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## Rates and correlates of risky firearm behaviors among adolescents and young adults treated in an urban emergency department★

Patrick M. Carter<sup>a,b,c,\*</sup>, Charles A. Mouch<sup>a,d</sup>, Jason E. Goldstick<sup>a,b</sup>, Maureen A. Walton<sup>a,e</sup>, Marc A. Zimmerman<sup>a,c,e</sup>, Ken Resnicow<sup>f</sup>, Rebecca M. Cunningham<sup>a,b,c,f,g</sup>

<sup>a</sup>Univ. of Michigan Injury Prevention Center, University of Michigan School of Medicine, 2800 Plymouth Road, NCRC 10-G080, Ann Arbor, MI 48109, United States of America

<sup>b</sup>Department of Emergency Medicine, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48105, United States of America

<sup>c</sup>Youth Violence Prevention Center, University of Michigan, School of Public Health, 1415 Washington Heights, Ann Arbor, MI 48109, United States of America

<sup>d</sup>Department of Surgery, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48105, United States of America

<sup>e</sup>University of Michigan, Addiction Center, Department of Psychiatry, School of Medicine, 4250 Plymouth Road, Ann Arbor, MI 48109, United States of America

<sup>f</sup>Department of Health Behavior & Health, Education, University of Michigan, School of Public Health, 1415 Washington Heights 3790A SPH I, Ann Arbor, MI 48109, United States of America

<sup>g</sup>Hurley Medical Center, Department of Emergency Medicine, 1 Hurley Plaza, Flint, MI 48503, United States of America

### Abstract

Firearm violence is a leading cause of death for urban adolescents and young adults (A/YAs). Little is known about patterns of risky firearm behaviors (RFBs) that may increase firearm-related fatality and non-fatal injury risk. To inform prevention efforts, we examined the rates and correlates of RFBs, including firearm carriage in risky situations (e.g., while drunk/high), discharge in risky situations (e.g., fleeing police), and firearm aggression (e.g., firearm threats/use against a partner/non-partner), among a sample of A/YAs (age-16–29) seeking medical or injury

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\*Corresponding author at: Patrick M. Carter, MD, Department of Emergency Medicine, University of Michigan, 2800 Plymouth Road, NCRC 10-G080, Ann Arbor, MI 48109, United States of America, cartpatr@med.umich.edu (P.M. Carter).

#### Contributors

All authors contributed to the conceptualization and writing of the manuscript, and reviewed and approved the final manuscript as submitted. Drs. Carter, Cunningham, Walton, Resnicow, and Zimmerman were responsible for designing the overall parent study and supervised data collection. Drs. Carter was responsible for initially conceptualizing and analyzing the current paper and preparing the initial manuscript. Dr. Goldstick was responsible for the analysis of the data and critical revisions to the manuscript. Dr. Mouch assisted with writing and editing of the manuscript. All authors provided critical feedback on analyses and approved the final submitted manuscript.

#### Declaration of competing interest

None of the authors has any financial interests or relationships relevant to the subject of this manuscript.

related care (7/2017–6/2018) at a Level-1 urban Emergency Department (ED). In total, 1312 A/YAs completed the survey (mean-age 23.2; 29.6%-male; 50.5%-Black; 56.3%-public assistance), with 102 (7.8%) engaging in RFBs. Among those engaging in RFBs, 42% reported firearm ownership, 68.6% firearm carriage in high-risk situations, 39.2% firearm discharge in risky situations, and 41.2% reported partner/non-partner firearm aggression. Regression identified RFBs correlates, including older age (AOR = 1.09), male sex (AOR = 1.63), Black race/ethnicity (AOR = 2.01), substance misuse (AOR = 2.75), attitudes favoring firearm use/retaliation (AOR = 1.38), peer firearm ownership/carriage (AOR = 3.26), higher levels of community violence exposure (AOR = 1.05), and active parole/probation (AOR 2.38). Higher coping skills were protective for RFBs (AOR = 0.83). Overall, we found that A/YAs seeking urban ED treatment reported elevated RFB rates, emphasizing the need for novel prevention initiatives, especially those incorporating tailored content addressing substance use, retaliatory violence, and peer delinquency/norms, while enhancing self-efficacy for avoiding RFBs and providing access to external resources within a resiliency-based framework. Such prevention approaches may be a critical step towards addressing the public health problem of firearm violence.

## Keywords

Firearm behaviors/violence; Substance use; Youth violence; Emergency medicine

## 1. Introduction

Among U.S. adolescents/young adults (A/YAs; age-16–29), firearms are the second leading cause of death; 60% from homicides (Cunningham et al., 2018; Centers for Disease Control and Prevention, 2017). Annually, firearms are responsible for > 60,000 emergency department (ED) visits for non-fatal assault (Centers for Disease Control and Prevention, 2017). Firearm injuries disproportionately affect African-American A/YAs, among whom homicide is the leading cause of death (Cunningham et al., 2018; Centers for Disease Control and Prevention, 2017). Such injuries are compounded by long-term health/social consequences, including repeat assaults (Cunningham et al., 2015a; Rowhani-Rahbar et al., 2015), firearm violence (Rowhani-Rahbar et al., 2015; Carter et al., 2015), substance use disorders (Walton et al., 2017), mental health issues (e.g., PTSD) (Garbarino et al., 2002), physical disabilities (DiScala and Sege, 2004), and criminal justice outcomes (Rowhani-Rahbar et al., 2015; Carter et al., 2018). Societal costs for firearm assaults are estimated as high as \$630-million annually for medical treatment alone before including long-term costs (e.g., lost wages/productivity, long-term treatment, justice/legal costs) (Howell and Abraham, 2013). Recently, national organizations (Butkus et al., 2018; Ranney et al., 2017; Bauchner et al., 2017; Dowd and Sege, 2012; Wintemute, 2013), including the Institute of Medicine (Leshner et al., 2013), have highlighted the need for prevention programs focused on decreasing firearm violence among high-risk populations.

Firearm carriage is an important risk factor for violence and violent injury (Borowsky et al., 2004; Branas et al., 2009; Carter et al., 2013; Dukarm et al., 1996; Durant et al., 1995; DuRant et al., 1997; Forrest et al., 2000; Lowry et al., 1998; Pickett et al., 2005; van Geel et al., 2014), increasing risk of serious injury/death for A/YAs carrying firearms, as well as

surrounding peers/partners (Branas et al., 2009; DuRant et al., 1997; Lowry et al., 1998; Pickett et al., 2005; Cheng et al., 2006; Cook, 1981; Felson and Steadman, 1983; Loughran et al., 2016; McDowall et al., 1992). Research has largely focused on characterizing risk factors for firearm possession and carriage, identifying key correlates, including substance use, prior violence/fighting, mental health issues, peer delinquency, neighborhood violence exposure, and retaliatory attitudes (Carter et al., 2013; Bergstein et al., 1996; Cao et al., 2008; Dong and Wiebe, 2018; Sheley and Brewer, 1995; Sheley and Wright, 1993; Steinman and Zimmerman, 2003; Vaughn et al., 2012; Hemenway et al., 1996; Hemenway et al., 2011). While researchers have identified factors influencing upstream carriage behaviors, few have focused on higher-risk behaviors involving a firearm such as carriage in risky situations (e.g., while drunk/high), discharge in risky situations (e.g., during a crime), or use (e.g., threatening/firing at someone) (Branas et al., 2009; Carter et al., 2017). Furthermore, researchers have largely focused on school- or criminal-justice samples (Bergstein et al., 1996; Cao et al., 2008; Sheley and Brewer, 1995; Sheley and Wright, 1993; Steinman and Zimmerman, 2003; Vaughn et al., 2012; Hemenway et al., 1996; Hemenway et al., 2011), with few healthcare-based studies (Rowhani-Rahbar et al., 2015; Carter et al., 2015; Branas et al., 2009; Carter et al., 2017). EDs are an important setting for violence prevention, especially since they provide access to A/YAs without primary care access, as well as those not in school or engaged in the justice system (Cunningham et al., 2009a). Characterizing risky firearm behaviors (RFBs) among a healthcare sample will provide data to inform interventions addressing upstream factors related to this lethal form of interpersonal violence.

Study objectives include to: (1) describe the rates/characteristics of RFBs among A/YAs seeking ED treatment; and, (2) examine risk/protective factors associated with RFBs. As a secondary objective, we characterize rates/characteristics of defensive firearm behaviors. We hypothesized, based on socio-ecological and health behavior theories (Gielen and Sleet, 2003; Bronfenbrenner, 1979; Bronfenbrenner, 1977; Sallis et al., 2008), as well as the firearm carriage/violence (Rowhani-Rahbar et al., 2015; Carter et al., 2015; Hemenway et al., 2011; Carter et al., 2017; Oliphant et al., 2019) literature that A/YAs engaged in RFBs would report greater substance use (Carter et al., 2015; Carter et al., 2013; Dukarm et al., 1996; Carter et al., 2017; Allen and Lo, 2012), violence exposure/involvement (e.g., violent injuries, positive firearm attitudes, community violence) (Durant et al., 1995; DuRant et al., 1997; Carter et al., 2017; Oliphant et al., 2019; Allen and Lo, 2012; Beardslee et al., 2018; Molnar et al., 2004; Webster et al., 1993), criminal justice involvement (Carter et al., 2018; Vaughn et al., 2012; Carter et al., 2017; Williams et al., 2002), mental health symptoms (Cunningham et al., 2015a; Carter et al., 2015; Simon et al., 1998), and peer ownership/carriage (Hemenway et al., 2011; Oliphant et al., 2019; Lizotte et al., 2000), as well as lower pro-social involvement (e.g., mentors, religious/school/community activities) (Oliphant et al., 2019; Zimmerman et al., 2002) and coping (Oliphant et al., 2019).

## 2. Methods

We present cross-sectional screening data collected as part of an intensive longitudinal study of firearm behaviors conducted among A/YAs seeking urban ED treatment. Procedures were approved by UM and Hurley Medical Center (HMC) IRBs; an NIH certificate of

confidentiality was obtained. The study was conducted in Flint (Michigan) at HMC, the region's only Level-1 trauma center. HMC provides treatment annually to ~75,000 adult/~25,000 children. The sample reflects Flint's socio-demographics (50–60% Black) (U.S. Census Bureau, 2010) and is similar to prior HMC studies (Cunningham et al., 2015a; Cunningham et al., 2009b; Cunningham et al., 2009c; Walton et al., 2010). Flint has elevated rates of violent crime and poverty (Federal Bureau of Investigation, n.d.; U.S. Census Bureau, 2018) that are comparable to other de-industrialized urban centers (e.g., Camden; Youngstown, Oakland) in the United States (Federal Bureau of Investigation, n.d.).

## 2.1. Population/recruitment

A/YAs (age-16–29) presenting to HMC-ED (7/10/2017–6/25/2018) for any reason were approached for screening/recruitment. Exclusion criteria included presentation for sexual assault, child maltreatment, suicidal ideation/attempt, serious mental illness (e.g., schizophrenia), or cognitive impairment precluding consent (e.g., intoxication). Participants in active police custody were excluded ( $n = 14$ ). Recruitment proceeded 7 days/week (2:00 pm–12:00 am).

## 2.2. Procedures

Research assistants (RAs) utilized electronic logs to identify/screen potentially eligible participants in consecutive order by arrival/triage time. RAs approached patients in treatment rooms/waiting spaces. Following written consent (and/or assent with parental/guardian consent if age < 18), patients self-administered the computerized survey. Remuneration for completing the screening survey was a gift (e.g., sudoku/crossword puzzle; earbuds; fidget spinners, etc) with an approximate value of \$1. RAs paused surveys for medical evaluation and/or testing/procedures. Surveys were administered privately; family/friends were not allowed to observe/participate.

## 2.3. Measures

**2.3.1. Risky Firearm Behavior (RFBs)**—Past 3-month risky firearm behaviors (RFBs) is a composite variable assessing three domains, including *risky carriage*, *risky discharge*, and/or *firearm aggression*. *Risky carriage* was assessed with Tulane Study (Sheley and Wright, 1995a) items measuring carriage in five situations (i.e., under influence of alcohol, under the influence of drugs, hanging with friends, doing a drug deal, or committing a crime). *Risky discharge* was assessed with Tulane Study (Sheley and Wright, 1995a) items measuring firearm discharge in seven situations (i.e., while drunk/high, hanging with friends, doing a drug deal, committing a crime, during a fight, while fleeing police, or to scare someone). *Firearm aggression* was assessed with four Conflicts Tactics Scale (CTS) items separately measuring threatening/using a firearm against partners (i.e., girlfriend/boyfriend, wife/husband) or non-partners (e.g., friends) (Straus, 2007). Each item used the CTS response scale, measuring frequency (never, 1-time, 2-times, 3–5 times, 6–10 times, 20+ times). Of note, those reporting firearm ownership/carriage exclusively for hunting or target/sport shooting and noting carriage/discharge while hanging with friends were excluded from the dependent variable. Consistent with the violence literature (Straus and Gelles, 1990; Cunningham et al., 2010), descriptive analyses characterizing RFBs frequencies were

calculated using the midpoint of the response options (i.e., for 3–5 times, 4 was used). Any past 3-month risky firearm behavior (RFB) was the main dependent variable (yes/no) for this analysis. This dichotomous outcome variable was utilized in all unadjusted/adjusted analyses given ease of clinical interpretation and high correlation between individual RFBs (see Appendix Table 1). Parallel Tulane Study (Sheley and Wright, 1995a) items assessed three defensive behaviors, including firearm carriage for protection, carriage in a dangerous area at night, or firearm discharge in self-defense.

**2.3.2. Socio-demographics**—Socio-demographic measures were from the Adolescent Health Study (Bearman et al., 1997), Data on Treatment Outcomes Study (DATOS) (United States Department of Health and Human Services, National Institutes of Health, National Institute on Drug Abuse, 1993–1995), and/or National Institutes of Health (NIH) guidelines on race/ethnicity reporting (National Institutes of Health, 2001). Number of children was assessed using a single item from the Flint Adolescent (FAS) Study (Zimmerman, 2014).

**2.3.3. Substance Use/Mental Health**—Past 3-month substance use, including alcohol, marijuana, illicit drugs (i.e., cocaine, hallucinogens, inhalants, methamphetamine, street opioids) and non-medical use of prescription drugs (i.e., opioids, sedatives, stimulants) were assessed using AUDIT-C (Saunders et al., 1993; Chung et al., 2000) and ASSIST (Group, 2002; Humeniuk et al., 2008). Binge drinking was defined as 5 drinks on one occasion. Non-medical prescription drug use was defined as taking more than prescribed, taking someone else's, and/or taking medications when sad or to “get high.” For analysis, alcohol misuse was defined as AUDIT-C 4 for males and AUDIT-C 3 for females (Chung et al., 2000). Drug misuse was defined by an ASSIST 4 on any drug subscale (Group, 2002; Humeniuk et al., 2008). Given multicollinearity, items were collapsed to any substance (i.e., alcohol, marijuana, illicit drugs, or prescription drugs) misuse for analysis.

Past 2-week anxiety and depression symptoms were assessed separately using the Generalized Anxiety Disorder (GAD-7) (Spitzer et al., 2006) and Patient Health Questionnaire (PHQ-2) (Richardson et al., 2010) scales, respectively. Items were summed to create total scores. Consistent with clinical recommendations, GAD-7 10 (Kroenke et al., 2007) and PHQ-2 3 (Kroenke et al., 2003) indicated moderate/severe anxiety and depression symptoms, respectively. Past-month PTSD symptoms were measured using the 6-item short-form civilian PTSD checklist (PCL-C) (Lang and Stein, 2005; Weathers et al., 2013), with PCL-C 14 indicating a positive screen (Lang and Stein, 2005). Clinical cut points were utilized in all analyses. Past 30-day suicidal ideation/attempt (yes/no) was assessed with two-items (Kroenke et al., 2001; Dube et al., 2010). Finally, a single brief reliance scale (Smith et al., 2008) item measured coping, defined as ability to “bounce back when something bad happens.” Scores were reverse-coded, with higher continuous scores indicating greater coping.

**2.3.4. Violence-related behaviors**—The 22-item CTS physical-assault subscale (Straus, 2007; Straus, 1979; Wolfe et al., 2001) measured moderate (e.g., shoved/slapped) and severe (e.g., threatened/used a knife/firearm) partner and non-partner victimization. Response scales ranged from 0 (never) to 6 (20-times). Items were combined to indicate any past 3-month violent victimization (yes/no). Reason for ED visit (i.e., violent injury)

was assessed with two-items indicating whether A/YAs were seeking care for an injury (e.g., cut/bruise) stemming from an altercation (i.e., where you/someone else were hitting/punching, kicking/slapping, using knife/gun, etc.) (Cunningham et al., 2015a). Firearm attitudes, a measure of willingness to use firearms to solve perceived/actual disputes and/or seek retaliation, were assessed using three Youth Gun Survey items (Sheley and Wright, 1995b). Items were coded/summed so that higher scores indicated greater willingness to use firearms. Criminal justice involvement was measured using a single Addiction Severity Index (ASI) (McLellan et al., 1992) item assessing current probation/parole.

**2.3.5. Peer, social, and community factors**—A single-item assessed whether A/YA's peers/friends owned/carried firearms (Sheley et al., 1992). Community violence exposure was assessed using the 10-item community violence subscale of the "Things seen/heard survey." (Richters and Saltzman, 1990; Richters and Martinez, 1992) Items were summed for analysis. Two FAS-items assessed religious (e.g., bible classes), community (e.g., Big brother/big sister), or school (e.g., clubs) activities (Ramirez-Valles et al., 1998). For analysis, results were dichotomized indicating any pro-social involvement (yes/no). A single-item assessed having a pro-social mentor (i.e., older-adult providing support) (Zimmerman et al., 2002).

## 2.4. Analytic approach

Descriptive statistics were calculated for individual firearm behaviors, as well as for the composite dichotomous dependent variable, RFBs (yes/no). Estimates of bivariate associations between exposure variables (i.e., risk and protective factors) and the dependent variable were calculated. Logistic regression was then used to estimate adjusted covariate effects for RFBs. Independent variables were chosen for the model based on theory and bivariate significance. Mental health variables were too highly correlated to include all conditions; anxiety was retained as it had the highest prevalence and given the association between anxiety and victimization/aggression and the role of anxiety as a precursor PTSD symptom (Gorman-Smith and Tolan, 1998). Similarly, ED visit for violent injury and recent victimization were highly correlated; ED visit was retained given that identifying populations among whom screening/intervention services should be focused is relevant to prevention (Cunningham et al., 2015a). A separate model estimating covariate predictors for the frequency of RFBs was considered (e.g., zero-inflated negative binomial regression); however, given the limited number of people with any RFBs (i.e.,  $n = 102$ ), there was insufficient power to examine the covariates that drive variation in frequency of RFBs as a separate model.

## 3. Results

During recruitment, 3340 A/YAs (age-16–29) presented for treatment (Fig. 1); 26.6% ( $n = 889$ ) were ineligible. Among RA-approached patients ( $n = 1657$  [67.6%]; missed = 794), 80.7% ( $n = 1338$ ) consented to inclusion (19.2%-refusal rate). Refusals were more likely male (22.9%-vs.-18.1%,  $p < .05$ ). No age or race/ethnicity differences were noted for refusals. Mean survey completion time was 34.8-min (SD = 27.7). Among the analytic sample ( $n = 1312$ ; 26 excluded for incomplete data), mean age was 22.2 (SD = 3.7), 29.6%

were male, 50.5% Black, and 56.3% were on public assistance. Only 28% of A/YAs were in school and 30.6% reported they were employed. A total of 136 participants (10.4%) reported firearm ownership.

### 3.1. Risky firearm behaviors

Within the sample ( $n = 1312$ ), 7.8% ( $n = 102$ ) engaged in past 3-month RFBs (Table 1), with an average of 12.8 (SD = 16.0) incidents in the prior 3 months. Only 42.2% ( $n = 43$ ) of those reporting RFBs also endorsed firearm ownership, while 74.5% ( $n = 76$ ) reported firearm carriage. Among those reporting RFBs and firearm carriage ( $n = 76$ ), A/YAs carried an average of 8.9-times (SD = 7.7) in the past 3-months. Among A/YAs endorsing RFBs and firearm ownership ( $n = 43$ ), 53.5% reported having children at home. A/YAs engaged in RFBs were more likely than those not endorsing RFBs to also report injuring/shooting someone severely enough to require ED/hospital care (27.5%-vs.-2.6%; OR = 14.4 [8.2–25.3]) in the prior 3-months.

### 3.2. Defensive firearm behaviors

Among the sample, 8.5% ( $n = 111$ ) reported firearm carriage for protection, averaging 8.2-times (SD = 8.0) in the prior 3-months. In addition, 2.3% ( $n = 30$ ) reported discharging a firearm in self-defense, averaging 3.9 (SD = 5.8) incidents in 3-months. Yet, 56.8% ( $n = 63$ ) of A/YAs reporting carriage for protection and 73.3% ( $n = 22$ ) reporting discharge for self-defense also engaged in RFBs during the concurrent time period. Similarly, among the 8.0% ( $n = 105$ ) who reported carriage in a dangerous area at night (average =  $8.2 \pm 7.8$  times), 62.9% ( $n = 66$ ) also reported RFBs.

### 3.3. Bivariate analysis

Compared to those not reporting RFBs (Table 2), A/YAs engaging in RFBs were older, male, and Black. No SES differences were noted between groups.

A/YAs engaged in RFBs had higher substance misuse than those not engaging in RFBs. Findings held regardless of type, with those engaged in RFBs reporting higher alcohol (35.3%-vs-24.1%; OR = 1.72 [95% CI = 1.12–2.63]), marijuana (67.6%-vs-37.4%; OR = 3.51 [95% CI = 2.28–5.40]), and illicit drug (14.7%-vs-3.9%; OR = 4.27 [95% CI = 2.29–7.94]) misuse. Of note, 46.1% of those reporting RFBs also reported 1 binge-drinking episode. Prescription drugs, including opiates (11.8%-vs-1.8%; OR = 7.20 [95% CI = 3.45–15.02]), sedatives (14.7%-vs-2.9%; OR = 5.79 [95% CI = 3.04–11.01]), and stimulants (8.8%-vs-2.2%; OR = 4.24 [95% CI = 1.94–9.28]), were positively associated with RFBs.

Compared to those not reporting RFBs, more A/YAs engaging in RFBs met clinical screening criteria for anxiety, depression, and PTSD. Rates of depression in the RFBs group were 39.2%, with 21.6% also reporting recent suicidal ideation/attempt. Nearly half (42.2%) of the RFB group experienced moderate-to-severe anxiety and almost a quarter (24.5%) experienced PTSD symptoms. Of note, A/YAs not engaging in RFBs endorsed higher coping ability than those reporting RFBs.

A/YAs in the RFB group were more likely seeking ED treatment for a violent injury, more likely to report recent victimization, and more likely on active parole/probation. A/YAs reporting RFBs endorsed higher levels of attitudes favoring using firearms to solve disputes. Among the RFBs group, more believed “it’s ok to shoot a person if that’s what it takes to get something you want” (1.6-vs-1.2; OR = 2.06, 95% CI(1.62–2.62)), “it’s ok to shoot someone who hurts/insults you” (1.9-vs-1.4; OR = 2.43, 95% CI(1.90–3.11)), and “it’s ok to shoot somebody who doesn’t belong in your neighborhood” (1.5-vs-1.2; OR = 2.27, 95% CI(1.71–3.01)).

A/YAs endorsing RFBs reported more exposure to peers with firearms, with 76.5% reporting friends/peers owned/carried firearms. A/YAs engaging in RFBs also reported higher community violence exposure. Pro-social activity involvement and having a mentor were not differentially associated with RFBs.

### 3.4. Regression analysis

In the regression (Table 3), substance misuse, firearm attitudes, peer firearm ownership/carriage, community violence exposure, and criminal justice involvement were associated with RFBs. Older male Black A/YAs were also more likely to report engaging in RFBs. In contrast, higher coping was negatively associated with RFBs. We found no evidence of multicollinearity in the model, with 1.33 the largest VIF. The Hosmer-Lemeshow test showed no evidence of lack-of-fit ( $\chi^2 = 7.90$ ,  $df = 8$ ,  $p = 0.44$ ), and the model showed good discriminatory power (AUC = 0.85, 95% CI:(0.81,0.89)).

## 4. Discussion

This study fills a critical gap by conducting a comprehensive analysis of RFBs among a large consecutively obtained ED A/YAs community sample. Although firearm carriage, as well as risk and protective factors predicting firearm carriage, has been previously characterized in multiple studies, including in large national samples (Carter et al., 2013; Oliphant et al., 2019; Cunningham et al., 2010; Kemal et al., 2018; Muula et al., 2008), this is the first study outside of research conducted among incarcerated A/YAs (Sheley and Wright, 1993), to characterize a series of higher risk behaviors involving firearms (e.g., carriage while drunk/high, discharge during a drug deal, threats/use against other people). Descriptive data on why/how A/YAs living in urban settings are engaging in this full range of RFBs, and the association between RFBs and various other behaviors, is a particularly novel addition to the literature, and critical to informing prevention initiatives.

RFB frequency was high, with an average of nearly thirteen incidents in the prior 3-months. While associated injury outcomes were not available, A/YAs reporting RFBs were five times as likely to have been victimized and fourteen times as likely to have precipitated a violent injury requiring medical treatment as those not reporting RFBs. Such findings are consistent with data suggesting that carrying, discharging, or threatening to use a firearm, especially within contexts involving alcohol/drug use, illegal behaviors (e.g., selling/buying drugs), and/or arguments between partners/peers, exacerbates the probability of serious injury/fatality either to A/YAs or those around them (Sheley et al., 1992; Hammig et al., 2001). Over half of A/YAs carrying/using a firearm to defend themselves were concurrently



engaged in RFBs, suggesting that while they primarily carry firearms for protection (Carter et al., 2013), they also used a firearm during the same period in a risky/aggressive manner. This is consistent with qualitative research highlighting that firearm carriage empowers A/YAs to act more aggressively in violent encounters or to enter dangerous environments they might normally avoid (Branas et al., 2009; Wilkinson and Fagan, 1996; Thompson et al., 2001; Ash et al., 1996; Black and Hausman, 2008; May, 1999; Baron, 2009). Longitudinal research is needed to determine factors that increase/decrease risks for those carrying for protection that do not engage in RFBs to prevent transition into RFBs. In the meantime, findings highlight the need for prevention programs to address behaviors known to increase impulsive firearm use (e.g., alcohol/drugs), contexts within which A/YAs carry/use firearms aggressively (e.g., for crime, sell/buy drugs), and factors motivating carriage (e.g., fear of victimization, need for protection).

A/YAs reporting RFBs endorsed high-levels of attitudes favoring firearm use to solve conflicts, including retaliation. Retaliation has been identified as a key motivation underlying firearm conflicts, especially firearm aggression (Carter et al., 2015; Carter et al., 2013; Carter et al., 2017; Copeland-Linder et al., 2007), with A/YAs indicating that retaliatory violence corrects perceived injustices, restores self-worth/peer respect, and deters future violence (Carter et al., 2017; Copeland-Linder et al., 2007; Cota-McKinley et al., 2001). Given that many health behavior models (Gielen and Sleet, 2003) suggest modifying violence attitudes and enhancing self-efficacy to safely navigate potentially violent situations are fundamental to reducing aggression, embedding cognitive skill training (CBT) that addresses reactive (e.g., emotion regulation, impulse control, anger management) and pro-active (e.g., non-violent conflict resolution, problem solving, positive communication skills) aggression within prevention programs (Walton et al., 2010; Carter et al., 2016; Purtle et al., 2015; Cooper et al., 2006; Shibru et al., 2007; Zun et al., 2006), and tailoring CBT to situational contexts involving firearms may be key to addressing higher severity RFBs, especially given that 40% of RFBs stemmed from firearm aggression towards people they knew (i.e., partners, peers).

Peer influences were a key predictor, with 75% of A/YAs reporting RFBs also noting their friends/peers owned/carried firearms. Prior research indicates peer firearm ownership/carriage (Cao et al., 2008; Sheley and Brewer, 1995; Hemenway et al., 2011; Williams et al., 2002; Lizotte et al., 2000; Wilcox et al., 2006) and delinquency (Hemenway et al., 2011; Beardslee et al., 2018; Williams et al., 2002; Lizotte et al., 2000; Luster and Oh, 2001; Tigri et al., 2016) are key risk factors for carriage. Taken together, this underscores the fundamental role that peer influences have during adolescence and emerging adulthood (Goldstick et al., 2017; Steinberg and Monahan, 2007; Goldstick et al., 2018). Researchers have found that firearm violence is often concentrated among a small group of peer social networks and neighborhood hotspots, mirroring an contagion model (Hemenway et al., 1996; Hemenway et al., 2011; Braga et al., 2010; Papachristos et al., 2013). Thus, A/YAs engaged in RFBs predominantly come into contact with other peers engaging in RFBs, enhancing their injury risk and altering social norms/perceptions regarding firearm carriage and engaging in violence behaviors (Hemenway et al., 1996; Hemenway et al., 2011; Braga et al., 2010; Papachristos et al., 2013). As a result, A/YAs often overestimate the prevalence of A/YAs carrying/using firearms in their neighborhood (Hemenway et al., 2011).

Overestimation of peer firearm carriage is an important factor underlying firearm carriage, with 34% of A/YAs indicating they are more likely to carry when they think their peers are also carrying (Hemenway et al., 2011) and qualitative research suggesting that “fear someone is carrying” is an important reason motivating carriage (Mateu-Gelabert, 2002). Such findings emphasize the importance of embedding normative feedback around carriage within interventions, as well as enhancing motivation, self-efficacy, and skills in avoiding high-risk locations and negative peer influences (Walton et al., 2010; Carter et al., 2016). Further, enhancing positive peer support may aid in countering normative misperceptions and increasing participation in pro-social activities (Hemenway et al., 2011; Neighbors et al., 2010; Walters and Neighbors, 2005; Altermatt and Pomerantz, 2005).

Consistent with prior research (Carter et al., 2013; Hemenway et al., 2011; Carter et al., 2017; Cunningham et al., 2010; DuRant et al., 1999; Freed et al., 2001; Ruggles and Rajan, 2014), A/YAs reporting substance misuse were three times more likely to report RFBs. Mechanisms underlying this association differ by substance type (Carter et al., 2017). Alcohol is theorized to precipitate violent conflict by decreasing inhibition, increasing the likelihood that behaviors are interpreted as threatening and leading to impulsive escalation of low-level conflict (Chermack et al., 2010; Chermack and Giancola, 1997). Alcohol use in social contexts may also enhance contact between A/YAs with prior conflict, prompting retaliatory violence. Alcohol use following conflict may also represent a coping mechanism for frequent violence involvement (Carter et al., 2017). In contrast, the relationship between RFBs and marijuana likely reflects either social/contextual factors (e.g., buying/selling drugs in violent situations) (Goldstein, 1985; Hoaken and Stewart, 2003) or chronic long-term use, which increases aggressive behavior by altering neural functioning in the pre-frontal cortex, rather than through acute pharmacological effects (Schoeler et al., 2016; Myerscough and Taylor, 1985). Similarly, illicit and prescription drugs may be associated with RFBs due to clustering of co-occurring problem behaviors (Jessor, 1987), acute pharmacological effects (Boles and Miotto, 2003), or socio-contextual factors (Catalano et al., 2011; Murphy et al., 2014). Alternatively, A/YAs engaged in RFBs may utilize marijuana or other drugs (e.g., prescription opioids) to self-regulate aggressive impulses and/or treat undiagnosed mental health symptoms (Martens and Gilbert, 2008). Future research, particularly intensive daily studies, characterizing temporal/contextual relationships between individual substance types and firearm behaviors is needed to understand this relationship and inform tailored interventions. Regardless, rates of firearm carriage/discharge while drunk/high and while engaged in buying/selling drugs among the RFB group demonstrates the importance of addressing substance use within firearm violence prevention initiatives. Given that single-session substance use (Cunningham et al., 2015b) and combined substance use/violence interventions (Cunningham et al., 2009b; Walton et al., 2010) have demonstrated efficacy in lower-risk samples, embedding these components within more intensive RFB interventions may aid in reducing firearm-related outcomes, while addressing service access barriers in urban communities (Wells et al., 2001; Wu et al., 2002; Heflinger et al., 2006).

Positive coping was negatively associated with RFBs, emphasizing the need for prevention programs to utilize a resilience-based framework. Resilience theory suggests that positive youth development can occur despite risk exposure by enhancing both internal assets (e.g., competence, coping skills, self-efficacy) and external resources (e.g., parental support,

mentoring, community activities) (Fergus and Zimmerman, 2005). Within this context, care management interventions actively linking A/YAs to community services (e.g., employment) have demonstrated efficacy reducing weapon carriage in lower-risk trauma patients (Zatzick et al., 2014). Enhancing such approaches with multisession behavioral therapy may be a viable approach to decreasing RFBs among higher risk youth. While anxiety was not significant in the model, A/YAs engaging in RFBs had high levels of co-occurring mental health symptoms and substance use, suggesting A/YAs experiencing anxiety, depression, or PTSD may be self-medicating with alcohol/drugs. Alternatively, marijuana use may exacerbate mental health issues (Hanna et al., 2017), with more longitudinal research needed to tease out causal effects (e.g., withdrawal). Regardless, elevated mental health symptoms, combined with high rates of suicidal ideation/attempts among those experiencing depression and RFBs, emphasizes the need for linkage to mental health services and safety planning.

Community violence exposure was higher among A/YAs reporting RFBs, emphasizing the importance of integrating individual-level interventions with those addressing other aspects of the socio-ecological spectrum. Neighborhood interventions focused on increasing social capital and community engagement are theorized to enhance community organization and neighborhood monitoring, leading to improved safety and less violence (Sampson and Groves, 1989; Heinze et al., 2016). Consistent with this, community interventions addressing blight remediation and vacant lot greening have demonstrated efficacy reducing firearm assaults, violent crime, and community stress, while enhancing neighborhood health and safety (Branas et al., 2016; Branas et al., 2018; Kondo et al., 2018; Branas et al., 2011; Heinze et al., 2018; Garvin et al., 2013; Kondo et al., 2016). Further, comprehensive approaches combining community and individual-level hospital interventions have demonstrated efficacy decreasing both violent crime and assault-injuries (Heinze et al., 2016). Expanding on this to address perceptions of neighborhood safety, especially as many A/YAs engaged in RFBs were also carrying firearms for defensive reasons, may aid in decreasing firearm carriage, victimization risk, and RFBs, while increasing safety.

As in prior studies (Carter et al., 2013; Cunningham et al., 2010), older male A/YAs were predictive of RFBs. Despite this, more than half reporting RFBs were female, stressing the need for prevention addressing both sexes. Black A/YAs were more likely engaged in RFBs, consistent with data on the disproportionate impact of firearm homicides among minority communities (Cunningham et al., 2018; Centers for Disease Control and Prevention, 2017) and likely reflecting unmeasured socio-economic factors (e.g., poverty). Data finding that justice-involved A/YAs were preferentially engaged in RFBs, combined with research highlighting that 80% of firearms owned/carried by youth are acquired through illegal channels (Carter et al., 2013), emphasizes the need for stronger enforcement of diversion policies, especially for A/YAs prohibited from owning/carrying firearms (e.g., those on parole/probation). However, it is important to note that only 11% of the RFB group were involved in the justice system, emphasizing opportunities for ED-based interventions to prevent such behaviors before A/YAs suffer long-term consequences related to arrest/incarceration (Carter et al., 2018).

Data also demonstrates the need for improved clinical screening to identify A/YAs at risk for RFBs and firearm-related outcomes. Only 42% engaged in RFBs reported firearm

ownership, demonstrating limitations to screening focused solely on identifying firearms in the home. Compared with older adults, who acquire/own firearms for extended periods, A/YAs carrying firearms in an urban context are more likely to acquire/carry firearms intermittently, as well as share, trade/sell, or hide them (Ash et al., 1996; Freed et al., 2001; Lizotte et al., 1996). Thus, screening on ownership will miss high-risk A/YAs not identifying themselves as traditional “owners.” Additionally, the finding that only one out of five A/YAs reporting RFBs were seeking violent injury treatment highlights the limitations of prevention programs focused exclusively among admitted assault-injured patients. Such programs, while important, may not reach many at-risk A/YAs engaged in RFBs that would benefit from more upstream prevention. Novel ED-based screening tools (e.g., SaFETy Score) for identifying A/YAs at risk for firearm violence outcomes have recently been developed (Goldstick et al., 2017). While prospective predictive validity studies are necessary, such tools represent a promising approach to enable clinicians to screen/identify A/YAs that would benefit from intensive prevention services. Importantly, providing safe storage counseling remains critically important, as over half of those reporting RFBs and firearm ownership had underage children at home (Grossman et al., 2005).

#### 4.1. Limitations

As data is from a single urban ED, results may not generalize to dissimilar samples from rural and/or suburban settings. Yet, as data reflects the socio-demographic and economic characteristics of the Flint population and given that where data overlaps with prior studies, results are consistent with extant research - findings from the current analysis are likely generalizable to other economically distressed urban settings with elevated rates of A/YAs engaged in violence. Future research including ethnic/racial (e.g., Hispanic) populations and samples from suburban/rural settings not studied would be useful. Potential exists for refusal bias, with those refusing participation potentially more likely to carry firearms. However, this bias is mitigated by describing the study broadly as a health survey assessing multiple risk behaviors and a low refusal rate (< 20%). While self-report data is a potential limitation, research has demonstrated the reliability/validity of this approach when privacy/confidentiality are assured, as was done in this study (Gray and Wish, 1998; Thornberry and Krohn, 2000; Buchan et al., 2002; Brener et al., 2003; Turner et al., 1998; Wright et al., 1998; Webb et al., 1999; Harrison et al., 2007). Given RFBs were not mutually exclusive, summary averages may overestimate frequency if occurring during the same event. Finally, the cross-sectional design limits causal attributions. Despite limitations, findings regarding RFBs are novel and make important contributions to the literature.

#### 4. Conclusions

Firearm violence remains a complex, but preventable public health problem. To our knowledge, this is the first study to describe RFBs among a consecutive sample of A/YAs seeking urban ED treatment. Findings emphasize the need for interventions addressing multiple socio-ecological levels, incorporating tailored content addressing substance use, retaliatory violence, and peer delinquency/norms, while enhancing self-efficacy for avoiding carriage and access to external resources within a resiliency-based framework. Understanding RFBs among A/YAs seeking ED treatment is a critical step to developing/

implementing effective violence prevention initiatives addressing the elevated morbidity/mortality associated with firearm injuries.

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## Appendix A

**Appendix Table 1**

Pearson correlation coefficients for individual RFB items included in the RFB dependent variable.

	Carriage under the influence alcohol/ Drugs	Carriage while hanging with friends	Carriage while doing drug Deal/ Crime	Firearm discharge under the influence alcohol/ Drugs	Firearm discharge while hanging with friends	Firearm discharge while doing drug deal or crime	Firearm discharge during a fight or fleeing police	Firearm discharge to scare someone	Non-partner firearm aggression (threats or use)	Partner firearm aggression (threats or use)
Carriage under influence alcohol/ drugs	1	<b>0.29</b> ***	<b>0.50</b> ***	<b>0.65</b> ***	<b>0.20</b> ***	<b>0.40</b> ***	<b>0.38</b> ***	<b>0.41</b> ***	<b>0.25</b> ***	0.05
Carriage while hanging with friends		1	<b>0.17</b> ***	<b>0.13</b> ***	<b>0.41</b> ***	<b>0.12</b> ***	<b>0.09</b> **	<b>0.27</b> ***	<b>0.13</b> ***	<b>0.11</b> ***
Carriage while doing drug deal/ crime			1	<b>0.36</b> ***	<b>0.13</b> ***	<b>0.37</b> ***	<b>0.42</b> ***	<b>0.35</b> ***	<b>0.26</b> ***	<b>0.17</b> ***
Firearm discharge under the influence alcohol/ drugs				1	<b>0.13</b> ***	<b>0.26</b> ***	<b>0.40</b> ***	<b>0.27</b> ***	<b>0.21</b> ***	-0.01
Firearm discharge while hanging with friends					1	<b>0.17</b> ***	<b>0.09</b> **	<b>0.20</b> ***	<b>0.20</b> ***	<b>0.07</b> **
Firearm discharge while doing drug deal or crime						1	<b>0.25</b> ***	<b>0.17</b> ***	<b>0.27</b> ***	<b>0.10</b> ***
Firearm discharge							1	<b>0.58</b> ***	<b>0.24</b> ***	-0.01

	Carriage under the influence alcohol/ Drugs	Carriage while hanging with friends	Carriage while doing drug Deal/ Crime	Firearm discharge under the influence alcohol/ Drugs	Firearm discharge while hanging with friends	Firearm discharge while doing drug deal or crime	Firearm discharge during a fight or fleeing police	Firearm discharge to scare someone	Non-partner firearm aggression (threats or use)	Partner firearm aggression (threats or use)
during a fight or fleeing police										
Firearm discharge to scare someone							1	0.33***		-0.01
Non-partner firearm aggression (threats or use)								1	0.25***	
Partner firearm aggression (threats or use)										1

Two-tailed test of significance:

\*  $P < .05$

\*\*  $P < .01$

\*\*\*  $P < .001$ .

## Abbreviations

<b>ED</b>	emergency department
<b>HMC</b>	Hurley medical center
<b>UM</b>	University of Michigan
<b>IRB</b>	Institutional review board
<b>RFB</b>	risky firearm behaviour
<b>COC</b>	certificate of confidentiality
<b>NIH</b>	National Institutes of Health
<b>PTSD</b>	post-traumatic stress disorder

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**Fig. 1.** Screening recruitment flowchart for project IntERact study (7/10/2017–6/25/2018).

**Table 1**

Prevalence and frequency of individual risky firearm behaviors among A/YAs (16–29 y/o) endorsing past 3-month risky firearm behavior (RFBs;  $n = 102$ ).

Past 3-month risky firearm behaviors (RFBs) <sup>a</sup>	Prevalence of Behavior among All RFBs	Frequency Of RFB <sup>b</sup>
	n (%)	(mean ± SD)
Carriage under the influence alcohol or drugs <sup>c</sup>	24 (23.5%)	7.0 ± 8.7
Carriage while hanging with friends <sup>d</sup>	54 (52.9%)	7.3 ± 7.7
Carriage while doing drug deal/crime <sup>e</sup>	13 (12.7%)	9.8 ± 10.8
<b>Risky firearm carriage</b>	<b>70 (68.6%)</b>	<b>10.6 ± 14.0</b>
Firearm discharge under the influence alcohol/drugs	14 (13.7%)	2.4 ± 2.0
Firearm discharge while hanging with friends <sup>d</sup>	15 (14.7%)	5.1 ± 6.3
Firearm discharge while doing drug deal or crime <sup>f</sup>	9 (8.8%)	7.8 ± 8.4
Firearm discharge during a fight or fleeing police <sup>g</sup>	7 (6.9%)	3.9 ± 3.8
Firearm discharge to scare someone	15 (14.7%)	2.3 ± 2.1
<b>Risky firearm discharge</b>	<b>40 (39.2%)</b>	<b>6.9 ± 10.5</b>
Non-partner firearm aggression (threats or use)	37 (36.3%)	5.2 ± 6.3
Partner firearm aggression (threats or use)	10 (9.8%)	10.8 ± 13.4
<b>Any firearm aggression</b>	<b>42 (41.2%)</b>	<b>7.1 ± 11.2</b>
<b>Any past 3-month RFBs (dependent variable)</b>	<b>102</b>	<b>12.8 ± 16.0</b>

<sup>a</sup>Risky firearm behaviors (RFBs) is a composite variable including any of the behaviors listed in Table 1, including risky firearm carriage, risky firearm discharge, or firearm aggression (i.e., threats or use of a firearm against someone else).

<sup>b</sup>Frequency is calculated as the mean of the midpoint for the individual item responses (and using 20 for the 20+ category) among only those participants reporting engaging in that specific RFB. Note: Behaviors may not have been mutually exclusive and may have taken place during same event.

<sup>c</sup>Carriage under the influence of alcohol and carriage under the influence of drugs were combined into a single variable for the table given they are similar behaviors.

<sup>d</sup>Carriage while hanging with friends and firearm discharge while hanging with friends both exclude participants reporting ownership/carriage of a firearm exclusively for the purposes of hunting/target shooting.

<sup>e</sup>Carriage while doing a drug deal and carriage while committing a crime were combined into a single variable for the table given low base rates of either behavior.

<sup>f</sup>Firearm discharge while doing a drug deal and discharge while committing a crime were combined for the table given low base rates of either behavior.

<sup>g</sup>Firearm discharge during a fight and discharge while fleeing police were combined for the table given low base rates of either behavior.

**Table 2**  
 Bivariate comparison of patient characteristics for A/YAs (age 16–29) who report engaging in RFBs in the prior 3-months compared to those no engaging in RFBs in the prior 3-months. (*n* = 1312).

	<b>RFB</b> N = 102 (7.8%)	<b>No RFB</b> N = 1210 (92.2%)	<b>Total sample</b> N = 1312	<b>OR (95% CI)</b>
<b>Baseline socio-demographics factors</b>				
Age (mean, SD)	23.2 (3.9)	22.1 (3.7)	22.2 (3.7)	1.08 (1.02–1.14)
Male (n, %)	48 (47.1%)	340 (28.1%)	388 (29.6%)	2.27 (1.51–3.42)
Black (vs. other)	68 (66.7%)	594 (49.1%)	662 (50.5%)	2.07 (1.35–3.18)
Public assistance (n, %)	58 (56.9%)	681 (56.3%)	739 (56.3%)	1.02 (0.68–1.54)
Married/living with someone (n, %)	24 (23.5%)	290 (24.0%)	314 (23.9%)	0.98 (0.61–1.57)
Full-time employment	36 (35.3%)	365 (30.2%)	401 (30.6%)	1.26 (0.83–1.93)
Currently in school (n, %) <sup>a</sup>	27 (26.5%)	340 (28.1%)	367 (28.0%)	0.92 (0.58–1.46)
<b>Substance use and mental health factors</b>				
Substance Misuse <sup>b</sup>	85 (83.3%)	596 (49.3%)	681 (51.9%)	5.15 (3.02–8.78)
Anxiety <sup>c</sup> (GAD7 score 10)	43 (42.2%)	311 (25.7%)	354 (27.0%)	2.11 (1.39–3.19)
Depression <sup>d</sup> (PHQ-2 score 3)	40 (39.2%)	254 (21.0%)	294 (22.4%)	2.43 (1.59–3.70)
PTSD <sup>e</sup> (PCL-C score 14)	25 (24.5%)	154 (12.7%)	179 (13.6%)	2.23 (1.38–3.60)
Coping <sup>f</sup>	2.89 (1.45)	3.45 (1.29)	3.41 (1.31)	0.73 (0.62–0.85)
<b>Violence, firearm attitudes, and criminal justice factors</b>				
ED visit for violent injury (n, %)	19 (18.6%)	91 (7.5%)	110 (8.4%)	2.81 (1.64–4.84)
Any violent victimization	78 (76.5%)	512 (42.3%)	590 (45.0%)	4.43 (2.76–7.10)
Parole/Probation <sup>g</sup>	11 (10.8%)	49 (4.0%)	60 (4.6%)	2.86 (1.44–5.70)
Firearm attitudes	5.04 (2.18)	3.82 (1.27)	3.92 (1.40)	1.50 (1.34–1.66)
<b>Peer, social, and community factors</b>				
Friends own/carry firearms	78 (76.5%)	504 (41.7%)	582 (44.4%)	4.55 (2.84–7.30)
Community violence	14.57 (9.35)	7.34 (7.84)	7.90 (8.19)	1.09 (1.07–1.11)
Religious/community/school involvement	51 (50.0%)	531 (43.9%)	582 (44.4%)	1.28 (0.85–1.92)
Positive mentor	62 (60.8%)	754 (62.3%)	816 (62.2%)	0.94 (0.62–1.42)

<sup>a</sup>School could be high-school, technical school, or college/master's program



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<sup>q</sup>Substance misuse includes misuse of alcohol, marijuana, illicit drugs (cocaine, methamphetamine, inhalants, hallucinogens, and street opioids), or prescription drugs (stimulants, sedatives, and opioids); within this sample alcohol misuse is defined as an AUDIT-C = 4 for males or AUDIT-C = 3 for females; drug misuse is defined as an ASSIST = 4 on any individual drug or prescription drug subscale.

<sup>c</sup>GAD7 score = 10 correlates with moderate to severe anxiety symptoms

<sup>d</sup>PHQ-2 score = 3 correlates with symptoms suggestive of major depressive disorder

<sup>e</sup>PCL-C score = 14 on the 6-item PCL-C correlates with a positive screen for PTSD symptoms

<sup>f</sup>Resiliency/coping measure is coded from 1 to 5 with higher scores indicating more confidence in ability to “bounce back when something bad happens.”

<sup>g</sup>Parole or probation indicates current status on active parole or probation.

**Table 3**

Multiple logistic regression examining patient characteristics correlated with engaging in past-3-month risky firearm behaviors (RFB) among A/YAs (age 16–29) seeking treatment in an urban emergency department (ED).

<b>Covariates</b>	<b>AOR (95% CI)</b>
Age	1.09 (1.02–1.16)
Male	1.63 (1.01–2.62)
Black (vs. other)	2.01 (1.22–3.31)
Public assistance	0.77 (0.48–1.25)
Substance misuse	2.75 (1.54–4.92)
Anxiety	1.14 (0.67–1.94)
ED visit for violent injury	1.58 (0.81–3.05)
Firearm attitudes	1.38 (1.21–1.57)
Friends own/carry firearms	3.26 (1.94–5.49)
Community violence	1.05 (1.02–1.07)
Coping	0.83 (0.68–0.99)
Parole/probation	2.38 (1.08–5.25)