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A scoping review of patterns, motives, and risk and protective factors for adolescent firearm carriage

Stephen N. Oliphant^{1,2}, Charles A. Mouch^{1,3}, Ali Rowhani-Rahbar^{1,4,5}, Stephen Hargarten^{1,6}, Jonathan Jay^{1,7}, David Hemenway^{1,7}, Marc Zimmerman^{1,9,10,11}, Patrick M. Carter^{1,8,9,10,11}, ACTS Consortium

¹Firearm Safety Among Children and Teens Consortium, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA

²Gerald R. Ford School of Public Policy, University of Michigan, 735 S State St, Ann Arbor, MI 48109, USA

³Department of Surgery, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA

⁴Department of Epidemiology, University of Washington, 1959 NE Pacific Street, Health Sciences Bldg, F-262, Seattle, WA 98195, USA

⁵Harborview Injury Prevention and Research, Center University of Washington, 401 Broadway, 4th Floor, Seattle, WA 98122, USA

⁶Department of Emergency Medicine and Comprehensive Injury Center, Medical College of Wisconsin, 8701 Watertown Plank Rd., Milwaukee, WI 53226, USA

⁷Department of Health Policy and Management, Harvard T. H. Chan School of Public Health, 3rd & 4th Floors, 677 Huntington Avenue, Boston, MA 02115, USA

⁸Department of Emergency Medicine, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA

⁹Department of Health Behavior and Health Education, University of Michigan School Public Health, 1415 Washington Heights 3790A SPH I, Ann Arbor, MI 48109, USA

¹⁰Youth Violence Prevention Center, Univ. of Michigan School of Public Health, 1415 Washington Heights, Ann Arbor, MI 48109, USA

¹¹Department of Emergency Medicine, Univ. of Michigan Injury Prevention Center, University of Michigan School of Medicine, 2800 Plymouth Road, NCRC 10-G080, Ann Arbor, MI 48109, USA

Abstract

*Patrick M. Carter, cartpatr@med.umich.edu.

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Firearm carriage is a key risk factor for interpersonal firearm violence, a leading cause of adolescent (age < 18) mortality. However, the epidemiology of adolescent firearm carriage has not been well characterized. This scoping review examined four databases (PubMed; Scopus; EMBASE; Criminal Justice Abstracts) to summarize research on patterns, motives, and underlying risk/protective factors for adolescent firearm carriage. Of 6156 unique titles, 53 peer-reviewed articles met inclusion criteria and were reviewed. These studies mostly examined urban Black youth, finding that adolescents typically carry firearms intermittently throughout adolescence and primarily for self-defense/protection. Seven future research priorities were identified, including: (1) examining adolescent carriage across age, gender, and racial/ethnic subgroups; (2) improving on methodological limitations of prior research, including disaggregating firearm from other weapon carriage and using more rigorous methodology (e.g., random/systematic sampling; broader population samples); (3) conducting longitudinal analyses that establish temporal causality for patterns, motives, and risk/protective factors; (4) capitalizing on m-health to develop more nuanced characterizations of underlying motives; (5) increasing the study of precursors for first-time carriage; (6) examining risk and protective factors beyond the individual-level; and, (7) enhancing the theoretical foundation for firearm carriage within future investigations.

Keywords

Firearm; Adolescent; Scoping review; Carriage patterns; Risk/protective factors; Motives

Introduction

Firearms are the second leading cause of death among U.S. children and adolescents, with 65% of pediatric firearm deaths resulting from interpersonal violence (Cunningham et al., 2018). Of the 1322 homicides that occurred among children and adolescents (age 1–17) in 2016, 64% resulted from firearms (CDC, 2017). Given a lack of progress reducing pediatric firearm injuries during the past decade, they now represent a critical public health endemic requiring increased attention (Christoffel, 2007), especially as firearm violence is associated with long-term health and social consequences, including repeat assault-injuries (Cunningham et al., 2015; Rowhani-Rahbar et al., 2015), subsequent firearm violence (Carter et al., 2015; Rowhani-Rahbar et al., 2015), long-term physical disabilities, substance use disorders, mental health issues (e.g., PTSD), and negative criminal justice outcomes (Carter et al., 2018a, b; Cunningham et al., 2009; DiScala & Sege, 2004; Greenspan & Kellermann, 2002; Rowhani-Rahbar et al., 2015; Walton et al., 2017). The costs of interpersonal firearm violence are substantial, with acute medical treatment for hospitalized firearm assaults alone averaging an estimated \$389 million annually before factoring in acute care costs for patients discharged after treatment in the emergency department or the indirect costs that are associated with lost wages and productivity, long-term medical care, and associated criminal justice proceedings (Peek-Asa et al., 2017).

Firearm carriage is a key risk factor for adolescent bullying, physical fighting, assault, and violent injuries requiring treatment (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). Adolescents who carry

firearms, as well as the peers surrounding them, are at increased risk for serious injury and death (Branas et al., 2009; Cheng et al., 2006; Cook, 1981; Durant et al. 1995; DuRant et al., 1997; Felson & Steadman, 1983; Loughran et al., 2016; Lowry et al., 1998; McDowall et al., 1992; Pickett et al., 2005). As a result, reducing firearm carriage among adolescent youth is among the key national health objectives outlined in Healthy People 2020 (HealthyPeople, 2018) and the Institute of Medicine and American Academy of Pediatrics have identified firearm violence prevention as a key research priority (Dowd & Sege, 2012; Leshner et al., 2013).

The objective of this study was to conduct a scoping review evaluating the existing literature related to contextual factors for adolescent firearm carriage. Specifically, this review synthesizes the published evidence on: (1) patterns; (2) motives; and, (3) risk and protective factors for adolescent firearm carriage. A secondary objective was to identify current gaps in the literature and establish a set of future research priorities. Understanding the current research findings, as well as the areas needed for future research, is critical to the development of effective public health interventions focused on reducing adolescent firearm carriage and associated negative health and social outcomes.

Methods

Search strategy

This scoping review (Arksey & O'Malley, 2005; Institute, 2015; Tricco et al., 2018) was conducted under the guidance of a medical research librarian at the UM Medical School (April–October; 2018). Scoping reviews systematically map large and diverse bodies of research to identify key concepts and gaps in the literature (Arksey & O'Malley, 2005; Grimshaw, 2010). Four databases were utilized, including PubMed, Scopus, EMBASE, and Criminal Justice Abstracts. A forward citation search was conducted (October 2018) to identify additional published articles. Reference sections of relevant studies were also reviewed to identify additional eligible studies. The initial search was limited to English-language articles published between January 1, 1985 and April 8, 2018. No limitations were placed on study design, although grey literature was excluded. Detailed search strategy is provided in “Appendix 1”. The Preferred Reporting Items for Scoping Reviews (PRISMA-ScR) flow diagram describing search strategy, study selection, and data abstraction is outlined in Fig. 1.

Study selection

Initial results were compiled in Endnote; duplicate articles were removed. The senior author (P.C.) conducted an initial title screen with a small set of articles (* 4%) to assess search quality. Two reviewers (S.O., C.M.) independently conducted a title/abstract review of the de-duplicated articles to assess inclusion eligibility. Discrepancies underwent full text review and were resolved by consensus/third party review. English-language articles reporting empirical research characterizing carriage patterns, motives, and/or risk/protective factors underlying firearm carriage among pediatric populations (age < 18) were included. Given limited prior research, quantitative studies, as well as qualitative studies providing contextual information about carriage, were included. Articles were excluded if they did not focus

specifically on firearm carriage (e.g., focused on weapon carriage or ownership), if they characterized non-U.S. populations, or if they focused exclusively on non-powder discharge firearms (e.g., air guns). Published reviews, narratives, and opinion articles were excluded. Articles reporting only carriage rates but not any of the other inclusion criteria were excluded. Research studies characterizing any portion of the pediatric population were included, while those conducted exclusively among adults (age > 17) were excluded.

Data abstraction, synthesis, quality assessment, and analysis

Full text review was independently conducted by two authors (S.O., C.M.). Data were abstracted using a standardized form, all entries were verified for accuracy, and discrepancies were resolved through consensus. Studies were classified as characterizing: (1) Patterns of firearm carriage (and/or initiation of firearm carriage); (2) Motives for firearm carriage; and/or, (3) Risk and protective factors for adolescent firearm carriage (i.e., factors that increased/decreased the propensity to carry firearms). For studies fitting more than one category, data were included in both data tables with relevant results. Abstracted data elements included study design, sample size, study population/setting, carriage rates, outcomes/dependent variables measured, results, and limitations. As recommended by the Cochrane Collaboration (Higgins, 2011), non-randomized trials/studies were assessed for methodological quality using an adapted version of the Newcastle–Ottawa Scale (NOS) (Wells et al., 2000). The NOS (see “Appendix 2”) assesses quality on a 9-point scale, with scores of 7 or above considered high quality (Lei et al., 2015). Quality assessments were completed independently by two reviewers (S.O., C.M.), with discrepancies resolved through group consensus. Scoping review results are described qualitatively and in evidence tables. A meta-analysis was deemed inappropriate given the significant heterogeneity in study designs, populations, and measures. Inter-rater reliability was not calculated as all data was discussed collectively and consensus reached on all studies.

Results

Search results

The initial search identified 7377 articles. In addition, 919 articles were identified from the forward citation search and 103 were identified by expert submission/hand search. After duplicate removal (n = 2243), 6156 unique articles remained. Title/abstract review excluded 6034 studies with 122 remaining for full-text review. Of these, 69 were excluded: 31 were related to weapon-carriage (i.e., not firearms), 17 focused only on firearm attitudes, access, acquisition, or ownership, 9 were review articles or non-peer reviewed publications, 6 focused on firearm homicide or violence exposure and not carriage, 3 were not able to be located, 2 were conducted among non-pediatric samples, and 1 focused on non-firearm defense. Of the 53 included studies (Tables 1, 2, 3), 15 investigated carriage patterns (Table 1), 13 examined carriage motives (Table 2), and 39 characterized risk and protective factors (Table 3). Twenty-nine were cross-sectional, 17 were longitudinal cohort studies, 6 were qualitative, and one was a case–control design.

Quality of included studies

There was considerable variation in study quality ($n = 53$), with NOS scores ranging from 4 to 7 (see Tables 1, 2, 3 for article scoring). In total, 18 articles (34%) scored a 7 or higher on the NOS scale (i.e., high quality). Longitudinal cohort ($n = 17$) and case control ($n = 1$) studies were consistently of moderate-to-high quality, while cross-sectional studies ($n = 29$) demonstrated considerable variability, with scores ranging from low-to-high quality. Although most studies employed validated measures, nearly all relied on self-report data subject to recall and social desirability bias. Most articles (55%) were cross-sectional.

Rates of carriage across studies included in this scoping review

Firearm carriage rates varied across included studies, reflecting heterogeneity in measures (i.e., response time-frame) and design (i.e., population, study setting). Consistent with national studies (Kann et al., 2018), most studies (Apel & Burrow, 2011; Arria et al., 1995; Carter et al., 2013; Cook & Ludwig, 2004; Cunningham et al., 2010; Hayes & Hemenway, 1999; Hemenway et al., 2011; Lizotte et al., 2000; Luster & Oh, 2001; Orpinas et al., 1999; Peleg-Oren et al., 2009; Ruggles & Rajan, 2014; Tigri et al., 2016; Vaughn et al., 2012, 2016; Williams et al., 2002; Xuan & Hemenway, 2015) identified recent carriage rates (i.e., past 12-months; past 6-months; past 30-days) between 5 to 10%, while lifetime carriage rates in most studies ranged between 15 to 20% (Beardslee et al., 2018a; Bergstein et al., 1996; Dong & Wiebe, 2018; Hemenway et al., 1996; Lizotte et al., 1997; Loeber et al., 2004; Luster & Oh, 2001; Simon et al., 1998; Steinman & Zimmerman, 2003; Webster et al., 1993). Researchers consistently found higher carriage among male (Arria et al., 1995; Dong & Wiebe, 2018; Molnar et al., 2004; Simon et al., 1998) and Black (Beardslee et al., 2018a; Dong & Wiebe, 2018) youth. Urban–rural comparisons were difficult because most studies sampled urban youth. Within the one study that examined suburban youth, lifetime carriage rates (17%) were similar to urban samples (Sheley & Brewer, 1995). Similarly, only one study (Kingery et al., 1996) explicitly measured rural carriage, finding past 12-month rates (10%) were similar to general carriage rates within urban samples. Youth carriage was markedly higher across all studies involving criminal justice samples, with recent and lifetime carriage rates ranging from 50 to 100% (Allen & Lo, 2012; Freed et al., 2001; McNabb et al., 1996; Reid et al., 2017; Sheley & Wright, 1993; Watkins et al., 2008; Wilkinson et al., 2009). Finally, rates of adolescent firearm carriage to school ranged between 1 to 3% (Bergstein et al., 1996; Cao et al., 2008; DuRant et al., 1999; Hemenway et al., 1996; Kingery et al., 1996; May, 1999; Peleg-Oren et al., 2009).

Patterns of firearm carriage

Eleven studies (Table 1), including seven longitudinal cohort (Arria et al., 1995; Beardslee et al., 2018b; Dong & Wiebe, 2018; Lizotte et al., 1997; Loeber et al., 2004; Reid et al., 2017; Steinman & Zimmerman, 2003) and four cross-sectional (Ash et al., 1996; Sheley, 1994; Vaughn et al., 2017; Watkins et al., 2008) studies characterized carriage patterns. There was significant heterogeneity with regards to operational definitions and time frames used to define carriage patterns. Among the seven longitudinal studies, most defined persistent or continuous carriage as that which extended beyond 1–2 waves of bi-annual (i.e., every 6 months) or annual data collection, with intermittent or episodic carrying defined as lasting

less than 1–2 years of adolescence. These studies highlighted that firearm carriage is more frequently an intermittent/episodic behavior rather than persistent/continuous behavior lasting throughout or beyond adolescence. Dong & Wiebe (2018) found that while 27% reported lifetime carriage, only 4–6% reported carrying during any single 12-month study wave and on average, youth reported carrying for less than 3 years (peak onset age 15). Similarly, Lizotte et al., (1997) identified comparable rates of lifetime carriage (22%) and past 6-month carriage at each wave (6–10%) among a male sample of middle/high-school students, noting that a minority (25%) carried for more than two 12-month waves. Loeber et al., (2004) found similar rates of multi-year carriage (30% of a male youth health clinic sample reported carrying for two-years or more), with 61% indicating that they carried for less than 1 year. Reid et al., (2017) found that among those reporting lifetime carriage, 57% carried for only one 6-month wave. Steinman and Zimmerman (2003) found that among those who carried (20% of a Black sample of high-risk high-school students), youth were three times more likely to carry episodically than persistently [15% vs. 5%].

In the four cross-sectional studies (Ash et al., 1996; Sheley, 1994; Vaughn et al., 2017; Watkins et al., 2008), carriage patterns were characterized descriptively. Ash et al., (1996) qualitatively defined four patterns, including non-carriers, intermittent carriers, part-time carriers, and constant carriers, finding that the majority (71%) self-identified as non-carriers and that purposeful firearm acquisition (vs. passive acquisition) was related to higher likelihood of frequent/constant carriage. Vaughn et al., (2017) conducted a latent class analysis of firearm carrying adolescents, identifying four classes (low risk carriers; high alcohol/marijuana only carriers; high violence only carriers; and severe carriers). Severe carriers had higher levels of alcohol/marijuana use, violence involvement, and delinquency, as well as higher carriage frequency than other classes. Sheley (1994) found that 12% of urban high school youth carried all/most of the time, while Watkins et al., (2008) found that a larger proportion of adolescent males in juvenile detention (46%) carried all/most of the time. No studies characterized carriage patterns among rural/suburban youth and none used intensive longitudinal or ecological momentary assessment (EMA) methods to characterize daily carriage patterns.

Four studies (Arria et al., 1995; Dong & Wiebe 2018; Sheley, 1994; Steinman & Zimmerman, 2003) characterized risk factors differentiating carriage patterns, with three finding positive correlations between the duration or frequency of carriage and higher violence (e.g., perpetration, fighting) and substance use (e.g., selling/using drugs) involvement. Arria et al., (1995) found that less-lethal weapon (e.g., knife) carriage was associated with higher likelihood of persistent firearm carriage. Dong and Wiebe (2018) also found a higher likelihood of criminal justice involvement among persistent carriers. No studies identified risk factors beyond the individual (e.g., social, community, policy) level or examined protective factors that mitigate/interrupt risk for persistent carriage.

Initiation of firearm carriage (i.e., first-time carriage)

Six studies examined initiation of carriage (Table 1), with two reporting age-of-onset descriptively (Dong & Wiebe, 2018; Loeber et al., 2004) and four (Beardslee et al., 2018a; Spano & Bolland, 2011, 2013; Spano et al., 2012) examining underlying factors leading to

first-time carriage. Dong and Wiebe (2018) found that the mean age of initiating carriage was 18 among urban youth, while Loeber et al., (2004) found that adolescents as young as age 10 reported carriage, with linear increases in carriage rates until age 17.

Factors leading to first time carriage were examined by three Mobile Youth Survey (Spano & Bolland, 2011, 2013; Spano et al., 2012) studies conducted among a predominantly Black adolescent sample recruited from twelve low-income Alabama neighborhoods, finding that 8% not carrying at baseline initiated carriage in the next 12 months. The first study specifically characterized the relationship between violence involvement (i.e., perpetration and/or exposure) and first-time carriage, finding that youth engaged in violence perpetration and/or with prior violence exposure were more likely to begin carrying than those who had neither, with only perpetration remaining significant when both were included in the same model (Spano et al., 2012). In a subsequent analysis (Spano & Bolland, 2013) examining violence perpetration and victimization (but not exposure), Spano found that victimization remained the more salient factor. Spano & Bolland (2013) also found no differences in the likelihood of youth to initiate carriage for offensive (i.e., perpetration only) or defensive (i.e., victimization only) reasons. Finally, Spano and Bolland (2011) examined the relationship between gang-involved youth, violence involvement, and carriage initiation, finding that carriage was concentrated among a small group of gang-involved youth, and that each additional cumulative risk factor increased first-time carriage risk, consistent with cumulative risk theory. Beardslee et al., (2018a) examined early childhood factors, finding that higher levels of conduct problems and peer delinquency in early childhood (grades 2–4), and youth with increases in conduct problems across childhood were more likely to initiate adolescent carriage.

Motives for firearm carriage

Thirteen studies (Table 2) characterized carriage motives. The majority found that a perceived need for protection/self-defense was the primary motive underlying carriage (Ash et al., 1996; Bergstein et al., 1996; Black & Hausman, 2008; Carter et al., 2013; Hemenway et al., 1996; Lane et al., 2004; McNabb et al., 1996; Sheley & Wright, 1993; Wilkinson & Fagan, 1996; Wilkinson et al., 2009), with one study (Kingery et al., 1996) among rural youth finding the primary motive for carriage to school was intention to use the firearm. No quantitative studies characterized reasons underlying a perceived need for protection (i.e., general deterrence against neighborhood violence or specific deterrence for threats made against them). However, qualitative studies (Mateu-Gelabert, 2002; Wilkinson et al., 2009) highlighted this distinction. Mateu-Gelabert (2002), interviewing Hispanic youth, found that carrying: (1) provided a sense of security in high-risk situations/areas (i.e., general deterrence); (2) was a means of protecting oneself against specific threats and “proving to others” that you weren’t afraid to defend yourself; and, (3) was a means of establishing “respect” among potential assailants (i.e., general deterrence). Wilkinson et al., (2009) also found that among violent offending male youth, carrying: (1) provided a means of protection for themselves and their peer group in dangerous neighborhoods (i.e., general deterrence); and, (2) provided a means for retaliating or for keeping safe after an altercation (i.e., specific deterrence). Notably, there was a lack of support across studies (Carter et al., 2013; Mateu-

Gelabert, 2002; Sheley & Wright, 1993; Wilkinson et al., 2009) for the “status hypothesis,” the notion that youth carry firearms to impress others, be cool, or achieve social recognition.

Several studies provided support for a social normative influence or contagion effect. Hemenway et al., (1996) found that among carriers, 34% reported they were more likely to carry if other peers carried. Mateu-Gelabert (2002) identified that a commonly reported reason for carrying among youth is that they believed they would “run into other youth who carry.” Several studies (Ash et al., 1996; Black & Hausman, 2008) highlighted that while firearms made youth feel “safer”, they also caused them to experience feelings of excitement/power (i.e., at being able to defend themselves), fear/anxiety (i.e., of being caught by police/family), and concern for potential escalation of altercations to deadly encounters. One study (Freed et al., 2001) characterized reasons adolescents avoided carrying regularly, finding the most common reasons were fear of arrest and a perceived lack of need due to low victimization risk (e.g., daytime, safer neighborhoods, engaging in prosocial activities).

Risk and protective factors for adolescent firearm carriage

Among individual-level factors, adolescent carriage was associated with male gender (Cao et al., 2008; Carter et al., 2013; Cunningham et al., 2010; DuRant et al., 1999; Hayes & Hemenway, 1999; Hemenway et al., 1996; Kingery et al., 1996; May, 1999; Molnar et al., 2004; Orpinas et al., 1999; Sheley & Brewer 1995; Vaughn et al., 2012, 2016; Williams et al., 2002) and older adolescent age (Cunningham et al., 2010; Hayes & Hemenway, 1999; Hemenway et al., 1996; Kingery et al., 1996; Loeber et al., 2004; May, 1999; Molnar et al., 2004; Watkins et al., 2008). Race/ethnicity and socio-economic status (SES) varied considerably across studies. White youth in rural/suburban samples were more likely to carry than Black youth in these settings (Kingery et al., 1996; Luster & Oh, 2001; Sheley & Brewer, 1995), while Black youth were more likely to carry than White youth in urban contexts (Cunningham et al., 2010; DuRant et al., 1999; Hayes & Hemenway, 1999; May, 1999; Watkins et al., 2008). Of note, many studies were limited to a single gender (Allen & Lo, 2012; Beardslee et al., 2018a; b; Cook & Ludwig, 2004; Freed et al., 2001; Lizotte et al., 2000; Luster & Oh, 2001; Reid et al., 2017; Watkins et al., 2008; Webster et al., 1993) or race/ethnicity (Hayes & Hemenway, 1999; Kingery et al., 1996; Lane et al., 2004; Loeber et al., 2004; Orpinas et al., 1999; Sheley, 1994; Watkins et al., 2008; Webster et al., 1993; Wilcox et al., 2006), precluding robust comparisons across subgroups. Tobacco (Hemenway et al., 1996, 2011; Ruggles & Rajan, 2014; Simon et al., 1998), alcohol (Cunningham et al., 2010; DuRant et al., 1999; Hemenway et al., 1996, 2011; Orpinas et al., 1995; Peleg-Oren et al., 2009; Ruggles & Rajan 2014; Simon et al., 1998; Vaughn et al., 2016; Williams et al., 2002), and other drugs (e.g., marijuana, cocaine/crack) (Carter et al., 2013; Cunningham et al., 2010; DuRant et al., 1999; Kingery et al., 1996; Lizotte et al., 2000; McNabb et al., 1996; Orpinas et al., 1995; Ruggles & Rajan 2014; Sheley, 1994; Sheley & Brewer 1995; Simon et al., 1998; Vaughn et al., 2012, 2016; Williams et al., 2002), were positively associated with firearm carriage, with several studies highlighting that earlier substance use initiation and/or higher severity use had a greater association with carriage than intermittent/casual use (DuRant et al., 1999; Lizotte et al., 2000; Peleg-Oren et al., 2009; Simon et al., 1998).

Firearm carriage was associated with both firearm availability (e.g., easy firearm access, firearms in the home) (Hemenway et al., 2011; Lizotte et al., 2000; Molnar et al., 2004) and prior violence, including violence exposure (e.g., witnessing violence) (Allen & Lo 2012; Beardslee et al., 2018b; McNabb et al., 1996; Molnar et al., 2004; Reid et al., 2017; Webster et al., 1993), fighting (Allen & Lo 2012; Cao et al., 2008; Carter et al., 2013; Cunningham et al., 2010; Hayes & Hemenway, 1999; Kingery et al., 1996; Vaughn et al., 2012; Webster et al., 1993), firearm and non-firearm aggression (Durant et al., 1999; Lizotte et al., 2000; Loeber et al., 2004; Vaughn et al., 2012; Williams et al., 2002), and victimization (e.g., bullying, firearm threats, robbery, violent injury, firearm victimization, and sexual assault) (Beardslee et al., 2018b; Cook & Ludwig 2004; Cunningham et al., 2010; Durant et al., 1999; Freed et al., 2001; Hemenway et al., 2011; Kingery et al., 1996; Lane et al., 2004; Lizotte et al., 2000; Molnar et al., 2004; Ruggles & Rajan 2014; Turner et al., 2016). Mental health issues, including stress/anxiety (Simon et al., 1998), depression (Simon et al., 1998), and conduct disorder (Beardslee et al., 2018a; Loeber et al., 2004) were also positively associated in several studies with carriage. Poor school performance (e.g., failing grades) (Allen & Lo 2012; Cunningham et al., 2010; Hemenway et al., 1996; Lane et al., 2004; Orpinas et al., 1995; Tigri et al., 2016), criminal justice involvement (i.e., arrest, criminal activity) (Sheley & Brewer, 1995; Vaughn et al., 2012; Webster et al., 1993; Williams et al., 2002) and delinquency behaviors, including selling drugs (Freed et al., 2001; Kingery et al., 1996; Lizotte et al., 2000; Sheley & Brewer, 1995; Vaughn et al., 2012), stealing/robbery (Vaughn et al., 2012, 2016), gang membership (Hayes & Hemenway, 1999; Hemenway et al., 2011; Lizotte et al., 2000; May, 1999; Tigri et al., 2016; Watkins et al., 2008; Williams et al., 2002), and skipping school (Hayes & Hemenway, 1999; Simon et al., 1998) were also associated with carriage. Other risk behaviors, including general measures of risk-taking and problem behavior involvement (Kingery et al., 1996; Simon et al., 1998; Vaughn et al., 2012), as well as specific behaviors such as less lethal weapon (e.g., knives) carriage (Arria et al., 1995) and sexually risky behavior (Cunningham et al., 2010; Orpinas et al., 1995), were also found to be associated with carriage. Finally, lower self-efficacy (i.e., for not fighting) (Hemenway et al., 1996; Kingery et al., 1996), a fear of being unsafe (Kingery et al., 1996; May, 1999; McNabb et al., 1996; Ruggles & Rajan 2014; Sheley & Brewer 1995), and attitudinal violence measures, including positive attitudes favoring retaliation (Carter et al., 2013) and/or attitudes favoring gang involvement (Kingery et al., 1996) and using guns (Allen & Lo 2012; Webster et al., 1993) as a means of avoiding fighting and solving neighborhood problems were found to be associated with carriage.

Fewer studies examined factors beyond the individual level. Among those examining peer influences, risk factors included peer gun ownership/carriage (Cao et al., 2008; Hemenway et al., 2011; Lizotte et al., 2000; Sheley & Brewer 1995; Wilcox et al., 2006; Williams et al., 2002) and peer delinquency measures (e.g., gang membership) (Beardslee et al., 2018a; Hemenway et al., 2011; Lizotte et al., 2000; Luster & Oh, 2001; Tigri et al., 2016; Williams et al., 2002). Perceived peer norms about firearms (Hemenway et al., 2011) were also associated with carriage, with youth overestimating the prevalence of peer carriage endorsing higher levels of carriage themselves. Family factors included a lack of family social support (e.g., closeness), available mentorship (e.g., supportive encouraging adult), and/or family discussions regarding firearm dangers (Hemenway et al., 2011; Kingery et al.,

1996). Youth with family members who had been the victim of a shooting were also more likely to carry firearms (Hemenway et al., 1996; Molnar et al., 2004). Community factors positively identified with carriage included higher perceived levels of community violence, crime, or lack of safety (Hemenway et al., 1996; Kingery et al., 1996; Luster & Oh 2001; Molnar et al., 2004; Simon et al., 1998), higher perceived levels of firearm ownership/prevalence within the community (Cook & Ludwig 2004; Hemenway et al., 2011), and elevated levels of neighborhood social and physical disorder (Molnar et al., 2004).

Few protective factors were examined, with most examined within the context of cross-sectional studies. Higher levels of school attachment (Wilcox et al., 2006), parental monitoring/involvement (Loeber et al., 2004; Luster & Oh 2001; Vaughn et al., 2012, 2016; Williams et al., 2002), and maternal respect (Luster & Oh, 2001) were associated with lower firearm carriage, as was exposure to school-based drug and violence prevention programs (Vaughn et al., 2012) and higher perceived neighborhood collective efficacy (Molnar et al., 2004). One study (Xuan & Hemenway, 2015) examined policy factors, finding that stricter state-level firearm laws were associated with lower adolescent carriage and that this was mediated by the law's impact on adult firearm ownership.

Discussion

This scoping review is the first to synthesize the current state of research related to patterns, motives, and risk/protective factors underlying adolescent firearm carriage. While this field has been underdeveloped to date, primarily due to a deficiency of funding for high-quality rigorous research (Carter & Cunningham, 2016; Hemenway & Miller, 2013; Weinberger et al., 2015; Wintemute, 2013), the compilation of articles in this review outlines an emerging picture of our collective knowledge about adolescent firearm carriage. Among adolescents who carry firearms, most carry intermittently throughout adolescence and for the purpose of self-defense or protection. Carriage appears higher among adolescent Black males, particularly those involved with the criminal justice system. Key individual level risk factors include substance use, firearm availability, prior violence involvement (exposure, aggression, victimization), mental health issues (e.g., stress, PTSD), poor school performance and involvement in delinquency behaviors (e.g., gangs). Beyond the individual level, risk factors include peer delinquency/firearm ownership, lack of parental involvement, and exposure to neighborhoods with elevated levels of violence/social disorder. Protective factors included school attachment, parental monitoring, neighborhood collective efficacy and firearm policies restricting firearm access. This scoping review also highlights several compelling research gaps. Based on our review, we have identified seven areas for future research needed to inform the science of pediatric firearm injury prevention and guide efforts to address the high rates of adolescent mortality stemming from firearms.

First, the current research is focused broadly on youth, with limited analyses focusing exclusively on adolescents (age < 18) or comparing adolescents to adult populations. Given that adolescence is a distinct developmental period characterized by unique risk and protective factors (Herrenkohl et al., 2000; Kretman et al., 2009) and that underlying factors related to carriage (e.g., patterns, motives) may differ from those for older youth or emerging adults (Dong & Wiebe, 2018; Steinman & Zimmerman, 2003; Sweeten et al., 2013),

additional research is needed that focuses specifically on adolescents. Our review also revealed that most studies sampled urban, predominantly Black, male youth, with only two (Kingery et al., 1996; Sheley & Brewer, 1995) explicitly conducted among non-urban rural/suburban samples and none examining the subpopulations of female carriers. While a focus on Black male youth in urban settings is appropriate given they have the highest firearm mortality risk (CDC, 2017; Cunningham et al., 2018), this lack of variability prohibits robust comparisons across subgroups or an examination of distinctive subsamples. Among the few studies that compared subgroups (Dong & Wiebe, 2018; Vaughn et al., 2017), there was significant heterogeneity noted in carriage patterns. Further, rates of carriage among the few studies examining rural or suburban youth noted elevated lifetime carriage rates on par with those in urban settings, although several of these studies were over 20 years old. Our review suggests that future research needs to include analyses further exploring these findings among high-risk sub-samples, as well as examining patterns, motives, and risk/protective factors across age, gender, racial/ethnic subgroups, and geographic location. Such work would aid in more effective tailoring of future interventions, enhancing efficacy by ensuring they are developmentally appropriate and population specific.

Second, we identified that few articles focused specifically on firearm carriage, with many excluded articles focused broadly on firearm ownership or aggregating firearms with other weapons (e.g., knife). Prior research (Ash et al., 1996; Freed et al., 2001) has highlighted that in comparison to adults, who acquire/own firearm for extended periods, adolescents are more likely to acquire firearms for shorter time periods, either passing/selling them or hiding them in communal locations. Thus, analyses focusing on ownership may miss a subpopulation who carry communal firearms for short time periods or do not consider themselves “owners” in a traditional sense. Similarly, analyses focusing broadly on weapon carriage may miss important distinctions between youth carrying firearms and those carrying other weapons. Firearms have a high degree of kinetic energy and are more likely to cause fatal injuries (Braga & Cook, 2018; Cao et al., 2008; Weaver et al., 2004). Thus, the decision to carry a firearm may be quantitatively different than those for lower velocity weapons, emphasizing that research needs to better characterize the unique motives and determinants for firearm carriage. This research is also limited by a lack of characterization of firearm type (e.g., handguns vs. longguns), precluding a comprehensive understanding of underlying reasons for carriage (e.g., hunting; shooting practice; protection) and/or contextual factors surrounding carriage. Among included studies, we also identified several methodological issues. Many studies utilized convenience sampling or were conducted among small circumscribed samples (e.g., schools, incarcerated youth), raising concerns for generalizability and selection bias. School-based studies have the potential to miss high risk adolescents who may not attend regularly and studies of incarcerated youth are not representative of the broader at-risk population (Beardslee et al., 2018a, b; Hemenway et al., 1996, 2011; McNabb et al., 1996; Simon et al., 1998; Steinman & Zimmerman, 2003; Watkins et al., 2008). Future research, especially government-based nationally representative surveys, should focus on distinguishing firearm carriage from other behaviors (e.g., ownership), disaggregating firearm from other weapon carriage, understanding firearm typology, employing more rigorous systematic or random sampling methods, and identifying populations distinct from school-based samples (e.g., healthcare).

Third, over half of studies were cross-sectional, precluding a comprehensive understanding of carriage patterns and the time-ordered causal and predictive utility of risk factor associations (i.e., simultaneity bias). In addition, carriage was often measured as a retrospective dichotomous outcome, rather than with more nuanced frequency measures. While several longitudinal studies (Arria et al., 1997; Dong & Wiebe, 2018; Lizotte et al., 1997; Loeber et al., 2004; Reid et al., 2017; Steinman & Zimmerman, 2003) highlighted that adolescents were more likely to carry intermittently than persistently, few identified causes underlying these two patterns. In addition, most examined risk factors at a single wave, which may miss more in-depth relationships between firearm carriage and time-varying risk factors and/or the differential effect of chronic repeated risk factor exposure (Beardslee et al., 2018a, b). Finally, none examined factors that may interrupt persistent carriage patterns. Future research should include rigorous longitudinal designs examining the temporal causality of risk factors, group-based trajectory analyses, and patterns across developmental stages (e.g., early vs. late adolescence vs. emerging adults) and populations. In addition, researchers should consider a range of more sensitive outcome measures, and capitalize on m-health technology (Anderson & Rainie, 2015; Bonar et al., 2017; Buu et al., 2017; Carter et al., 2017) to conduct EMA or intensive longitudinal studies allowing for a more comprehensive characterization of daily carriage behaviors. Such data will provide a more in-depth understanding of firearm carriage across different populations and will help guide future intervention development.

Fourth, given that many behavioral interventions are focused on addressing motives for risk behaviors, our finding that the literature on carriage motives was largely descriptive and failed to disaggregate broad categories of commonly identified motives has significant implications for intervention development. While most youth reported a perceived need for protection as the primary motive (Ash et al., 1996; Bergstein et al., 1996; Black & Hausman, 2008; Carter et al., 2013; Freed et al., 2001; Hemenway et al., 1996; Mateu-Gelabert, 2002; Sheley & Wright, 1993; Wilkinson & Fagan, 1996), no quantitative studies differentiated between carrying as a means of general deterrence (i.e., carriage for general protection in a dangerous neighborhood) or for specific deterrence against threats from potential assailants (i.e., protection from a known assailant or from retaliation after a prior altercation). Further, studies often did not include validated retaliation measures (Webster et al., 1993) or combined retaliation (e.g., revenge) with other motives (e.g., defense) (Bergstein et al., 1996; Kingery et al., 1996). Given that retaliatory violence is a key cause of adolescent firearm violence (Carter et al., 2015, 2017; Copeland-Linder et al., 2007) and that distinctive intervention strategies are utilized for planned aggression (e.g., non-violent conflict resolution, violence alternatives) and for impulsive/reactive aggression (e.g., anger management/emotion regulation techniques, impulse control) (Carter et al., 2016; Walton et al., 2010), having a more complete understanding of motives underlying proximal behaviors (e.g., carriage) may aid in developing tailored interventions. In addition, only one study focused on reasons why youth choose not to carry (Freed et al., 2001). Given that many interventions include decisional balance exercises designed to affirm change talk around reasons for not engaging in risk behaviors such as firearm carriage (Carter et al., 2016; Walton et al., 2010), understanding the nuances of such factors may aid intervention development. Finally, the motives literature was also limited by a focus on global

motivations (i.e., prior 6-month). Firearm carriage is a dynamic behavior, with most youth indicating they don't carry firearms daily (Ash et al., 1996; Sheley, 1994; Watkins et al., 2008). The decision to carry a firearm likely depends on a complex combination of transient motives, cognitive factors (e.g., mood), and co-occurring risk factors (e.g., substance use). Thus, in addition to collecting validated measures clarifying the intent behind a perceived need for protection, future research should include time-line follow-back (Carter et al., 2017) or intensive longitudinal daily diary studies (Bonar et al., 2017; Carter et al., 2018a) that collect frequent prospective assessments of daily carriage, as well as associated behaviors and underlying motives.

Fifth, our review suggested that future research should have a greater focus on first-time firearm carriage, which has been suggested as both a critical inflection point in the trajectory of violence involvement (Dodge, 2001; Spano, 2012) and an appropriate primary prevention target (Rivara, 2002), especially given that this behavior is illegal for adolescents (age \leq 18). The three Mobile Youth (Spano & Bolland, 2011, 2013; Spano et al., 2012) studies investigated determinants of first-time firearm carriage, finding support for a cumulative risk model. More recent studies (Beardslee et al., 2018a, b) have examined early childhood factors and/or differential exposure to firearm and non-firearm violence. However, given the limited research within this area, several questions remain. Future work should focus on understanding both static and time-varying childhood and adolescent precursors to first-time carriage, as well as the consequences to normal adolescent development that occur as a result of differential onset age (i.e., earlier vs. later). Research should also expand on recent efforts to gain more knowledge about the relationship between violence exposure and first time carriage, including whether it is differentially related to violence exposure (e.g., witnessing violence vs. violent victimization), severity (e.g., injury severity) and weapon-type (e.g., firearm vs. non-firearm exposure). Such data will aid in prevention and policy-related efforts to assess how factors that delay onset age for first-time carriage might decrease adolescent firearm violence involvement. Such policy-related approaches (e.g., graduated drivers licensing) have been effective in delaying the onset of other adolescent risk behaviors such as risky teen driving (Fell et al., 2011).

Sixth, we identified that the risk and protective factor literature is almost exclusively focused on individual-level risk, while other socio-ecological contexts (e.g., social, community, policy) remain understudied (Cao et al., 2008; Dong & Wiebe, 2018; Hayes & Hemenway, 1999; Molnar et al., 2004; Steinman & Zimmerman, 2003). This is especially true for peer-related influences. Multiple studies (Beardslee et al., 2018a, b; Cao et al., 2008; Hemenway et al., 2011; Lizotte et al., 2000; Luster & Oh, 2001; Sheley & Brewer, 1995; Wilcox et al., 2006; Williams et al., 2002) highlighted the importance of peer influences given that peer firearm ownership, victimization, and delinquency were found to be related to carriage. In addition, our review highlighted the importance of perceived peer norms around carriage and their influence on adolescent carriage patterns (Hemenway et al., 2011). This is consistent with research (Goldstick et al., 2017; Steinberg & Monahan, 2007) demonstrating that peers become more influential than parents during adolescence, as well as prior violence research demonstrating that firearm violence is often concentrated among a small number of social networks and neighborhood hotspots, mirroring an infectious disease context (i.e., contagion model) (Braga et al., 2010; Hemenway et al., 1996, 2011; Papachristos et al., 2013). Future

research should expand on this framework with a greater focus on factors beyond the individual level, as well as how such factors (e.g., socialization within violent neighborhoods; intergenerational violence transmission; peer social networks) influence adolescent firearm carriage. We also identified few studies that examined protective factors related to firearm carriage other than parental monitoring. Given that most youth residing in high-risk neighborhoods do not carry firearms (Ash et al., 1996; Dong & Wiebe 2018; Steinman & Zimmerman, 2003; Vaughn et al., 2016), a greater focus on characterizing the protective factors that promote healthy adolescent development in spite of risk exposure, both through enhancing internal assets (e.g., self-efficacy) or access to resources (e.g., positive mentors), is needed to inform interventions focused on reducing risky firearm behaviors through a resiliency-based framework (e.g., youth empowerment) (Fergus & Zimmerman, 2005). Finally, future research should examine how such risk and protective factors intersect to affect firearm carriage risk. For example, do high levels of parental monitoring counteract the effects of negative peer influences on firearm carriage behaviors.

Finally, most studies were empirical investigations, lacking an underlying theoretical context. Theoretical frameworks provide a systematic means of understanding complex multi-faceted behavioral issues. Several studies (Beardslee et al., 2018b; Steinman & Zimmerman, 2003) have proposed explanatory models (e.g., the protection model; social influence model; antisocial pre-disposition model) for adolescent firearm carriage. While such models have been proposed, they have not been sufficiently tested to date across adolescent subpopulations and future research should work to test such models, as well as expand on these frameworks to develop more rigorous explanatory models for this complex behavior.

Several limitations should be noted. Most significantly, only fifty-three articles met inclusion criteria and most were of low-to-moderate quality (Wells et al., 2000). Thus, conclusions must be interpreted within the context of the underlying methodology and quality of included articles. In addition, although search methodology conformed to PRISMA-ScR guidelines (Arksey & O'Malley, 2005; Institute, 2015; Tricco et al., 2018), some relevant publications may have been missed. We attempted to address this with a robust forward citation search and the addition of any articles identified by expert review or hand-search of reference lists. Exclusion of non-peer reviewed reports from the gray literature also has the potential to miss relevant data. Yet, given our objective was to catalog the current state of the science on firearm carriage, reviewing the gray literature was noted to be out of scope. In addition, although our review employed rigorous methodology (e.g., multiple reviewers) to minimize error/bias, data extraction and scoring methods are inherently subjective and potential exists for incorrect categorization and/or quality assessment. Finally, while most articles included prevalence data on firearm carriage, it is important to note that the focus of this review was on characterizing patterns, motives, and risk/protective factors for carriage and not on capturing the entire range of articles presenting prevalence statistics. Thus, prevalence data should be interpreted within the context of this limitation.

Conclusion

This scoping review, in addition to summarizing the literature on patterns, motives, and risk/protective factors for adolescent firearm carriage, highlights the substantial deficits that exist in the current literature and outlines a series of research priorities urgently needed to inform the field. While addressing these priorities will require substantial financial resources, such an investment would have the potential to catalyze the science of pediatric firearm injury prevention and lead to novel and effective public health interventions across the individual, community, and policy spectrum. Similar investments for other leading public health problems (e.g., smoking, cancer, HIV) have generated transformative results for the prevention of these diseases. Given the substantial morbidity and mortality resulting from firearm injuries among adolescents, there is an urgent moral imperative to apply similar approaches to the science of pediatric firearm injury prevention.

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Appendix 1:: Sample database search for articles in PubMed

Date Searched:

April 8, 2018.

Filters:

Publication date from 1985/01/01 to 2018/12/31. (((gun[tiab] OR guns[tiab] OR handgun*[tiab] OR firearm*[tiab] OR firearms[MeSH Terms] OR gunshot*[-tiab] OR shooting[tiab]) AND (homicide[tiab] OR homicides[tiab] OR murder*[tiab] OR fatalities[tiab] OR “homicide”[MeSH Terms] OR killing[tiab] OR killings[-tiab] OR death[tiab] OR deaths[tiab] OR “death”[MeSH Terms] OR “accidents”[MeSH Terms] OR accident*[tiab] OR unintentional[tiab] OR suicide[tiab] OR suicides[tiab] OR suicidal[tiab] OR “suicide”[MeSH Terms] OR “Wounds and Injuries”[Mesh] OR injury[tiab] OR injuries[tiab] OR mortality[tiab] OR non-fatal[tiab] OR nonfatal[tiab] OR wounds,gunshot[mesh] OR united states/epidemiology[mesh]) AND (adolescent[MeSH Terms] OR youth[MeSH Terms] OR child[MeSH Terms] OR teenager[Title/Abstract] OR teen[Title/Abstract] OR adolescen*[Title/Abstract] OR child[Title/Abstract] OR youth[title/abstract] OR children[Title/Abstract] OR min- or[Title/Abstract] OR minors[title/abstract] OR delinquent[Title/Abstract] OR delinquency[Title/Abstract] OR pediatric*[Title/Abstract] OR juvenile*[tiab] OR parent*[tiab])))) NOT (((((economics[MeSH Subheading] OR cost[Title/Abstract] OR costs[Title/Abstract] OR “cost-effectiveness”[tiab] OR costs and

cost analysis[MeSH Terms] OR economic*[tiab] OR productivity[tiab] OR expenditure*[tiab] OR quality of life[mesh] OR “quality of life”[tiab] OR “quality-adjusted life years”[mesh] OR QALY[tiab])) OR ((Possession[tiab] OR possess[tiab] OR storage[tiab] OR carriage[tiab] OR carrying[tiab] OR carry[tiab] OR own[tiab] OR owner[tiab] OR ownership[-tiab] OR ownership[mesh])) OR ((“Adolescent Behavior” [Mesh] OR “Behavioral Symptoms”[Mesh] OR “Firearms/statistics and numerical data” [Mesh] OR “Family Relations”[Mesh] OR “Social Behavior”[Mesh] OR “Accidents, Home” [Mesh] OR “Social Environment”[Mesh] OR “Residence Characteristics”[Mesh] OR “Sex Distribution”[Mesh] OR “Family Characteristics”[Mesh] OR “Sex Factors”[Mesh] OR “Population Surveillance”[Mesh] OR “Rural Population”[Mesh] OR “Urban Population” [Mesh] OR “Self-Injurious Behavior”[Mesh] OR “Schools”[Mesh] OR “Violence”[Mesh] OR “Crime Victims”[Mesh] OR (firearms[Mesh] AND culture[Mesh]) OR “Exposure to Violence”[Mesh] OR “Communications Media”[Mesh] OR “Mass Casualty Incidents” [Mesh] OR “Substance-Related Disorders”[Mesh] OR “Street Drugs”[Mesh] OR “Prescription Drugs”[Mesh] OR “Prescription Drug Misuse”[Mesh] OR (Ownership[Mesh] AND Firearms[Mesh]) OR “firearm ownership”[ti] OR (firearm*[ti] AND access[ti]) OR storage[ti] OR “firearm storage”[ti] OR “firearm availability”[ti] OR (Firearm[ti] AND Acquisition[ti]) OR (Illegal[ti] AND Firearm[ti]) OR “interpersonal violence”[ti] OR victimization[ti] OR “self-defense”[ti] OR “self-defence”[ti] OR “self-injury”[ti] OR “self-inflicted”[ti] OR “self-harm”[ti] OR “gun culture”[ti] OR (exposure[ti] AND “gun violence” [ti]) OR ((home[ti] OR household[ti]) AND (firearms[Mesh] OR gun[ti])) OR “community violence”[ti] OR “neighborhood violence”[ti] OR “mass shooting*”[ti] OR “mass violence” [ti] OR “substance abuse”[ti] OR “drug abuse”[ti] OR “illegal drug*”[ti] OR rural[ti] OR urban[ti])))).

Appendix 2:: Modified Newcastle–Ottawa Scales used for individual article quality assessment

See Table 4.

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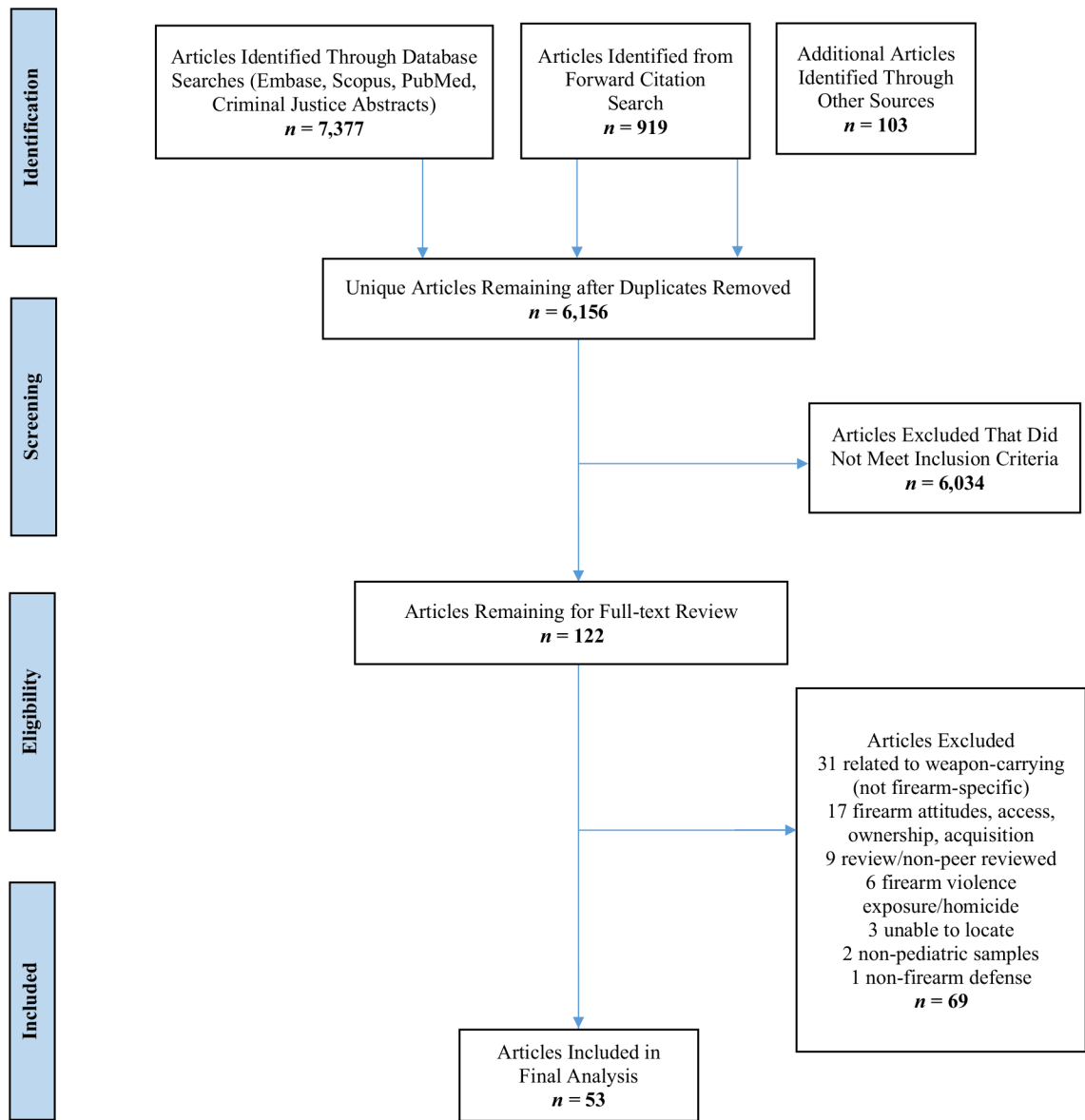


Fig. 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram

Table 1 Articles reporting data on age of onset for firearm carriage and patterns of firearm carriage

Article	Design	Sample size	Study sample and setting	Unique attributes	Key results for patterns of carriage	Limitations	Nos score
Arria et al. (1995)	Cohort Surveyed annually for 5 years	1714	Students from 43 classrooms within 19 public schools from 5 districts in Baltimore, MD	M age (w1) 9 M age (w5) 13 50% Male 73% Black 26% White	Past 1-year carriage = 10% (male); 1% (female). Rates of gun carriage increased across waves of data, starting at < 2% (w1) and increasing to 10% (male) and 1% (female) by wave 5 Less lethal weapon carriage (stick, knife) was associated with initiating carrying a gun at later waves across multiple waves	Limited generalizability Single city Younger adolescent sample Missed students who may have dropped out at later waves Self-report data	6
Ash et al. (1996)	Qualitative Semi-structured interviews	63	Youth offenders recruited from 5 detention centers in Atlanta, GA	Ages 13–18 M age 15.7 67% Male 66% Black 34% White	Patterns of carriage: Identified 4 distinct carrier types Non-carriers (n = 14): 71% of this group owned a gun Intermittent carriers (n = 14): Defined as having weeks and/or months without carrying; each owned 1 gun Part-time carriers (n = 11): Carried more frequently than intermittent carriers and had increasing frequency over time in response to stressors (e.g., friend was shot) Constant carriers (n = 24): Defined as carrying all/most of the time; had carried constantly since acquiring a gun Small minority of carriers decreased carriage over time (n = 6) Purposeful acquisition of first firearm positively correlated with becoming frequent/constant carriers ($p < 0.05$)	Limited generalizability Nonrandom convenience sample of youth offenders from single city Self-report data Small sample	6
Beardslee et al. (2018a)	Cohort Pittsburgh Youth Study Analysis from 6-month surveys (3-year; grade 2–4) and 12-month surveys (age 10–17)	485	Random sub-sample of male participants from youngest cohort of large school-based longitudinal study in Pittsburgh, PA	100% male 56% Black 41% White Excluded non-White/Black participants	Lifetime carriage = 27% (Black); 12% (White); Black youth more likely to carry in adolescence than White youth (OR = 3.3); Youth with higher levels of conduct problems and peer delinquency at earlier childhood waves, as well as those with increases in conduct problems across early childhood, were more likely to initiate gun carriage prior to age 18 Examining whether racial differences in carrying were due to differential exposure to risk factors or differential sensitivity, study found more support for differential exposure, with 60% of the race effect on carriage being attributable to either initial peer delinquency levels or initial levels of conduct problems	Limited generalizability Limited to male Black/White youth sample Single city sample Self-report data. Small sample size may limit ability to detect group differences in gun carriage predictors	6
Beardslee et al. (2018b)	Cohort Pathway to Desistance Study: Youth surveyed every 6-month for 3 years then every 12-month for 4 years	1170	Male youth offenders recruited from court system in two counties; one in AZ (Maricopa) and one in PA (Philadelphia)	Ages 14–19 at baseline 100% male. 42% Black 34% Hispanic 19% White 100% offenders 70% on active probation at baseline	Across 10 waves, carriage rates ranged from 15% (w1) to 10% (w10) with non-linear decrease; peak gun carriage was 17% at w7 data collection (i.e., 4 years after baseline; mean age 21) Youth with gun violence exposure (witness/victim of gun violence) were 43% more likely to engage in gun carriage at the next wave after controlling for time-stable and time-varying (exposure to peers who carried; exposure to peers engaged in other criminal acts, developmental changes, changes in gun carrying from incarceration or institutionalization) covariates. No evidence that non-gun violence exposure conferred same risk	Limited generalizability Male sample of juvenile offenders in two states Self-report data Youth offenders likely have fluctuations in carrying over time	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Key results for patterns of carriage	Limitations	Nos score
Dong and Wiebe (2018)	Cohort NLSY97 administered annually between 1997 to 2011 and then biennially (16 waves)	1585	Youth living in urban areas (as defined by Census criteria) at wave 1 data collection	Data from the 1997 Nat. Longitudinal Survey of Youth (NLSY97) Age 14.27 (SD1.49) 76% Male 29% Black 26% Hispanic 44% White	27.1% lifetime handgun carriage incidence 4–6% past 12-month handgun carriage (at each wave) Mean age of initiation of carriage = 18.2 years old Temporary peak of carriage at age 15; decline during late adolescence until a steady increase in carriage at age 22 Participants carried for an average of 2.7 years Urban Black/Hispanic youth were more likely to carry during late adolescence/early adulthood and less likely to carry than White youth during adulthood Duration of carriage was associated with higher odds of violence perpetration (OR = 1.2) and selling drugs (OR = 1.2) Persistent carriers (those carrying before and after age 18) had higher likelihood of arrest than adolescent carriers (IRR = 2.6)	Data could not distinguish between legal and illegal handgun carriage Self-report data Measures of adult drug sale and violent offending restricted to respondents reporting prior arrest; small comparison group	6
Lizotte et al. (1997)	Cohort Rochester Youth Survey administered at 6-month intervals (w1–9) then 2.5 years intervals (w 9–10)	615	Male youth recruited from Rochester public schools (7th/8th grade); High-crime areas (defined by arrest rates) oversampled	M Age 15 100% male 63% Black Analysis limited to male youth in the sample for w4 through w10	22% carried a gun at some point during any wave of the study; 6% carried a gun at w4 (age 15) 10% carried at w10 (age 20) Overall carriage rate consistent across waves Patterns of Carriage Only 1/3 of subjects carried from one wave to another, suggesting intermittent carriage among participants 53% who reported carrying only carried in one wave 21% who reported carrying carried in 2 waves 26% who reported carrying carried for 3 waves	Self-report data Sample limited to male youth Oversampled high-crime areas, not involving suburban/rural sample	6
Loeber et al. (2004)	Cohort Developmental Trends Study with dyad (parent and their child) cohort administered at 12-month intervals for 13 years	177	Male children living with 1 biological parent referred from primary care clinics in either PA or GA	Ages 7–12 (baseline); followed annually to 19 30% Black 70% White 53% Urban 57% not living with biological father 41% from low SES	20% carried a gun at least once during the study 1% reported carrying a gun at age 12 12% carried carrying a gun at age 17 Earliest age of carriage was 10 years old (<2%) Patterns of Carriage 61% reported carrying for only 1 year 31% carried for 2-years 8% carried for 3–4 years	Limited generalizability Small convenience sample referred from healthcare clinic Self-report data. Sample limited to male youth	7
Reid et al. (2017)	Cohort Pathways to Desistance Study, administered every 6 months for 2 years	1170	Convicted male youth offenders in PA and AZ (recruited from court setting). Proportion charged with drug offenses capped at 15%	Ages 14–19 M age 16 100% male 42% Black 34% Hispanic 19% White	Among the 51% of youth who reported lifetime carriage: 57% carried during 1 period 25% during 2 periods 11% during 3 periods 6% during 4 periods 2% during all 5 periods	Limited generalizability Sample limited to male offenders from two cities Self-report data	6
Sheley (1994)	Cross-sectional	758	Male students from 10 urban schools in 5 cities in CA, IL, LA, and NJ. All schools had prior firearm incidents	M age 16 Range (age 15–17) 72% Black 3% White 19% Hispanic	12% of students carried a gun routinely (all/most of the time) with 23% reporting carriage intermittently (now/then) Youth who used and sold drugs or only sold drugs but did not use drugs were more likely to carry routinely (19% vs. 5%, $p < 0.05$)	Cross-sectional data Non-representative sample of urban youth (non-random) Self-report data	4

Article	Design	Sample size	Study sample and setting	Unique attributes	Key results for patterns of carriage	Limitations	Nos score
Spano and Bolland (2011)	Cohort Mobile Youth Survey administered annually for 2 years	1049	Adolescents from 12 high-poverty neighborhoods in Mobile, Alabama were recruited from school, homes, community and church locations	Age 9–19 M age 13 (T1) 42% male 100% Black (2000–2001) Sample limited to those who were included in T2 and had not carried at T1	8% initiated gun carrying at T2 (past 90-day); Results support the nexus hypothesis (carriage occurs among a small number of gang youth at increased risk for violence behavior and exposure) over the diffusion hypothesis (gun carriage results directly from violence exposure) for initiation of gun carriage in urban youth Youth gang members who were exposed to violence at T1 were more likely to initiate gun carriage at T2 (OR = 6.5) Gang members engaged in violent behavior at T1 were more likely to initiate gun carriage at T2 (OR = 5.8) Gang members who were engaged in violent behavior and had exposure to violence at T1 were more likely to initiate gun carriage at T2 (OR = 7.7)	High attrition rate (36%) Focused on T1 factors predicting carriage initiation (T2) Single 1-year follow-up Limited generalizability 100% Black sample Single city Sample of at-risk youth	6
Spano et al. (2012)	Cohort Mobile Youth Survey administered annually for 2 years	1049	Adolescents from 12 high-poverty neighborhoods in Mobile, Alabama were recruited from school, homes, community and church locations	Age 9–19 M age 13 (T1) 42% male 100% Black (2000–2001) Sample limited to those who were included in T2 and had not carried at T1	8% initiated gun carrying at T2 (past 90-day); Key findings: Consistent with the stepping stone model, youth engaged in violent behavior (T1) were more likely to initiate carriage at T2 after controlling for violence exposure (AOR = 1.8) Consistent with the cumulative risk model, youth engaged in violent behavior and exposed to violence at T1 were more likely to initiate carriage at T2 compared to youth who had neither (AOR = 2.5)	High attrition rate (36%) Focused on T1 factors predicting carriage initiation (T2) Single one-year follow-up Limited generalizability 100% Black sample Single city Sample of at-risk youth	6
Spano and Bolland (2013)	Cohort Mobile Youth Survey administered annually for 2 years	1049	Adolescents from 12 high-poverty neighborhoods in Mobile, Alabama were recruited from school, homes, community and church locations	Age 9–19 M age 13 (T1) 42% male 100% Black (2000–2001) Sample limited to those who were included in T2 & had not carried at T1	8% initiated gun carrying at T2. Key findings: Youth experiencing violent victimization (OR = 2.3) and violent behavior (OR = 1.9) at T1 increased the likelihood of initiating gun carriage at T2 when examined separately, but only violent victimization (OR = 2.1) was significant when both were included in the model There was no difference between the likelihood of youth who initiated gun carriage at T2 for offensive (i.e., violent behavior only at T1) versus defensive (i.e., violent victimization only at T1) purposes	High attrition rate (36%) Focused on T1 factors predicting carriage initiation (T2) Single one-year follow-up Limited generalizability 100% Black sample Single city Sample of at-risk youth	7
Steinman and Zimmerman (2003)	Cohort Flint Adolescent Study administered annually for 4 years during high-school (9th–12th grade)	705	African-American public high school students with a GPA 3.0 at risk for school dropout	M age 15 49% male 100% Black Sample limited to Black students given low base rates of gun carriage among White students Included youth who had left school	20% of youth reported carrying a gun (80% had never carried) Patterns of carriage 15% carried episodically (during one or two waves) 5% carried persistently (during three or four waves) Compared to non-carriers, episodic carriers were more likely male (AOR = 3.6), selling drugs (AOR = 3.2), engaging with adults who carry (AOR = 1.6), engaging in fighting behaviors (AOR = 1.6) and using marijuana (AOR = 1.03) Compared to persistent carriers, episodic carriers were more likely engaging in fighting behaviors (AOR = 1.6) and selling drugs (AOR = 3.3)	Self-report measures. Limited generalizability Sample limited to Black youth Study did not extend earlier than 9th grade so earlier risk and protective factors could not be examined	7
Vaughn et al. (2017)	Cross-Sectional Analysis uses pooled data from the National Survey	7872	Analysis of adolescents age 12–17 from the NSDUH national sample who	Age 12–14: 40% 15–17: 60% 83% Male 15% Black	Latent class analysis (LCA) of handgun carrying (1 + times) adolescents identified 4-class solution: “Low-Risk” (48%): Low substance use, violence, delinquency	Cross sectional data Self-report Motivations not included	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Key results for patterns of carriage	Limitations	Nos score
Watkins et al. (2008)	on Drug Use and Health Cross-sectional	967	reported past year gun carriage (2002–2013)	60% White 20% low SES 78% Urban	<p>“Alcohol/MJ users”: (20%); High substance use, low levels of violence and delinquency</p> <p>“Fighters”: (20%); High levels of violence and delinquency, but low levels of MJ and other drug use</p> <p>“Severe”: (12%); High levels of alcohol, MJ, other drugs, violence and delinquency behaviors</p> <p><i>Socio-demographics</i>: Compared to other classes, the low risk class was made up of more rural White youth from high SES households with fathers. Alcohol/MJ users were more likely older (15–17) Black youth from urban settings.</p> <p>“Fighter” class was more likely younger (12–14) Black youth from low SES homes in urban settings. “Severe” class had highest % females (males still more common), and were from urban settings.</p> <p><i>Behavioral</i>: Compared to the low-risk group, youth in classes 2–4 were more likely to report greater risk propensity, greater parental conflict, and lower school engagement. This was most pronounced in the “severe” group. The Alcohol/MJ group and Severe group had lower levels of parental-limit setting</p> <p><i>Frequency of gun carriage</i>: Severe subset youth were more likely to carry frequently compared to the low risk (RR 1.5), alcohol/MJ class (RR 1.5), and fighter class (RR 1.4). No difference between first 3 classes for frequency. Class 4 (severe) had higher likelihood of lifetime and past year arrest</p>	<p>Limited generalizability</p> <p>Small sample of juvenile arrestees from a single city</p> <p>Mostly Black sample</p> <p>Self-report measures</p> <p>Cross-sectional data</p>	6

Table 2
Articles reporting data on motivations for firearm carriage among adolescent youth

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Key findings on motivations for firearm carriage	Limitations	NOS score
Ash et al. (1996)	Qualitative Semi-structured interviews	63	Youth offenders recruited from 5 detention centers in Atlanta, GA	Ages 13–18 Male 16 67% Male 66% Black 34% White	Not reported	89% of gun owners reported most important reason for carrying was “for protection” Most common location to carry was “to a club” (35%) as “that’s where my enemies are” and because I “might look at somebody wrong or they might snap on you.” Respondents reported that when carrying they “felt safer” (40%); were anxious about being stopped by police (34%); energized, excited, or powerful (40%), or more dangerous (7.5% reported temptation to commit crime/saw themselves as magnet for trouble)	Limited generalizability Nonrandom convenience sample of offenders from single city Self-report data Small sample	6
Bergstein et al. (1996)	Cross-sectional “Hands without guns” study	1192	7th (n = 752) and 10th (n = 440) grade students from 12 public schools in Boston, MA and Milwaukee, WI	49% Male	Past 30-day carriage to school = 3% Lifetime gun carriage = 17%	Motivations for firearm carriage: Perceived safety/threats/revenge (73%) Casual handling (17%) Hunting (4%) Being cool (3%) Target practice (2%) Gang involvement (1%)	Limited generalizability Oversampled minorities Limited to NE/MW Cross-sectional data Potential underestimate due to excluding truant youth and dropouts No socio-demographic measures beyond sex	6
Black and Hausman (2008)	Qualitative Semi-structured interviews	23	Youth recruited from a peer-educator violence prevention program in Philadelphia, PA	Ages 13–18 Male 16.3 61% Male	Not reported	Protection was primary motivation for carriage, including: Protection during drug dealing Guns considered part of conducting drug deals; provided respect/symbol of wealth, power, status Protection from disrespect Among youth not involved in drug deals, guns were way to gain respect/prevent disrespect Protection from bullying Guns were seen as a means of restoring the balance of power for bullying victims Responses to gun handling Excitement/Power Initial reaction faded over time Youth excited by the gun often engaged in gunplay (flossing), which was often intermediate step between posturing and automatic behavior Fear Youth not excited by guns typically experienced fear of getting injured or getting caught Reactions to peers who carried: fear, indifference, and respect	Limited generalizability Small sample from single urban city Self-report data Note: Study sample taken from 2001	7
Carter et al. (2013)	Cross-sectional “Flint Youth Injury” Study	689	Assault-injured urban youth seeking ED treatment at a Level-1	Ages 14–24 Male 20 50% Male 61% Black.	Past 6-month carriage = 10%	Motivations for firearm ownership/carriage: Protection (37%) Holding it for someone (10%) Friends carry guns (9%)	Limited generalizability Single urban ED sample Predominantly Black youth	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Key findings on motivations for firearm carriage	Limitations	NOS score
Freed (2001)	Qualitative Semi-structured Interviews	45	Randomly selected incarcerated male youth recruited from a MD juvenile justice facility	73% low SES Ages 14–18 Male 16 100% Male 67% Black 61% Urban	Lifetime gun carriage = 60%	Only 17% of firearms purchased legally Reasons for not carrying a gun: Supply-side Factors Inability to find usual/trusted source (20%) Price of gun/History of gun (11%) Demand-side Factors Fear of arrest/incarceration (69%) Opinion of respected others (31%) Concern about hurting self/others (36%) No need for a gun (60%) Respondents indicated decision to carry a gun involved weighing perceived benefits (e.g., protection) against risks (e.g., getting caught, disrespecting others, hurting others/self). Half reported carrying a gun made them anxious, mainly due to fear of being caught and carrying made them "safe but in danger"	Cross-sectional data Self-report data Exclusion of suicidal and sexual assault patients may underestimate true firearm possession rates Limited generalizability Sample limited to incarcerated male youth Qualitative study Small sample Self-report data	6
Hemenway et al. (1996)	Cross-sectional "Hands without guns" Study	1192	7th (n = 752) and 10th (n = 440) grade students from 12 public schools in Boston, MA and Milwaukee, WI	49% male	Past 30-day carriage to school = 3% Lifetime gun carriage = 17%	Majority of respondents indicated that protection or self-defense was the reason for carrying a gun. Among those who said they carried guns, 34% reported that they were more likely to carry a gun to school if others do and only 8% were less likely (supporting the contagion hypothesis)	Limited generalizability Oversampled minorities Geographic limitation Cross-sectional data Potential underestimate due to excluding truant youth and drop outs No socio-demographic measures beyond sex	6
Kingery et al. (1996)	Cross-sectional	1072	Randomly selected 8th (n = 464) and 10th (n = 608) grade middle and high school students in rural TX	49% Male 70% White 17% Black Primarily rural population	Past 12-month gun carriage to school = 10%	Motivations for gun carriage (to school): Angry with someone/I was thinking of shooting them (55%) It made me feel safer (48%) It showed me I could get away with breaking rules (20%) It helped me get other students to do what I wanted (19%) It made me more accepted by friends (11%)	Limited generalizability Rural Sample Mostly White sample Only assessed carriage/motivations for carriage to school Cross-sectional data Self-report data	4
Lane et al. (2004)	Cross-sectional	223	Black youth living in low-SES neighborhoods (random digit dial sampling of houses) in San Francisco, CA	Ages 13–19 Male 16 42% Male 100% Black	3-Month intention to carry = 25% (males) and 9% (females)	In males, intent to carry was associated with fear of victimization (OR 3.3) and delinquency (OR 14.2) In females, intent to carry was associated with fear of victimization (OR 4.5) and delinquency (OR 4.1)	Limited generalizability Small, Black sample from low-income neighborhood Cross-sectional data Self-report data Proxy carriage measure	7
Mateu-Gelabert, (2002)	Qualitative Semi-structured interviews	25	7th grade students living in a New York City, NY neighborhood	60% Male 100% Hispanic 84% Dominican 12% Puerto	Not reported	Motivations for firearm carriage (themes) Deterrence against threats/provides a sense of security in high-risk areas/situations	Limited generalizability Hispanic youth from single NYC neighborhood	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Key findings on motivations for firearm carriage	Limitations	NOS score
McNabb et al. (1996)	conducted as part of a longitudinal ethnographic cohort study	38 cases 103 controls	were followed annually for 3 years	Rican 44% 1st generation immigrant 44% low SES	Past 30-day carriage Case = 71% Control = 20% Lifetime carriage Case = 100% Control = 29% School carriage Case = 34% Control = 4%	Respect—Flashing/showing guns confers immediate respect among peers and potential attackers Self-protection and a means of proving youth are not afraid to stand up/defend oneself Necessary for illicit drug trade/protect drug markets Many report carrying because they believe others that they run into will also carry (i.e., social norms in the neighborhood)	Qualitative study Small sample size Self-report data	7
Sheley (1995)	Case control	835	Youth (< age 19) charged with illegal gun carriage in Jefferson Parish LA and age-, gender-, and school-matched controls recruited from public school (3:1 match)	Ages 13–18. M age 16 94% Male 46% White 43% Black	Lifetime carriage = 55% (routinely) Case = 55% Control = 29% School carriage = 34% Control = 4%	Self-defense was most common reason (40%) identified for gun carriage among both case and control subjects Reasons for gun carriage (during a crime): Defense/Ready to defend self (80%) Chance victim would be armed (58%) Need a weapon to escape crime scene (49%) Victim won't put up a fight (45%) People don't mess with armed person (42%) Circumstances most likely to carry a gun: During a drug deal (50%); Raising hell (32%) In a strange area (72%); At night (58%) Hanging with friends (38%); Friends were carrying (39%); Needing protection (75%); Planning to do a crime (37%) Based on above results, no support for status hypothesis; Most circumstances involved needing gun for protection	Cases significantly more likely to be Black youth than gun-carrying controls Potential bias of underreported delinquency Low case response rate (54%) may misrepresent true rate of gun carriage Self-report data	4
Wilkinson and Fagan (1996)	Cross-sectional	30	Male inmates recruited from 6 correctional facilities in CA, NJ, IL, LA.	Age 12–21 M age 17 100% Male 46% Black 29% Hispanic > 50% Urban	Not reported	Carrying a firearm provided sense of personal safety All respondents reported that carrying guns was necessary for self-defense or protection of themselves, peers, family members, or girls. Underlying reasons for need for protection varied, including both general and specific deterrence reasons. Respondents endorsing need for "protection" also noted that this was often followed by violent conflict or victimization	Limited generalizability Small qualitative sample Subsample of larger study Self-report data	4
Wilkinson et al. (2009)	Qualitative Semi-structured Interviews	416	Subsample of larger qualitative study of Inner-city adolescent males recently released from Rikers Island Prison between 4/1995–5/1996	Ages 16–24 100% Male	80% carried a firearm at least some of the time	50% reported that protection was the main reason for carrying Emerging qualitative themes included that peer pressure to carry guns was primarily around the need to carry for safety/protecting peer group	Limited generalizability Violent offender sample Single urban setting Qualitative Interviews Self-report data	4

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Key findings on motivations for firearm carriage	Limitations	NOS score
			(1) conviction for illegal gun possession/violent offence; (2) violent injury requiring hospital care; or (3) recent violence involvement		Perceived peer carriage = 79% 21% youth perceive that their peers carry guns everyday	(e.g., pre-emptively address threats of violence), to realitate for prior altercation, or to provide safety after a violent event. Less common to carry a weapon for status symbol, social recognition/reputation. Perceived reasons for peer gun carriage: For protection (65%) Involvement in drug trade (30%) Carry to avoid beefs (21%) Carry b/c it is cool (6%) Carry b/c they have to (2%) Carry gun to have it (1%) Carry to kill/claim turf (2%) Perceived peer carriage = 79%	Note: Original Interviews conducted 9/1995–7/1998	

Table 3

Articles reporting data on risk and protective factors for adolescent firearm carriage

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Allen and Lo (2012)	Cross-sectional Secondary analysis of data from Shelley (1994) Study	835 juvenile inmates 695 students	Male inmates from 6 correctional facilities and 9th-12th grade students from 10 inner-city public high schools in CA, LA, IL, and NJ	Ages 15–19 100% male Students: M age 17 73% Black 18% Hispanic Inmates: M age = 17 46% Black 29% Hispanic	Rates of co-occurring drug trafficking and gun carriage: Students = 16% Inmates = 65%	<i>Students:</i> After controlling for age, absentee father, employment, h/o expulsion (OR 2.6), and code-based beliefs (OR 1.2) were positively associated with co-occurring drug dealing and gun carriage. Negative associations were Non-black (OR 0.10) and Hispanic (OR 0.47) race/ethnicity <i>Inmates:</i> After controlling for age/employment, having an absentee father (OR 3.7), h/o violent behavior (OR 4.4), and code-based beliefs (OR 1.2) were positively associated with drug dealing/gun carriage. Negative associations were non-black (OR 0.1) and Hispanic (OR 0.2) race/ethnicity	Limited generalizability All-male student and inmate samples from select cities in four states Cross-sectional data Self-report data Questionnaires were not identical for samples. Note: study sample is from 1991 (published 2012)	6
Apel and Burrow (2011)	Cohort 2 waves of data from National Longitudinal Youth Survey	1524	Nationally representative sample of US youth with oversampling of Black/Hispanic youth	M age 13 (w1) 52% male 15% Black 12% Hispanic	Lifetime carriage = 7.4% in w1 Past 1-year carriage = 5.8% in wave 2	In cross-sectional model (independent/dependent variables from 1997 data: exposure to violence (i.e., gunshots in neighborhood) was correlated with carriage (OR 2.3), bullying was not correlated after adjusting for demographic, family, school, peer affiliation, and other factors. In longitudinal model (independent variables 1997; dependent variables 1998), exposure to violence was correlated with carriage (OR 2.0), but bullying was not correlated after adjustment	Self-report data Limited to young adolescent sample Note: study sample taken from 1997 (published 2011)	6
Arria et al. (1995)	Cohort Surveyed annually for 5 years	1714	Students from 43 classrooms within 19 public schools from 5 districts in MD	M age (w1) 9 M age (w5) 13 50% Male 73% Black 26% White	Past 1-year carriage = 10% (Male) 1% (Female)	Rates of gun carriage increased across waves of data, starting at < 2% (w1) and increasing to 10% (male) and 1% (female) by w5 data collection; Less lethal weapon carriage (stick, knife) was associated with gun carrying at later waves across multiple waves	Limited generalizability Single city; Younger Adolescent sample Missed student dropouts Self-report data	6
Beardslee et al. (2018a)	Cohort Pittsburgh Youth Study; Data is from 6-month surveys (3 years) and then 12-month surveys in ages 10–17	485	Random sub-sample of male youth from youngest cohort of large school-based longitudinal study in Pittsburgh, PA	100% male 56% Black 41% White Excluded non-White/Black participants	Lifetime gun carriage = 27% (Black) 12% (White)	Youth with higher levels of conduct problems and peer delinquency at earlier childhood waves, as well as those with increases in conduct problems across early childhood waves, were more likely to initiate gun carriage before 18 Examining whether racial differences in carrying behavior were due to differential exposure to risk factors or differential sensitivity, study found more support for differential exposure model, with 60% of the race effect on carriage being attributable to either initial peer delinquency levels or initial levels of conduct problems	Limited generalizability Limited to male Black/White youth sample Single city sample Self-report data. Small sample size may limit ability to detect group differences in predictors of carriage	6
Beardslee et al. (2018b)	Cohort Pathway to Desistance Study; Data collected every	1170	Male offenders recruited from court system in two counties in AZ	Ages 14–19 at baseline 100% male 42% Black 34% Hispanic	Past 6-month Carriage = 15% (w1); 15% (w3);	Among youth with recent offending, gun violence exposure (witness/victim of gun violence) were 43% more likely to engage in carriage at the next wave after controlling for time-stable and time-varying (exposure to peers who carried; exposure	Limited generalizability Male sample of juvenile offenders in two states Self-report data Youth offenders likely had	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Cao et al. (2008)	6-month for 3 years then every 12-month for 4 years Cross-sectional Nat. Crime Victim. Survey (School Crime Supp. data)	7391	(Maricopa) and PA (Philadelphia) Youth in public or private school. Limited to Black and White (Hispanic and non-Hispanic) youth. Nat. representative sample	19% White 70% on active probation at baseline Ages 12–17 M age 15 52% male 70% White 16% Hispanic 14% Black 91% public school	12% (w5); 12% (w6) Past 12-month carriage 17% (w7); 10% (w10) Past 6-month carriage to school = 0.5%	to peers engaged in other criminal acts, developmental changes, changes in gun carrying from incarceration or institutionalization) covariates No evidence that non-gun violence exposure conferred same risk Among adolescents attending public/private school, those carrying a gun for protection were more likely to report recent involvement in physical fighting (AOR 1.1); knowing a peer carrying guns (AOR 2.0), and not being female (AOR = 0.8). Factors not significant in the model included fear of being attacked, avoidance, substance use factors, gangs at school, truancy, security guards, age, race, parental education, rurality, and region	fluctuations in carrying over time Limited generalizability Low incidence of carriage Limited ethnic/racial groups Cross-sectional data Excluded carriage-related factors (e.g., sell drugs) Fighting may have been aggression or victimization	6
Carter (2013)	Cross-sectional Flint Youth Injury Study	689	Assault-injured urban youth seeking ED treatment at a Level-1 trauma center in Flint, MI	Ages 14–24 M age 20 50% Male 61% Black 73% low SES	Past 6-month carriage = 10%	Male gender (AOR 2.8), higher SES status (AOR 1.5), illicit drug use (AOR 1.6), serious physical fighting (AOR 1.7), and attitudes favoring retaliatory violence (AOR 1.6) were associated with firearm possession. Age and race were not significant predictors of possession (carriage/ownership)	Limited generalizability Single urban ED sample Predominantly Black youth Cross-sectional data Self-report data Exclusions may lead to underestimation of carriage	7
Connolly and Beaver (2015)	Cohort National Longitudinal Survey of Youth, surveyed annually for 8 years	1304 sibling pairs	Sibling pairs nested within the nationally representative sample of youth; oversampled Black/Hispanic adolescents	Ages 12–18 at start of study; 27 monozygotic (MZ) twins, 932 dizygotic (DZ) twin/full sibling pairs, 75 half-sibling (HS) pairs	Lifetime carriage = 9.6% (among the full sibling sample) 5% (MZ) 10% (DZ) 13% (HS)	Half-siblings reported higher rates of gun carrying than MZ twins, DZ twins, or full siblings. Within-sibling concordance was higher for MZ twins ($p < 0.05$) than for DZ twins/full siblings ($p < 0.05$), and half-siblings ($p < 0.05$). Additive genetic effects explained 27% of variation in gun carriage. Common genetic influences explained 66% of covariance between gun carrying and gang membership. Shared environmental factors didn't explain variance across models, with non-shared environmental factors explaining remainder of variance not accounted for by genetic factors	Limited generalizability Sample of sibling pairs may not represent non-siblings Self-report data Note study sample taken from 1997 to 2005 (published 2015)	6
Cook and Ludwig (2004)	Cross-sectional 1995 National Survey of Adolescent Males (NSAM)	1151	Male youth living in US households. Survey was of youth 15–19, but analytic sample restricted to under age 18	Ages 15–17 100% male 38% White 28% Black 31% Hispanic 46% Urban 34% Suburban 20% Rural	Past 30-day carriage = 10%	Likelihood of gun carriage among youth was positively associated with rate of robbery (AOR 6.0) and prevalence of gun ownership (AOR 4.9) after controlling for individual and household characteristics Of note, Black and Hispanic youth were more likely to carry guns than others, although for Hispanics-effect was limited to those in English-speaking homes. Gun carriage was not associated with age, grade, or household SES status	Cross-sectional data. Self-report data Used proxy variable (FS/S, suicides committed with guns) for measure of gun availability	7
Cunningham et al. (2010)	Cross-sectional	2069	Consecutive sample of adolescents (age	Ages 14–18. 45% Male	Past year carriage = 7%	Gun carriage was associated with Black race (OR 2.4), Male sex (OR 2.4), failing grades (OR 1.5),	Limited generalizability	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
DuRant et al. (1999)	Cross-sectional	2227	14-18) presenting for any reason for ED treatment at a Level-1 trauma center in Flint, MI	57% Black 53% low SES 40% seeking ED treatment for an injury	Ever carried to school = 3%	Marijuana use (OR = 3.3), recent gun victimization (OR 1.9), recent physical fighting activity (OR = 1.6), group fighting (OR = 3.3), sexual activity (OR = 2.4). Gun carriage frequency was associated with older age (IRR = 1.3), male sex (IRR = 1.3), falling grades (IRR = 1.6), employed (IRR = 1.4), lower SES (IRR = 1.8), binge drinking (IRR = 1.3), fighting resulting in injury (IRR = 1.8), recent gun victimization (IRR = 1.2), serious fighting (IRR = 1.3), and group fighting (IRR = 1.6)	Urban mostly Black sample Cross-sectional data Self-report data Exclusion of suicidal and sexual assault patients may underestimate gun carriage	7
DuRant et al. (1999)	Cross-sectional	2227	Randomly selected 6-8th grade students attending 53 randomly selected public middle schools in NC	Ages 11-16 36% age 13 51% male 64% White 28% Black 2% Hispanic	Ever carried to school = 3%	RF for carriage included Male sex (AOR 7.1), Minority ethnicity (AOR 3.3), Alcohol use (AOR 4.6), Cocaine use (AOR 3.0), Marijuana use (AOR 3.7), and Smoking frequency (AOR 1.3). Having ever carried a gun, having been threatened with weapon/in a fight, and suicidality were not predictive. Those who smoked daily were 8 times as likely to carry. Controlling for age/sex, earlier age of onset for substance use (i.e., cigarette, alcohol, and marijuana use) was associated with carriage to school	Cross-sectional data Self-report data Sampling design doesn't account for potential for clustering of behaviors within schools	7
Freed et al. (2001)	Qualitative semi-structured Interviews	45	Male youth incarcerated in a MD juvenile justice facility	Ages 14-18 M age 16 100% Male 67% Black 61% Urban	Lifetime gun carriage = 60%	Bivariate comparisons found that those who owned or carried a gun were more likely to be have sold drugs (89% vs 56%, $p = 0.05$), been victimized by someone with a weapon (81% vs 33%, $p < 0.01$), and to have lived in city (71% vs 39%, $p < 0.05$)	Limited generalizability Incarcerated male youth Qualitative study Small sample Self-report data	6
Hayes and Hemenway (1999)	Cross-sectional Youth Risk Behavior Survey (YRBS) in MA	3153	Random sample of 9-11th graders from MA public schools	Age 15-18 50% Male 71% White 9% Black 8% Hispanic 50% Urban 14% Rural	Past 30-day carriage = 5%	Risk factors associated with past 30-day gun carriage included: male gender (OR 5.0), Black race (OR 2.5), older age within class (OR 2.1), gang membership (OR 7.2), missing school out of concern for safety (OR 2.5), seeking medical treatment after a fight (OR 4.5), and fighting without seeking medical treatment (OR 5.7)	Cross-sectional data Self-report data Misses students not in school Excluded large % of original sample (entire 12th grade)	7
Hemenway et al. (1996)	Cross-sectional "Hands without guns" study	1192	7th (n = 752) and 10th (n = 440) graders from 12 public schools in Boston, MA and Milwaukee, WI	49% male	Past 30-day carriage to school = 3% Lifetime carriage = 17%	RFs associated with higher likelihood of concealed gun carriage included male sex (OR 5.1), older age/grade (OR 2.1), smoking (OR 5.5), alcohol use/binge drinking (OR 1.8), poor academic performance (OR 1.7), lack of self-efficacy to avoid fighting (OR 2.7), family member victim of shooting (OR 2.3), neighborhood with a lot of shootings (OR 2.9), and no serious discussion with parents about guns (OR 1.5)	Limited generalizability Oversampled minorities Limited to NE/MW Cross-sectional data. Potential underestimate due to excluding truants/dropouts No socio-demographic measures beyond sex	6
Hemenway et al. (2011)	Cross-sectional Biennial Boston Youth Survey	1737	9th-12th grade students in Boston, MA recruited from 22 public high schools; Analytic sample restricted to	28% 10th grade 46% male 41% Black 32% Hispanic 9% White	Past 12-month carriage = 5%	Risk factors for carriage included male sex (OR 2.8), alcohol, tobacco, or drug use in past month (OR 2.4), lack of an adult who encouraged them (OR 2.7), having witnessed violence in past month (OR 2.3), recent peer victimization (OR 3.5), gang membership (OR 4.7), and gun access	Limited generalizability Mainly minority youth sample Mainly urban high schools Cross sectional data	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Kingery et al. (1996)	Cross-sectional	1072	Randomly selected 8th (n = 464) and 10th (n = 608) grade middle and high school students in rural TX	49% Male 70% White 17% Black Primarily rural population	Past 12-month gun carriage to school = 10%	(OR 2.0). In addition, living in neighborhoods where gun carriage rates high (> 8%) predicted carriage (OR 2.2), as did youth overestimates of peers carrying (OR 2.5). On average, youth estimated that peer carriage in their neighborhood was 33% with mean estimates higher than "actual" levels in every neighborhood tested. Among youth who overestimated rates of peer carriage, 69% reported that they would be less likely to carry themselves	Self-report data No information on non-responders (7%) or those not in school (31%)—potential for underestimate of actual level of gun carriage.	4
Lane et al. (2004)	Cross-sectional	223	Black youth living in low-SES neighborhoods (random digit dial sampling of houses) in San Francisco, CA	Ages 13–19 M age 16 42% Male 100% Black	3-month intention to carry = 25% (males) and 9% (females)	Discriminant analysis found 18 factors related to past year carriage, including exposure to unsafe neighborhoods, cocaine use (lifetime), recent physical fighting, riding on empty buses/trains, belief that carrying is effective to avoid fighting, earlier initiation of cocaine use, being victimized while on the school bus, going outside to sell items door-to-door alone, being threatened but not hurt in past year (outside of school), victim of forced sex, male sex, higher frequency crack use, attitudes favoring gang membership as means of avoiding fighting, higher grade, having possessions stolen by force/threat of force, less instruction in school on means of avoiding fighting/violence, White race, being threatened (but not hurt in past year) at school	Limited generalizability Rural Sample Predominantly White sample Only assessed carriage and motivations for carriage to school Cross-sectional data Self-report data	7
Lizotte et al. (2000)	Cohort Rochester Youth Survey given at 6-month intervals (w 1–9) then 2.5 year intervals (w 9–10)	617	Male Youth recruited from Rochester public schools (7th/8th grade); Oversampled high-crime areas (defined by arrest rates)	100% Male M age 14 (w2) M age 20 (w10) 63% Black 20% White 18% Hispanic Analysis limited to male youth remaining at w10	Past 6-month carriage = 5–6% (w2) and 8–10% in w9–10.	In males, intent to carry was associated with fear of victimization (OR 3.3) and delinquency (OR 14.2). In females, intent to carry was associated with fear of victimization (OR 4.5) and delinquency (OR 4.1)	Limited generalizability Small, Black youth sample from low-income neighborhood Cross-sectional data Self-report data Intention to carry gun was proxy measure for carriage	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Loeber et al. (2004)	Cohort Develop-mental Trends Study with dyads at 12-month intervals for 13 years	177	Male children living with 1 biological parent referred from primary care clinic in either PA or GA	Ages 7–12 (baseline); followed to 19 30% Black 70% White 53% urban 57% not living with bio-father 41% low SES	Lifetime carriage = 20% 1% carriage (age 12) 12% carriage (age 17)	Gun carriage significantly associated with older age youth (IRR 1.7), violent behavior (IRR 1.1), conduct disorder (IRR 5.2), and maternal psychopathy (IRR 1.1). Youth were less likely to carry firearms if they had been victimized (IRR 0.8). Protective factors included parental monitoring (IRR 1.1), Race/ethnicity, SES, rurality, and anxiety disorder were significant in bivariate model but were not included in the multivariate model	Limited generalizability Small, convenience sample referred from a healthcare clinic Self-report data Sample limited to male youth	7
Luster and Oh (2001)	Cross-sectional 1997 National Longitudinal Youth Survey (NLYS97)	4619	Representative sample of U.S. male youth from the NLYS97 survey limited to males Separate analysis for those < 15; and those 15	Age 12–16 100% male 50% White, 25% Black, 21% Hispanic 57% Urban 43% Rural M Income = 47 K	Past 1-year carriage = 9% Lifetime = 16% <15; past 1-year carriage = 8% 15 past 1-year carriage = 11%	<i>Under age 15:</i> White youth (OR 2.9), Problem Behaviors (OR 1.5), witnessed shooting before age 12 (OR 2.1). Relatives of friends in a gang (OR 1.7), gang membership (OR 3.0), hearing gunshots in their neighborhood (OR 1.2). Protective factors included parental monitoring (OR 0.9) and high-levels of maternal respect (OR 0.9) <i>Over age 15:</i> Problem Behaviors (OR 1.5), witnessed shooting before age 12 (OR 2.4), negative peer influence (1.3), and gang involvement (OR 3.2)	Limited generalizability Oversampled Black and Hispanic youth Cross-sectional data Self-report data Excluded those who carried a gun previously but not within the past 12-months	6
May (1999)	Cross-sectional	8338	High school students from urban and rural counties in MS selected via two-stage process (urban, non-urban)	Ages 13–20. 45% Male 53% Black 47% White	Lifetime carriage to school = 8%	Factors associated with gun carriage to school included male sex (OR 4.4), Black race (OR 1.6), older age (OR 1.7), higher household income (OR 1.1), gang membership (OR 5.3), perceived neighborhood incivility (OR 1.1), and higher fear index (OR 1.1). Gun carrying to school was less likely in those from two-parent homes (OR 0.8) and with higher social control index scores (OR 0.9)	Limited generalizability Majority Black sample from MS Non-random selection Cross-sectional data Self-report data Note: study sample taken from 1992 (published 1999)	5
McNabb et al. (1996)	Case control	38 cases; 103 controls	Youth (< age 19) charged with illegal gun carriage in Jefferson Parish LA & age-, gender- and school-matched controls recruited from public school (3:1 match)	Ages 13–18 M age 16 94% Male 46% White 43% Black	<i>Past 30-day carriage</i> Cases = 71% Controls = 20% <i>Lifetime carriage</i> Cases = 100% Controls = 29% <i>School carriage</i> Cases = 34% Controls = 4%	Risk factors for firearm carriage included reporting that the school was not safe (AOR 9.0), seen a shooting (AOR 7.0), marijuana use (OR 6.8), and a history of firing a gun (OR 17) Risk factors for being charged with firearm carriage included the lack of an employed male in households with male parents (AOR = 8.6), marijuana use (AOR = 11.7), and watching TV for more than 6 h/day (AOR 6.5)	Cases significantly more likely to be Black youth than gun-carrying controls Potential bias of underreported delinquency Low case response rate (54%) may misrepresent true rate of gun carriage Self-report data	7
Molnar et al. (2004)	Cross-sectional Project Human Development	1842	Population-based sample of age 9–19-year-old youth from	Ages 9–19 36% age 9–12 36% age 13–15 29% age 16–19	Lifetime carriage = 3% (4.9% boys, 1.1% girls)	After controlling for individual/family factors, neighborhood factors significant in separately tested models included lack of neighborhood safety (OR 5.8), neighborhood social disorder	Limited generalizability Single urban sample with large Hispanic population	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Orpinas et al. (1999)	Cross-sectional Students for Peace Study	8865	218 neighborhoods in Chicago, IL	50% male 30% Black 42% Hispanic 14% White 25% low SES	Past 30-day carriage = 10%	(OR 1.9), and neighborhood physical disorder (OR 2.3). Neighborhood protective factors included collective efficacy (OR 0.3). Significant individual/family factors influencing gun carriage differed by model, but included male gender, older age, presence of guns at home, prior family member shot with gun, witnessed prior violence, and prior victimization by violence. Note, 76% of those who carried a gun had a family member shot by gun. Most gun carriers (63%) were in highest quartile on scale of delinquent & aggressive behaviors ($p < 0.05$)	Cross-sectional data Self-report data	7
Peleg-Oren et al. (2009)	Cross-sectional FL Youth Substance Abuse Survey (FYSAS) & FL YRBS	12,352	Randomly selected 11th and 12th grade students from FL schools. FYSAS data collected 2006 (N = 10,626) and YRBS in 2005 (N = 1726)	YRBS 54% Female 57% 11th grade 50% White 24% Hispanic FYSAS 54% Female 58% 11th grade 61% White 14% Hispanic	YRBS: Past 30-day carriage to school = 5% FYSAS Past 1-year = 5% (outside school) Past 1-year = 1% (in school)	Students with low parental monitoring were significantly more likely to carry a handgun than those who had very high monitoring (Boys OR 19.8, Girls OR 26.3). Students who got along “very bad” with their parents were more likely to carry a handgun than those who get along “very well” (Boys OR 7.9, Girls OR 22.7). No multivariate model predicting gun carriage (only weapon carriage)	Limited generalizability Single urban school district Mainly Hispanic sample Cross-sectional data Self-report data Missed students not in school	6
Reid et al. (2017)	Cohort Pathways to Desistance Study, given every 6 months for 2 years	1170	Convicted male youth offenders in PA and AZ (recruited from court). Proportion charged with drug-related offenses capped at 15%	Ages 14–19, M age 16 100% male 42% Black 34% Hispanic 19% White	Lifetime carriage at beginning of study = 51%	YRBS: After controlling for socio-demographic factors (sex, race, grades), very early drinkers (vs. early drinkers) [AOR = 3.1] and very early drinkers (vs. non-drinkers) [AOR = 29.4] were predictive of gun carriage. FYSAS: After controlling for socio-demographic factors (sex, race, grades), very early drinkers (vs. early drinkers) [AOR = 2.5] and very early drinkers (vs. non-drinkers) [AOR = 5.6] were predictive of gun carriage and also gun carriage to school (AOR of 2.6 and 5.1, respectively)	Limited generalizability Sample limited to male juvenile offenders from two cities Self-report data	6
Ruggles and Rajan (2014)	Cross-sectional CDC Youth Risk Behavioral Survey (YRBS)	88,608 (Six waves of data)	9th-11th grade students drawn from randomized sample of US high schools. Analytic window is YRBS data from 2001 to 2011	Not reported	Past 30-days 5.7% (2001) 6.1% (2003) 5.4% (2005) 5.2% (2007) 5.9% (2009) 5.1% (2011)	43 out of 54 risk behaviors included in the YRBS were associated with carriage, including strongest associations with alcohol, tobacco, and drug use overall and at school. Gun carriage was also strongly associated with feeling unsafe and being threatened at school. Finally, carriage also had associations with being the victim of sexual	Cross-sectional data Self-report data Limitations associated with hierarchical clustering methodology	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Sheley (1994)	Cross-sectional	758	Male students from urban schools in 5 cities in CA, IL, LA, and NJ. All schools had prior gun incidents	M age 16 Range (age 15–17) 72% Black 3% White 19% Hispanic	12% carried routinely (all/most time) 23% carried now/then	assault, to be engaged in disordered eating behaviors, to not wear sunscreen regularly, to have ridden in a car with a drunk driver, and mental health factors (e.g., suicidality) Youth who used and sold drugs or only sold drugs but did not use drugs were more likely to report carrying a gun routinely (19% vs. 5%, $p < 0.05$) Those who endorsed heavy drug use had higher rates of gun carriage (72 vs 10%, $p < 0.05$).	Behaviors could be proxies for broader social issues Cross-sectional data Not a representative sample of urban youth (non-random recruitment) Self-report data	4
Sheley and Brewer (1995)	Cross-sectional	418	10 and 11th grade students at 3 of 7 suburban public high schools in Jefferson Parish LA	M age 16 48% male 66% White, 21% Black	Current carriage = 17%	Gun carriage was associated with male sex (AOR = 1.1), White race (AOR = 1.4), drug activity (AOR = 1.2), and violent criminality (AOR = 1.7). Dangerous environmental exposure is significant overall (i.e., threatened with gun). Environmental findings differed by sex, with having been threatened with gun significant for boys, while fear of being shot by age 25 was significant for girls	Limited generalizability Suburban sample Cross-sectional data Self-report data	6
Simon et al. (1998)	Cohort	2200	9th and 12th grade students from 6 school districts in San Diego and Los Angeles, CA. Analytic sample is 12th grade students with complete data	44% Male 30% White 38% Hispanic 8% Black 11% Asian 32% low SES	Lifetime gun carriage Boys = 22% Girls = 5%	<i>Psychosocial</i> : Risk-taking (male = AOR 3.1; female = AOR 4.1), depression (male = AOR 1.6; female = AOR 2.4), stress (male = AOR 1.9; female = AOR 2.8), and temper (male = AOR 1.9; female = AOR 2.8) in 9th grade was predictive of carriage in 12th grade for male and female students <i>Behavioral</i> : 9th grade factors including 3 + days school absence (AOR 2.4), 2 + parties in prior month (AOR 1.9), cigarette (AOR = 2.2), alcohol (AOR = 1.9), and MJ (AOR 2.3) use were predictive of carriage in 12th grade for males. For females, cigarette (AOR 5.1), alcohol (AOR 3.7), and MJ (AOR 3.6) use in 9th grade predicted 12th grade carriage Perceptions neighborhood crime and SES were associated w/carriage after adjusting for demographics (age, gender)	Limited generalizability Geographic distribution Self-report data Only included students completing survey at both timepoints (may miss school dropouts who may be more likely to carry guns)	7
Tigri et al. (2016)	Cohort National Longitudinal Survey of Youth, data from 5 yrs of annual surveys	5018	Nationally representative sample of youth throughout the US. Analysis excludes NLSY oversample of Black and Hispanic youth	M age 14 at baseline; M age 19 at last wave 50% male 70% White	Lifetime carriage = 9% at baseline Past 1-year carriage = 4% at final wave	After adjusting for age, race, sex, prior carriage, prior peer gang membership, prior gang membership, prior delinquency, current gang membership (OR ranging 2.5–4.2), current peer gang membership (OR ranging 1.6 to 2.2), and delinquency behaviors OR ranging 1.8–2.8) were associated with carriage. Gang membership was strongest RF; delinquency measure most consistent. When examined by sex, gang membership is stronger for both sexes in early adolescence and diminishes in late adolescence (esp for females). Association of gang membership with carriage was inconsistent across race/ethnicity	Self-report data No characterization of gun carrying frequency No temporal causality given that RF were examined concurrently at time points (although accounted for lagged RF from prior waves of data)	5

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Tumer et al. (2016)	Cohort National Longitudinal Survey of Youth, Sample drawn from 14 years of annual data	6641	Nationally representative sample of youth throughout the US. Analysis excludes NLSY oversample of Black and Hispanic youth.	M age 14 at start of study, M age 27 at end of study. 51% Male 70% White 16% Black 14% Hispanic	Lifetime carriage = 28% Past 1-year carriage = 24% Past 30-day carriage = 13% Past 30-day carriage to school = 1%	Repeat bullying victims were more likely (than non-victims) to carry during past 1-year (OR 1.3) and 30-days (OR 1.2) after controlling for prior carriage and socio-demographic factors, peer gang membership, neighborhood gang presence, gang membership. When examined by age, only childhood bullying victims remained significantly associated with carriage; adolescent victims and victims during childhood & adolescence were not associated with carriage. Repeat bullying and childhood repeat bullying predicted gun carriage in propensity score matching analysis	Self-report data Recall bias from retrospective measure of bullying Unclear cross-over effect (i.e., proportion of bullying victims were also aggressors)	6
Vaughn et al. (2012)	Cross-sectional 2008 National Survey on Drug Use and Health (NSDUH)	17,842	Multistage probability sample weighted to create a nationally representative sample of US youth (age > 12); Sample restricted to age 12-17 y/o	Mean age 15 51% Male 59% White 18% Hispanic 14% Black 16% low SES	Past year carriage = 3%	Factors associated with carriage included male sex (AOR 4.5), prior incarceration (AOR 3.8), selling drugs (OR 16.1), stealing > \$50 (AOR 7.5), aggression (AOR 7.0), serious fighting at school (AOR 3.8), ecstasy (OR 5.3), hallucinogen (AOR 4.1), cocaine/crack (AOR 7.7), MJ (AOR 4.1), or heroin (AOR 5.3) use, danger seeking (AOR 4.4), and risk taking behavior (AOR 4.7). Across a range of parental involvement and monitoring behaviors, all were significantly associated with lower likelihood of carrying a gun. Youth who were exposed to violence prevention and drug prevention programming/messaging outside of school were associated with lower likelihood of gun carriage	Cross-sectional data Self-report data	7
Vaughn et al. (2016)	Cross-sectional National Survey on Drug Use and Health (NSDUH)	197,313	Multistage probability sample weighted to create a nationally representative sample of US youth (age > 12); Sample restricted to age 12-17 y/o	Ages 12-17 51% male 66% White 15% Black 19% Hispanic	Past year carriage = 3%	Carriage is examined by race/ethnicity (White, Black, Hispanic). Across all groups, male gender and history of violence/delinquency (i.e., fighting at school/work, violent aggression, selling drugs, stole > \$50) were associated with carriage. Black youth with household income < \$20 K were more likely to carry (OR 2.2). Hispanic youth engaged in binge drinking were more likely to carry (OR 1.8). Marijuana use (OR 1.5) and having substance using friends (OR 1.3) increased likelihood of carriage in Black youth. High parental affirmation protected against carriage for White (OR 0.7) and Hispanic (OR 0.6) youth, while parental control was protective for White (OR 0.9) youth only	Self-report data Cross-sectional data May have missed adolescents most likely to carry a gun (i.e., not in school) Does not investigate specific contextual factors that relate to gun carrying	7
Watkins et al. (2008)	Cross-sectional	967	338 males in juvenile detention (< age 17); 629 incarcerated adult male; Recruited from St. Louis, MO Correctional Facilities	Adolescents M age 15 100% Male 94% Black Adults M age 31 100% Male 87% Black	Past 12-month carriage 46% most/all of time 41% seldom	Among subsample of juvenile males in detention who also endorsed gun possession (N = 202), factors predicting an increased frequency of gun carriage included age, black race, and gang membership. Among perceptual factors, you who perceived an increase in the prevalence of guns over the past year were less likely to report gun carriage Deterrent measures, such as perceptions about gun use penalties and increased risk of arrest were not	Limited generalizability Small sample of juvenile arrestees from single city Mostly Black sample Cross-sectional data Self-report	6

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Webster et al. (1993)	Cross-sectional	294	7th and 8th grade students at two inner-city public high schools in low SES/high-crime areas of Washington, D.C.	Ages 11–16 M age 14 (School A) M age 13 (school B) 100% Black	Past 2 wk carriage = 16% (carriers) Lifetime carriage Males = 23% (A) Males = 40% (B) Females = 4% (A) Females = 5% (B)	significant and appeared to have no effect on gun carriage Factors predicting gun carriage (for protection or use in a fight) among male youth included prior arrest (OR 16.1), knowing more victims of violence (OR 1.1), history of initiating fights (OR 51.5), perceptions about peer acceptability of violence behaviors (norms) (OR 1.2), and more willingness to endorse views that there are justifiable reasons to shoot someone (OR 1.6). Of note, all males who had a history of arrest for drug-related charges reported carrying a firearm in the sample	Limited generalizability Small geographic Distribution Analysis restricted to male and Black youth Cross-sectional data Self-report data Convenience sample	4
Wilcox et al. (2006)	Cohort Rural Substance Abuse and Violence Project (RSVP)	3968	7th–9th grade students from 113 public middle/high schools in KY followed annually for 4 years (2001–2004)	48% Male 89% White Analysis restricted to first three waves of data	Past yr school gun carriage reported as ordinal scale (1–5) with 1 = never; 5 = daily W1 M = 1.04 W2 M = 1.04	Using SEM, authors found support for the “triggering” over the “fear and victimization” hypothesis around carriage. They found that the frequency of carriage in 8th grade was positively associated with 9th grade fear, risk perception, victimization, and offending (supporting the triggering hypothesis). Authors also found that fear and victimization in 7th grade was not related to carriage in 8th grade (non-significant) and that 7th grade risk perception was negatively related to carriage (contradicting the fear and victimization hypothesis). Further, previous carriage and gun ownership were strong predictors related to gun carriage.	Limited generalizability KY sample Sample size limited by need for parental consent (low response rate, potentially biasing sample) Self-report data Large number of missing data cases	5
Williams et al. (2002)	Cross-sectional	21,981	Representative sample of 6th, 8th, and 10th grade public school students across 27 IL communities (ages 10–19)	Ages 10–19 M age 14 50% Male, 65% White 13% Black 12% Latino 64% urban or suburban 32% low SES (eligible for school lunch)	Past year carriage = 5% Past year carriage to school = 1%	<i>Demographic/Hangout Model:</i> Across models, male gender, being seen as being cool if carrying a gun, less parental monitoring, and increased number of peers carrying guns was predictive of having ever carried, having ever carried to school, and having ever carried and having carried to school. SES was inconsistently associated. Attitudes favoring not taking a gun to school were protective. <i>Violence/Delinquency Model:</i> Across models, increased freq of aggression, gang membership, prior arrest, and substance use were associated with having ever carried, carrying to school, & having ever carried/carrying to school. <i>Family, School, Community Models:</i> Across models, no consistent findings regarding family, school, or community variables with regards to having ever carried, carrying to school, and having every carried/carrying to school	Cross-sectional data Self-report data Survey distributed by untrained teachers rather than research staff No measures assessed victimization	7

Article	Design	Sample size	Study sample and setting	Unique attributes	Carriage rates	Results	Limitations	NOS score
Xuan and Hemenway (2015)	Cross-sectional Data was from the 2007, 2009, and 2011 Youth Risk Behavior Survey (YRBS)	228,904	Nationally representative sample of 9th-12th graders drawn from 38 U.S. states	Not reported	Past 30-day gun carriage = 7%	Gun carriage among youth in 19 states with stronger gun laws was 5.7% compared to youth in the 19 states with weaker laws where carriage was 7.3%. A 10 point increase in firearm law score (i.e., strength of the gun laws for 5 areas—curbing firearm trafficking, stronger background checks, child safety laws, military assault-style weapon ban, and restricting guns in public places) was associated with a 9% reduction in the odds of youth gun carriage (AOR 0.9). Adult firearm ownership mediated the association between the state gun law score and youth gun carriage (AOR 0.9) with 29% attenuation of the regression coefficient	Cross-sectional data Self-report data Non-validated scoring for strength of state firearm laws Local policies were not included in the weighted firearm law scores	5

Table 4

Modified Newcastle–Ottawa Scale for cross-sectional studies

Selection (max 3 points)	Representativeness of the sample	1—Truly representative of the average target population (all subjects or random sampling)	1—Somewhat representative of the average target population (not random sampling, but based on solid sampling strategies)	0—Small or biased subgroup of potential respondents	0—No description of the sampling strategy
	Sample size	1—Justified and satisfactory		0—Not justified	
	Non-response rate	1—Response rate is satisfactory (> 70%)		0—Response rate is unsatisfactory (<70%)	0—No description of response rate
Comparability (max 2 points)	Comparability of participants	1—Study controls for the single most important factor	1—Study controls for any additional factors	0—Non-responders differ from responders in important ways	
Outcome (max 4 points)	Validity of outcomes	1—Independent blind assessment of behavior	1—Medical record review	0—Self-report	0—No description
	Ascertainment of the exposure (risk factor)	2—Validated measurement tool	1—Non-validated tool but available or described	0—Non-validated measurement tool and not described	
	Statistical test	1—Statistical test is clearly described and appropriate, includes confidence intervals and probability level		0—Statistical test is not appropriate, not described, or incomplete	
Selection (max 3 points)	Is the case definition adequate?	1—Yes, with independent validation		0—Yes, with record linkage or based on self-report	0—No description
	Representativeness of the cases	1—Consecutive or obviously representative series of cases		0—Potential for selection biases or not stated	
	Selection of controls	1—Community controls		0—Hospital controls	0—No description
	Definition of controls	1—No history of disease (endpoint)		0—No description of source	
Comparability (max 2 points)	Comparability of cases and controls on the basis of the design or analysis	1—Study controls for the single most important factor	1—Study controls for any additional factors		
Exposure (max 3 points)	Ascertainment of the exposure	1—Secure record	1—Structured interview where blind to case/control status	0—Interview not blinded to case/control status	0—Written self-report or medical record only
	Same method of ascertainment for cases and controls	1—Yes		0—No	0—No description
	Non-response rate	1—Same rate for both groups		0—Non-respondents described	0—Rate different and no designation
Selection (max 4 points)	Representativeness of the exposed cohort	1—Truly representative of the average population within the studied community	1—Somewhat representative of the	0—Selected group of uses (nurses, volunteers)	0—No description of how the cohort was selected

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	average population within the community			
	0—Drawn from a different source as the exposed cohort	0—No description of the source of the non-exposed cohort		
	0—Self-report	0—No description		
	0—No			
Comparability (max 2 points)	1—Study controls for any additional factors			
Outcome (max 3 points)	1—Record linkage	0—No description		
	1—Self-report			
	0—No			
	1—Subjects lost to follow-up but unlikely to introduce bias (more than 80% retention) or adequate description of those lost to follow-up	0—Follow up Rate < 80% and no description of those lost to follow-up		
	1—Complete follow-up (all subjects accounted for)			
Selection of the non-exposed cohort	1—Drawn from the same community as the exposed cohort			
Ascertainment of exposure:	1—Secure record (medical records)			
Demonstration that outcome of interest was not present at start of study	1—Yes			
Comparability of cohorts on the basis of the design or analysis	1—Study controls for the single most important factor			
Assessment of outcome	1—Independent blind assessment			
Was follow-up long enough for outcomes to occur?	1—Yes			
Adequacy of follow up of cohorts	1—Complete follow-up (all subjects accounted for)			