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INTENTIONAL VIOLENCE (S BONNE AND M CRANDALL, SECTION EDITORS)

Violent Trauma Reinjury and Preventive Interventions in Youth: a Literature Review

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Abstract

Purpose of Review This article reviews the literature on youth violent trauma reinjury regarding relevant demographic and clinical risk factors, reinjury characteristics, and the effectiveness of existing violence intervention (VIP) programs aimed at reducing reinjury.

Recent Findings The literature suggests that black race, being an older teenager, male sex, disadvantaged socioeconomic status, and having mental health conditions are risk factors for violent trauma reinjury. Experiencing an injury from violent trauma increases the likelihood of presenting with another violent injury and also increases the risk of mortality. Additionally, current VIP programs do not consistently demonstrate reinjury reduction and tend to be brief, temporary, and have short follow-up.

Summary There remains limited data on youth violent trauma reinjury and its risk factors. Also, VIP programs have exhibited mixed results regarding reinjury reduction. Continued assessment and research of predisposing features related to pediatric and young adult violent trauma reinjury is critically important.

Keywords Pediatric trauma · Violent injury · Violent trauma · Assault-related injuries · Intentional injuries · Trauma reinjury

Introduction

From 2010 to 2020, 59,542 child and young adult mortalities in the USA were related to violent-injury homicides [1]. Violent injury pertains to intentional firearm injuries (such as gunshot wounds), stab wounds, and physical assaults. Among children and young adults that survive a traumatic injury, there is a subset that will suffer from a subsequent traumatic injury. Trauma reinjury, which is a repeat presentation for separate injury events, has been well studied in the adult population, with rates ranging from 2 to 45% for violent injuries [2••, 3–6]. Violent trauma reinjury is less well studied in the pediatric population, with the few existing studies reporting rates of 1 – 37% [2••, 7–9, 10••]. Some of these studies extend into young adulthood [7–9]. Identifying youth at risk for violent trauma reinjury after a non-fatal index injury provides a unique opportunity for intervention and secondary prevention, and may ultimately reduce overall mortality due to injury.

Ascertaining the underlying risk factors for recurrent injury are important when designing and implementing interventions aimed at reducing violent trauma reinjury. The primary aim of this review was to review and summarize the existing literature on pediatric and young adult violent trauma reinjury regarding relevant risk factors and defining characteristics. The secondary aim was to summarize the literature that evaluate the effectiveness of existing violence intervention programs aimed at reducing pediatric and young adult violent trauma reinjury. The overall goal was to understand the current state of our collective knowledge on this topic to better guide further research and inform intervention strategies.

This article is part of the Topical Collection on *Intentional Violence*

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Characteristics of Violent Trauma Reinjuries

A variety of risk factors and relevant characteristics have been identified in a heterogenous body of literature that are associated with violent trauma reinjury in children and young adults. Study characteristics are described in Table 1, while Table 2 includes details pertaining to demographic risk factors for reinjury.

Age

Youth at highest risk for reinjury are older teenagers at the time of index injury. Cortolillo et al. found that children < 13 years old had lower rates of reinjury than 14 – 17-year olds (37% vs. 63%), and regression analysis showed that age < 13 years was not associated with reinjury ($p = 0.36$) [10••]. Tellez et al. found that the mean age for reinjury at the time of repeat injury was 21 ± 3 years, compared to 20 ± 3 years of age for the non-reinjury population ($p < 0.05$) [7]. Chong et al. found that the mean age of reinjury at time of repeat injury was 19 years (range 17 – 21) while the mean age of the non-reinjury population was 20 years (range 18 – 22); however, these findings were not statistically significant [8]. Cunningham et al. included patient age in their regression model to evaluate its association with assault related reinjury and did not find age to be statistically significant [9]. Another study found that reinjury from penetrating trauma was higher in the 0 – 19-year old cohort compared to the 0 – 16-year old cohort, indicating higher incidence in those between the ages of 17 – 19 years [11]. While the data is imperfect, it suggests that older teenage children who present with a violent injury are at higher risk of reinjury.

Sex

Male sex is also a commonly identified risk factor for reinjury after violent trauma, though some studies showed conflicting results. While it is more common for victims of index firearm injuries to be male, a number of violent trauma reinjury studies found male sex to also be a predictor for reinjury as well. In a study examining risk factors for assault-related reinjury, male sex was an independent predictor for reinjury (adjusted odds ratio [OR] = 2.00 [95% confidence interval (CI) 1.06 – 3.80], $p < 0.03$) [8]. Additionally, all of those experiencing reinjury in the Gibson et al. population that explored characteristics of reinjury in firearm victims were male [2••]. Another study found that reinjury rates were lower in females (18% vs. 82%) and that female sex was protective against reinjury (OR 0.55 [95% CI 0.42 – 0.71]) [10••]. Tellez et al. found no difference in sex distribution between the violent trauma reinjury and non-reinjury populations, but those undergoing reinjury were more likely to be male (92%) [7]. Cunningham et al. was the only study that found female sex to be predictive of assault-related reinjury (relative risk = 1.30 [95% CI 1.02 – 1.65], $p < 0.05$) [9]. This may be due to a gradual annual increase in female violence over time [12]. However, youth who at higher risk of violent trauma reinjury tend to be male.

Race and ethnicity

A number of studies found black race is associated with a higher risk of reinjury when compared to other races or ethnicities [2••, 7, 8]. Gibson et al. evaluated reinjury populations in firearm injury victims and found that 95% were black and 4% were Latino. The race of the non-reinjury population was not reported for comparison [2••]. Another study determined that victims of reinjury were more likely to be black (64%, $p < 0.001$) when compared to other races in their evaluation of reinjury [7]. Chong et al. found that a majority of reinjury patients were black (72%) and Latino (20%), but only black race was an independent predictor of violent trauma reinjury in their multivariate analysis (adjusted OR = 2.10 [95% CI 1.44 – 3.06], $p < 0.001$) [8]. However, one study did not find black race to predictive of reinjury (OR = 1.39 [95% CI 0.97 – 1.98]) [9].

Socioeconomic status and rurality

Only a few studies evaluating reinjury after violent trauma included additional demographic information such as socioeconomic status and type of insurance. Chong et al. showed that 26% of the reinjury population were uninsured, 68% had public insurance, and 6% had private insurance [8]. However, there was no statistically significant difference in insurance coverage compared with the non-reinjury population ($p = 0.08$) [8]. Another study showed that only 17% of the reinjury population had private insurance [10••]. In regards to socioeconomic status, 88% of those experiencing reinjury were considered to live in a neighborhood with low or low-middle socioeconomic status, defined as 12 – 19% and 19 – 40% of the population living below the federal poverty level, respectively [8]. In Cortolillo et al., 50% of patients with reinjury for assault lived in a household with a median income < $38,000 [10••]. Gibson et al. found that low socioeconomic status was determined to be a predictor of recurrent violent injury (OR 1.59 [95% CI 1.12 – 2.25], $p = 0.02$) and that 32% of reinjury victims were living in poverty [2••]. Descriptive characteristics and comparative analyses of the non-reinjury population were limited.

Gibson et al. found that, compared to the non-reinjury population home zip codes, the home zip codes of the reinjury population had a higher proportion of unemployment,

Table 1 Summary of reinjury journal articles for intentional violent injuries in children and young adults

Author, year	Journal	Location (population)	Type of study	Type of intentional injury	Study period (number of years)	Sampling frame	Patient population (*N*; ages)	Method for reinjury identification	Reinjured patients, *N* (%)	Non-reinjured patients, *N* (%)	Notes
Tellez, 1995 [7]	American Journal of Surgery	California (Trauma Admissions)	RC, SI chart review	Firearm, stab wound, assault	1/1/91–12/31/93 (3 years)	Every other consecutive patient	*N* = 552; < 25 years	Chart review for prior lifetime injury treated at same hospital	87 (16)	465 (84)	Bivariate analysis
Chong, 2015 [8]	Journal of Surgical Research	California (Trauma Registry)	RC, SI chart review	Firearm, stab wound, assault	1/1/05 – 12/31/10 (6 years)	All consecutive patients	*N* = 1890; 12 – 24 years	Followed for total of 2 – 8 years (until 12/31/2012) to identify subsequent injury	162 (9)	1726 (91)	Bivariate and multivariable analyses
Cunningham, 2015 [9]	JAMA Pediatric	Missouri (ED Patients)	PC, SI	Firearm, stab wound, assault	12/2/09 – 9/30/11 (1 year, 9 months)	All consecutive patients	*N* = 349; 14 – 24 years	Followed for 2 years after study sample obtained to identify subsequent injury	128 (37)	221 (63)	Bivariate and multivariable analyses
Gibson, 2016 [2••]	Journal of Trauma and Acute Care Surgery	New Jersey (Trauma Database)	RC, SI chart review	Firearm	2000 – 2011 (12 years)	All consecutive patients	*N* = 896; 0 – 18 years	Chart review over the same 12-year period	79 (9)	817 (91)	Comparison of reinjury and non-reinjury population zip codes
Cortolillo, 2020 [10••]	Pediatric Surgery International	22 states, 2048 hospitals (Nationwide Readmissions Database)	RC, MI chart review	Firearm, penetrating, assault	1/1/10 – 12/31/14 (5 years)	Patients with available data; qualified by ICD-9 codes	*N* = 46,294 [T], 12,585 [P], 7638 [F]; 0 – 17 years	Reinjury within 1 year identified by corresponding E-code with "late effects" modifier to exclude readmission from index injury	409 (1) [T] 109 (1) [P] 86 (1) [F]	45,885 (99) [T] 12,476 (99) [P] 7552 (99) [F]	Univariate and multivariable analyses

JAMA, Journal of the American Medical Association; *ED*, Emergency Department; *RC*, retrospective cohort; *SI*, single-institution; *PC*, prospective cohort; *MI*, multi-institutional; *T,* total assault-injured population; *P*, penetrating injury population; *F*, firearm injury population

Table 2 Risk factors for reinjury after intentional violent injury in children and young adults

Author, year	Reinjured patients, *N* (%)	Age of reinjury	Time to subsequent injuries	Sex (%)	Race/ethnicity (%)	Rural or urban	Socioeconomic status (%)	Type of insurance (%)	Mortality (%)	Key points
Tellez, 1995 [7]	87 (16)	Average: 21 y +/− 3	94% in prior 5 y	Male: 92	Black (64) Hispanic (22) Non-Hispanic White (12) Asian/Pacific Islander (2)	Urban	—	—	5	-5% had more than 1 prior injury -Average length of time between index and prior injury was 22 months
Chong, 2015 [8]	162 (9)	Average: 19 y	Median time was 20 m (1 w–7 y)	Male: 93	Black (72) Latino (20) White (3) Asian (3) Other (3)	Urban	Low (64)[a] Low-middle (24)[a] High-middle (10)[a] High (1)[a]	Public (68) Uninsured (26) Private (6)	—	-Reinjury victims were more likely to be male, black, be injured by firearms, and live in low socioeconomic locations
Cunningham, 2015 [9]	128 (37)	Average: 20 y	Most returned within 6 m	Female: 49	Black (64) Other (36)	Urban	—	—	—	-Reinjury victims returned to the ED with a diagnosis of PTSD/drug use disorder > 60% of the time -Assault injured had 2 × the reinjury risk for assault that non-assault injured
Gibson, 2016 [2••]	79 (9)	1% (< 14 y) 7% (14 y) 6% (15 y) 26% (16 y) 32% (17 y) 28% (18 y)	32% in 1 y 53% in 2 y 66% in 3 y	Male: 100	Black (95) Latino (4) White (1)	Urban	-Unemployed (16) -Household income ($40 K) -Household public assistance (40) -Children living in poverty (32)	—	8 (2nd)[b] 22 (≥ 3rd)[b]	-1% were seen more than twice for firearm injuries -Children have 1 in 12 chance of multiple firearm injuries -53% of reinjury victims were located in 4 zip codes
Cortolillo, 2020 [10••]	5278 (11) [T] 959 (8) [P] 772 (10) [F]	—	Within 1 yr	Female: 18	—	MET & NMET	—	—	—	-Firearm-injured patients are at significantly increased risk for readmission and reinjury

T, total assault-injured population; *P*, penetrating injury population; *F*, firearm injury population; *Y*, years; *W*, weeks; *M*, months; *MET*, metropolitan; *NMET,* non-metropolitan*; ED*, Emergency Department; *PTSD*, post-traumatic stress disorder

[a]Neighborhood socioeconomic status

[b]Number of reinjury visits

a higher percentage of female headed households without a partner, more vacant houses, greater population density, and lower school enrollment in children aged 15 – 19 years [2••]. Another study discovered that residence in zip codes associated with the lowest socioeconomic quartile had a 57% increased odds of reinjury from violent trauma compared to those living in zip codes with the highest socioeconomic quartile (adjusted OR = 1.57 [95% CI 1.11 – 2.22], $p = 0.01$) [8]. Most studies took place in urban or metropolitan environments, and few evaluated reinjury populations in rural or non-metropolitan environments [2••, 7, 8, 10••, 11, 13•].

Social factors

A few studies evaluated additional clinical and social factors for violent trauma reinjury and identified other aspects that place youth at increased risk of its occurrence, especially since victims of violent trauma have increased psychosocial needs [14]. Cunningham et al. identified post-traumatic stress disorder ($p = 0.008$) and drug use disorder ($p = 0.03$) as a risk factor for a repeat violent injury and death, with a greater than 60% chance of a return ED visit in patients that have both diagnoses and a 40% chance of return in patients that have either post-traumatic stress disorder or drug use disorder [9]. However, Tellez et al. reported no significant difference in alcohol or drug use between reinjury and non-reinjury populations [7]. Adult studies have shown incarceration, weapons use, housing instability, observation of violence, and murder of a family member to portend violent trauma reinjury, but a study of these factors in children and young adults is lacking [3, 15, 16]. Community level violence and parental risk factors that influence pediatric violent trauma reinjury have not been well studied. Gang membership is another risk factor for reinjury. Youth join gangs due to family connections, protection, respect, and financial gain [17]. They can be 3.5 times more likely to be involved in multiple physical altercations and are also 50% more likely to have experienced more than one episode of violent victimization within a year [17]. However, only one study commented on gang membership, with their results showing that no reinjury victims had suspected gang involvement [7].

Clinical characteristics and outcomes

A few studies have evaluated the clinical characteristics and hospital outcomes of youth violent trauma reinjury. One study showed no significant difference in injury severity score, disposition after trauma resuscitation, and intensive care unit length of stay for reinjured patients [8]. However, hospital length of stay was significantly different for the reinjury group (median 2.0 [interquartile range 1.0 – 6.0]) compared to those not reinjured (median 2.0 [interquartile range 1.0 – 4.0], $p = 0.02$) via Wilcoxon rank-sum test, but unadjusted logistic regression analysis showed no significant difference (OR 1.00 [95% CI 0.99 – 1.02], $p = 0.68$) [8]. Gibson et al. demonstrated higher rates of admission, need for step-down care or an intensive care unit, operative intervention, and mortality in the trauma bay for those presenting with recurrent firearm injuries compared to those that did not [2••]. In regards to index injury, leaving against medical advice was associated with a high risk of violent reinjury (OR 7.45 [95% CI 3.78 – 14.67]) [10••].

Mortality rates varied between studies for reinjured populations. Davis et al. found that 85% of those experiencing reinjury died due to firearm injuries and that reinjury mortality rates were 15% for firearm injuries and 4% for stab wounds [11]. For those that presented with firearm injuries at least three times, they had a mortality rate of 22% [2••]. Alternatively, Tellez et al. found no significant difference in mortality between reinjury and non-reinjury populations [7]. However, among reinjury victims that experienced assault-related injuries, four patients died, all due to firearms [7].

Mechanism of repeat injury

Among violent trauma reinjuries, the majority were due to firearm injuries. One study showed that in a subgroup of children and young adults injured by a firearm, 6% returned with a firearm-related injury [9]. For the patients that experienced recurrent violent injury in the study by Chong et al., victims were reinjured by blunt assault, stabbing, and firearms 11%, 11%, and 78% of the time, respectively [8]. However, firearm injury was the only significant mechanism associated with reinjury (OR 1.67 [95% CI 1.12 – 2.50], $p = 0.01$) [8]. Davis et al. demonstrated that 69% of their 0 – 19-year old cohort and 75% of their 0 – 16-year old cohort that experienced a firearm injury in their index injury had a repeat firearm injury with their recurrent injury [11]. In all other reinjuries from repeat mechanisms, including non-violent incidences, reinjury from the same mechanism only occurred 19 – 22% of the time [11].

Mechanism of index injury

Not only were firearm injuries the most common mechanism of repeat violent trauma, they were also a risk factor for reinjury itself. Cortolillo et al. showed that firearm injuries were significantly associated with an increased risk of reinjury compared to non-firearm injuries (1% vs. 0.9%, $p = 0.01$) [10••]. Another study determined that a higher proportion of the reinjury population presented with penetrating trauma during their index admission as compared to the non-reinjury population (28% vs. 16%, $p < 0.001$), and a larger proportion of reinjury victims experienced firearm or stabbing injuries, as compared to those not experiencing

reinjury (11% vs. 8% and 9% vs. 6%, respectively, $p < 0.001$) [13•]. Overall, these authors identified penetrating injury to be a significant risk factor for reinjury (OR 2.12 [95% CI 1.96 – 2.28]) [13•]. Intentional violent injury was also a significant risk factor for reinjury when compared to unintentional injury (OR 1.52 [95% CI 1.40 – 1.64]) [13•].

Reinjury encounters and length of follow-up

There was a subset of patients that presented with more than one episode of violent trauma reinjury, with one study showing that 5% of the reinjury population presented with more than one prior injury [7]. Of those victims, 57%, 25%, and 18% were due to assaults, stab wounds, and firearm injuries, respectively [7]. Other authors estimated firearm injuries estimated a greater than 1 in 12 chance of being shot multiple times [2••]. Gibson et al. reported that 1% of victims presented more than twice for firearm injuries [2••].

Reinjury capture is inherently dependent on the length of time a population is followed, and among the studies reviewed, there was large variation in length of follow-up, ranging from 1 to 20 years. In general, reinjury occurred within 2 years of the initial injury. In one study evaluating firearm injuries, 32%, 53%, and 66% of subsequent injuries occurred within 1, 2, and 3 years of the index injury, respectively [2••]. Tellez et al. reported the average time to subsequent injury was 22 months and that 94% of reinjury victims presented within 5 years [7]. Chong et al. reported that the median time to reinjury was 20 months with a range from 1 week to 7 years [8]. Another study noted that most reinjury episodes occurred within 6 months and that 37% returned within 2 years [9]. There were also very few studies that discussed further injuries past the initial reinjury incident in specific detail [7].

Cost considerations

Studies in the pediatric and young adult population have shown different average cost estimates based on mechanism of injury and hospitalization for management of violent injury. A 2007 study utilized year-2000 US converted costs from multiple combined national data sets to estimate medical and productivity costs [18]. Overall costs for patients 0–24 years old that experienced assault injuries were estimated at $1.7 billion for medical costs and $14 billion in lost productivity, whereas fatality costs were estimated at $33 million for medical costs and $9 billion in lost productivity [18]. Pediatric firearm injuries were estimated to cost $12,984 per patient in a study that evaluated the Healthcare Cost and Utilization Project Kids' Inpatient Database from 2003 to 2012 [19•]. For stab wounds, the Centers for Disease Control's nonfatal average hospitalization costs per patient for 2019 were estimated to be $45,282 for medical costs, $9135 for work life costs, and $25,822 for quality of life costs, while for assaults, the estimated average costs were $58,566 for medical costs, $9135 for work life costs, and $145,080 for quality of life costs [20]. Tellez et al. compared mean hospitalization costs between the reinjury and non-reinjury populations and found no significant difference; however, this study was performed from 1991 to 1993 [7]. There is a paucity of literature regarding costs in relation to violent injury pediatric and young adult reinjury.

Violent Injury Interventions for Reinjury Prevention

Studies evaluating the impact of interventions to reduce and prevent violent trauma reinjury have been performed with varying results [14, 21–26]. Randomized control trials and other studies evaluating interventions to prevent violent injuries demonstrated reinjury rates ranging from 0 to 8% in the intervention groups and 2 – 20% in the control groups [14, 21–29]. With follow-up varying from 6 months to 2 years, some interventions showed no significant difference in reinjury compared to controls; however, the statistical methods used, mechanism of injury, location, and populations studied were notably varied (Table 3) [22].

Hospital-based interventions

Caught in the Crossfire, a program aimed at preventing violence and providing positive role models through peer-based methods, was evaluated to understand its effectiveness at preventing subsequent hospitalization for a violence-related injury in a 6-month follow-up period after the initial injury [21]. However, there was no significant difference in hospitalization or reinjury rates between the treatment and control group [21, 25]. Another study that evaluated the cost-effectiveness of hospital-centered violence intervention programs showed a reinjury rate of 4% in the control group and 3% in the intervention group, though no statistical analysis was performed between the groups [29].

Aboutanos et al. evaluated using brief violence intervention (BVI), which consisted of motivational interviewing, psychoeducation, and cognitive-behavioral therapy during hospitalization, in conjunction with community case management services (CCMS) to reduce violent trauma reinjury in those injured by assault, firearms, or stab wounds. BVI and CCMS were compared against BVI alone and there was no difference between the two groups [26].

Zun et al. showed that significant violent trauma reinjury reduction occurred in a treatment group after case management services were utilized after patients presented to the Emergency Department (ED), with a post-violent injury self-assessment depicting an 8% and 20% report of

Table 3 Pediatric and young adult trauma reinjury and violence intervention programs for intentional violent injuries

Author, year	Journal	Study location	Type of study	Type of intervention	Number of patients	Age of patients	Reinjury rate, %	Significance	Follow-up interval
Marcelle, 2001 [27]	Wisconsin Medical Journal	Wisconsin	Retrospective cohort review	Community-based	218 (all intervention)	10 – 18	Intervention: 1.4	---	Up to 2 years
Becker, 2004 [21]	Journal of Adolescent Health	California	Retrospective case–control	Hospital-based	112 (43 intervention, 69 control)	12 – 20	Intervention: 2.3 Control: 1.5	Unreliable OR (cell numbers <5)	6 months
Borowsky, 2004 [23]	Pediatrics	Minnesota	Randomized control trial	Primary care-based	224 youth-parent pairs (112 intervention, 112 control)	7 – 15	Intervention: 1.1 Control: 7.2	Adjusted OR: 4.70 (95% CI 1.33 – 16.59, $p=0.02$)	9 months
Zun, 2006 [24]	American Journal of Emergency Medicine	Illinois	Randomized control trial	Emergency Department-based with case management	188 (96 intervention, 92 control)	10 – 24	-Self-reported victim of violence: Intervention: 8.1 Control: 20.3	Self-reported victim of violence ($\chi^2=3.87$, $p=0.05$)	12 months
Shibru, 2007 [25]	Journal of the American College of Surgeons	California	Retrospective cohort review	Hospital-based	154 (75 intervention, 79 control)	12 – 20	Intervention: 8.0 Control: 9.0	RR = 0.90 (95% CI 0.32 – 2.56, $p=0.97$)	18 months
Cheng, 2008 [22]	Pediatric Emergency Care	Maryland	Randomized control trial	Emergency Department-based with case management	50 (25 intervention, 25 control)	12–17	-Youth report: Intervention: 0.0 Control: 8.0 -Parent report: Intervention: 0.0 Control: 14.3	-Youth report: OR: 0.19 (95% CI 0.01 – 4.22) -Parent report: OR: 0.12 (95% CI 0.01 – 2.42)	6 months
Cheng, 2008 [14]	Pediatrics	Maryland	Randomized control trial	Community-based	166 families (87 intervention, 79 comparison)	10 – 15	Intervention: 5.7 Control: 7.8	Adjusted rate ratio: 0.58 (95% CI 0.09 – 3.94)	6 months
Aboutanos, 2011 [26]	Journal of Trauma Injury, Infection, and Critical Care	Virginia	Randomized control trial	Hospital- and community-based	75 (36 BVI [group 1], 39 BVI + CCMS [group 2])[a]	10 – 24	Groups 1 and 2 at 6 weeks: 0.0 Groups 1 and 2 at 6 months: 6.0	---	6 months
Chong, 2015 [29]	The American Journal of Surgery	California	Cost-effective analysis	Hospital-based	511 (155 intervention, 356 control)	12 – 20	Intervention: 2.5 Control: 4.0	---	1 year

BVI, brief violence intervention; *CCMS*, community case management services; *OR,* odds ratio; *CI*, confidence interval; *RR*, relative risk

[a] *BVI* consists of motivational interviewing, psychoeducation, and cognitive-behavioral therapy while *CCMS* consists of community-based youth and family case management

violence in the treatment and control group, respectively ($\chi^2 = 3.87$, $p = 0.05$) [24]. Another ED intervention that utilized dedicated case management services was implemented to decrease violent behavior and the risk of reinjury [22]. Results of this case management services intervention also showed no significant difference between the intervention and control (OR = 0.19 [95% CI 0.01 – 4.22]) over a 6-month follow-up period [22].

Community- and outpatient-based interventions

Borowsky et al. established an outpatient primary care-based intervention, which focused on addressing mental health, promoting healthy child-parent relationships, and implementation of a telephone-based parenting education program called Positive Parenting. In follow-up, parents reported a fight-related reinjury rate in their children of 1% in the intervention group and 7% in the control group ($p = 0.02$) [23]. Cheng et al. studied a violent trauma reinjury intervention that included violence prevention through mentorship and family health education to provide parental monitoring and case management services [14]. Assessment of the intervention with the comparison group, which received a list of community of resources, showed a reduction of fight injuries in the intervention group by 42% at the 6-month follow-up period through self-assessment (adjusted RR = 0.58 [95% CI 0.09 – 3.94]), but this reduction was not statistically significant [14].

Project UJIMA, which is another preventive intervention program that utilizes community-based, home visiting services, was also evaluated. An early preliminary study evaluating Project UJIMA showed a reinjury rate of 1% [27]. A separate analysis performed a decade later in a non-peer reviewed best practice guide for launching violence intervention programs showed no significant difference in repeat violent injury between the intervention group (0 patients [0%]) and control group (8 patients [9%], $p = 0.06$) [28].

Future Directions for Risk Factor Determination and Violence Intervention Programs

The literature that exist suggests that the demographic and clinical risk factors which portend pediatric and young adult violent trauma reinjury include black race, being an older teenager, male sex, disadvantaged socioeconomic status, and experiencing mental health conditions such as post-traumatic stress disorder and drug use disorder. Those that experience violent trauma injury are also more likely to present again with a violent injury and have an increased risk of mortality. Additionally, the literature most commonly focuses on firearm injuries, which has elucidated that certain populations have a higher likelihood of reinjury than others. More research regarding social, demographic, and clinical patient-level risk factors in addition to neighborhood level factors and the victim's environment, is needed to more precisely identify the children and young adults most at risk for violent trauma reinjury so that specific interventions can be created, tailored, and implemented.

Violent trauma reinjury is an important area for injury prevention efforts. Various violence intervention programs have been developed at the hospital-, ED-, and community-level to address violent injuries. However, current violent injury prevention programs fail to consistently demonstrate reduction in violent trauma reinjury. Intervention strategies tended to be brief and temporary, lasting for a limited amount of time. Study follow-up for the interventions was also short, lasting no more than 1 year for most studies. Future research on violence intervention programs should focus on implementation of the intervention programs for longer periods of time and include follow-up beyond 1 year. Interventions should extend past the ED- and/or hospital-course to include the post-discharge period to more effectively address contributing socioeconomic factors.

Given that the risk of violent trauma reinjury is highest in older teenagers, consideration of adult data evaluation may also be important and relevant. Inclusion of young adults provides opportunity to capture the true incidence and risk of violent trauma reinjury since there may be a subset of patients that experience their repeat injury in early adulthood. While many barriers exist to obtaining data for older adolescents through adulthood, overcoming these challenges is potentially critical for thorough, effective evaluation and prevention.

Preventive Education and Clinical Screening Tools

In addition to continuing to strengthen violence intervention programs, there are other aspects that are important for consideration in preventing violent trauma reinjury. Trauma centers, in particular the ED, are key for reducing violent trauma reinjury in children and young adults, especially since they may be the only connection the patient has with the healthcare system [30, 31]. This is especially important since many patients are discharged from the ED without admission. Utilizing time while in the ED to intervene and provide education immediately after the injury can be critical in preventing injury recurrence [32]. However, providers are frequently unable to perform preventive education due to lack of time, resources, proper training, and concerns about safety [31, 33, 34•]. Recognizing ways to reduce barriers to effectively provide violence prevention intervention could assist with reducing reinjury.

Development and utilization of efficient clinical screening tools for various risk factors for reinjury in the immediate setting after injury could be a means of surmounting the aforementioned barriers for identifying victims who have the highest risk of reinjury and who need preventive education. In particular, screening youth at risk for violent injury retaliation, carrying a weapon, substance use, and post-traumatic stress disorder may be of particular importance [31, 34•]. Assessing a patient's psychosocial needs for post-discharge services is also a relevant consideration. However, such screening tools that have been validated and standardized for efficient use are scarce [31]. Further development and adaptation of screening tools could be important as another method of preventing recurrent injury. Helping and educating providers as to ways they can implement violent reinjury risk assessment and preventive measures are also keys.

Population-Level Disparities and Public Health Considerations

The propagation of violence should be treated as a public health epidemic [35]. Therefore, consideration of disparities that exist at the population- and community-level, and how interventions can be implemented within those spheres, also warrant investigation for ultimately preventing violent trauma reinjuries. Systemic racism within minority populations is a risk factor for violence and its perpetuation in youth; its existence leads to isolation, a high sense of perceived danger, lack of ability for communities and families to protect children, and a higher degree of psychological trauma that limits a child's ability to manage stress [35, 36]. Other aspects such as poverty and equitable access to housing, education, and healthcare also contribute to the cycle of violence [35, 36, 37••]. Additionally, a lack of urban green spaces, which are open-areas containing natural environment, has also been shown to be associated with violence in addition to crowding, noise, and high temperatures [38–40]. Taking these population- and community-level factors into account is critical for intervention creation and implementation, particularly for ensuring any intervention has a long-term impact in preventing violent reinjuries.

Consequently, ascertaining which communities are most at risk of violent reinjury via geographic assessment is critical to identify where efforts should be targeted at the population- and community-level. A measure of socioeconomic status at the neighborhood-level, the Area Deprivation Index, ranks socioeconomic status by utilizing factors that include employment, level of education, housing quality, and income [41, 42]. Another neighborhood-level measure called the Childhood Opportunity Index maps the quality of resources that help children grow in a healthy manner, such as education, health and environment, and social/economic factors [43]. Utilization of such indices in relation to violent injuries could indicate which youth are more at risk of reinjury depending on the neighborhood they live in. Measures relating to public health advocacy, provision of mental health resources, family support, firearm violence policies and preventive education, and school programs could then be subsequently implemented to prevent not only reinjury but also the index injury [35, 44, 45].

Conclusions

There remains limited data on pediatric and young adult trauma reinjury as regards to violent injuries in addition to the risk factors that lead to its occurrence. Additionally, the existing data are heterogenous. Violent injury prevention programs have demonstrated mixed results when it comes to repeat injury risk reduction, but most have shown minimal impact and long-term outcomes are unknown. The continued assessment of predisposing features and social determinants related to pediatric and young adult violent trauma reinjury on an individual-, community-, and population-level is critically important, such that sustainable data-driven interventions aimed at effectively preventing repeat injuries can be developed.

Declarations

Conflict of Interest The authors declare no competing interests.

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•• Of major importance

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