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ADDRESSING KEY GAPS IN EXISTING LONGITUDINAL RESEARCH AND ESTABLISHING A PATHWAY FORWARD FOR FIREARM VIOLENCE PREVENTION RESEARCH

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Abstract

The main purpose of this article and this special section is to encourage greater attention to the key gaps that exist in our understanding of the epidemiology of adolescent firearm violence and to provide a pathway forward for future longitudinal research that will inform prevention efforts. This increased attention is especially salient given: (a) firearms are the leading cause of death for adolescents and emerging adults in the United States, with the majority of these deaths due to interpersonal violence; (b) significant health and social disparities with regards to the populations that are most affected by interpersonal firearm violence have been documented; and, (c) limitations in federal research funding during the past 30 years have created a deficit of knowledge about key risk and protective factors necessary to inform evidence-based prevention efforts. We discuss the implications of the articles in this special edition for existing and novel prevention programs. We also identify key considerations for future epidemiological research, including the need for a greater focus on collecting longitudinal data among nationally representative samples enriched with subgroups of at-risk youth, the need to examine the role of protective factors and mediating variables within existing and novel theoretical models of firearm risk behaviors, the need to examine key factors across all levels of the socio-ecological model, and the need to incorporate novel and innovative research designs, methods and analyses.

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IDENTIFYING SALIENT RESEARCH GAPS

In the United States, firearms are the leading cause of death for adolescent youth and emerging adults (age 10-24), with 56% of fatalities resulting from interpersonal violence (Centers for Disease Control and Prevention, 2018; Cunningham et al., 2018). Non-fatal firearm assaults also occur among youth populations at a rate more than twice that of the general U.S. population, with more than 30,000 injured severely enough every year to require medical treatment in an emergency department (ED) setting (Centers for Disease Control and Prevention, 2018; Cunningham et al., 2018). Long-term morbidity from firearm assault injuries remains substantial, with ~50% of hospitalized youth requiring disability and/or long-term rehabilitative care upon discharge from an inpatient setting (DiScala & Sege, 2004). Youth involved in firearm violence are at elevated risk for long-term health and social consequences, including a higher risk of subsequent fatal and non-fatal assault injuries (Cunningham et al., 2015; Rowhani-Rahbar et al., 2015), future firearm violence involvement (Carter et al., 2015; Rowhani-Rahbar et al., 2015), substance use disorders (Walton et al., 2017), mental health (e.g., anxiety, depression, PTSD) issues (Garbarino et al., 2002), and criminal justice (e.g., arrest, incarceration) involvement (Carter et al., 2018; Rowhani-Rahbar et al., 2015). Substantial disparities exist in these outcomes, with rates of firearm homicide, substance use disorders, and incarceration higher among Black youth residing in urban centers (Centers for Disease Control and Prevention, 2018; Cunningham et al., 2018). The economic costs of interpersonal firearm violence are substantial, with the acute medical treatment of hospitalized firearm assault injures alone estimated at nearly \$400 million annually before including the long-term costs associated with lost wages and productivity, long-term disability care, and the costs of legal proceedings (Peek-Asa et al., 2017). Given the substantial human and economic toll resulting from firearm violence, combined with a lack of progress addressing this problem over the past three decades, firearm violence is now recognized as a critical public health endemic (Christoffel, 2007) requiring increased attention by researchers, as well as leading public health organizations and policy-makers (Alper et al., 2019; Bauchner et al., 2017; Butkus et al., 2018; Dowd & Sege, 2012; Leshner et al., 2013; Office of Disease Prevention and Health, 2020; Ranney et al., 2017; Wintemute, 2013).

Building on this critical need, the Firearm Safety among Children and Teens (FACTS) Consortium was funded in 2017 by the National Institutes of Health (NIH), with a primary goal of convening a team of multi-disciplinary academic experts to catalyze the science of firearm injury prevention by stimulating novel research programs, creating a centralized data repository for secondary analyses of existing data, and training the next generation of public health scientists (Cunningham et al., 2019c). As a fundamental first step, the FACTS consortium conducted substantive scoping reviews of the existing extant literature from the past 30 years (Ngo et al., 2019; Oliphant et al., 2019; Ranney et al., 2019; Schmidt et al., 2019; Zeoli et al., 2019) and completed a rigorous nominal group process among 25 leading

scientists in the field to define a research agenda outlining critical gaps in our current knowledge and a pathway forward for future research (Cunningham et al., 2019a). As part of that agenda (Cunningham et al., 2019a), scientists identified that existing epidemiological data is largely cross-sectional in nature, limiting our ability to identify key risk and protective factors, the temporal ordering of these factors, and the causal relationships that exist between these risk factors and firearm-related outcomes. Researchers called for a greater focus on collecting longitudinal data that tests new and existing theoretical models to fully understand the epidemiology of firearm carriage, risky firearm behaviors, and firearm violence among adolescent and emerging adult populations (Cunningham et al., 2019a). The FACTS Consortium highlighted this as a fundamental first step in informing future prevention efforts addressing this public health problem.

ADDRESSING CRITICAL GAPS USING EXISTING LONGITUDINAL RESEARCH

In this special section of the *Journal of Clinical Child and Adolescent Psychology*, Drs. Pardini and Mulvey, the section editors, have brought together a series of outstanding contributions (Beardslee et al., 2019a; Pardini et al., 2020; Schulman et al., 2020; Sweeten & Fine, 2020) to the scientific literature that begin unravelling several questions raised in the FACTS research agenda through an examination of existing longitudinal data from the Pittsburgh Youth (PYS) Study (Loeber et al., 2011), the Pathways to Desistance Study (Mulvey, 2004), the Crossroads Study Shulman (2020), and the National Longitudinal Survey of Youth (Bureau of Labor Statistics US Department of Labor, 2008). In the lead off contribution to the special issue, Beardslee (2019a) examines the role of socio-economic disadvantage as a risk factor for future firearm violence involvement through the lens of social disorganization (Sampson & Groves, 1989; Sampson et al., 1997), social learning, and family stress theory (Conger et al., 1994). Social disorganization and social learning theories posit that economic disadvantage in urban communities leads to lower levels of social organization or control as a result of a lack of economic resources and opportunity, low residential participation in community organizations, reduced social investment from community institutions, high levels of residential mobility, and an elevated rate of single parent households (Maimon & Browning, 2010; Sampson & Groves, 1989; Sampson et al., 1997). The external stressors experienced by adult parents residing in communities characterized by high levels of disorganization is thought to lead to less parental monitoring of developing adolescent problem behaviors, allowing for more delinquent peer associations and a normalization of problem behaviors such as firearm carriage and violence (Brody et al., 2001; Dodge et al., 2006; Maimon & Browning, 2010; Simon et al., 1997; Wilkinson & Fagan, 2001). Further, family stress theory highlights that this economic instability also creates financial strain on young parents that serves to disrupt normal parent-child relationships, allowing for the emergence of childhood aggression and other problem behaviors that may progress to increasingly violent behaviors during later adolescence and young adulthood (Conger et al., 1994; Haegerich et al., 2014). Within this theoretical context, the authors examined whether peer delinquency and childhood conduct problems mediate the relationship between economic disadvantage and firearm violence in a longitudinal sample of over 500 male youth interviewed from elementary school (age 7)

through late adolescence and emerging adulthood (age 20), finding that socioeconomic disadvantage was associated with higher initial levels of peer delinquency and a greater emergence of conduct problems during childhood. This was also associated with an increased likelihood of later firearm violence involvement. While this relationship was significant, the authors also identified that the magnitude of this mediated effect was relatively small, indicating a need to explore alternative theoretical associations to explain this relationship in future research.

In the second paper, Pardini (2020), capitalizes on longitudinal cohort data from the Pathways to Desistance Study (Mulvey, 2004) to characterize the incremental contributions of a series of risk and protective factors for firearm violence beyond firearm carriage among more than 1,000 male juvenile offenders interviewed across ten waves spanning early adolescence into young adulthood. The authors investigate three models (self-protection model; antisocial propensity model; social influence model) posited to explain the relationships that exist between adolescent firearm carriage and violence outcomes, examining several risk factors in these models and their relationship to subsequent firearm violence involvement after controlling for co-occurring firearm carriage. They also examined prosocial protective factors that may counterbalance the negative consequences of the risk factors posited in these models. In the self-protection model (Beardslee et al., 2018; Oliphant et al., 2019; Spano & Bolland, 2013), adolescents are theorized to carry firearms as a means of self-defense because they reside in high crime neighborhoods where they have significant exposure to violence (e.g., witnessing violence, violent victimization) and criminal activity. In these settings, minor altercations often escalate to more lethal firearm violence in the presence of an available firearm. In contrast, the anti-social propensity model (Beardslee et al., 2019b; Oliphant et al., 2019; Spano & Bolland, 2013) posits that dispositional factors (e.g., impulse control problems, conduct problems) intersect with specific problem behaviors (e.g., substance use, buying/selling drugs) to increase the likelihood that youth will carry firearms and become engaged in more severe violence involving a firearm while carrying. In the social influence model (Beardslee et al., 2019b; Lizotte et al., 2000; Oliphant et al., 2019; Spano & Bolland, 2013), frequent social interactions with negative peers provides both easy access to firearms that they carry with them and establishes a social norm around carrying and using a firearm for self-protection and as a means to resolve conflicts or disputes with others. Within this context, the authors both confirm prior research demonstrating that firearm carriage and prior firearm violence involvement are robust risk factors for future firearm violence and extend the current literature by demonstrating that risk factors in the self-protection model (i.e., violence exposure), anti-social propensity model (i.e., drug selling, substance misuse, anti-social attitudes), and social influence model (i.e., gang membership, peer firearm carriage) are also independently associated with subsequent firearm violence, even after controlling for co-occurring firearm carriage. They also examined positive factors that helped protect against the risks they identified for future firearm violence involvement. These positive factors included adult social support, concern for others, religious beliefs, and aspirations for future work and family formation. Each of these positive variables continued to predict less firearm violence even after controlling for the role of the risk factors noted above.

In the third paper, Shulman (2020) examines within-person changes in internalizing (e.g., anxiety, depression) and externalizing (e.g., physical aggression) behaviors in response to either firearm victimization (i.e., shot with a firearm) or exposure to firearm violence (e.g., witnessing someone get shot) in a longitudinal sample of 1,216 first-time male juvenile offenders followed over a five year period. The authors identified that among this at-risk sample, youth experienced an increase in anxiety symptoms and physical aggression behaviors during waves where they were exposed to firearm violence (either through victimization or witnessing violence). These findings held even after controlling for relevant confounders, including exposure to non-firearm related violence. Further, the authors found that while exposure to firearm violence was associated with both pro-active and reactive forms of aggression, the link with reactive aggression behaviors was stronger. It is also important to note that there was no evidence for reverse causality in reciprocal effects models testing whether increased internalizing or externalizing symptoms increased the likelihood of exposure to firearm violence. Notably, the authors also found that firearm carriage was also noted to increase during waves when youth also noted an increase in exposure to violence. Taken together, the findings from this paper suggest a mechanism by which youth who are exposed to firearm violence experience significant mental health (e.g., anxiety) and behavioral health issues (e.g., reactive aggression) that may serve to perpetuate the cycle of violence if left untreated.

The final paper in this special edition (Sweeten & Fine, 2020) is focused further upstream, examining between- and within-person factors related to firearm carriage among nearly 9,000 youth interviewed across 10 waves from age 12 to 26 as part of the National Longitudinal Survey of Youth. In this nationally representative sample, the authors found an average past-year carriage rate of 4.8%, with 55% of youth reporting handgun carriage during a single 12-month wave of data collection. Developmental differences emerged in patterns of carriage, with younger-aged firearm carriers mostly carrying for short time periods (i.e., one 12-month wave) and infrequently carrying during that time period, while older handgun carriers report carrying persistently across multiple waves of data collection and were more likely to endorse carrying regularly (i.e., daily/near daily) in a habitualized pattern. Examining within-person factors, the authors identified that in waves in which handgun carriage was more likely, youth were also likely to have elevated social risk factors including neighborhood gang presence, peer gang membership, self-report of gang membership. They also found handgun carriage in this sample was associated with drug involvement (drug selling, illicit substance use) and crime facilitation (aggression, property crime, arrest). The authors also regressed past month carriage on past year risk factors, as well as past year carriage on prior year risk factors to establish temporal ordering of these risk factors in relation to the onset of carriage and to rule out reverse causation as a motive for the identified relationships. Further, in one of the first analyses that examines differences in carriage by gender, the authors found that while overall rates of handgun carriage were lower for female youth, they found no differences in the risk factors that precipitate carriage for male and female youth in this sample. Given the descriptive findings regarding variable carriage patterns between younger and older youth, the authors also examined differences in the key predictors by age, finding that while predictors for the drug involvement model remained stable between younger/older youth, they found that the presence of neighborhood

gangs and crime facilitation (i.e., prior arrest) were more salient risk factors for older youth compared to younger respondents.

IMPLICATIONS FOR PREVENTION PROGRAMS

The authors in this special edition (Beardslee et al., 2019a; Pardini et al., 2020; Schulman et al., 2020; Sweeten & Fine, 2020) make important contributions to our understanding of adolescent firearm behaviors and provide valuable data to inform on-going individual and community wide prevention efforts. First, consistent with other research (Branas et al., 2009; Cheng et al., 2006; DuRant et al., 1997; Lowry et al., 1998; Spano et al., 2008), data from the Pardini (2020) study found that adolescent firearm carriage was a robust risk factor for subsequent firearm violence despite controlling for prior violence involvement. This is consistent with other cross-sectional and longitudinal research demonstrating that adolescent youth who carry firearms are at increased risk for engaging in higher risk firearm (e.g., firearm aggression against peers/partners) behaviors (Carter et al., 2020b; Carter et al., 2015) and are at elevated risk for serious or fatal injury (Branas et al., 2009; Cheng et al., 2006; Cook, 1981; DuRant et al., 1997; Felson & Steadman, 1983; Loughran et al., 2016; Lowry et al., 1998; McDowall et al., 1992; Pickett et al., 2005). Firearm carriage among underage youth has been conceptualized as one part of a larger cluster of risk taking behaviors (e.g., drinking, fighting) that occur during adolescence and influence negatively developmental trajectories (Baumrind, 1987; Gabriel et al., 1996; Irwin & Millstein, 1986; Jessor, 1982, 1991). Initial risk behaviors are often characterized by minor forms of aggression (e.g., bullying, fighting) and less lethal (e.g., knife) weapon carriage (Elliott, 1994; Monahan et al., 2014) with progression to more severe behaviors such as firearm carriage, risky firearm behaviors (e.g., carriage while intoxicated), and interpersonal firearm (e.g., firearm threats/discharge at another person) violence (Loeber et al., 2013; Loeber & Hay, 1997; Loeber et al., 1993; Mustanski et al., 2013). Later stages of this problem trajectory are characterized by experiencing or perpetrating violent injuries (e.g., firearm injuries) against others, entry into the criminal justice system (i.e., arrest), and/or death (Elliott, 1994; Fontaine et al., 2014; Loeber et al., 2013; Menard & Huizinga, 1998). Within this framework, risk and promotive factors may accelerate or decrease this problem trajectory (Fontaine et al., 2014; Harris Abadi et al., 2011; Mustanski et al., 2013). The data presented within this special edition continues to emphasize the importance of early prevention efforts focused on addressing upstream factors such as first-time firearm carriage (Rivara, 2002), especially given that initiating firearm carriage has been demonstrated to be an important inflection point for adolescent youth in the trajectory of their violence involvement (Dodge, 2001; Spano, 2012). Further, given that most adolescent youth attain firearms through illegal channels (Carter et al., 2013), such findings also suggest a greater role for community programs and public policy initiatives that decrease illegal firearm acquisition by underage youth.

Yet, results from the Pardini study (Pardini et al., 2020) also demonstrate that the majority of youth that carry firearms do not engage in subsequent aggressive or risky firearm violence behaviors. This is consistent with data from intensive longitudinal daily diary (Carter et al., 2020a) and time-line follow-back (Carter et al., 2017b) studies indicating that firearm carriage alone does not fully explain an adolescent's increased risk of engaging in risky

firearm behaviors (RFBs). Future research is needed to understand the factors across socio-ecological levels that differentiates the trajectory of this sub-group of firearm carriers from those that engage in firearm violence as it may inform tailored prevention programs, harm reduction efforts, and the development of evidence-based behavioral interventions for risky firearm behaviors.

Second, data from studies in this special edition (Pardini et al., 2020; Sweeten & Fine, 2020) indicate that adolescent firearm carriage is an episodic behavior, especially among younger adolescents who both carried less frequently and for shorter durations than older adolescents, among whom firearm carriage was a more persistent and habitual behavior. While these carriage patterns are consistent with prior research (Arria et al., 1995; Dong & Wiebe, 2018; Lizotte et al., 1996; Loeber et al., 2004; Reid et al., 2017; Steinman & Zimmerman, 2003), the studies in this special section add to our current understanding by examining differences in risk factors for these carriage patterns across younger and older youth within the context of existing theoretical models. Sweeten (2020) examined within-person factors associated with the social influence, drug involvement, and crime facilitation models and found that while delinquent peer associations (e.g., friends that carry firearms/in gangs) and peer groups (e.g., gang membership) were salient risk factors across all ages, a history of selling drugs was a greater risk factor among younger youth and the presence of neighborhood gangs and a recent history of arrest differentially influenced the likelihood of carrying firearms among older youth. Given that a need for protection is consistently reported as a motive for adolescent carriage across all ages (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), such data indicates that intermittent carriage patterns among younger adolescents may be influenced more by situational motives (e.g., selling drugs) requiring protection within the context of engaging in other risky behaviors. Conversely, for older youth, persistent daily carriage may be motivated more by a general need to protect themselves from violence given greater overall involvement in illegal behaviors and/or recent associations with hard-core offender populations with whom they have had prior conflict. This is consistent with prior research showing that retaliatory violence is a key motive differentiating violent firearm encounters from other less lethal violence encounters (Carter et al., 2017b). Recent data (Sokol et al.) also suggests alternate factors may also be at play, with analyses examining the relationship between community violence exposure and firearm carriage through the lens of procedural justice theory (Novich & Hunt, 2018; Tyler & Wakslak, 2004; Watson & Angell, 2007), finding that youth reporting elevated community violence exposure are more likely to report ownership or carriage when they are also experiencing high levels of police distrust. Such data also suggests that youth may carry firearms to protect themselves because they don't trust police to provide community protection or because they have experienced prior negative police interactions due to racial profiling or implicit bias. Regardless, given that most behavioral interventions address the motives underlying risky problem behaviors and that distinctive intervention strategies are applied to planned aggression (e.g., non-violent conflict resolution, violence avoidance strategies) as compared to impulsive or reactive aggression (e.g., anger management/emotion regulation, impulse control strategies), future research that explores the difference in the motives underlying such behaviors, as well as

how motives may change across different periods of adolescence or contexts would be helpful for tailoring prevention programs to be relevant for different aged youth. Findings from this set of articles emphasize the importance of firearm violence prevention programs that include a focus on addressing co-occurring risk behaviors, retaliatory violence, and strategies for managing multiple forms of aggression. Further, the findings of newer research may also suggest an expanded role for implicit bias training for police, as well as ongoing community policing initiatives to establish greater trust between police services and residents of high-crime communities (National Research Council, 2004) as a component of community-level initiatives to address firearm violence.

Despite the key differences between younger and older youth, it is also important to note the overwhelming influence of the social influence variables on the likelihood of firearm carriage irrespective of age. This highlights the outsized role that peer influences have during adolescence, especially in regards to firearm behaviors (Goldstick et al., 2017; Goldstick et al., 2018; Steinberg & Monahan, 2007), and is consistent with data demonstrating that firearm violence is often concentrated among small peer groups, with a pattern of spread that mirrors an infectious disease context (Huesmann, 2018). The concentration of these behaviors within insular peer networks remains a principal factor in normalizing risky firearm behaviors among high risk youth groups and has been found to lead to an overestimation of the number of peers that actually carry or use firearms in their neighborhood (Hemenway et al., 2011). It is important to note that while the analyses within this special edition highlight the role of gang membership within this peer social context, analyses conducted amongst non-criminal justice samples (e.g., Emergency Department populations) also indicate that peer influences are a critical factor underlying risky firearm behaviors despite lower levels (<5%) of youth endorsing gang membership (Carter et al., 2020b). Regardless, such data emphasizes the importance of addressing firearm behaviors early in adolescence before they become habitualized, as well as the need to incorporate normative feedback around carriage within prevention initiatives that are also focused on enhancing motivation, self-efficacy, and cognitive and behavioral skills to avoid high-risk locations, negative illegal activities (e.g., selling drugs), and negative peer influences (Carter et al., 2016b; Walton et al., 2010). Recent data from the Flint Youth Injury (FYI) Study, a longitudinal cohort study of assault-injured youth (Cunningham et al., 2015), also suggests that enhancing positive prosocial peer support may be an effective countermeasure to negative peer influences. Sokol (2020a) conducted a within-person analyses among the FYI sample, finding that youth were less likely to carry firearms during waves where youth had more positive pro-social peer exposure than was typical for them. Future research should continue to explore the underlying factors that differentiate carriage patterns across different developmental periods as older and younger youth will likely require different interventional content to reduce risky firearm behaviors.

The Sweeten (2020) article is among the first to explore the differences in carriage that exist between male and female youth, finding that while female adolescents carry firearms at lower rates and for shorter durations than their male counterparts, the risk factors that precipitate firearm carriage among female adolescents remain relatively similar to those underlying firearm carriage for male youth. These findings are particularly novel, especially given most longitudinal studies have been unable to disaggregate handgun carrying by sex

due to low base rates of carriage among the female youth in their samples. It is important to note, however, that the focus of these models is primarily on identifying models of carriage related to non-partner (i.e., peer) violence outcomes. Given recent data from the national violent death reporting system (NVDRS) highlighting that over 60% of intimate partner homicides occurring amongst adolescents (age 11-18; 90% female youth) result from firearms, future research should also examine firearm carriage within the context of theoretical models that account for on-going violence occurring within adolescent dating relationships (Adhia et al., 2019; Kistin et al., 2019). While additional study is needed to fully understand the differences between male and female youth that carry to inform appropriate tailoring of prevention efforts, findings from the analyses in this special edition emphasize the need for existing individual and community interventions addressing carriage and risky firearm behaviors to be focused broadly among both at-risk male and female youth, and to consider both non-partner and partner mechanisms underlying violence outcomes.

Multiple articles in this special issue (Pardini et al., 2020; Sweeten & Fine, 2020) emphasize the importance of the relationship between substance use and firearm violence. Sweeten (2020) found that both using and selling drugs were robust risk factors for adolescent handgun carrying. Pardini (2020) found that selling/dealing drugs and heavy drinking were independent risk factors for firearm violence involvement. The relationship between substance use and firearm violence remains complex, with bi-directional mechanisms that differ by substance type. Alcohol is thought to precipitate firearm aggression and/or increase victimization risk primarily through pharmacological disinhibition, increasing the likelihood that low-level conflicts become lethal encounters when they occur in the presence of a firearm (Chermack & Giancola, 1997; Chermack et al., 2010). Given that adolescent alcohol use most commonly occurs within social contexts (McCabe et al., 2014) and that such social situations may enhance contact between youth with prior conflict, this may explain firearm violence that occurs after or during the context of social drinking. Alcohol consumption following conflict, however, may reflect use by adolescents as a coping mechanism, either to address negative affective symptoms or to calm themselves down following an firearm altercation (Carter et al., 2017b). Such mechanisms differ from those underlying the association between marijuana and firearm violence, which most often results from social contextual factors such as buying or selling drugs in potentially violent situations or carrying firearms as a means of protection while engaged in illegal drug-related behaviors (Goldstein, 1985; Hoaken & Stewart, 2003). Yet, researchers have also recently suggested a potential physiological mechanism underlying this association, finding that chronic long-term use of marijuana may increase aggressive behaviors by altering neural functioning within the pre-frontal cortex (Myerscough & Taylor, 1985; Schoeler et al., 2016). Illicit (e.g., heroin) and prescription (e.g., opioids, benzodiazepines, stimulants) drug use may be related to firearm violence outcomes through similar mechanisms, including co-occurring involvement in other problem behaviors (Jessor, 1987), acute pharmacological disinhibition (Boles & Miotto, 2003), or socio-contextual factors (Catalano et al., 2011; Murphy et al., 2014). Alternatively, youth engaging in firearm behaviors may utilize illicit and/or prescription drugs as a way to self-regulate aggressive impulses, treat pain following a violent encounter, or as a means of addressing undiagnosed mental health (e.g., anxiety) conditions (Martens & Gilbert, 2008).

Regardless, substance use remains a critical modifiable risk factor for a range of negative firearm-related outcomes in prior research (Carter et al., 2020b; Carter et al., 2020c; Carter et al., 2017b; Carter et al., 2015; Cunningham et al., 2015) and is an important risk behavior to address within existing and future firearm prevention initiatives.

The Shulman (2020) article also highlights the complex relationship that exists between mental health symptoms and firearm violence outcomes, especially among vulnerable youth populations. It is vital to note that serious mental illnesses such as schizophrenia, bipolar disorder, and acute psychosis are *not* a risk factor for firearm violence despite public and media perception to the contrary (Barry et al., 2013; McGinty & Webster, 2016). In fact, researchers have reported that only 3-5% of all violent events that are outwardly directed towards others, including firearm violence, can be attributed to those experiencing these serious mental illnesses (Swanson et al., 1990). However, Schulman (2020) highlights that firearm violence exposure, either directly through victimization (i.e., getting shot) or indirectly by witnessing violent firearm encounters occurring in their neighborhood, is associated with concurrent increases in mental health issues such as anxiety and behavioral issues such as aggression. Given that anxiety has been highlighted as a precursor symptom to other mental health issues (Gorman-Smith & Tolan, 1998) such as post-traumatic stress disorder (PTSD), such findings are consistent with research finding that a diagnosis of PTSD is predictive in cross-sectional and longitudinal analyses of violent injury recidivism, firearm violence outcomes, and the perpetration of risky firearm behaviors (Carter 2020b; Carter 2015; Cunningham 2015). Physiological symptoms associated with anxiety and PTSD states that result from repeated trauma exposure such as hyperarousal (e.g., heightened alertness, exaggerated startle responses, increased and labile anger states) are thought to contribute to this firearm violence risk by increasing outwardly aggressive behaviors towards others, while impaired processing, hypervigilance, and high rates of concurrent substance use that are associated with PTSD are thought to concurrently decrease normal defensive signals that lead to an increased risk for violent firearm-related victimization (Orcutt et al., 2002; Rich & Sullivan, 2001). This relationship emphasizes the need for individual-level firearm violence prevention programs to screen for violence exposure and mental health conditions such as anxiety and PTSD, as well as refer youth to appropriate treatment programs. In addition, the Shulman (2020) finding that the link between firearm violence exposure and physical aggression is more pronounced for reactive forms of aggression highlights the importance of incorporating strategies such as emotion regulation, anger management, and impulse control strategies in firearm violence prevention initiatives in addition to typical strategies for managing planned aggression. Finally, the findings of the Schulman article emphasize the need for expanded public policy initiatives that address the disparities in access to mental health services (Heflinger et al., 2006; Wells et al., 2001; Wu et al., 2002) that continue to exist within many communities experiencing elevated rates of firearm violence. In fact, one way to staunch the firearm epidemic may be to concentrate mental service availability in high violence communities as a way to break the cycle from firearm violence exposure to PTSD to subsequent reactive firearm aggression/use.

Researchers to date have mostly focused on delineating individual factors that increase risk for negative outcomes, with few exploring promotive factors that reduce or prevent negative firearm-related outcomes, including carriage and/or violence outcomes (Schmidt et al.,

2019). Pardini (2020), however, begins to move beyond this risk factor focused approach by examining several promotive factors (i.e., concern for others, future aspirations, religious beliefs, adult support) that decreased the risk of engaging in firearm violence. Importantly, these factors included both individual beliefs (assets) and social influences (resources) that are consistent with resilience theory. Resilience theory posits that negative adolescent developmental trajectories can be countered despite risk exposure by enhancing adolescents own internal assets (e.g., competence, coping skills, self-efficacy) for avoiding risk behaviors and strengthening the availability of external resources (e.g., parental support, adult mentoring, engaging in community activities) that serve to enhance positive youth development (Fergus & Zimmerman, 2005). Pardini's study helps to direct attention to modifiable promotive factors that build an adolescent's own intrinsic motivation to change these behaviors and help create supportive environments for healthy development. The findings of the current research continue to suggest that applying a resilience-based framework to the design of individual- and community interventions focused on reducing negative firearm-related behaviors is an essential ingredient in promoting positive youth development and addressing firearm violence risk.

Finally, the Beardslee (2019a), article highlights the role of early childhood socio-economic disadvantage on subsequent adolescent firearm behaviors, establishing a potential developmental mechanism for this relationship through greater exposure to delinquent peers in the face of lower neighborhood social cohesion, that in turn, leads to conduct problems and subsequent firearm violence involvement. This is consistent with place-based literature indicating that living in a higher income block group in neighborhoods with higher levels of collective efficacy serves to mitigate individual-level firearm violence risk (Braga et al., 2010; McNeeley & Wilcox, 2015). It is important to note, however, that the mediated effect in the Beardslee analysis was relatively small. This suggests that other unexplored mechanisms may also be operating that explain the role that economic disadvantage has in propagating firearm violence. Future research that examines mediating factors at ecological levels beyond the individual such as the physical qualities of the neighborhood (e.g., vacant lots, building decay) and social interactions in the neighborhood (e.g., neighborhood watch, social interactions) may be useful directions for future research. Regardless, these findings highlight the need for a comprehensive approach to addressing firearm violence that does not focus solely on individual-level prevention programs, but also addresses broader issues of community investment, early childhood development, parenting skills for young parents, and economic, academic, and employment opportunities for adolescents as they transition into emerging adulthood.

Community-level research on the effects of urban decay remediation and vacant lot greening interventions supports this approach, finding reductions in firearm assaults and violent crime, as well as concurrent improvements in several leading indicators of neighborhood (e.g., increased exercise activity, decreased community stress) health (Branas et al., 2011; Branas et al., 2016; Branas et al., 2018; Heinze et al., 2018; Hohl et al., 2019; Jay et al., 2019; Kondo et al., 2018; Rupp et al., 2020). Further, while not tested specifically for firearm violence, researchers have also reported that implementing multi-faceted interventions focused across all levels of the socio-ecological model (e.g., individual-level hospital/school-based behavioral interventions; socially-oriented mentoring programs;

community policing and greening) as a comprehensive package is efficacious reducing negative violence outcomes (e.g., ED visits for violent injury; police-reported assaults) (Heinze et al., 2016). Future research that expands on these findings by investigating whether additional interventions addressing the role of economic disadvantage show promise, as well as whether comprehensive interventions demonstrating efficacy for other forms of violence are applicable to decreasing firearm violence, specifically, would help strengthen our knowledge base for firearm violence prevention.

Importantly, Beardslee (2019a) also found that while race was associated with firearm violence in the bivariate model, this relationship was not significant in the multi-variate model after adjusting for the role of socio-economic disadvantage. This is consistent with research suggesting that race/ethnicity is largely a proxy for unmeasured socio-economic variables when accounting for firearm violence risk (Walker et al., 2016). However, this finding differs from other analyses that indicate that Black residents living in higher income neighborhoods have firearm injury rates mirroring those of lower income White residents (Beard et al., 2017) and research indicating that Black children are more likely to be hospitalized with firearm injuries than white children after adjusting for neighborhood socio-economic disadvantage (Carter et al., 2017a; Kalesan et al., 2016). Such data indicates that additional structural factors such as redlining, racial segregation, police distrust, and systemic racism may serve to concentrate firearm violence risk among Black adolescents (Reardon et al., 2015; Rothstein, 2017; Sampson, 2012; Sharkey, 2014). Future research needs to explore the influence of such factors, as well as include a focus on ecological levels beyond the individual level that may effect firearm violence outcomes and existing health disparities.

UNANSWERED EPIDEMIOLOGICAL QUESTIONS AND FUTURE RESEARCH DIRECTIONS

While the articles (Beardslee et al., 2019a; Pardini et al., 2020; Schulman et al., 2020; Sweeten & Fine, 2020) included in this special section provide a wealth of new data to inform the field, they also raise questions for future research (Cunningham et al., 2019a; Ranney et al., 2017). In the following section, we outline five key areas of focus for future epidemiological research that will inform the science of adolescent firearm injury prevention and guide evidence-based public health efforts to address the high rates of morbidity and mortality resulting from interpersonal firearm violence.

Importance of Prospective Longitudinal Research Studies

As noted above, a key limitation of the extant literature is that the majority of epidemiological research remains cross-sectional in nature, primarily due to the deficiency of federal funding for firearm-related research during the past twenty years (Carter & Cunningham, 2016a; Hemenway & Miller, 2013; Weinberger et al., 2015; Wintemute, 2013). This deficit limits our knowledge about the time-ordered causality of identified risk factors (i.e., simultaneity bias), the accumulated effects of multiple risk factor exposure, the effect of long-term chronic risk factors (as compared to short term exposure), and the timing of when exposure to certain risk factors may exert their greatest influence on firearm

violence outcomes, especially during the dynamic adolescent developmental period. Further, among the longitudinal research that currently exists, most analyses continue to focus on identifying between person factors that define high-risk sub-groups of youth in need of prevention, missing key within-person factors that may change or alter risk trajectories over time and largely neglecting ecological levels beyond individual and families that might inform behavioral and community prevention. As the studies in this special edition demonstrate (Beardslee et al., 2019a; Pardini et al., 2020; Schulman et al., 2020; Sweeten & Fine, 2020), examining high quality longitudinal data will allow researchers to account for the temporal and causal dimensions of epidemiological risk in relation to firearm violence outcomes. Future research that builds on this work, focusing on a more nuanced understanding of individual risk by examining both between and within person factors and community and structural factors that influence behavior may help expand the range of firearm-related predictors, identify community level modifiable risk factors, and focus attention on positive factors that help protect against risk factors for firearm violence. Further, given data within this special edition (Sweeten & Fine, 2020), as well as in the broader literature (Dong & Wiebe, 2018; Steinman & Zimmerman, 2003; Sweeten et al., 2013), highlighting differences in firearm behaviors between younger and older youth, future research should include an emphasis on examining such factors across critical adolescent transition periods, as well as among adult samples among whom firearm carriage is a legal behavior, to inform age appropriate prevention and harm reduction strategies. Finally, research focusing on both the direct effects of risk factors on outcomes and the mechanisms by which these effects may operate (i.e., mediating factors) needs to be expanded. This will also require application of more sophisticated analytic techniques such as group-based trajectory analyses, structural equation modeling, and multi-level modeling that allow for a more nuanced characterization of how identified risk factors contribute to key firearm-related outcomes.

Increased Focus on Diverse Nationally Representative Youth Samples

Other than the Sweeten article (Sweeten & Fine, 2020) that examined firearm carriage within a nationally representative sample, the longitudinal studies in this special section remain focused on firearm-related outcomes among high risk sub-samples of predominantly urban male youth, including male juvenile offenders (Pardini et al., 2020; Schulman et al., 2020) and delinquent adolescents (Beardslee et al., 2019a). While characterizing firearm violence among subsamples at increased risk for negative outcomes is important (Centers for Disease Control and Prevention, 2018; Cunningham et al., 2018), a focus on narrow urban youth subsamples (e.g., assault-injured Emergency Department youth, delinquent youth, juvenile offenders) continues to be a limitation of the extant literature as it precludes robust comparisons across at-risk subgroups, as well as the ability to generalize findings to the entire U.S. adolescent population. This is especially important in light of older research (Kingery et al., 1996; Sheley & Brewer, 1995) demonstrating that rates of lifetime carriage among rural and suburban youth parallel those of urban youth samples. Further, while nationally representative data exist (e.g., Youth Risk Behavior Surveillance System; National Longitudinal Study of Adolescent Youth), these studies are not traditionally focused on firearm related behaviors so they have a limited emphasis on understanding factors related to firearm risk, often omitting key variables beyond firearm carriage. These national samples

also often utilize school-based sampling techniques that may exclude youth at the highest risk for risky firearm behaviors (Carter et al., 2013; Chatterji, 2006; Ellickson et al., 1998; Ramirez et al., 2012), limiting generalizability. Further, given low base rates of firearm carriage among general community samples of youth (Schmidt et al., 2019), such studies often do not have the necessary sample size to examine differences across important subgroups. Given that the few studies characterizing firearm carriage among nationally-representative samples demonstrate carriage is a heterogeneous behavior (Dong & Wiebe, 2018; Oliphant et al., 2019; Vaughn et al., 2017), even among adolescent populations, future research dedicated to longitudinal analyses focused on characterizing carriage patterns, motives for carriage, and risk and protective factors for firearm violence within nationally representative samples is needed. This will also allow for comparisons across developmental periods, gender, diverse racial/ethnic subgroups, and geographic (rural/urban) differences with more robust estimates. Further, to counteract potential low base rates of carriage within general community samples, such studies should be enriched by oversampling at-risk youth populations and key sub-groups (e.g., rural youth) to allow for comparisons between distinctive at-risk subgroups and provide a more comprehensive understanding of the risk and protective factors related to firearm violence, as well as critical data needed to inform efficacious prevention initiatives enhanced by tailoring to specific sub-populations. Such data would also allow for characterizing national estimates that can help guide federal and state-oriented policy initiatives.

Examining Protective Factors and the Role of Mediating Variables

As the Pardini article demonstrates, most at-risk youth that carry firearms do not subsequently engage in firearm aggression and several pro-social factors (e.g., supportive adult mentors) have been identified that guard against negative firearm violence outcomes (Pardini et al., 2020). Despite these findings, research examining protective factors across ecological levels is lacking. Especially critical to developing effective evidence-based interventions is understanding the role of protective factors in promoting healthy development despite simultaneous exposure to individual- and community-level risk factors (Fergus & Zimmerman, 2005). Future research that expands on the variables studied in the Pardini article (Pardini et al., 2020) and also examines both compensatory (main effects) and protective (buffering or moderation effects) models of positive factors that reduce the negative consequences of risk factor exposure will aid tailoring of public health interventions that focus on enhancing positive factors in adolescent's lives. This approach will also help identify factors beyond the individual level, including those resources in communities that should be expanded in an effort to help enhance positive youth development and reduce firearm violence.

The articles in this special edition also highlight another key deficit in the current literature, specifically, adequate attention to the role of mediating variables and theoretical or explanatory models for high-risk firearm-related behaviors. Recent scoping reviews (Oliphant et al., 2019; Schmidt et al., 2019) highlight that existing literature is concentrated mostly on understanding the direct effects of individual-level risk factors on firearm violence outcomes. As the Beardslee article (Beardslee et al., 2019a) demonstrates, we have a need to examine the mediating effects of a range of variables on specific firearm-related outcomes.

Such analyses aid in establishing explanatory models and/or theoretical frameworks for these adolescent risk behaviors, providing a systematic means of understanding complex multi-faceted behaviors within the context of intersecting risk and protective factors. Future longitudinal research that includes a focus on empirically testing the role of mediating factors within the context of theoretically grounded explanatory models for firearm-related behaviors would be especially useful. In addition, given that most explanatory models for firearm carriage and violence behaviors are focused within an urban, male, youth context, there is a need for future research to expand on this framework with theoretical models that explain firearm carriage and violence outcomes among diverse populations that carry firearms (e.g., rural youth; female adolescents) and have not been a primary focus of prior research. This could help inform the development of evidence-based prevention programs that are effective addressing both proximal and distal risk and protective factors that may prevent or reduce negative outcomes and would allow more nuanced tailoring of such initiatives to the needs of high-risk populations.

Extending Research Beyond the Individual-Level

Another distinct gap in the existing literature requiring attention in future epidemiological research is the role of factors beyond the individual-level of the socio-ecological model. With the exception of the role of delinquent peers, few researchers have examined factors within the social or community levels, particularly the influence of school- or family-level variables (Oliphant et al., 2019; Schmidt et al., 2019). Further, existing literature examining community-level factors has either been narrow in overall scope or has relied on neighborhood variables derived from census tract data (e.g., % single parent households), potentially missing the key influences of such factors (e.g., neighborhood monitoring, social capital) on social relationships (Oliphant et al., 2019; Schmidt et al., 2019). Finally, limited policy-level variables have been examined in prior research related to interpersonal firearm violence, with a single cross-sectional analysis (Xuan & Hemenway, 2015) finding that stricter state-level firearm laws were associated with lower adolescent carriage, with that effect mediated by the effect of the law on adult firearm ownership. This highlights the need for future epidemiological research to examine the role of risk and protective factors across multiple ecological levels, especially understudied factors within the school- (e.g., school attachment, relationships with pro-social teachers, extra-curricular sports/programs, perceptions of school safety), family- (e.g., parental warmth, parental support, monitoring), and community-level (e.g., pro-social community organizations, neighborhood monitoring, neighborhood mentors, social capital, state-level firearm policy variables). Such studies need to include a focus on examining both the independent direct effects of such factors, as well as how cumulative exposure to multiple factors influences firearm-related outcomes among developing adolescent youth to continue to advance our knowledge.

Inclusion of Novel Measures and Innovative Research Designs

We also need to include longitudinal research that expands on the existing compilation of panel studies, as well as those used for the papers in this special edition (Beardslee et al., 2019a; Pardini et al., 2020; Schulman et al., 2020; Sweeten & Fine, 2020). While they are among the best longitudinal data we currently have, most were not designed to have a focus on firearm violence or are focused within narrow subpopulations, thereby limiting the range

of variables and research questions that can be studied. In addition, novel methods that capitalize on innovative m-health technologies (e.g., smartphone APPs; text-based surveys; passive data collection) and intensive ecological momentary assessments of risk behaviors (Anderson & Rainie, 2015; Bonar et al., 2017; Buu et al., 2017; Carter et al., 2020a) have not been widely applied in past firearm research despite their promise to provide valuable information to inform prevention efforts. Expanding beyond panel study designs will aid in addressing key deficits in the field, including the absence of valid and sensitive prospective measures of firearm behaviors (e.g., carriage, use, storage). Further, such data will provide a more nuanced understanding of the daily contextual factors (e.g., motives) behind adolescent firearm behaviors (Oliphant et al., 2019). Prior literature has highlighted broad categories of firearm carriage motives (e.g., protection), as well as how specific motives may differentiate firearm violence (e.g., retaliation) from other forms of adolescent fighting (Ash et al., 1996; Bergstein et al., 1996; Black & Hausman, 2008; Carter et al., 2013; Carter et al., 2015; Copeland-Linder et al., 2007; Freed et al., 2001; Hemenway et al., 1996; Mateu-Gelabert, 2002; Wilkinson & Fagan, 1996). Yet, few researchers have examined the nuances of such motives, or the role that daily cognitive factors (e.g., anger/mood, stress/anxiety, impulsivity) and co-occurring risk behaviors (e.g., buying/selling drugs, substance use, risky locations) may have in precipitating aggressive firearm behaviors and/or avoiding conflicts within the context of daily carriage. Further, while most youth indicate that they carry firearms for protection, existing research does not distinguish between general deterrence (i.e., carriage for protection because they live in a dangerous neighborhood) and specific deterrence (i.e., protection from a known assailant or from retaliation in response to a prior altercation) motives. As the Sweeten (2020) and Pardini (2020) articles demonstrate, firearm behaviors (e.g., carriage, use) are dynamic and underlying motivations may differ between younger and older youth, as well as in response to specific contextual factors. Recent research (Bonar et al., 2017; Carter et al., 2019; Carter et al., 2018) highlighting the feasibility and acceptability of intensive longitudinal daily data methods for prospectively collecting data about sensitive daily risk behaviors, including firearm carriage and violent aggression, suggests that a useful direction for future research would be to consider integrating burst EMA assessments as a component of larger traditional panel studies. Such data will expand our understanding of risky firearm behaviors, as well as inform the development of just-in-time adaptive behavioral (JITAI) interventions (Nahum-Shani et al., 2014) that provide dynamic real-time behavioral support that is highly tailored to the individual's needs at the time they are most in need of it and within the context of their daily behaviors.

CONCLUSION

The editors for this special issue have compiled an outstanding set of contributing articles and that advance our understanding of the epidemiology of firearm injury prevention within youth populations. Each of these studies leverages existing longitudinal data collected among unique samples to provide important information pertinent to understanding key factors related to the onset, persistence, and consequences of firearm carriage and violence. Such data will serve to inform the development of future evidence based interventions and prevention initiatives addressing risky firearm behaviors. The articles included within this special issue demonstrate the power of longitudinal data to answer such questions, but they

also illustrate the limitations of current data to examine issues associated with firearm violence. Given recent increases in federal funding (Cunningham et al., 2019b; Subbaraman, 2019) and a renewed interest in addressing this key public health issue among leading scientists and policy makers, this special issue is timely in helping inform research that needs to be done. The application of rigorous scientific methods has achieved considerable success in other disciplines of public health and injury prevention (e.g., motor vehicle crashes) and parallel research to advance the science of firearm injury prevention has the potential to reverse current trends in adolescent firearm deaths. It is our hope that the work of these investigators and the outlined research agenda will be a beginning for the kind of systematic research necessary to end the epidemic of firearm death and injury that plagues youth in the United States.

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