect of witnessing a violent death on smoking, alcohol consumption, and marijuana use among girls and boys participating in the BYS by propensity score matching.

The goal of the propensity approach is to identify individuals that are as alike as possible to each other with respect to the probability of receiving the “treatment” or experiencing the exposure—that is of having witnessed a violent death. These potentially “exchangeable” individuals are matched on their propensity score so that differences in their health outcomes can be compared. Therefore, each individual who witnessed a violent death is matched with another individual that resembles its counterfactual had it not witnessed a violent death.

Using probit regression, a propensity score was calculated for each child as the probability of witnessing a violent death, conditional on the observed individual and neighborhood covariates listed above. Probabilities of witnessing a violent death vs. not witnessing a violent death were then matched across the area of common support (where the distribution of propensity scores overlap) using the nearest two neighbors matching method with calipers set to 0.01. This method matches students with witnessing and not witnessing a violent death pattern scores on their probability of witnessing a violent death, conditional on all covariates. Propensity score analyses were conducted using Stata’s `PSMATCH2` command. Of the sample, 409 girls and 317 boys were not matched and therefore excluded from the sample. Again, analyses were conducted separately for girls (treated=137; untreated=183) and boys (treated=93; untreated=143).

The distributions of the propensity scores for the exposed and unexposed were determined to see if they overlapped as expected. Also, to evaluate if the elimination of confounding bias was eliminated we used the *t* test to compare the means of each covariate between the exposed and unexposed groups. Also, the standardized difference and the bias percentage reduction were calculated after propensity score matching analyses.

RESULTS

More than half of the participants were female ($n=729$, 56.9 %). Average age was 16.3 years ($SD=1.3$) and 16.4 years ($SD=1.3$) among girls and boys, respectively. Of the girls, 9.6, 46.8, 8.4, and 25.8 % were White, Black, Asian, and Hispanic respectively. Similarly, among boys, 14.3, 43.6, 8.7, and 29.5 % were White, Black, Asian, and Hispanic respectively (Table 1).

Among the sample, 18.8 % of girls and 17.4 % of boys reported witnessing a violent death in the last 12 months ($\chi^2=0.34$, $p=0.56$). Among girls living in very high, high, low, and very low SES neighborhoods, 11, 11, 17, and 27 % reported witnessing a violent death in the past 12 months. Also, among girls living in neighborhoods with low, medium, and high proportions of blacks, 10, 25, and

TABLE 1 Characteristics of students participating in the Boston Youth Survey 2008 ($n=1,282$)

	Girls ($n=729$)		Boys ($n=553$)	
	Number	Percent	Number	Percent
Witnessed a violent death in the last 12 months				
No	592	81.2	457	82.6
Yes	137	18.8	96	17.4
Age				
13 and 14	62	8.5	39	7.1
15	155	21.3	100	18.1
16	190	26.1	159	28.8
17	199	27.3	153	27.8
18	99	13.6	73	13.2
19	24	3.3	29	5.2
Race				
White	70	9.6	79	14.3
Black	341	46.8	241	43.6
Asian	61	8.4	48	8.7
Hispanic	188	25.8	163	29.5
Other	69	9.5	22	4.0
Immigrant status				
US born	541	74.2	386	69.8
Moved in the last 4 years	55	7.5	47	8.5
Moved greater than 4 years ago	133	18.2	120	21.7
Neighborhood SES				
Very low	270	37.0	188	34.0
Low	223	30.6	170	30.7
High	173	23.7	144	26.0
Very high	63	8.6	51	9.2
Proportion Black in neighborhood				
Low	272	37.3	237	42.9
Medium	273	37.5	175	31.7
High	184	25.2	141	25.5

23 %, respectively, reported witnessing a violent death in the past 12 months ($\chi=22.44, p<0.01$). A similar trend was observed among boys. Boys living in very high, high, low, and very low SES neighborhoods 6, 15, 18, and 22 % reported witnessing a violent death ($\chi=8.14, p<0.05$). Among boys living in neighborhoods with low, medium, and high proportions of blacks, 13, 21, and 21 % reported witnessing a violent death ($\chi=6.41, p<0.05$), respectively.

Smoking behavior was more prevalent among boys (14.8 %) than girls (10.9 %) ($\chi=3.96, p<0.05$). No significant difference was observed between girls (38.4 %) and boys (40.4 %) regarding alcohol consumption ($\chi=0.46, p=0.50$). Marijuana use was more common among boys (23.8 %) in comparison to girls (15.7 %) ($\chi=12.85, p<0.01$).

Tables 2 and 3 shows the four sets of models among girls and boys, respectively. The unadjusted model (model 1) displays the association between witnessing a violent death and smoking, alcohol consumption, and marijuana use. Confounders, mediators, and effect modifiers were added in models 2, 3, and 4, respectively.

In bivariate analyses, witnessing a violent death was associated with an increased likelihood for smoking, alcohol consumption, and marijuana use among girls (Table 2) and boys (Table 3). Compared with girls who did not witness a violent death, those who did were more likely to use marijuana (RR=1.09, 95 % CI=1.02, 1.18) and tended toward a higher likelihood to smoke (RR=1.06, 95 % CI=0.99, 1.12) and consume alcohol (RR=1.07, 95 % CI=0.98, 1.18). The likelihood of engaging in the three behavioral outcomes was greater among boys than in girls. Boys who witnessed a violent death were more likely to smoke (RR=1.20, 95 % CI=1.11, 1.30), consume alcohol (RR=1.34, 95 % CI=1.20, 1.49) and use marijuana (RR=1.34, 95 % CI=1.22, 1.48) in comparison to boys who have not.

Results of the multivariate logistic regression analyses indicated that witnessing a violent death was significantly associated with increased likelihood of consuming alcohol and marijuana use among both girls and boys. The likelihood was greater among boys than among girls. Witnessing a violent death was significantly associated with smoking among boys only. In comparison to girls who did not witness a violent death, those who did were more likely to use marijuana (RR=1.09, 95 % CI=1.02, 1.17). Similarly, among boys, those who witnessed a violent death were significantly more likely to smoke (RR=1.20, 95 % CI=1.11, 1.29), consume alcohol (RR=1.30, 95 % CI=1.17, 1.45), and use marijuana (RR=1.33, 95 % CI=1.21, 1.46).

When exhibiting depressive symptoms was included in the models, the likelihood estimates for smoking, alcohol consumption, and marijuana use were not attenuated among girls or boys (Tables 2 and 3). For example, among boys, those who witnessed a violent death were more likely to smoke (RR=1.18, 95 % CI=1.10, 1.28), consume alcohol (RR=1.28, 95 % CI=1.15, 1.43), and use marijuana (RR=1.30, 95 % CI=1.19, 1.43), results that are similar to those without depressive symptoms in the models. Also, with the exception of the multivariate model for alcohol use among girls, witnessing a violent death was associated with an increased risk for depressive symptoms.

Results of testing possible mediation relationships are shown in Table 4. In bivariate analyses, those who witnessed a violent death were significantly more likely to exhibit depressive symptoms among girls [RR=1.07 (95 % CI=1.01, 1.14)] and boys [RR=1.20 (95 % CI=1.00, 1.42)]. Also, those who exhibited depressive symptoms were more likely to smoke, consume alcohol, and use marijuana.

When an interaction term witnessing a violent death X having an adult in school for social support were included in the models to test for moderation, the term was

TABLE 2 Association between witnessing a violent death and tobacco use, alcohol consumption, and marijuana use among girls

	Tobacco use			Alcohol use			Marijuana use		
	Crude	Model 1	Model 2	Model 3	Crude	Model 1	Model 2	Model 3	Model 1
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Witness to a violent death									
No (ref)									
Yes	1.06 (0.99, 1.12)	1.06 (1.00, 1.13)	1.05 (0.99, 1.12)	1.05 (0.99, 1.13)	1.07 (0.98, 1.18)	1.07 (0.97, 1.18)	1.07 (0.97, 1.17)	1.12 (1.01, 1.25)	1.09 (1.02, 1.17)
Age (ref: 14 years)									
15 years	1.00 (0.90, 1.11)	1.00 (0.90, 1.11)	0.99 (0.89, 1.09)	0.98 (0.98, 1.12)	1.02 (0.87, 1.20)	1.02 (0.87, 1.20)	1.02 (0.87, 1.20)	1.03 (0.88, 1.21)	1.05 (0.93, 1.19)
16 years	1.02 (0.92, 1.13)	1.02 (0.92, 1.13)	1.01 (0.91, 1.11)	1.00 (0.90, 1.10)	1.05 (0.89, 1.22)	1.04 (0.89, 1.22)	1.04 (0.89, 1.22)	1.05 (0.90, 1.23)	1.14 (1.01, 1.29)
17 years	1.00 (0.91, 1.11)	1.00 (0.91, 1.11)	1.00 (0.91, 1.10)	1.00 (0.90, 1.10)	1.04 (0.89, 1.21)	1.04 (0.89, 1.21)	1.04 (0.89, 1.21)	1.04 (0.89, 1.22)	1.09 (0.97, 1.22)
18 years	1.08 (0.97, 1.20)	1.08 (0.97, 1.20)	1.06 (0.95, 1.18)	1.06 (0.95, 1.18)	1.16 (0.98, 1.37)	1.16 (0.98, 1.37)	1.16 (0.98, 1.37)	1.17 (0.99, 1.39)	1.15 (1.01, 1.29)
Race									
White (ref)									
Black	0.83 (0.74, 0.93)	0.83 (0.75, 0.93)	0.83 (0.75, 0.93)	0.83 (0.75, 0.93)	1.00 (0.84, 1.19)	1.00 (0.84, 1.19)	1.00 (0.84, 1.19)	1.00 (0.84, 1.18)	0.91 (0.80, 1.04)
Asian	0.89 (0.75, 1.05)	0.89 (0.75, 1.05)	0.89 (0.75, 1.05)	0.88 (0.75, 1.04)	0.80 (0.61, 1.03)	0.80 (0.61, 1.03)	0.80 (0.61, 1.03)	0.79 (0.61, 1.03)	0.82 (0.67, 1.00)
Hispanic	0.80 (0.71, 0.89)	0.80 (0.72, 0.89)	0.80 (0.72, 0.89)	0.80 (0.72, 0.90)	1.01 (0.84, 1.20)	1.01 (0.84, 1.20)	1.01 (0.84, 1.20)	1.01 (0.85, 1.20)	0.85 (0.75, 0.97)
Other	0.86 (0.76, 0.98)	0.87 (0.76, 0.99)	0.87 (0.76, 0.99)	0.87 (0.76, 0.99)	0.80 (0.65, 0.98)	0.80 (0.65, 0.98)	0.80 (0.65, 0.98)	0.81 (0.66, 0.99)	0.88 (0.76, 1.03)
US nativity									
US born (ref)									
Immigrant (≤4 years)	0.93 (0.82, 1.05)	0.93 (0.83, 1.05)	0.93 (0.83, 1.05)	0.93 (0.82, 1.05)	0.88 (0.73, 1.06)	0.88 (0.73, 1.06)	0.88 (0.73, 1.06)	0.90 (0.75, 1.09)	0.88 (0.76, 1.03)

Immigrant (4 years)	1.00 (0.94, 1.07)	1.00 (0.93, 1.07)	1.00 (0.93, 1.07)	1.02 (0.92, 1.13)	1.02 (0.92, 1.13)	1.02 (0.92, 1.14)	0.95 (0.88, 1.03)	0.95 (0.88, 1.03)	0.95 (0.88, 1.03)
Neighborhood SES (ref: very low)									
Low SES	0.98 (0.92, 1.05)	0.98 (0.92, 1.05)	0.98 (0.92, 1.05)	0.98 (0.88, 1.08)	0.98 (0.88, 1.08)	0.97 (0.88, 1.08)	1.04 (0.96, 1.13)	1.04 (0.96, 1.17)	1.05 (0.97, 1.14)
High SES	1.01 (0.94, 1.08)	1.00 (0.93, 1.07)	1.01 (0.94, 1.08)	0.95 (0.85, 1.06)	0.95 (0.85, 1.06)	0.94 (0.84, 1.05)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)	1.10 (1.01, 1.20)
Very high SES	1.08 (0.95, 1.23)	1.07 (0.94, 1.21)	1.08 (0.95, 1.22)	1.17 (0.96, 1.43)	1.17 (0.96, 1.43)	1.16 (0.94, 1.41)	0.99 (0.85, 1.15)	0.98 (0.84, 1.13)	0.99 (0.85, 1.15)
Percentage of neighborhood Black									
Low (ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium	0.99 (0.92, 1.06)	0.99 (0.93, 1.06)	0.99 (0.93, 1.06)	0.93 (0.84, 1.04)	0.93 (0.84, 1.04)	0.93 (0.84, 1.04)	0.99 (0.91, 1.07)	0.99 (0.91, 1.07)	0.98 (0.90, 1.06)
High	1.00 (0.92, 1.08)	1.00 (0.92, 1.09)	1.00 (0.92, 1.08)	0.96 (0.84, 1.09)	0.96 (0.85, 1.09)	0.96 (0.85, 1.09)	1.05 (0.96, 1.16)	1.06 (0.96, 1.17)	1.05 (0.95, 1.16)
Depression									
No (ref)		1.00	1.00			1.00		1.00	1.00
Yes		1.11 (1.03, 1.19)	1.10 (1.02, 1.19)			1.01 (0.90, 1.14)		1.08 (0.99, 1.17)	1.07 (0.98, 1.18)
Adult support in HS									
Yes (ref)			1.00			1.00			1.00
No			1.05 (0.97, 1.14)			1.03 (0.91, 1.16)			1.08 (0.98, 1.18)
Witness*adult interaction			1.00 (0.86, 1.16)			0.77 (0.61, 0.98)			1.04 (0.87, 1.24)

TABLE 3 Association between witnessing a violent death and tobacco use, alcohol consumption, and marijuana use among boys

	Tobacco use			Alcohol use			Marijuana use				
	Crude		Model 3	Crude		Model 3	Crude		Model 3		
	OR (95 % CI)	Model 1 (95 % CI)	Model 2 (95 % CI)	OR (95 % CI)	Model 1 (95 % CI)	Model 2 (95 % CI)	OR (95 % CI)	Model 1 (95 % CI)	Model 2 (95 % CI)	Model 3 (95 % CI)	
Witness to a violent death											
No (ref)											
Yes	1.20 (1.11, 1.30)	1.20 (1.11, 1.29)	1.18 (1.10, 1.28)	1.19 (1.09, 1.30)	1.34 (1.20, 1.49)	1.30 (1.17, 1.45)	1.28 (1.15, 1.43)	1.36 (1.19, 1.54)	1.33 (1.21, 1.46)	1.30 (1.19, 1.43)	1.31 (1.18, 1.47)
Age (ref: 14 years)											
15 years		0.92 (0.80, 1.06)	0.91 (0.79, 1.04)	0.90 (0.79, 1.04)		1.05 (0.86, 1.28)	1.03 (0.84, 1.25)	1.04 (0.86, 1.27)	1.01 (0.85, 1.20)	0.99 (0.83, 1.17)	0.99 (0.83, 1.17)
16 years		0.94 (0.82, 1.07)	0.93 (0.81, 1.06)	0.92 (0.81, 1.06)		1.05 (0.87, 1.28)	1.04 (0.86, 1.26)	1.07 (0.89, 1.29)	1.00 (0.84, 1.18)	0.99 (0.84, 1.16)	0.99 (0.84, 1.17)
17 years		0.95 (0.83, 1.09)	0.95 (0.83, 1.08)	0.95 (0.83, 1.08)		1.13 (0.93, 1.37)	1.12 (0.93, 1.35)	1.14 (0.94, 1.37)	1.02 (0.87, 1.20)	1.01 (0.86, 1.19)	1.01 (0.86, 1.19)
18 years		1.07 (0.93, 1.23)	1.06 (0.92, 1.22)	1.05 (0.92, 1.21)		1.23 (1.00, 1.50)	1.21 (0.99, 1.48)	1.23 (1.01, 1.51)	1.18 (0.99, 1.40)	1.16 (0.98, 1.38)	1.17 (0.98, 1.39)
Race											
White (ref)											
Black		0.77 (0.69, 0.87)	0.79 (0.70, 1.04)	0.78 (0.69, 0.88)		0.82 (0.69, 0.97)	0.83 (0.70, 0.98)	0.84 (0.71, 0.98)	0.89 (0.77, 1.03)	0.90 (0.78, 1.04)	0.90 (0.79, 1.04)
Asian		0.80 (0.68, 0.93)	0.81 (0.69, 0.94)	0.81 (0.69, 0.94)		0.80 (0.64, 1.00)	0.81 (0.65, 1.00)	0.80 (0.65, 1.00)	0.91 (0.75, 1.10)	0.92 (0.76, 1.11)	0.92 (0.76, 1.10)
Hispanic		0.75 (0.67, 0.84)	0.76 (0.68, 0.85)	0.76 (0.68, 0.85)		1.00 (0.85, 1.17)	1.01 (0.87, 1.19)	1.01 (0.87, 1.19)	0.90 (0.79, 1.04)	0.92 (0.80, 1.05)	0.92 (0.80, 1.05)
Other		0.79 (0.66, 0.94)	0.80 (0.67, 0.95)	0.80 (0.67, 0.95)		0.98 (0.76, 1.26)	0.98 (0.77, 1.26)	1.01 (0.79, 1.30)	1.06 (0.85, 1.32)	1.07 (0.86, 1.33)	1.08 (0.87, 1.33)
US nativity											
US born (ref)											
Immigrant		0.89 (0.79, 1.00)	0.89 (0.83, 1.00)	0.90 (0.79, 1.01)		0.90 (0.76, 1.08)	0.90 (0.76, 1.07)	0.87 (0.73, 1.04)	0.81 (0.69, 0.94)	0.80 (0.69, 0.93)	0.79 (0.68, 0.92)
(≤4 years)											

Immigrant (4 years)	0.95 (0.88, 1.03)	0.96 (0.89, 1.04)	0.96 (0.89, 1.04)	0.98 (0.88, 1.09)	0.99 (0.89, 1.23)	0.98 (0.88, 1.09)	0.87 (0.79, 0.96)	0.88 (0.80, 0.97)	0.88 (0.80, 0.96)
Neighborhood SES (ref: very low)									
Low SES	1.08 (1.00, 1.17)	1.07 (0.99, 1.16)	1.07 (0.99, 1.16)	1.03 (0.92, 1.16)	1.02 (0.91, 1.14)	1.01 (0.90, 1.13)	0.98 (0.89, 1.08)	0.96 (0.87, 1.06)	0.96 (0.87, 1.06)
High SES	1.03 (0.94, 1.12)	1.02 (0.93, 1.11)	1.02 (0.93, 1.11)	0.96 (0.84, 1.06)	0.95 (0.84, 1.08)	0.93 (0.82, 1.06)	1.02 (0.92, 1.14)	1.01 (0.91, 1.13)	1.01 (0.90, 1.13)
Very high SES	1.05 (0.91, 1.21)	1.03 (0.90, 1.19)	1.03 (0.90, 1.19)	1.03 (0.84, 1.25)	1.01 (0.83, 1.23)	1.01 (0.83, 1.23)	0.89 (0.75, 1.06)	0.88 (0.74, 1.04)	0.88 (0.80, 0.96)
Percentage of neighborhood Black									
Low (ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium	1.03 (0.95, 1.12)	1.03 (0.95, 1.11)	1.02 (0.94, 1.11)	1.07 (0.95, 1.20)	1.06 (0.95, 1.20)	1.06 (0.95, 1.19)	1.04 (0.94, 1.15)	1.03 (0.93, 1.14)	1.03 (0.93, 1.14)
High	1.04 (0.95, 1.15)	1.03 (0.90, 1.19)	1.03 (0.94, 1.13)	1.05 (0.92, 1.21)	1.04 (0.91, 1.19)	1.04 (0.91, 1.19)	1.02 (0.91, 1.15)	1.01 (0.90, 1.14)	1.01 (0.90, 1.14)
Depression									
No (ref)		1.00	1.00		1.00	1.00		1.00	1.00
Yes		1.27 (1.10, 1.47)	1.27 (1.10, 1.47)		1.30 (1.06, 1.59)	1.29 (1.05, 1.58)		1.38 (1.15, 1.64)	1.38 (1.15, 1.64)
Adult support in HS									
Yes (ref)									
No			1.00 (0.90, 1.04)						1.00 (0.95, 1.14)
Witness*adult interaction			0.97 (0.84, 1.17)						1.04 (0.97, 1.19)

TABLE 4 Bivariate analyses of the relationship between depression and witness to a violent death and smoking, alcohol consumption, and marijuana use among girls and boys: Boston Youth Study; Boston; 2008

	Witness to someone killed	Tobacco use	Alcohol consumption	Marijuana use
	95 % CI	95 % CI	95 % CI	95 % CI
Girls				
Depression				
No (ref)	1.00	1.00	1.00	1.00
Yes	1.07 (1.01, 1.14)	1.13 (1.05, 1.22)	1.05(0.93, 1.18)	1.09(1.00, 1.19)
Boys				
Depression				
No (ref)	1.00	1.00	1.00	1.00
Yes	1.20 (1.00, 1.42)	1.36 (1.18, 1.58)	1.37 (1.11, 1.70)	1.48 (1.22, 1.78)

significant within the multivariate model looking at the relationship between witnessing a violent death and alcohol consumption (RR=0.77, 95 % CI=0.61, 0.98) among girls only (Table 2). Therefore, among girls who witnessed a violent death, those who had no adult at school for support were more likely to consume alcohol. Girls who had an adult at school for support were less likely to consume alcohol.

Results of Propensity Score Analyses

Figure 1 presents the distribution of the propensity scores according to exposure status. These graphs indicate that there is an acceptable overlap between the two sets of propensity scores. A propensity score analysis is considered to be valid when it reduces covariate bias between treated and untreated participants.⁴¹ Table 5 presents the mean values of the covariates before matching. Of the 22 covariates, 9 (among girls’ model) and 7 (among boys’ model) had a significant *t* test (*p*<0.05) suggesting different means between the exposed and unexposed. Table 6 presents the mean values of the covariates after matching. After matching, no covariates had a significant *t* test (*p*>0.05) between the exposed and unexposed among both girls and boys, which indicates that confounding has been eliminated.

When propensity score matching was utilized, being a witness to a violent death was significantly associated with smoking, alcohol consumption, and marijuana use among boys only. Among girls, witnessing a violent death was not significantly associated with smoking (RR=1.35, 95 % CI=0.77, 2.37), alcohol consumption (RR=1.09, 95 % CI=0.85, 1.39), and marijuana use (RR=1.44, 95 % CI=0.92, 2.25). Conversely, among boys, witnessing a violent death was significantly associated with smoking (RR=2.85, 95 % CI=1.46, 5.55), alcohol consumption (RR=1.74, 95 % CI=1.34, 2.26), and marijuana use (RR=2.10, 95 % CI=1.44, 3.05).

DISCUSSION

In this cross-sectional study in Boston, Massachusetts, we found that adolescents who witnessed a violent death were more likely to smoke, consume alcohol, and use marijuana. This effect was stronger and more consistent among boys than girls. Having depressive symptoms did not appear to act as a mediator of the relationship

FIGURE 1. The distribution of propensity scores among the exposed and unexposed, stratified by girls (*top*) and boys (*bottom*).

between witnessing a violent death and maladaptive health behaviors. However, having adult support in high school may be protective against consuming alcohol, at least for girls, as we found evidence of moderation.

TABLE 5 Covariate imbalance before propensity score matching

Covariates	Girls				Boys					
	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value
Age										
14 years	0.09	0.06	-0.125	1.24	0.22	0.08	0.02	-0.276	2.10	0.04
15 years	0.22	0.18	-0.093	0.96	0.34	0.19	0.16	-0.079	0.69	0.49
16 years	0.26	0.28	0.047	-0.49	0.62	0.29	0.26	-0.073	0.64	0.52
17 years	0.27	0.31	0.091	-0.98	0.33	0.27	0.32	0.123	-1.11	0.27
18 years	0.17	0.18	0.021	-0.22	0.82	0.17	0.24	0.165	-1.53	0.13
Race										
White	0.11	0.04	-0.244	2.31	0.02	0.16	0.07	-0.276	2.16	0.03
Black	0.45	0.56	0.233	-2.46	0.01	0.43	0.46	0.055	-0.49	0.63
Asian	0.10	0.01	-0.424	3.61	<0.01	0.10	0.04	-0.216	1.73	0.08
Hispanic	0.26	0.27	0.034	-0.36	0.72	0.28	0.39	0.234	-2.15	0.03
Other	0.09	0.12	-0.089	-0.98	0.33	0.04	0.04	0.012	-0.10	0.92
Immigrant status										
US born (ref)	0.73	0.80	0.155	-1.59	0.11	0.70	0.69	-0.028	0.25	0.81
Immigrant (≤4 years)	0.09	0.03	-0.246	2.28	0.02	0.09	0.06	-0.102	0.87	0.39
Immigrant (>4 years)	0.18	0.18	-0.023	0.24	0.81	0.21	0.25	0.095	-0.86	0.39
Neighborhood SES										
Very low	0.33	0.53	0.392	-4.22	<0.01	0.32	0.43	0.218	-1.99	<0.05
Low SES	0.31	0.28	-0.057	0.60	0.55	0.30	0.32	0.04	-0.36	0.72
High SES	0.26	0.14	-0.307	3.03	<0.01	0.27	0.22	-0.117	1.02	0.31
Very high SES	0.09	0.05	-0.168	1.63	0.10	0.11	0.03	-0.295	2.28	0.02
Percentage of neighborhood Black										
Low	0.41	0.20	-0.483	4.80	<0.01	0.45	0.31	2.54	2.54	0.01
Medium	0.35	0.49	0.288	-3.09	<0.01	0.30	0.39	0.176	-1.60	0.11
High	0.24	0.31	0.170	-1.84	0.07	0.25	0.30	0.128	-1.16	0.24
Depression										
Yes	0.10	0.18	0.215	-2.45	0.01	0.03	0.11	0.326	-3.64	<0.01
Adult support in HS										
No	0.20	0.20	-0.006	0.06	0.95	0.24	0.30	0.133	-1.21	0.23

TABLE 6 Covariate imbalance after propensity score matching

Covariates	Girls					Boys						
	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value	Bias reduction (%)	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value	Bias reduction (%)
Age												
14 years	0.08	0.06	-0.078	-0.25	0.80	62.9	0.04	0.01	-0.341	1.78	0.08	-32.9
15 years	0.24	0.18	-0.128	-0.97	0.33	8.3	0.17	0.16	-0.042	-0.78	0.44	-183.5
16 years	0.25	0.28	0.073	0.27	0.79	54.4	0.29	0.26	-0.072	-0.34	0.74	30.8
17 years	0.29	0.30	0.033	0.53	0.59	-96.7	0.23	0.33	0.223	1.76	0.08	-16.1
18 years	0.15	0.18	0.067	0.24	0.81	55.5	0.23	0.24	0.043	0.71	0.48	-141.3
Race												
White	0.04	0.04	-0.004	-0.00	1.00	100.0	0.08	0.08	-0.016	0.00	1.00	100.0
Black	0.60	0.56	-0.074	-0.86	0.39	-40.3	0.51	0.47	-0.094	-0.07	0.94	88.2
Asian	0.03	0.01	-0.157	-1.01	0.32	29.1	0.03	0.04	0.052	0.38	0.70	-9.0
Hispanic	0.22	0.27	0.109	1.06	0.29	-16.5	0.34	0.37	0.050	-0.31	0.76	8.2
Other	0.11	0.12	0.034	0.29	0.77	-1.1	0.03	0.04	0.091	0.60	0.55	2.2
Immigrant status												
US born (ref)	0.80	0.80	0.009	-0.31	0.76	-295.6	0.77	0.70	-0.152	-1.37	0.17	-32.4
Immigrant	0.03	0.03	0.008	0.38	0.70	-456.2	0.06	0.07	0.020	0.31	0.76	-121.2
(≤4 years)												
Immigrant	0.17	0.17	-0.013	0.16	0.87	-45.9	0.17	0.23	0.154	1.32	0.19	-25.2
(>4 years)												
Neighborhood SES												
Very low	0.53	0.52	-0.012	-1.16	0.25	-1058.2	0.40	0.41	0.028	-0.15	0.88	19.8
Low SES	0.25	0.29	0.076	0.96	0.34	-51.6	0.33	0.32	-0.014	-0.31	0.75	-239.5
High SES	0.18	0.14	-0.109	-0.17	0.86	81.6	0.23	0.23	0.001	0.54	0.59	-7200.0
Very high SES	0.04	0.05	0.058	1.10	0.27	-111.9	0.04	0.03	-0.041	0.00	1.00	100.0
Percentage of neighborhood Black												
Low	0.24	0.20	-0.091	-0.30	0.77	60.7	0.37	0.33	-0.076	-0.16	0.88	69.6

TABLE 6 (Continued)

Covariates	Girls						Boys					
	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value	Bias reduction (%)	Unexposed (mean)	Exposed (mean)	Standardized difference	t Test	p Value	Bias reduction (%)
Medium	0.42	0.49	0.140	0.67	0.51	41.9	0.38	0.38	-0.012	-0.46	0.65	-476.3
High	0.35	0.32	-0.068	-0.45	0.65	19.9	0.25	0.29	0.095	0.67	0.50	-5.0
Depression												
Yes	0.13	0.17	0.112	0.58	0.56	35.5	0.04	0.07	0.113	0.47	0.64	34.8
Adult support in HS												
No	0.19	0.20	0.033	-1.21	0.23	-319.8	0.27	0.30	0.057	0.41	0.68	-6.7

We hypothesized that the association between witnessing a violent death and negative health behaviors might be mediated by depressive symptoms. Previous evidence has suggested that exposure to violence is associated with depressive symptoms among adolescents.^{38,42} In turn, exhibiting depressive symptoms has been shown to be positively associated with smoking, alcohol consumption, and marijuana use.^{13–15} However the association between witnessing a violent death and smoking, consuming alcohol, and marijuana use was only slightly attenuated by the inclusion of exhibiting depressive symptoms, suggesting that depressive symptoms did not mediate the relationship. However, we cannot exclude the possibility that depressive symptoms, which were found to be associated with witnessing a violent death, predated the witnessing of violence (or indeed, the initiation of the health behaviors) since this study was cross-sectional and timing of onset of depressive symptoms cannot be ascertained. Future analyses should include latent growth curve analysis on longitudinal cohorts so that we can identify pathways between witnessing a violent death and adverse health behaviors.

Our results indicated that having an adult in school for support is protective against alcohol consumption—at least for girls. This may be an indication that the provision of social support is an effective strategy to prevent alcohol consumption. This finding is consistent with other studies that indicate that adolescent females are more responsive to social support than males.^{43,44} Other ways to prevent adoption of adverse behaviors among boys may be needed. Boys have been socialized as such that they receive more task-focused support during childhood,⁴⁵ and are therefore more likely to seek out instrumental rather than emotional support.^{46–48} For example, instead of seeking support from social relationships, boys are more likely to resort to stress reducing activities to cope.

It is also important to emphasize that our findings indicate that there are disparities in exposure to violence. Adolescents living in neighborhoods of lower SES and higher proportions of blacks were more likely to witness a violent death, which is consistent with previous studies.⁴⁹ These disparities may partly explain the disparities in smoking, alcohol consumption, and marijuana use behaviors. In other words, children living in neighborhoods at greater risk for violence have an increased risk for engaging in adverse behaviors. A public health intervention to reduce the traumatic effects of witnessing violence and increase coping skills may be especially effective for children living in these neighborhoods.

The differences in results found between the multivariate and propensity score analyses among girls suggest that the association between witnessing a violent death and adverse health behaviors is confounded by other respondent characteristics. Other characteristics that were not measured that may confound the relationship include individual level SES such as household income, family structure, family environment, and attachment to family and friends.

These findings should be interpreted in light of the limitations of this study. First, we used cross-sectional data, thus the study does not inform us about the direction of causation. However, our study hypotheses and directionality have intuitive appeal and are based on previous work. Additionally, we relied on self-report for exposure to a violent death. Thus, some exposure misclassification is possible, which was likely non-differential and therefore tend to drive the associations toward the null. Residual confounding might also be a limitation since important variables such as household income or parental education were not asked in the BYS. Since these individual level socioeconomic variables were not collected, we therefore resorted to the use of neighborhood level indicators of SES. Also, the Baron and Kenny method

of mediation assessment may lead to biased results because unknown confounders may exist between mediator and outcome.^{50,51} Finally, this study was conducted in the Boston area; thus we may be only able to generalize these findings to adolescents in comparable urban centers.

CONCLUSION

This study adds to the evidence base on the burden of violence by shedding insight into how exposure to violence can lead to the adoption of adverse health behaviors, especially in neighborhoods characterized by low SES and high rates of violent events. This better understanding can lead to potential effective interventions to reduce the lifelong impact of trauma exposure on children and adolescents. Future research may include using longitudinal data to help further disentangle these relationships, as well as continuing to develop and evaluate effective treatment strategies for exposure to violence.

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