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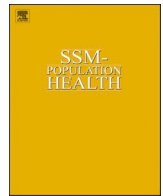
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Age at first alcohol use and weapon carrying among adolescents: Findings from the 2019 Youth Risk Behavior Survey

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ABSTRACT

Background: Although studies have investigated the association between alcohol use and violent behaviors such as weapon carrying, few studies have examined the association between age at first alcohol use and weapon-carrying among adolescents. The objective of this study was to investigate the association between age at first alcohol use and weapon carrying among adolescents.

Methods: Data for this study came from the 2019 Youth Risk Behavior Survey. An analytic sample of 13,442 adolescents aged 14–18 years old (51% female) was analyzed using binary logistic regression. The outcome variable investigated in this study was weapon carrying during the past 30 days, and the main explanatory variable investigated was age at first alcohol use.

Results: Of the 13,442 adolescents, 13.5% carried a weapon during the past 30 days, and 15.4% reported having their first alcoholic drink before age 13. In the multivariable logistic regression, adolescents who reported having alcohol before age 13 had more than double the odds of carrying a weapon when compared to those who never had alcohol before age 13 (AOR = 2.32, $p < .001$, 95% CI = 1.87–2.89). Other significant factors associated with weapon carrying include male gender, victim of bullying, teen dating violence, sexual violence, suicidal ideation, and history of substance use. Adolescents who self-identified as Black/African American or Hispanic were significantly less likely to carry a weapon when compared to adolescents who self-identified as non-Hispanic White.

Conclusion: The findings of this study underscore the importance of developing age appropriate intervention strategies to curb early initiation of alcohol use and weapon carrying among adolescents.

1. Introduction

Weapon carrying among adolescents in the United States (US) is a significant public health concern (Baiden, Findley, & Onyeaka, 2021; Button & Worthen, 2017; Cunningham et al., 2018; Khubchandani and Price, 2018; Vaughn et al., 2016) and has been on the increase in recent years (Levine & McKnight, 2017). According to the Centers for Disease Control and Prevention's (CDC) 2017 Youth Risk Behavior Survey (YRBS), 15.7% of students had carried a weapon (gun, knife, or club) at least once during the 30 days before the survey date (Kann et al., 2018). Other studies have found prevalence estimates of weapon carrying

during the past month to range between 8% and 15% (Baiden et al., 2019; Ferguson & Meehan, 2010; Rudatsikira et al., 2007; Stayton et al., 2011).

Although most school districts in the US have policies restricting the possession or use of weapons on school grounds (Jones et al., 2007), adolescent high school students are known to carry weapons on school property (Bailey et al., 1997; Rudatsikira et al., 2007; Stayton et al., 2011; Vaughn et al., 2016). In addition to providing easy access to potentially lethal methods of death by suicide (Anestis, 2016; Stanley et al., 2017), weapon carrying could quickly escalate violent behaviors at the slightest provocation when self-control and discipline are lacking

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(Bolland et al., 2018; Pickett et al., 2005). Weapon carrying and its related violent incidents can affect the perpetrators, victims, and bystanders' health, safety, and mental well-being (Smith et al., 2020; Valdebenito et al., 2017). Hence, taking a closer look at adolescent weapon carrying behaviors and factors associated with weapon carrying is critical to the early identification of adolescents who might engage in potential violent behaviors.

One important factor that has been found to be associated with violent and risky behaviors among adolescents is alcohol use (Bossarte & Swahn, 2011; Crews et al., 2016; Ellickson et al., 2003). Alcohol use among adolescents in the US has also been identified as a pervasive and major public health concern (Cheng et al., 2016; Haberstick et al., 2014; Patrick & Schulenberg, 2013). Bouchery et al. (2011) estimated the economic cost of excessive alcohol consumption in the United States to be \$223.5 billion in 2006 (72.2% from lost productivity, 11.0% from healthcare costs, 9.4% from criminal justice costs, and 7.5% from other effects). Among adolescents, excessive drinking, including early initiation of alcohol use accounts for more than 4,300 deaths each year and cost the US \$24 billion in 2010 (Sacks et al., 2015; Stahre et al., 2014). Alcohol use is associated with many health and social problems, including motor vehicle crashes, behavioral problems, suicidal behaviors, cognitive impairment, risky sexual behaviors, academic problems, alcohol dependence, alcohol and drug poisoning, interpersonal violence such as homicides, assaults, and rapes, as well as unintentional injuries such as burns, falls, and drowning (Gart & Kelly, 2015; Kann et al., 2018; Peleg-Oren et al., 2009; Swahn et al., 2008; Wadsworth & Hammond, 2019; Williams et al., 2007; Xue et al., 2009). Systematic reviews and meta-analytic studies have also found an association between alcohol use and mental health problems (Borges et al., 2017; Norström & Rosow, 2016).

1.1. Age at first alcohol use

Age at first alcohol use has been highlighted as a critical factor contributing to a number of health risk behaviors (Baiden, Mengo, Boateng, & Small, 2019; Caetano et al., 2014; Ciairano et al., 2009; Hingson et al., 2016; Hingson & Zha, 2009; Peleg-Oren et al., 2009). Liang and Chikritzhs (2015) examined data from the National Longitudinal Study of Adolescent Health (Add Health) and found that age at first alcohol use before age 18 was significantly associated with a higher risk of heavy episodic drinking at follow-up. This was after adjusting for demographic factors, household income, parental alcohol use, and self-perceived physical and mental health. Other observational studies have also found age at first alcohol use to be associated with social, behavioral, and mental health outcomes (Agrawal et al., 2009; Blomeyer et al., 2011; Darke & Torok, 2014; Doran & Waldron, 2017; Hingson et al., 2016; Liang & Chikritzhs, 2012; Temcheff et al., 2016). However, few studies have investigated the extent to which early initiation of alcohol might be associated with violent behaviors such as weapon carrying among adolescents. This study aims to fill this gap by examining the association between age at first alcohol use and weapon carrying among adolescents.

1.2. Risk factors associated with weapon carrying

The extant literature has found a number of risk factors to be associated with weapon carrying among adolescents. These include bullying victimization (Esselmont, 2014; Mukherjee, Taleb, & Baiden, 2020; Perlus et al., 2014; Pham et al., 2017; Semprevivo et al., 2020), teen dating violence (TDV), and sexual victimization (SV) (Baiden et al., 2021; DuPont-Reyes et al., 2014; Muula et al., 2008; Pool et al., 2017; Rosario et al., 2014). Some scholars have noted that adolescents who have been victimized resort to carrying a weapon as a form of self-protection in response to the fear and trauma from past abuse (Arria et al., 1997; Valdebenito et al., 2017; Vaughn et al., 2006). Other studies have also found that adolescent substance use factors such as cigarette

smoking (Khubchandani & Price, 2018a), cannabis use (Orpinas et al., 2017; Stayton et al., 2011), and illicit drug use (Carter et al., 2013) to be associated with weapon carrying. Mental health factors such as depression and anxiety (Abaya et al., 2019; Carter et al., 2015, 2020; Kim, 2018), suicidal behaviors (Romero et al., 2017), conduct disorders (Barkley et al., 2004), and sleep deficit (Hildenbrand et al., 2013; Meldrum et al., 2020; Umlauf et al., 2011) have also been found to be associated with weapon carrying.

Concerning demographic factors, numerous studies have found the prevalence of weapon carrying to be higher among adolescent males than adolescent females (Dukes et al., 2010; Muula et al., 2008; Romero et al., 2018; Rudatsikira et al., 2007). Other scholars have noted sex differences in the choice of weapon, with adolescent females more likely to carry knives or mace than guns (Erickson et al., 2006). Studies have also found a significant association between race/ethnicity and weapon carrying among adolescents (Carter et al., 2020; Muula et al., 2008; Williams et al., 2007). Adolescents who self-identified as sexual minorities are also more likely to carry a weapon when compared to their heterosexual counterparts (Button & Worthen, 2017).

1.3. Theoretical framework

This study is guided by Jessor's Problem Behavior Theory (PBT) (Jessor, 1998; Jessor & Jessor, 1977). According to PBT, adolescence is a period characterized by quick and drastic change with observable problem behaviors as adolescents begin to define and formulate their own identities (Jessor & Jessor, 1977). Jessor (1998) conceptualizes personality, perceived environment, and social structure as domains, all acting synergistically to explain problem behaviors. Factors such as individual beliefs, motivation, sense of personal control, values, and attitudes, such as denunciation of problem behaviors, fall within the personality domain and are crucial in explaining adolescent problem behaviors. Regarding perceived environment, PBT emphasizes the impact of psychosocial factors such as parenting style, the school environment, and peers' models of substance use behavior. Finally, socio-demographic factors, parental socioeconomic status (SES), and family structure are construed as background social structural factors that influence factors within the personality and perceived environment domains, both of which directly influence problem behaviors (Jessor & Jessor, 1977). PBT acknowledges that these three interrelated systems do not necessarily assess all aspects of a problem behavior equally, but rather, they symbolize the "nature of the person" from a sociological perspective (Jessor & Jessor, 1977, p. 19). PBT recognizes that the seriousness of problem behaviors is essentially dependent upon the number of risk factors that exist across the multiple domains and structures (Jessor, 1998; Jessor et al., 2003).

PBT emphasizes the presence of developmental history and the age at which problem behaviors are initiated as critical in engaging in other problem behaviors (Donovan et al., 1988). Thus, according to Jessor (1998), problem behaviors represent a collection of symptoms for a troubled adolescent acting together to provide a path that further leads to engaging in problem behaviors. Thus, an adolescent who precociously initiates certain problem behaviors (e.g., alcohol use) at an early age is more likely to be involved in other risk behaviors later on in life (Ciairano et al., 2009; Donovan et al., 1988; Hingson & Zha, 2009). The classical literature on the timing of developmental transitions also tells us that early onset of certain behaviors may be a reflection of the developmental history of an individual, including differences in personality traits, the family socioeconomic background, parenting styles, as well as pubertal timing (Hummel et al., 2013). In the context of this study, PBT would suggest that early initiation of alcohol use is part of a cascade of events that link earlier disadvantage with later internalizing and externalizing behavior problems, including violence and weapon carrying.

Various studies have applied PBT as a theoretical framework in understanding problem behaviors (e.g., alcohol, drug use, delinquency,

risky driving, and precocious sexual behaviors) among adolescents in the US and other international settings (Alexander et al., 2018; Chan et al., 2019; Donovan et al., 1999; Hingson & Zha, 2009; Sussman et al., 2004; Vazsonyi et al., 2008, 2010; Walsh et al., 2013; Zamboanga et al., 2004). For instance, Vazsonyi et al. (2010) found strong support for PBT in understanding problem behavior syndrome in general, defined as theft, vandalism, assault, and disorderly conduct behaviors in samples of 10,310 adolescents from eight distinct contexts, including Asian, Eastern and Western European, North American, and Eurasian/Muslim cultures (Vazsonyi et al., 2010). Hingson and Zha (2009) also examined age at first alcohol use and its association with alcohol dependence/abuse, heavy episodic drinking, and unintentional injury to oneself and others using longitudinal data from the National Epidemiologic Survey on Alcohol and Related Conditions. They found that individuals who started drinking before age 14 had a greater likelihood between the two waves to experience alcohol dependence/abuse, engage in heavy episodic drinking, drive under the influence of alcohol, or be in situations where they could injure themselves or others. This was after controlling sociodemographic characteristics, family history of alcohol misuse, and measures of depression and antisocial behaviors (Hingson & Zha, 2009). Other studies utilizing PBT have also found similar results regarding the association between age of first alcohol use and engaging in conduct that puts individuals or others at risk for injury (Ciarrano et al., 2009; DuRant et al., 1999). Other studies have also utilized social capital theory in understanding the link between access to a firearm and public health-related behaviors (Kawachi et al., 1999; Kennedy et al., 1998). However, in the current study, there were no measures of social capital, hence, the use of PBT in understanding the link between age at first alcohol use and weapon carrying among adolescents.

1.4. Current study

Although various studies have investigated and found age at first alcohol use to be associated with adverse social, behavioral, and mental health outcome (Agrawal et al., 2009; Blomeyer et al., 2011; Ciarrano et al., 2009; Darke & Torok, 2014; Doran & Waldron, 2017; DuRant et al., 1999; Hingson et al., 2016; Liang and Chikritzhs, 2012, 2015; Temcheff et al., 2016), to our knowledge, few studies have investigated the association between age at first alcohol use and weapon carrying among adolescents. Most of the existing studies tend to focus on the association between current alcohol use and weapon carrying among adolescents (Bailey et al., 1997; DuRant et al., 1997; Goebert et al., 2004; Khubchandani and Price, 2018a, 2018b; Muula et al., 2008), without taking into account the age at which adolescents had their first alcoholic drink. Thus, drawing on a large nationally representative sample of adolescents, the current study seeks to fill the knowledge gap by examining the association between age at first alcohol use and weapon carrying. We hypothesized that controlling for demographic, victimization, mental health, and substance use factors, adolescents who had their first alcoholic drink before age 13 will have a greater likelihood of carrying a weapon.

2. Methods

2.1. Data source and participants

Data for this study came from the 2019 Youth Risk Behavior Survey (YRBS). The YRBS is a cross-sectional, school-based national survey conducted by the CDC every two years to examine health-risk behaviors that contribute to the leading causes of death and disability among adolescents in the US and to monitor progress toward achieving the Healthy People objectives. The YRBS recruited 9th to 12th graders from both public and private schools to complete self-administered surveys. The YRBS utilized a three-stage cluster sample design to create a nationally representative sample of high school students. Detailed information about the YRBS, including the objectives, methodology, and

sampling procedure, are available in (Brener et al., 2013; Centers for Disease Control and Prevention, 2020; Kann et al., 2018; Underwood et al., 2020) and in other publications by the authors (Baiden, Xiao, et al., 2020; Baiden, Graaf, Zaami, Acolatse, & Adeku, 2019; Baiden, LaBrenz, Asiedua-Baiden, & Muehlenkamp, 2020; Baiden, Mengo et al., 2019; Baiden & Tadeo, 2019, 2020; Baiden, Tadeo, Tonui, Seastrunk, & Boateng, 2020). The study protocol for conducting the YRBS was approved by the CDC's Institutional Review Board (IRB) and is publicly available. The current study was exempted from IRB approval by the lead author's institution as the data had already been de-identified and did not contain any personal information.

There were 13,677 respondents in the 2019 YRBS; however, the analyses conducted in this study were based on 13,442 adolescents aged 14 to 18. The percent of missing data ranged from less than 1%–25%, with illicit drug use, TDV, and SV victimization having the highest number of missing data. Missing data analysis was conducted using Pearson chi-square test of association to assess whether a group of respondents with observed data on one variable are significantly different from a group of respondents with missing data on another variable. We found that data were missing completely at random (MCAR), that is to say, the probability of missingness on a particular variable is not dependent on any observed data (van Ginkel et al., 2020). Given that data were MCAR, Multiple Imputation using Chained Equations (MICE) was chosen as the most appropriate technique to impute complete data (Van Buuren, 2018). Multiple imputation is a simulation-based approach for analyzing missing data that replaces missing values with multiple sets of simulated values to complete the dataset and adjust for missing data uncertainty (Rubin, 1996). With multiple imputation, imputed datasets are based on a set of linear regression models for continuous variables, or logistic regression models for categorical variables (van Ginkel et al., 2020). We followed the four steps recommended by Azur et al. (2011) in imputing missing data. Given the amount of missing data present in the current study, we followed the recommendation of Graham et al. (2007) and generated 20 imputed datasets. This number is generally considered sufficient to improve the model's statistical power (Azur et al., 2011; Graham et al., 2007).

2.2. Variables

2.2.1. Outcome variable

The outcome variable investigated in this study is weapon carrying and was measured as a binary variable. Adolescents were asked, "During the past 30 days, on how many days did you carry a weapon such as a gun, knife, or club?" with the following response options "1 = 0 days", "2 = 1 day", "3 = 2 or 3 days", "4 = 4 or 5 days", and "5 = 6 or more days." Adolescents who indicated carrying a weapon at least once during the past 30 days were recoded as 1. In contrast, adolescents who did not carry a weapon during the past 30 days were recoded as 0.

2.2.2. Explanatory variable

The main explanatory variable was age at first alcohol use and was measured as a nominal variable. The original question asked respondents, "How old were you when you had your first drink of alcohol other than a few sips?" with the following response options, "I have never had a drink of alcohol other than a few sips," "8 years old or younger", "9 or 10 years old", "11 or 12 years old", "13 or 14 years old", "15 or 16 years old" and "17 years old or older". Following prior studies (e.g., Peleg-Oren et al., 2009; Swahn & Bossarte, 2007; Swahn et al., 2008), this variable was recoded into "0 = never (never-drinkers)", "1 = 13 years or older (early drinkers)", and "2 = before age 13 (very early drinkers)."

2.2.3. Control variables

The following variables were also included in the analysis as control variables: school bullying and cyberbullying victimization, TDV and SV, symptoms of depression, suicidal ideation, current use of alcohol,

cigarette smoking, current use of marijuana, and illicit drug use. School bullying and cyberbullying victimization were measured based on two questions. The 2019 YRBS defined the term bullying to mean, "bullying is when one or more students tease, threaten, spread rumors about, hit, shove, or hurt another student over and over again. It is not bullying when two students of about the same strength or power argue or fight or tease each other in a friendly way." School bullying victimization was measured based on response to one question, "During the past 12 months, have you ever been bullied on school property?" Cyberbullying victimization was measured based on response to the question, "During the past 12 months, have you ever been electronically bullied? (Count being bullied through texting, Instagram, Facebook, or other social media.)" Responses to both questions were coded as "0 = No" and "1 = Yes".

Both TDV and SV were measured as binary variables. Victim of TDV was measured based on the question, "During the past 12 months, how many times did someone you were dating or going out with physically hurt you on purpose? Count such things as being hit, slammed into something, or injured with an object or weapon." For the purposes of this study, adolescents who did not date or go out with anyone during the past 12 months or were dating but were not physically hurt were coded as 0. Adolescents who were dating and were physically hurt on one or more occasions were coded as 1. SV was measured based on the question, "During the past 12 months, how many times did anyone force you to do sexual things that you did not want to do? (Count such things as kissing, touching, or being physically forced to have sexual intercourse)" with the following response options "1 = 0 days", "2 = 1 day", "3 = 2 or 3 days", "4 = 4 or 5 days", and "5 = 6 or more days." For the purposes of this study, adolescents who experienced SV victimization at least once during the past 12 months were recoded as 1, whereas adolescents who did not experience SV victimization during the past 12 months were coded as 0.

Symptoms of depression was measured based on the question, "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?" Adolescents who answered "yes" were coded as 1, whereas those who answered "no" were coded as 0. Suicidal ideation was measured as a binary variable based on response to the question, "During the past 12 months, did you ever seriously consider attempting suicide?" Adolescents who answered "yes" were coded as 1, whereas adolescents who answered "no" were coded as 0.

Adolescents who reported drinking alcohol at least once during the 30 days before the survey were coded as 1; otherwise, they were coded as 0. Adolescents who smoked a cigarette at least once during the past 30 days were coded as 1; otherwise, they were coded as 0. Adolescents who reported using marijuana at least once during the past 30 days were coded as 1, whereas those who did not use marijuana during the past 30 days were coded as 0. A measure of illicit drug use was included as a binary variable (0 = no illicit drug use versus 1 = illicit drug use) based on a positive response to ever having used any of the following illicit drugs: cocaine (powder, crack, or freebase); inhalants (glue, aerosol spray cans, paints); heroin (smack, junk, or China White); methamphetamines (speed, crystal, crank, or ice); ecstasy (MDMA); hallucinogenic drugs (LSD, acid, PCP, angel dust, mescaline, or mushrooms); synthetic marijuana (K2, Spice, fake weed, King Kong, Yucatan Fire, Skunk, or Moon Rocks); and steroid pills.

2.2.4. Demographic variables

The study controlled for the following demographic variables. Age was measured in years, whereas sex was coded as "0 = Female" versus "1 = Male." Sexual orientation was coded as a nominal variable into "0 = Heterosexual", "1 = Lesbian/gay", "2 = Bisexual", and "3 = Not sure" based on sexual identity and sex of sexual contacts. Race/ethnicity was coded as a nominal variable into the following categories "0 = non-Hispanic White", "1 = Black/African American", "2 = Hispanic", "3 = Asian", "4 = Native American/American Indian", and "5 Other race/

ethnicity."

2.3. Data analyses

Data were analyzed using descriptive and multivariable analytic techniques. The general distribution of all the variables included in the analysis was first examined using percentages. Bivariate associations among the explanatory and control variables were examined to check for the presence of multicollinearity. The results suggest that none of the variables had a variance inflation factor greater than four to pose a problem of multicollinearity. The main analysis involves using binary logistic regression to examine the association between age at first alcohol use and the outcome variable (weapon carrying) while simultaneously controlling for the effect of demographic factors and other control variables. Two multivariable logistic regression models were fitted. In Model 1, we regressed weapon carrying on age at first alcohol use. In Model 2, we regressed weapon carrying on age at first alcohol use while controlling for the effects of demographic factors and other control variables. Variables were considered significant if the *p*-value was less than 0.05. Stata's "svyset" command was used to account for the weighting and complexity of the cluster sampling design employed by the YRBS. All analyses were performed using Stata version 14.

3. Results

3.1. Sample characteristics

Table 1 shows the general distribution of the study variables. Of the 13,442 adolescents, 13.5% reported carrying a weapon at least once during the past 30 days. About one in six adolescents (15.4%) started having alcohol before age 13, one in four (40.6%) had alcohol by age 13 or over, and 44.0% never had alcohol. The sample was almost evenly distributed by sex, with females making up 51% of the sample. About 9% of the adolescents self-identified as bisexual, 4.3% as "not sure", and 2.8% as lesbian/gay. One in five (20%) adolescents were victims of school bullying, and 15.7% were victims of cyberbullying. A little over one in ten adolescents (11.3%) experienced SV during the past year, and 5.9% experienced TDV during the past year. More than a third (36.7%) of the adolescents reported feeling sad or hopeless almost every day for two weeks or more in a row such that they stopped doing some usual activities. The distribution of the other variables is provided in Table 1 below.

3.2. Multivariable logistic regression examining the association between age at first alcohol use and weapon carrying

Table 2 shows the multivariable logistic regression results examining the association between age at first alcohol use and weapon carrying. In Model 1, adolescents who started having alcohol before age 13 had more than fourfold higher odds of carrying a weapon (odds ratio (OR) = 4.63, $p < .001$, 95% CI = 3.86–5.56), and adolescents who started having alcohol by age 13 or over had 1.88 times higher odds of carrying a weapon (OR = 1.88, $p < .001$, 95% CI = 1.61–2.18) when compared to those who have never had alcohol. This significant effect was partially attenuated with the addition of demographic and control variables in Model 2. Controlling for the effects of other factors, adolescents who started having alcohol before age 13 had 2.32 times higher odds of carrying a weapon (adjusted odds ratio (AOR) = 2.32, $p < .001$, 95% CI = 1.87–2.89), and adolescents who started having alcohol by age 13 or over had 1.25 times higher odds of carrying a weapon (AOR = 1.25, $p = .040$, 95% CI = 1.01–1.53) when compared to those who have never had alcohol.

Compared to females, males were 4.78 times more likely to report carrying a weapon (AOR = 4.78, $p < .001$, 95% CI = 4.10–5.58). Compared to adolescents who self-identified as non-Hispanic White, adolescents who self-identified as Black/African American (AOR =

Table 1
Sample characteristics (n = 13,442).

Variables	Frequency (Weighted %)
Outcome variables	
Carried a weapon	
No	11,632 (86.5)
Yes	1,810 (13.5)
Main explanatory variable	
Age at first alcohol use	
Never	5,921 (44.0)
13 years and above (early drinkers)	5,457 (40.6)
Before age 13 years (very early drinkers)	2,064 (15.4)
Control variables	
Age	
14 years	1,681 (12.5)
15 years	3,451 (25.6)
16 years	3,609 (26.9)
17 years	3,094 (23.0)
18 years	1,607 (12.0)
Sex	
Female	6,849 (51.0)
Male	6,593 (49.0)
Sexual orientation	
Heterosexual	11,273 (83.9)
Lesbian/gay	379 (2.8)
Bisexual	1,204 (9.0)
Not sure	586 (4.3)
Race/ethnicity	
Non-Hispanic White	6,805 (50.6)
Black/African-American	2,072 (15.4)
Hispanic	3,059 (22.8)
Asian	625 (4.6)
Native American/American Indian	215 (1.6)
Other race/ethnicity	666 (5.0)
School bullying victimization	
No	10,758 (80.0)
Yes	2,684 (20.0)
Cyberbullying victimization	
No	11,337 (84.3)
Yes	2,105 (15.7)
Teen dating violence	
No	12,649 (94.1)
Yes	793 (5.9)
Sexual violence victimization	
No	11,928 (88.7)
Yes	1,514 (11.3)
Symptoms of depression	
No	8,516 (63.3)
Yes	4,926 (36.7)
Suicidal ideation	
No	10,813 (80.4)
Yes	2,629 (19.6)
Currently drink alcohol	
No	9,352 (69.6)
Yes	4,090 (30.4)
Current cigarette smoking	
No	12,625 (93.9)
Yes	817 (6.1)
Current marijuana use	
No	10,450 (77.7)
Yes	2,992 (22.3)
Use of illicit drugs	
No	11,449 (85.2)
Yes	1,993 (14.8)

0.62, $p = .004$, 95% CI = 0.49–0.87), Hispanic ($AOR = 0.73$, $p = .006$, 95% CI = 0.60–0.93), or Asian ($AOR = 0.41$, $p < .001$, 95% CI = 0.25–0.67) were less likely to report carrying a weapon. Adolescents were more likely to report carrying a weapon if they: were victims of school bullying ($AOR = 1.33$, $p = .031$, 95% CI = 1.03–1.72), victims of TDV ($AOR = 1.76$, $p < .001$, 95% CI = 1.33–2.33), victims of SV ($AOR = 1.51$, $p = .002$, 95% CI = 1.18–1.95), or experienced suicidal ideation ($AOR = 1.48$, $p = .002$, 95% CI = 1.17–1.86). Also, adolescents were more likely to report carrying a weapon if they use the following substances: alcohol ($AOR = 1.36$, $p = .006$, 95% CI = 1.10–1.69), smoke a

Table 2
Multivariable logistic regression results predicting weapon carrying (n = 13,442).

Variables	Model 1		Model 2	
	AOR (95% C.I.)	p-value	AOR (95% C.I.)	p-value
Age at first alcohol use (Never)				
13 years and above	1.88	<.001	1.25	.040
(early drinkers)	(1.61–2.18)		(1.01–1.53)	
Before age 13 years	4.63	<.001	2.32	<.001
(very early drinkers)	(3.86–5.56)		(1.87–2.89)	
Demographic and control variables				
Age in years			1.05	.255
			(0.97–1.13)	
Sex (Female)			4.78	<.001
Male			(4.10–5.58)	
Sexual orientation (Heterosexual)			0.53	.057
Lesbian/gay			(0.28–1.02)	
Bisexual			1.15	.352
			(0.85–1.57)	
Not sure			1.07	.743
			(0.71–1.61)	
Race/ethnicity (Non-Hispanic White)				
Black/African-American			0.62	.004
			(0.45–0.85)	
Hispanic			0.73	.006
			(0.58–0.91)	
Asian			0.41	.001
			(0.25–0.67)	
Native American/ American Indian			1.02	.961
			(0.52–1.97)	
Other race/ethnicity			1.22	.207
			(0.89–1.65)	
School bullying victimization (No)				
Yes			1.33	.031
			(1.03–1.72)	
Cyberbullying victimization (No)				
Yes			1.10	.492
			(0.84–1.44)	
Teen dating violence victimization (No)				
Yes			1.76	<.001
			(1.33–2.33)	
Sexual violence victimization (No)				
Yes			1.51	.002
			(1.18–1.95)	
Symptoms of depression (No)				
Yes			1.08	.390
			(0.90–1.30)	
Suicidal ideation (No)				
Yes			1.48	.002
			(1.17–1.86)	
Currently drink alcohol (No)				
Yes			1.36	.006
			(1.10–1.69)	
Currently smoke cigarette (No)				
Yes			1.88	<.001
			(1.46–2.42)	
Currently use marijuana (No)				
Yes			1.04	.700
			(0.86–1.25)	
Ever used Illicit drugs (No)				
Yes			1.73	<.001
			(1.38–2.16)	

Note: Reference category is indicated in bracket.

cigarette ($AOR = 1.88$, $p < .001$, 95% CI = 1.46–2.42), or ever used illicit drugs ($AOR = 1.73$, $p < .001$, 95% CI = 1.38–2.16).

4. Discussion

The primary objective of this study was to examine the association between age at first alcohol use and weapon carrying among adolescents. Findings indicate that in 2019, about one in six adolescents

(15.4%) started drinking alcohol before age 13, and 13.5% of adolescents reported carrying a weapon such as a gun, knife, or club on at least one day during the month preceding the survey date. The proportion of adolescents who reported carrying a weapon found in this study is similar to previous studies (Ferguson & Meehan, 2010; Rudatsikira et al., 2007), although lower rates also have been reported in other studies (Baiden et al., 2019; Stayton et al., 2011).

Although previous studies have established a link between alcohol use and violence or aggressive behaviors (Albers et al., 2015; Hingson et al., 2009; Kponee et al., 2014; Swahn et al., 2008), including weapon carrying (Goebert et al., 2004; Vaughn et al., 2006) among adolescents, to the best of our knowledge, this is one of a few studies to specifically examine the association between age at first alcohol use and weapon carrying among adolescents. Controlling for demographic and risky health behaviors in the fully adjusted model, we observed that adolescents who started having alcohol before age 13 had 2.32 times higher odds of carrying a weapon when compared to those who have never had alcohol. Our findings extend the literature in this field by indicating an association between early initiation of alcohol (before age 13) and weapon carrying among adolescents.

The association between age at first alcohol use and weapon carrying found in our study could be explained by past studies that have found alcohol use is an independent correlate of delinquent and violence-related behaviors (Goebert et al., 2004; Komro et al., 2000), including increased risk for fighting and being injured in a fight (Albers et al., 2015; Kponee et al., 2014), and feeling unsafe in school (Burgess Dowdell, 2006). The extant literature also suggests that the link between alcohol use and violence is relatively complex (Brady et al., 2008; Maldonado-Molina et al., 2011). Some reasons have been offered in explaining the connection between age at first alcohol use and violent behaviors. One plausible explanation draws from PBT and suggests that the age at which problem behaviors are initiated is important in engaging in other risk behaviors (Donovan et al., 1988). This is further supported by findings from several longitudinal studies. For example, Ellickson et al. (2003) followed a cohort of seventh graders for ten years to evaluate the effects of early alcohol use and found that early alcohol users were more likely to be delinquent, violent, use substances, and involved in criminality by age 23 compared to their counterparts who did not start drinking alcohol at a very early age. Similar associations have been observed between age at first alcohol use and violence risk behaviors using longitudinal designs (Hingson & Zha, 2009; Maldonado-Molina et al., 2011). It is also possible that early initiation of alcohol use and weapon carrying may both be symptoms of common underlying risk factor of mental health problem and risk-taking.

Also, the finding that adolescents who used substances such as alcohol, tobacco, or illicit drugs are significantly more likely to report carrying a weapon corroborates prior studies that have found substance use to be associated with weapon carrying among adolescents in the US (Chen & Wu, 2016; Peleg-Oren et al., 2009). The current study findings underscore the importance of developing age-appropriate alcohol prevention policies and interventions to curb the early initiation of alcohol and prevent violence-related behaviors, including weapon carrying.

Our findings also demonstrate that students who self-identified as males were more likely to report carrying a weapon. This finding corroborates previous studies that have also observed sex differences in weapon carrying among adolescents (Bailey et al., 1997; Lewis et al., 2007; Muula et al., 2008; Rudatsikira et al., 2007). In one cross-national survey of 161,082 students from 35 countries, Pickett et al. (2005) observed that the prevalence of weapon carrying among adolescent males ranged from 10% to 21%, whereas the range for females was 2% to 5%. There is some evidence suggesting that exposure to differential risk factors such as gender socialization may drive some of the differences in weapon carrying and other violent behaviors among adolescent males and females. For example, Moffitt et al. (2001) found that across all racial and ethnic groups, adolescent males are relatively more exposed to risk factors for violent behaviors than adolescent females,

resulting in an elevated likelihood for violent behaviors such as weapon carrying among adolescent males. The gender socialization process whereby boys are taught to be boys may also help explain why adolescent males are more likely to report carrying a weapon than their female counterparts. Various studies have found that most violent crimes, school shootings, domestic violence, and sexual violence are perpetrated by boys or men (Fleming et al., 2015; Silva et al., 2021; Van Doorn et al., 2021). Given the well-established relationship between alcohol use and future violent behavior such as weapon carrying, coupled with the gendered findings on violence, developing interventions that target boys would likely be an effective measure to reduce violence and other risk factors.

Furthermore, our results indicate that adolescents who self-identified as non-Hispanic Whites were significantly more likely to carry weapons than their non-White counterparts. Some studies have shown that minorities, including Black/African American and Hispanic adolescents, are more likely to carry weapons and engage in delinquent or violent acts than non-Hispanic White counterparts (Carter et al., 2020; Muula et al., 2008; Spano, 2012; Williams et al., 2007). Further, there is even strong evidence to show that Black/African American adolescents are at a significantly higher risk of violent death by firearms compared to Whites in the US (Ertl et al., 2019; Khubchandani & Price, 2018b; Lemaire, 2005; Price & Khubchandani, 2019). Yet, our study is one of a few studies highlighting that non-Hispanic White adolescents may have a greater likelihood of weapon carrying than non-Hispanic Black/African American and Hispanic adolescents.

Although the reasons behind the association between race/ethnicity and weapon carrying are unclear from our study, access to weapons may help explain the finding that non-Hispanic Whites are more likely to carry a weapon. This reasoning is supported by studies showing a differential prevalence of handgun ownership by race/ethnicity, with increasing prevalence noted among non-Hispanic Whites (Prickett et al., 2019; Vaughn et al., 2016). Furthermore, the impact of racial profiling, surveillance, and over-policing of Black and Brown youth may explain why non-Hispanic Black/African American and Hispanic adolescents are less likely to carry a weapon. Yet, non-Hispanic Black/African American and Hispanic adolescents experience disproportionate consequences and criminalization (Elliott & Reid, 2019; Mooradian, 2012; Pederson et al., 2020).

With respect to victimization, we found that adolescents who experienced bullying, TDV, and SV were more likely to carry weapons when compared to their counterparts who did not experience such adverse events. These findings corroborate findings from previous studies on the link between victimization experiences and weapon carrying (Dukes et al., 2010; Orpinas et al., 2017; Rudatsikira et al., 2007; Vaughn et al., 2006). A large meta-analysis study on bullying and weapon carrying found that bullies and bully-victims were more likely to carry weapons than uninvolved peers (Van Geel et al., 2014). Similarly, Vivolo-Kantor et al. (2016) examined data from the 2013 YRBS and found significant associations between experiencing physical and sexual TDV and a higher likelihood of weapon carrying at school. One possible explanation for the link between victimization and increased risk of weapon carrying is the vulnerability/self-protection theory. The vulnerability/self-protection hypothesis posits that victimized adolescents may turn to gun or weapon carrying as a means of self-protection (Valdebenito et al., 2017). Adolescents who are victims of bullying, TDV, or SV may experience fear and develop coping mechanisms to protect themselves from perceived threats in the school environment. This line of reasoning is further supported by empirical research indicating that self-protection and defense is one of the most commonly cited reasons for weapon carrying by adolescents (Arria et al., 1997; Baiden et al., 2021; Bender et al., 2015; Lewis et al., 2007; Valdebenito et al., 2017) as well as several studies demonstrating that victimization and perception of imminent danger or threat, both real and assumed, may play a direct role in identifying a weapon as a source of self-protection and subsequently result in weapon carrying (Arria et al., 1997; Chang et al., 2003;

Valdebenito et al., 2017).

We also found that adolescents who reported experiencing suicidal ideation were more likely to carry weapons. This finding matches observations from some past studies that examined the association between weapon carrying and suicide-related behavior (Baiden et al., 2019; Romero et al., 2017; Watkins & Lizotte, 2013). Our results have significant public health importance for adolescent violence and suicide prevention. The literature suggests that possession and access to weapons and firearms is a strong risk factor for suicidal behaviors (Baiden et al., 2019; Klonsky & May 2014; Stanley et al., 2017). While we cannot infer the reasons for carrying weapons at school from our data, adolescents who experience suicidal ideation may carry weapons as a means of attempting suicide. Therefore, screening for weapon carrying among students may be an effective suicide reduction prevention strategy.

4.1. Implications

The findings of this study have some implications for public health. First, alcohol prevention and intervention programs should target adolescents younger than 13 years of age to delay early onset of alcohol use. Second, educational programs should target enhancing parents' and educators' awareness of the co-occurrence of early alcohol use and weapon carrying, and the subsequent associated risk behaviors. Emphasis should be placed on delaying onset of alcohol use and decreasing young people's access to weapons. Third, school-based programs should work to enhance students' sense of safety in the school environment (e.g., through anti-bullying programs and enhanced supervision) and to facilitate open dialogue regarding topics such as mental health, peer victimization, substance use and weapon-carrying. Students exhibiting risk factors identified in this study should be referred for more targeted intervention.

4.2. Limitations

This study has some limitations that are worth noting. First, the use of secondary data limits our ability to examine other theoretically relevant factors such as parental ownership of weapons, adverse childhood experiences, gang affiliation, and neighborhood violence, all of which are known to be associated with weapon carrying (Bradshaw et al., 2013; Forster et al., 2020; Reed et al., 2014). Also, we were unable to examine the reasons for weapon carrying and the specific type of weapon being carried. Another important consideration for future research is to consider the specific location where a weapon is carried, as studies such as Meldrum et al. (2020) have focused on handgun carrying in general and at school. All of these are important for policy development especially given that some weapons (e.g., handguns) are more lethal and have the potential to do more damage quickly than others (e.g., clubs). Second, the cross-sectional nature of the data precludes us from making any causal claims between age at first alcohol use and weapon carrying. Therefore, only an association can be inferred. It is possible that some adolescents may have tried alcohol before age 13 and later quit alcohol use before carrying a weapon on school property. It is also possible that weapon carrying may have preceded school bullying, TDV and SV victimization, suicidal ideation, or substance use behaviors. Given that alcohol use is a time-varying variable, longitudinal studies are needed to establish the temporal order between age at first alcohol use and weapon carrying among adolescents. Also, longitudinal studies may offer further insights on which interventions might help break the link between early initiation of alcohol use and weapon carrying among adolescents. Lastly, the YRBS was conducted using self-reported measures of weapon carrying and alcohol use, which are relatively sensitive and may be under-reported or subject to recall bias.

4.2. Conclusion

In conclusion, drawing on a large nationally representative sample of adolescents, the present study's findings demonstrate an association between age at first alcohol use and weapon carrying over and above other well-established factors known to be associated with weapon carrying. School counselors working with adolescents who initiate alcohol use before age 13 should also assess for weapon carrying and should identify interventions appropriate for mitigating future risk among these students. Understanding the association between age at first alcohol use and weapon carrying among adolescents will contribute to the early identification of adolescents who are likely to carry a weapon or engage in violence-related behaviors.

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Ethical statement

The study protocol for conducting the YRBS was approved by the CDC's Institutional Review Board (IRB) and the de-identified data are publicly available. The current study was exempted from IRB approval by the lead author's institution as the data had already been de-identified and did not contain any personal information.

CRedit authorship contribution statement

Philip Baiden: Study concept and design, Acquisition of data, Analysis and interpretation of data, Drafting of the manuscript, Critical revision of the manuscript for important intellectual content. **Nusrat Jahan:** Study concept and design, Analysis and interpretation of data, Drafting of the manuscript, Critical revision of the manuscript for important intellectual content. **Henry K. Onyeaka:** Drafting of the manuscript, Critical revision of the manuscript for important intellectual content. **Shawndaya Thrasher:** Drafting of the manuscript, Critical revision of the manuscript for important intellectual content. **Savarra Tadeo:** Critical revision of the manuscript for important intellectual content. **Erin Findley:** Critical revision of the manuscript for important intellectual content, All authors contributed significantly to the writing of the manuscript and approval of the final version.

Declaration of competing interest

The authors declare that they have no conflicts of interests with respect to the authorship and/or the publication of this paper.

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