The Turkish Journal of Pediatrics 2022; 64: 971-984
https://doi.org/10.24953/turkjped.2021.4564

Original Article

Clinical characteristics of firearm-related injuries in children in Turkey

Göksel Vatansever[1], Hayri Levent Yılmaz[2], Tuğçe Nalbant[3], Murat Kanğin[4], Habip Almış[5], Alper Köker[6], Mehmet Çeleğen[7], Özlem Tekşam[8], Gülçin Bozlu[9], Merve Havan[10], Ali Ertuğ Arslanköylü[11], Okşan Derinöz Güleryüz[12], Fatih Battal[13], Pınar Yazıcı Özkaya[14], Nazik Yener[15], Dinçer Yıldızdaş[16], Rıdvan Duran[17], Deniz Tekin[1], Betül Ulukol[18], Tanıl Kendirli[19], Turkish Pediatric Firearm Study Group*

Divisions of [1]Pediatric Emergency Medicine, [18]Social Pediatrics and [19]Pediatric Intensive Care, Department of Pediatrics, Ankara University Faculty of Medicine, Ankara; Divisions of [2]Pediatric Emergency Medicine and [16]Pediatric Intensive Care, Department of Pediatrics, Çukurova University Faculty of Medicine, Adana; [3]Divisions of Pediatric Emergency Medicine, Department of Pediatrics, Tepecik Education and Research Hospital, İzmir; [4]Division of Pediatric Intensive Care, Department of Pediatrics, Sağlık Bilimleri University, Gazi Yasargil Training and Research Hospital, Diyarbakır; [5]Department of Pediatrics, Adıyaman University Faculty of Medicine, Adıyaman; [6]Division of Pediatric Intensive Care, Department of Pediatrics, Antalya University Faculty of Medicine, Antalya; [7]Division of Pediatric Intensive Care, Department of Pediatrics, Afyon University Faculty of Medicine, Afyon; [8]Division of Pediatric Emergency Medicine, Department of Pediatrics, Hacettepe University Faculty of Medicine, Ankara; [11]Division of Pediatric Intensive Care, [9]Department of Pediatrics, Mersin University Faculty of Medicine, Mersin; [10]Division of Pediatric Intensive Care, Mersin City Hospital, Mersin, [12]Division of Pediatric Emergency Medicine, Department of Pediatrics, Gazi University Faculty of Medicine, Ankara; [13]Department of Pediatrics, Çanakkale Onsekiz Mart University Faculty of Medicine, Çanakkale; [14]Division of Pediatric Intensive Care, Department of Pediatrics, Ege University Faculty of Medicine, İzmir; [15]Division of Pediatric Intensive Care, Department of Pediatrics, Ondokuz Mayıs University Faculty of Medicine, Samsun; [17]Department of Pediatrics, Trakya University Faculty of Medicine, Edirne, Türkiye.

ABSTRACT

Background. A significant number of children are injured by or die from firearm-related incidents every year, although there is a lack of global data on the number of children admitted to pediatric emergency departments (PEDs) and pediatric intensive care units (PICU) with firearm injuries. This study is the most comprehensive analysis of firearm injuries sustained by children in Turkey to date.

Methods. This multicenter, retrospective, cohort study was conducted between 2010 and 2020 with the contributions of the PEDs, PICUs, intensive care units, and surgery departments of university hospitals and research hospitals.

Results. A total of 508 children were admitted to hospital with firearm-related injuries in the research period, although the medical records of only 489 could be obtained. Of the total admissions to hospitals, 55.0% were identified as unintentional, 8.2% as homicide, 4.5% as self-harm, and 32.3% as undetermined. The Glasgow Coma Scale (GCS) and ventilation support were found to be the most significant predictors of mortality, while head/neck injury, length of stay (LOS) in the hospital and surgical interventions were found to be the most significant predictors of disability. The overall mortality of firearm-related injuries was 6.3%, and the mortality for children admitted to the PICU was 19.8%. The probability of disability was calculated as 96.0% for children hospitalized with firearm injuries for longer than 75 days.

Conclusions. Head/neck injury, LOS in the hospital, and surgical interventions were found to be the most significant parameters for the prediction of disability. Hospitalization exceeding 6 days was found to be related to disability.

Key words: firearm injuries, disability, mortality, pediatric emergency medicine, pediatric intensive care.

✉ Göksel Vatansever
vatansevergoksel@gmail.com

Received 12th October 2021, revised 4th July 2022, accepted 1st August 2022.

Firearm-related injuries are an important health problem, leading to both serious morbidity and death in children.[1,2] According to the American Academy of Pediatrics' 2012 policy statement on firearm injuries, firearm-related deaths are one of the three main causes of death among children in the United States aged 1–17 years, and the cause of 25.0% of the deaths in adolescents aged 15–19 years.[1] It is the second leading cause of injury-related death in this age group, surpassed only by motor vehicle injury deaths in the United States.[3] Many such injuries are present to pediatric emergency departments (PEDs) and pediatric intensive care units (PICUs). Pediatric emergency departments play an important role in the treatment of firearm-related injuries, with approximately 20,000 children presenting to PEDs with firearm-related injuries in the United States every year.[2]

Despite the significant number of child victims of firearm-related injuries and deaths, there is a distinct lack of data on children admitted to PEDs, hospitals and PICUs with firearm injuries. Previous studies of firearm injuries among children have focused on particular outcomes, such as death or hospitalization, or certain types of firearms injury, such as homicide or assault.

There is a lack of information about firearm-related deaths, sequelae and injuries in children and adolescents in Turkey. The aim of this study was to investigate the characteristics of children aged 0–18 years admitted to hospital with firearm-related injuries in Turkey to identify the factors determining the mortality and morbidity associated with firearm-related injuries.

Material and Method

This multicenter, retrospective, cohort study was conducted between January 2010 and August 2020 with the involvement of PEDs, emergency departments, PICUs, general intensive care units and surgery departments of university hospitals and research hospitals in Turkey. After the enrollment of 26 centers, patients under 18 years of age with admissions for firearm-related injuries were identified and included in the study. Diagnoses were established based on the International Classification of Disease 10th edition codes (W32-Accidental handgun discharge and malfunction, W33-Accidental discharge of hunting rifle, initial encounter, W34-Accidental discharge and malfunction from other and unspecified firearms and guns, X73-Intentional self-harm by rifle, shotgun and larger firearm discharge, X74-Intentional self-harm by other and unspecified firearm and gun discharge,Y23-Rifle, shotgun and larger firearm discharge, undetermined intent, Y24-Other and unspecified firearm discharge, undetermined intent, Y35.0- Legal intervention involving firearm discharge). Patients aged ≥18 years who presented to hospital with firearm-related injuries, and those whose file data could not be accessed, were excluded from the study. The study protocol was approved by the Ethical Committee of Ankara University (I7-448-20) and it was conducted in accordance with the principles of the Declaration of Helsinki.

For the purpose of the study, a firearm-related injury was defined as a gunshot wound or penetrating injury from a handgun, rifle, shotgun or other such weapon. The garnered demographic information included age at the time of admission to the hospital and gender. The patients were categorized into four groups based on their ages, similar to previous studies (0–4, 5–9, 10–14, and 15–17 years).[4,5]

There are standard definitions used for firearm-related injuries, including homicide, self-harm, unintentional and undetermined. The region of injury is defined based on eight categories, being head and neck, spine, chest, abdomen, extremity, skin, multiple and others. Multiple injuries are defined as three or greater in number in more than one body region. In the study, it is the injuries that are tabulated, not the patient, and so some patients may be included in more than one category. The setting in which the injury was sustained was defined in four categories: home, street, other and unknown.

The Glasgow Coma Scale (GCS) was used to evaluate patient state upon admission to the emergency department based on which they were categorized as mild (13–15), moderate (9–12) or severe (≤8). The Emergency Severity Index (ESI) triage instrument was used for patients who underwent an immediate life-saving intervention in the emergency department. Life-saving interventions were defined as those occurring within the first hour of arrival to the ED, and included airway and breathing support (intubation or emergent noninvasive positive pressure ventilation), electrical therapy (defibrillation, emergent cardioversion or external pacing), procedures (including chest, pericardiocentesis or open thoracotomy), hemodynamic support (significant intravenous fluid resuscitation in the presence of hypotension, blood administration or control of major bleeding) and emergent medications (naloxone, dextrose, atropine, adenosine, epinephrine or vasopressors).

All patients were evaluated in terms of hospitalization, LOS in the hospital and PICU, surgical procedures and discharge status according to the type of injury. The surgical procedures were tabulated rather than the patients, and so some patients may be included in more than one classification. Patients admitted to the PICU were evaluated in terms of LOS, respiratory support, circulatory support (fluid resuscitation, inotropes, blood product transfusion, and multiples thereof), and discharge according to the type of injury.

The World Health Organization International Classification of Functioning, Disability and Health (ICF) framework states that disabilities arise in the context of the dynamic interaction between a child's health conditions, functioning, activities, participation in life, and environmental/contextual and personal factors. In the present study, bodily function disability is defined based on the ICF classification (such as neuromusculoskeletal and movement-related functions, sensory functions and pain) and disability is defined based on the patient's status at discharge.

Statistical Analysis

Categorical variables were assessed with a $\chi 2$ test and expressed as number and percentage. Kolmogorov-Smirnov and Shapiro-Wilk tests were applied for the evaluation of the normality of continuous variables. Continuous variables (median [25^{th}–75^{th} percentile]; age, LOS in the hospital and PICU) were analyzed with a Kruskal-Wallis test. A Receiver Operator Characteristic (ROC) curve analysis was used to determine threshold values. The relationship between hospitalization days and disability was analyzed with a logistic regression analysis, and probability curves were plotted based on its outputs. The specificity, sensitivity, positive predictive value and negative predictive value of the relationship between hospitalization days and disability were determined.

The data analysis was conducted using IBM SPSS Statistics (Version 21.0. Armonk, NY: IBM Corp.) and MedCalc Version 12.5 software. A two-tailed p-value of <0.05 was considered significant.

Results

In the study period between January 2010 and August 2020, 508 children were admitted to medical centers in Turkey for firearm-related injuries, among which 489 met the inclusion criteria. The patients' median age was 13.66 [10–16] years. The firearm-related injuries of 55.0% were unintentional, while 8.2% were a result of homicide, 4.5% were self-harm and 32.3% were undetermined. Most admissions to hospital with firearm injuries were by those aged >10 years (p<0.0001). Of those admitted with firearm-related injuries, 77.9% were male, indicating a significant difference in gender (p=0.005). Unintentional injuries were more common in younger children (<10 years of age), but tended to decrease with age (0–4 years - 84.1%, 5–9 years - 76.6%, 10–14 - years 54.3%, 15–17 years - 40.6%.). In contrast, self-harming firearm-related injuries were predominant in children 10 years and older (especially >15 years) (Fig. 1). In terms of the setting in which

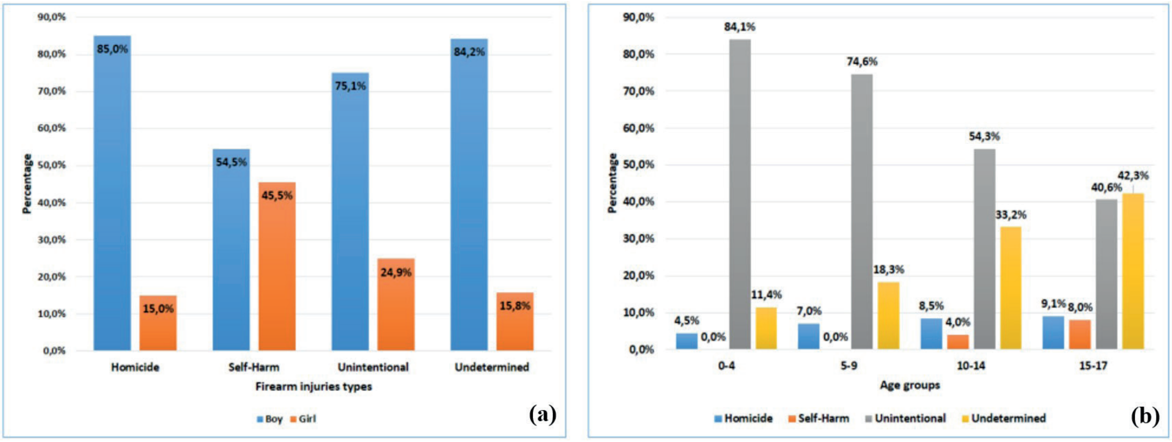

Fig. 1. Characteristics of firearm-related injuries in children, Firearm injury types by gender (a); Firearm injury types by age (b).

the injury was sustained, homicides were more common in the street, while self-harm were more common in the home (p<0.0001). In most of cases, the injuries were to extremities (49.5%). The demographic data of children with firearm injuries is shown in Table I.

Of the total, 41 (8.4%) of the patients admitted to hospital had a GCS of ≤8, and 29 of the 31 (93.5%) patients who died from their injuries had a GCS of ≤8. There were two deaths among the patients with an initial GCS above 12. Twenty-two of the 31 (71.0%) patients who died from their injuries had a head/neck injury, and their GCS was 8 or less. Furthermore, 30 of the 31 patients who died were intubated in the emergency room, and cardiopulmonary resuscitation was performed on 13 children, 12 (92.3%) of whom died. As a life-saving intervention, inotropic agents were administered to 18 patients who died. Of the 31 patients who died, 27 (87.1%) were in shock at the time of emergency room admission. The patients' characteristics data is presented in Table II.

Due to the lack of PICUs in some hospitals in our country, 2.1% of the patients were followed up in adult intensive care units. Despite the increase in the number of hospitalized patients over the years, there was no significant difference in the rate of hospitalized patients in need of PICU (Fig. 2). Hospitalizations with unintentional injuries were the most frequent, whereas hospitalizations resulting from self-harm were infrequent. Hospitalizations requiring admission to the PICU were most frequent among the self-harm patients. In children all of ages, among the hospitalizations necessitating admissions to PICU, unintentional injuries were the most common. The mean LOS in the hospital due to firearm-related injuries was 9.5±15.2 (1-123) days, with a median of 5 [2–10], and the mean stay in the PICU was 8.83±14.22 (1-107) days, with a median of 4 [2-10].

Ventilatory support was required in 68 of the 106 children admitted to the PICU. Of those who required ventilatory support, four (6.6%) needed noninvasive ventilator support and 57 (93.4%) needed mechanical ventilatory support, while the data for seven children were missing. The ventilatory support requirement rate was the highest among children admitted to the PICU due to self-harm (63.6%, p<0.0001). Circulatory support was required in 62 of the 106 patients admitted to the PICU, with the need for circulatory support being highest among those who sustained self-harm(45.5%, p<0.0001). Inotropes were the most commonly used circulatory support agents (66.1%). Of all the hospitalized children, 57.1% required surgical interventions for bullet/pellet removal (27.2%), wound repair (18.3%) and bone/tendon/nerve repair (17.6%) (Table III).

Table I. Demographic data of children with firearm injuries.

Characteristic	Homicide		Self-harm		Unintentional		Undetermined		Total		p
	n	%	n	%	n	%	n	%	n	%	
Gender											0.005
Male	34	(85.0)	12	(54.5)	202	(75.1)	133	(84.2)	381	(77.9)	
Female	6	(15.0)	10	(45.5)	67	(24.9)	25	(15.8)	108	(22.1)	
Age (years)											<0.0001
0-9	7	(17.5)	0	(0.0)	90	(33.5)	17	(10.8)	114	(23.3)	
10-17	33	(82.5)	22	(100.0)	179	(66.5)	141	(89.2)	375	(76.7)	
Season											0.010
Winter	7	(17.5)	6	(28.6)	48	(17.8)	39	(24.8)	100	(20.5)	
Spring	5	(12.5)	7	(33.3)	63	(23.4)	29	(18.5)	104	(21.4)	
Summer	9	(22.5)	4	(19.0)	100	(37.2)	46	(29.3)	159	(32.6)	
Autumn	19	(47.5)	4	(19.0)	58	(21.6)	43	(27.4)	124	(25.5)	
Setting of injury											<0.0001
Home	4	(10.0)	17	(77.3)	85	(31.6)	8	(5.1)	114	(23.3)	
Street	28	(70.0)	2	(9.1)	101	(37.5)	24	(15.2)	155	(31.7)	
Others	3	(7.5)	2	(9.1)	58	(21.6)	120	(75.9)	183	(37.4)	
Unknown	5	(12.5)	1	(4.5)	25	(9.3)	6	(3.8)	37	(7.6)	
Location of injury											
Head/neck	11	(27.5)	14	(63.6)	82	(30.5)	27	(17.1)	134	(27.4)	<0.0001
Spinal	4	(10.0)	1	(4.5)	11	(4.1)	2	(1.3)	18	(3.7)	0.064
Chest	10	(25.0)	5	(22.7)	53	(19.7)	29	(18.4)	97	(19.8)	0.799
Abdomen	12	(30.0)	3	(13.6)	52	(19.3)	21	(13.3)	88	(18.0)	0.076
Extremity	20	(50.0)	2	(9.1)	123	(45.7)	97	(61.4)	242	(49.5)	<0.0001
Skin	2	(5.0)	0	(0.0)	19	(7.1)	11	(7.0)	31	(6.5)	0.602
Multiple	4	(10.0)	0	(0.0)	10	(3.7)	5	(3.2)	19	(3.9)	0.162
Others	1	(2,5)	0	(0.0)	1	(0.4)	1	(0.6)	3	(0.6)	0.435

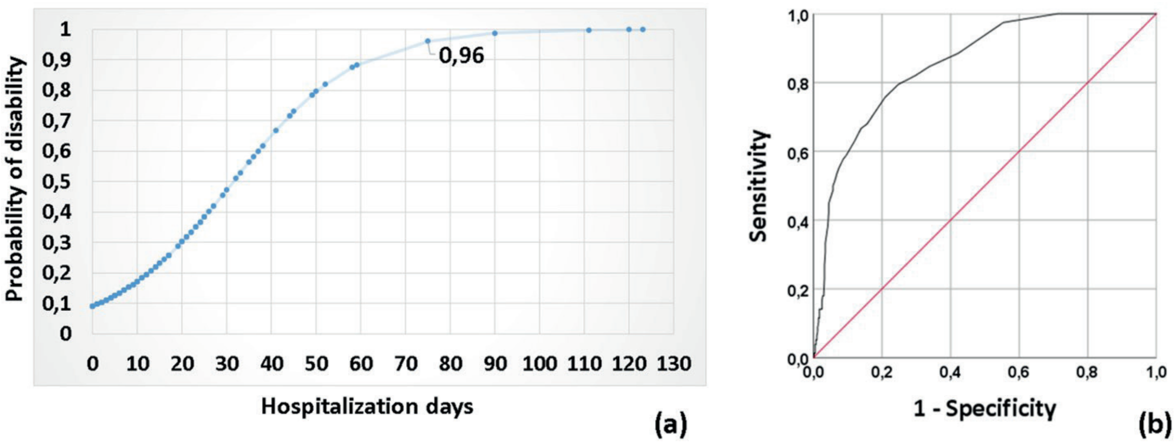

Fig. 2. Logistic relationship between the probability of disability and hospitalization days (a), and curve (b).

Table II. Patients characteristics of firearm-related injuries.

Characteristic	Homicide		Self-harm		Unintentional		Undetermined		Total		p
	n	%	n	%	n	%	n	%	n	%	
Total	40	(100)	22	(100)	269	(100)	158	(100)	489	(100)	
PED Admission	25	(62.5)	9	(40.9)	173	(64.3)	74	(46.8)	281	(57.5)	0.002
GCS											<0.0001
13-15	32	(80.0)	10	(45.5)	237	(88.1)	142	(89.9)	421	(86.1)	
9-12	3	(7.5)	1	(4.5)	16	(5.9)	7	(4.4)	27	(5.5)	
≤8	5	(12.5)	11	(50.0)	16	(5.9)	9	(5.7)	41	(8.4)	
Shock	8	(20.0)	11	(50.0)	31	(11.5)	19	(12.0)	69	(14.1)	<0.0001
Life-saving intervention	17	(42.5)	17	(77.3)	77	(28.6)	45	(28.5)	156	(31.9)	
BVM ventilation	4	(10.0)	2	(9.1)	22	(8.2)	12	(7.6)	40	(8.2)	0.546
Intubation	8	(20.0)	14	(63.6)	28	(10.4)	15	(9.5)	65	(13.3)	0.003
Surgical airway	1	(2.5)	2	(9.1)	4	(1.5)	2	(1.3)	9	(1.8)	0.505
IV fluid resuscitation	10	(25.0)	9	(40.9)	53	(19.7)	32	(20.3)	104	(21.3)	0.480
Blood administration	7	(17.5)	8	(36.4)	38	(14.1)	21	(13.3)	74	(15.1)	0.942
Control of major bleeding	3	(7.5)	2	(9.1)	19	(7.1)	14	(8.9)	38	(7.8)	0.392
Intraosseous access	1	(2.5)	0	(0.0)	0	(0.0)	0	(0.0)	1	(0.2)	0.042
Needle decompression	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	
Chest tube	6	(15.0)	6	(27.3)	13	(4.8)	11	(7.0)	36	(7.4)	0.204
Pericardiocentesis	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	
CPR	3	(7.5)	5	(22.7)	2	(0.7)	3	(1.9)	13	(2.7)	0.002
Inotropes	4	(10.0)	7	(31.8)	17	(6.3)	4	(2.5)	32	(6.5)	0.039

PEDs: pediatric emergency departments, GCS: Glasgow Coma Scale, BVM: Bag valve mask, IV: Intravenous, CPR: Cardiopulmonary resuscitation.

The overall mortality from firearm-related injuries was 6.3%, and 19.8% among those admitted to the PICU. The majority of firearm-related deaths were in males (58.1%) (p=0.06). The highest percentage of in-hospital deaths from firearm-related injuries was among those who attempted self-harm (40.9%, p<0.0001). Mortalities were more common in winter (40%) and summer (33.3%) than in spring (20.0%) and autumn (6.7%) (p=0.016). The most common causes of death were brain death (67.7%), sepsis (12.9%) and hemorrhagic shock (9.7%), while the other causes of death were cardiopulmonary arrest (6.4%) and pneumothorax (3.2%). The mortality rate of patients hospitalized in PICUs (19.8%) was higher than in the surgery departments (2.5%) (p<0.0001). Mortality was higher in the patients who received respiratory (77.4, p<0.0001) or circulatory support (71.0%, p<0.0001) or both (71.0%, p<0.0001). A logistic regression analysis assessing the relationship between the initial characteristics of the patient admissions and mortality revealed mortality to be positively associated with gender, season, setting of injury, injury category, head/neck injury, GCS, shock, life-saving interventions, CPR, PICU admission, LOS in the PICU, ventilation support and circulation support. GCS and ventilation support were found to be the most significant predictors of mortality (Table IV).

Of the total, 78 children were discharged from the hospital with some level of disability. The morbidity rate of patients hospitalized in the PICUs (29.7%) was higher than from the surgery departments (16.1%) (p<0.0001). The most frequent firearm-related disabilities were related to neuromusculoskeletal and movement-related function (60.3%), followed by sensory function and pain (30.8%), and functions of the digestive, metabolic and endocrine systems

Table III. Patients characteristics of firearm-related injuries related to hospitalizations and Pediatric Intensive Care Unit.

Characteristic	Homicide		Self-harm		Unintentional		Undetermined		Total		p
	n	%	n	%	n	%	n	%	n	%	
Total	40	(100)	22	(100)	269	(100)	158	(100)	489	(100)	
Hospitalization	33	(82.5)	19	(86.4)	202	(75.1)	119	(75.3)	373	(76.3)	0.497
PICU	8	(24.2)	10	(52.6)	72	(35.6)	16	(13.4)	106	(28.4)	<0.0001
Surgery Department	22	(66.7)	10	(52.6)	144	(71.3)	103	(86.6)	279	(74.8)	0.001
ICU	5	(15.2)	0	(0.0)	0	(0.0)	2	(1.7)	7	(1.9)	<0.0001
Length of stay - mean											
PICU											
Median	5		5		4		3		4		0.339
[25th-75th percentile]	[2-21.75]		[2-15]		[2-10]		[2-5]		[2-10]		
Hospital											
Median	6		3		5		4		5		0.304
[25th-75th percentile]	[2.25-13.50]		[1-17]		[2-10]		[1-8]		[2-10]		
Ventilation	7	(17.5)	14	(63.6)	33	(12.3)	14	(8.9)	68	(13.9)	<0.0001
Noninvasive	1	(14.3)	0	(0.0)	3	(9.7)	0	(0.0)	4	(6,6)	0.425
Mechanical	6	(85.7)	11	(100)	28	(90.3)	12	(100.0)	57	(93.4)	
Circulatory support	8	(20.0)	10	(45.5)	34	(12.6)	10	(6.3)	62	(12.7)	<0.0001
Inotropes	4	(50.0)	6	(60.0)	23	(67.6)	8	(80.0)	41	(66.1)	0.574
IV fluid resuscitation	3	(37.5)	1	(10.0)	7	(20.6)	3	(30.0)	14	(22.6)	0.509
Blood product transfusion	4	(50.0)	3	(30.0)	6	(17.6)	2	(20.0)	15	(24.2)	0.264
Multiple	3	(37.5)	1	(10.0)	7	(20.6)	4	(40.0)	15	(24.2)	0.324
Surgical intervention	25	(62.5)	11	(50.0)	156	(58.0)	87	(55.1)	279	(57.1)	0.733
Wound repair/ debridement/graft	4	(16.0)	1	(9,1)	23	(14.7)	23	(26.4)	51	(18.3)	0.117
Bullet/pellet removal	6	(24.0	0	(0.0)	58	(37.2)	12	(13.8)	76	(27.2)	<0.0001
Bone/tendon/nerve repair	3	(12.0	1	(9.1)	28	(17.9)	17	(19.5)	49	(17.6)	0.722
Maxilla/mandible reconstruction	1	(4.0)	2	(18.2	2	(1.3)	0	(0.0)	5	(1.8)	<0.0001
Head/neck surgery	1	(4.0)	1	(9.1)	5	(3.2)	3	(1.1)	10	(3.6)	0.790
Laparotomy	7	(28.0)	2	(18.2)	20	(12.8)	12	(13.8)	41	(14.7)	0.248
Eye surgery	1	(4.0)	0	(0.0)	8	(5.1)	0	(0.0)	9	(3.2)	0.163
Chest Tube	4	(16.0)	3	(27.3)	7	(4.5)	8	(9.2)	22	(7.9)	0.014
Artery/vein repair	0	(0.0)	1	(9.1)	10	(6.4)	10	(11.5)	21	(7.5)	0.229
Others	1	(4.0)	1	(9.1)	3	(1.9)	1	(1.1)	6	(2.2)	0.337
Discharge											
All patients											<0.0001
Home	29	(72.5)	11	(50.0)	209	(77.6)	128	(81.0)	376	(77.1)	
Died	5	(12.5)	9	(40.9)	8	(3.0)	9	(5.7)	31	(6.3)	
Disabilities	6	(15.0)	2	(9.1)	51	(19.0)	19	(12.0)	78	(16.0)	
Patient referral	0	(0.0)	0	(0.0)	1	(0.4)	2	(1.3)	3	(0.6)	
PICU patients											0.155
Home	4	(50.0)	4	(40.0)	35	(52.2)	8	(50.0)	51	(50.5)	
Died	3	(37.5)	4	(40.0)	8	(11.9)	5	(31.3)	20	(19.8)	
Disabilities	1	(12.5)	2	(20.0)	24	(35.8)	3	(18.8)	30	(29.7)	

PICU: Pediatric intensive care unit, ICU: Intensive care unit, IV: Intravenous.

Table IV. Logistic regression of initial characteristics for prediction of mortality in patients with firearm-related injuries.

Characteristic	Univariate regression model		Multivariate regression model	
	OR (95% CI lower-upper)	P	OR (95% CI lower-upper)	P
Gender	2.760 (1.306-5.832)	0.008		
Season	0.591 (0.414-0.846)	0.004		
Scene by injury	0.540 (0.351-0.831)	0.005		
Injury categories	0.569 (0.392-0.826)	0.003		
Head/neck injury	7.552 (3.379-16.878)	<0.0001		
GCS	29.227 (11.848-72.097)	<0.0001	11.683 (4.075-33.495)	<0.0001
Shock	66.857 (22.322-200.242)	<0.0001		
CPR	288.632 (35.665-2335.834)	<0.0001		
PICU administration	5.822 (2.749-12.328)	<0.0001		
Length of stay PICU	1.038 (1.008-1.069)	0.014		
Ventilation support	32.260 (13.149-79.144)	<0.0001	8.749 (1.162-65.869)	<0.0001
Circulation support	25.544 (11.021-59.208)	<0.0001		

GCS: Glasgow Coma Scale, CPR: Cardiopulmonary resuscitation, PICU: Pediatric intensive care unit.

(25.6%) (Table V). Unintentional injuries were the most common cause of disability (Table III).

A logistic regression analysis assessing the relationship between the initial characteristics of the patients at the time of admission and disability revealed disability to be positively associated with head/neck injury, GCS, shock, life-saving interventions, PICU administration, LOS in the PICU, LOS in the hospital, ventilation support, circulation support and surgical intervention. Head/neck injury, LOS in the hospital and surgical intervention were found to be the most significant predictors of disability (Table VI). The probability curve of disability from firearm-related injuries was calculated based on hospitalization days, and the probability of disability was calculated as 96.0% for children hospitalized for longer than 75 days (Fig. 2). The relationship between hospitalizations for more than 6 days and disability was calculated, and revealed a sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 75.64% (64.60–84.65%), 79.16% (74.86–83.0%), 41.26% (35.86–46.88%), 94.38% (91.88–96.14%) and 78.6% (74.65–82.17%), respectively (Fig. 2).

Discussion

In this comprehensive, multicenter retrospective study of firearm-related injuries in children admitted to PEDs and PICUs in Turkey, firearm-

Table V. Firearm-related cause of disabilities characteristics.

Cause of disabilities	n	%
Neuromusculoskeletal and Movement-Related Functions	47	60.3
- Functions of the joints and bones	22	28.2
- Muscle functions	41	52.6
- Movement functions	47	60.3
Sensory Functions and Pains	24	30.8
- Sight and related functions	18	23.6
- Hearing and vestibular functions	1	1.3
Functions of the Digestive, Metabolic and Endocrine Systems	20	25.6
- Functions related to the digestive systems	20	25.6
Genitourinary and Reproductive Functions	8	10.3
- Urinary functions	7	9.0
- Genital and reproductive functions	1	1.3
Functions of the Skin and Related Structures	8	10.3
- Functions of the skin	6	7.7
- Functions of the hair and nails	3	3.8
Mental Functions	7	9.0
Voice and Speech Functions	5	6.4
Functions of Cardiovascular, Hematological, Immunological and Respiratory Systems	5	6.4
- Functions of respiratory systems	5	6.4

Table VI. Logistic regression of initial characteristics for prediction of disability in patients with firearm-related injuries.

Characteristic	Univariate regression model		Multivariate regression model	
	OR (95% CI lower-upper)	P	OR (95% CI lower-upper)	P
Head/neck injury	3.117 (1.892-5.136)	<0.0001	3.648 (2.013-6.610)	<0.0001
GCS	1.747 (1.240-2.459)	0.001		
Shock	3.615 (2.040-6.404)	<0.0001		
Life-saving interventions	2.677 (1.635-4.384)	<0.0001		
PICU administration	3.395 (2.028-5.686)	<0.0001		
Length of stay PICU	1.102 (1.056-1.150)	<0.0001		
Length of stay hospital	1.076 (1.052-1.101)	<0.0001	1.052 (1.029-1.074)	<0.0001
Ventilation support	3.707 (2.089-6.578)	<0.0001		
Circulation support	3.989 (2.216-7.181)	<0.0001		
Surgical intervention	8.457 (3.968-18.022)	<0.0001	5.549 (2.364-13.023)	<0.0001

GCS: Glasgow Coma Scale, PICU: Pediatric intensive care unit.

related injuries were found to vary by patient demographics, which is a pattern that has been well described in the pediatric population in the United States, but not in Turkey.[3] The findings in this article highlight the characteristics of firearm-related injuries among children in Turkey. To the best of our knowledge, this is the first multicenter study conducted to date analyzing the clinical characteristics of pediatric firearm-related injuries in Turkey.

The incidence of firearm injuries varies considerably between regions, age groups and genders.[6] In the present study, the majority (79.9%) of children affected by firearm-related injuries were male, concurring with previous studies in literature.[4,7] Risk also increases with age, with older adolescent males accounting for the majority of firearm-related injuries. These findings and those of previous studies suggest that efforts to prevent firearm-related injuries in children should begin at an early age, and should focus particularly on males.[6,7]

In 2019, there were 15,824 deaths among children aged 0–14 years in Turkey[8], among which more than 6.0% were due to "external causes of injury and poisoning".[8] In the study of Cunningham et al., firearm-related injuries were the second leading cause of death among children and adolescents in the United States, of which 59.0% were attributable to homicide and 35.0% to self-harm, while 4.0% were unintentional.[9] In contrast, among Turkish children, 29.0% were attributable to self-harm, 25.8% were unintentional, 16.1% were homicide and 29.0% were unknown in our study. The differences between the United States and Turkey are thought to arise from the differences in the laws governing the ownership of firearms.

Firearm injuries to the head are the most lethal, and many people do not survive after sustaining such an injury. Researchers have reported survival rates of 7.0–15.0%, and that more than 90.0% of people sustaining a firearm injury to the head eventually die, mostly within minutes due to respiratory and circulatory arrest.[10] In the present study, 22 of the 31 patients admitted to hospital who died due to firearm injuries had head/neck injuries, and a positive association with mortality.

Recent studies have identified a link between the GCS of a patient at the time of admission and the outcome of the patients, with an 85.0% likelihood of mortality in those with a GCS of less than 7.[10,11] In the present study, the GCS of 41 (8.4%) of the patients admitted to the hospital was ≤8, and 29 (70.7%) of these died. GCS was thus found to be one of the most accurate predictors of mortality, as in previous studies. In a study by Ewing-Cobbs et al.[12], the GCS score at baseline was able to predict moderate and severe disabilities in 69.0% and 23.0% of cases, respectively. Similar to this study, disability was found to have a positive association with GCS in the present study.

Firearm-related injuries lead to emergency department visits and hospitalizations, and around 40.0% of such injuries in children require hospitalization in the intensive care unit.[4,13,14] Pediatric emergency services are the entry point for many trauma patients, such as those who have sustained firearm injuries. In the United States, approximately 19 children receive treatment for, or die in the emergency department from firearm-related injuries every day.[15] As with all admissions to the PED, the ability to make effective interventions is of paramount importance. In the present study, early and effective life-saving interventions were shown to be important for the prevention of mortality and disability in cases of firearm-related injury. Intensive care unit interventions include the frequent use of invasive or noninvasive mechanical ventilatory support, circulatory support, such as vasopressor use, IV fluid replacement, and blood product transfusions. Our analysis revealed that firearm-related injuries resulting from self-harm required more frequent intensive care unit admissions (28.4%), and these patients needed more respiratory and circulatory support than those with other types of injury. This is because children are uniquely vulnerable, they have larger heads and torsos, densely calcified bones are lacking, and skin and muscles are not sufficiently developed.[14] Furthermore, the high energy of a bullet leads to a wide field of tissue injury in children.[14] Children with firearm injuries are more likely to be admitted to the ICU than children with other penetrating injuries,[16] and PICU admission was found to be a significant predictor mortality and disability in the present study.

Firearm-related injuries lead to hospitalizations, and around 50.0–69.0% of children require surgical interventions.[13] Typically, these children must be cared for at tertiary hospitals and by a multidisciplinary team of pediatric surgery, neurosurgery, orthopedics and plastic surgery specialists.[14] In the present study, a large proportion (57.1%) of the patients required surgical interventions, although there were no significant differences in the surgical interventions made within the different firearm-related injury groups. The most common surgical interventions were bullet/pellet removal (27.2%), wound repair/debridement/graft (18.3%) and bone/tendon/nerve repair (17.6%).

Pediatric firearm injuries are associated with a higher likelihood of prolonged hospital or PICU stay.[14] Wolf et al.[16] reported a hospital LOS of children with firearm injuries of 5.0 days and an ICU LOS of 5.1 days. In the present study, the hospital LOS was 9.50±15.20 days and PICU LOS was 8.83±14.22days, which were longer than in Wolf et al.[16] ICU admission and longer LOS are associated with increased risk of morbidity and complications.[16] Our reported a probability of disability of 96.0% among children hospitalized with firearm injuries whose LOS was longer than 75 days, and a relationship between hospitalizations exceeding 6 days and disability in firearm injuries.

Pediatric suicides are common and are associated with the greatest odds of in-hospital mortality.[15,17,18] The CDC reported an increase in the suicide rate among children aged 15–19 from 2007 to 2015.[19] In the present study, the mortality rate was highest among those with self-directed firearm injuries than in the other groups, which is similar to the findings of earlier studies.[20-22] A continuous rise can be seen in cases of self-harm by firearms among children[20], and previous studies have reported that firearm-related injuries contribute to the rate of disabilities among children, making gun violence an important public health issue.[7] Around half of all children hospitalized with firearm injuries are discharged with disabilities.[14] Many hospitalized patients report a significant long-term decline in physical and/or mental health.[4,23] In a study by Discala et al.[4], more than one-third of the children developed short-term disabilities as a result of injuries to the extremities, while 6.5% developed long-term disabilities due to injuries to the central nervous system.[4] In the present study, we assessed the physical consequences of non-fatal firearm-related injuries at the time of discharge from hospitalization, classifying the disabilities according to the ICF. It was found that the most common disabilities resulting from firearm injuries were in neuromusculoskeletal and movement-related functions, accounting to 60.3%, sensory function and pain, with 30.8%, and functions of the digestive, metabolic and endocrine systems, with 25.6%. Unintentional firearm-related injuries were the most common cause of disability.

There are a few limitations to this study, the first of which is its retrospective design which prevented access to all the data on firearm-related injuries in children. One of the reasons for this was that the standard national database that is available today was not available for the period in question. This study is dependent on the accuracy and completeness of ICD-10. If these codes may be underreported in the data base the patients did not selected. As patient data were missing from the hospital database, the number of patients in the undetermined group of firearm-related injuries was high, and this high number of undetermined patients prevents the clarification of the exact distribution. This limitation may be eliminated in future prospective studies, or by informing clinicians about the need to provide more detail for databases of firearm-related injuries.

Second, the centers in all cities of our country could not participate in our hospitals participating in this study are tertiary care facilities in major Turkey metropolitan cities. As such, while our findings cannot be generalized for all firearm-related injuries in Turkey, they do provide information about the distribution of firearm-related injuries in children in the country.

Third, firearm-related injuries that that resulted in mortality prior to hospital admission were disregarded in this study, leading to a low mortality rate for Turkey being recorded. Fourth, regarding the data on disabilities resulting from firearm injuries, we considered the condition of the patients at the time of discharge, while the long-term disabilities of patients are disregarded. A further study is thus needed to determine the long-term disabilities of firearm-related injuries in children in Turkey.

Fifth, our study made use of data only from centers with PEDs and PICUs in Turkey, while patients admitted to adult trauma centers were excluded from the study. Our results may thus not represent the true PICU requirement.

Our study found GCS and ventilation support to be the most significant predictors of mortality, while head/neck injuries, LOS in the hospital, and surgical intervention were found to be the most significant predictors of disability, along with hospitalization exceeding 6 days. Firearm injuries can be severe and can require frequent major therapeutic interventions, and are associated with high mortality and disability rates. Knowledgeable care teams that can provide the appropriate management and treatment for the long-term disabilities experienced by patients are thus needed. An assessment of the regional variations in pediatric firearm-related injuries may lead to the reduction of the rate of unintentional occurrences through the routine informing of families in high-risk areas.

Turkish Pediatric Firearm Study Group*

List of the Study Group

İhsan Özdemir, Utku Çağlayan (Division of Pediatric Emergency Medicine, Department of Pediatrics, Ankara University Faculty of Medicine, Ankara), Emrah Gün (Division of Pediatric Intensive Care, Department of Pediatrics, Ankara University Faculty of Medicine, Ankara), Gamze Gökulu, Pınar Çay (Division of Pediatric Emergency Medicine, Department of Pediatrics, Çukurova University Faculty of Medicine, Adana, Turkey), Gamze Gökalp (Division of Pediatric Emergency Medicine, Department of Pediatrics, Tepecik Education and Research Hospital, İzmir), Mehmet Nur Talay (Division of Pediatric Intensive Care, Department of Pediatrics, Sağlık Bilimleri University, Gazi Yasargil Training and Research Hospital, Diyarbakır), Fatih Doğan (Department of Plastic, Reconstructive and Aesthetic Surgery, Adıyaman University Faculty of Medicine, Adıyaman), Oğuz Dursun (Division of Pediatric Intensive Care, Department of Pediatrics, Antalya University Faculty of Medicine, Antalya) Bahri Ünal (Division of Pediatric Emergency Medicine, Department of Pediatrics, Hacettepe University Faculty of Medicine, Ankara), Evrim Özkaraca Boyacı (Department of Pediatric Surgery, Afyon University Faculty of Medicine, Afyon) Özden Özgür Horoz (Division of Pediatric Intensive Care, Department of Pediatrics, Çukurova University Faculty of Medicine, Adana), Mehmet Alakaya (Division of Pediatric Intensive Care, Department of Pediatrics, Mersin University Faculty of Medicine, Mersin), Özlem Çolak (Division of Pediatric Emergency Medicine, Department of Pediatrics, Gazi University Faculty of Medicine, Ankara), Okan Bardakçı (Department of Emergency Medicine, Çanakkale Onsekiz Mart University Faculty of Medicine, Çanakkale, Turkey), Kazım Zararcı (Division of Pediatric Intensive Care, Department of Pediatrics, Ege University Faculty of Medicine, İzmir), Hatice Elif Kınık Kaya (Division of Pediatric Intensive Care, Department of Pediatrics, Ondokuz Mayıs University Faculty of Medicine, Samsun), Nuri Alaçakır (Division of Pediatric Intensive Care, Department of Pediatrics, Trakya University Faculty of Medicine, Edirne), Muhterem Duyu (Division of Pediatric Intensive Care, Department of Pediatrics, Medeniyet University Göztepe Training and Research Hospital, İstanbul), Esra Şevketoğlu, Nihal Akçay (Division of Pediatric Intensive Care Unit, Department of Pediatrics, Bakırköy Dr. Sadi Konuk Health Training and Research Center, İstanbul), Nilüfer Yalındağ Öztürk, Feyza İnceköy Girgin (Division of Pediatric Intensive Care, Department of Pediatrics, Marmara University Faculty of Medicine, İstanbul), Ayhan Yaman (Division of Pediatric Intensive Care, Department of Pediatrics, İstinye University Faculy of Medicine, İstanbul, Turkey), Ülkem Koçoğlu Barlas (Division of Pediatric Intensive Care Unit, Department of Pediatrics, Bağcılar Health Training and Research Center, İstanbul), Ayşe Filiz Yetimakman (Division of Pediatric Intensive Care, Department of Pediatrics, Kocaeli University Faculty of Medicine, Kocaeli), Osman Yeşilbaş (Division of Pediatric Intensive Care, Department of Pediatrics, Karadeniz Teknik University Faculty of Medicine, Trabzon, Turkey), Gökhan Kalkan, Songül Tomar Güneysu (Division of Pediatric Intensive Care, Department of Pediatrics, Gazi University Faculty of Medicine, Ankara, Turkey).

Acknowledgments

We give thanks to the "Turkish Pediatric Firearm Study Group" for their valuable contributions to the study.

Ethical approval

The study protocol was approved by the Ethical Committee of Ankara University (I7-448-20) and it was conducted in accordance with the principles of the Declaration of Helsinki.

Author contribution

The authors confirm contribution to the paper as follows: study conception and design: GV,TK,DT,BU,HLY, DY; data collection: GV, TK, HLY, TN, MK, HA, AK, MÇ, ÖT, GB, MH, AEA, ODG, FB, PY, NY, DY, RD, DT, BU, Turkish Pediatric Firearm Study Group; analysis and interpretation of results: GV, TK, BU, HLY, TN, MK, HA, AK, MÇ, ÖT, GB, MH, AEA, ODG, FB, PY, NY, DY, RD, DT, Turkish Pediatric Firearm Study Group; draft manuscript preparation: GV,TK,DT,BU,HLY. All authors reviewed the results and approved the final version of the manuscript.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

1. Leventhal JM, Gaither JR, Sege R. Hospitalizations due to firearm injuries in children and adolescents. Pediatrics 2014; 133: 219-225. https://doi.org/10.1542/peds.2013-1809
2. Parikh K, Silver A, Patel SJ, Iqbal SF, Goyal M. Pediatric firearm-related injuries in the United States. Hosp Pediatr 2017; 7: 303-312. https://doi.org/10.1542/hpeds.2016-0146
3. Fowler KA, Dahlberg LL, Haileyesus T, Gutierrez C, Bacon S. Childhood firearm injuries in the United States. Pediatrics 2017; 140: e20163486. https://doi.org/10.1542/peds.2016-3486
4. DiScala C, Sege R. Outcomes in children and young adults who are hospitalized for firearms-related injuries. Pediatrics 2004; 113: 1306-1312. https://doi.org/10.1542/peds.113.5.1306
5. Kamat PP, Santore MT, Hoops KEM, et al. Critical care resource use, cost, and mortality associated with firearm-related injuries in US children's hospitals. J Pediatr Surg 2020; 55: 2475-2479. https://doi.org/10.1016/j.jpedsurg.2020.02.016

6. Newgard CD, Kuppermann N, Holmes JF, et al. Gunshot injuries in children served by emergency services. Pediatrics 2013; 132: 862-870. https://doi.org/10.1542/peds.2013-1350

7. Sofer D. Gun violence and children. Am J Nurs. 2017; 117: 14. https://doi.org/10.1097/01.naj.0000524529.50050.7b

8. Turkish Statistical Institute (TÜİK). Ölüm ve Ölüm Nedeni İstatistikleri, 2019. Available at: https://data.tuik.gov.tr/Bulten/Index?p=Olum-ve-Olum-Nedeni-Istatistikleri-2019-33710

9. Cunningham RM, Walton MA, Carter PM. The major causes of death in children and adolescents in the United States. N Engl J Med 2018; 379: 2468-2475. https://doi.org/10.1056/NEJMsr1804754

10. Liu R, Liu Y, Liu W, et al. Gunshot penetrating brain injury in children: report of three cases with review of the literature. Childs Nerv Syst 2018; 34: 1459-1463. https://doi.org/10.1007/s00381-018-3858-y

11. Suddaby L, Weir B, Forsyth C. The management of .22 caliber gunshot wounds of the brain: a review of 49 cases. Can J Neurol Sci 1987; 14: 268-272. https://doi.org/10.1017/s0317167100026597

12. Ewing-Cobbs L, Thompson NM, Miner ME, Fletcher JM. Gunshot wounds to the brain in children and adolescents: age and neurobehavioral development. Neurosurgery 1994; 35: 225-233; discussion 233. https://doi.org/10.1227/00006123-199408000-00007

13. Weiss R, He C, Gise R, Parsikia A, Mbekeani JN. Patterns of pediatric firearm-related ocular trauma in the United States. JAMA Ophthalmol 2019; 137: 1363-1370. https://doi.org/10.1001/jamaophthalmol.2019.3562

14. Flaherty MR, Klig JE. Firearm-related injuries in children and adolescents: an emergency and critical care perspective. Curr Opin Pediatr 2020; 32: 349-353. https://doi.org/10.1097/MOP.0000000000000905

15. Cutler GJ, Zagel AL, Spaulding AB, Linabery AM, Kharbanda AB. Emergency department visits for pediatric firearm injuries by trauma center type. Pediatr Emerg Care 2021; 37: e686-e691. https://doi.org/10.1097/PEC.0000000000001846

16. Wolf AE, Garrison MM, Mills B, Chan T, Rowhani-Rahbar A. Evaluation of injury severity and resource utilization in pediatric firearm and sharp force injuries. JAMA Netw Open 2019; 2: e1912850. https://doi.org/10.1001/jamanetworkopen.2019.12850

17. Tseng J, Nuño M, Lewis AV, Srour M, Margulies DR, Alban RF. Firearm legislation, gun violence, and mortality in children and young adults: a retrospective cohort study of 27,566 children in the USA. Int J Surg 2018; 57: 30-34. https://doi.org/10.1016/j.ijsu.2018.07.010

18. Kalesan B, French C, Fagan JA, Fowler DL, Galea S. Firearm-related hospitalizations and in-hospital mortality in the United States, 2000-2010. Am J Epidemiol 2014; 179: 303-312. https://doi.org/10.1093/aje/kwt255

19. QuickStats: Suicide Rates for Teens Aged 15-19 Years, by Sex - United States, 1975-2015. MMWR Morb Mortal Wkly Rep 2017; 66: 816. https://doi.org/10.15585/mmwr.mm6630a6

20. Srinivasan S, Mannix R, Lee LK. Epidemiology of paediatric firearm injuries in the USA, 2001-2010. Arch Dis Child 2014; 99: 331-335. https://doi.org/10.1136/archdischild-2013-304642

21. Saunders NR, Moore Hepburn C, Huang A, et al. Firearm injury epidemiology in children and youth in Ontario, Canada: a population-based study. BMJ Open 2021; 11: e053859. https://doi.org/10.1136/bmjopen-2021-053859

22. Bagdure D, Foster CB, Garber N, et al. Outcomes of children with firearm injuries admitted to the PICU in the United States. Pediatr Crit Care Med 2021; 22: 944-949. https://doi.org/10.1097/PCC.0000000000002785

23. Greenspan AI, Kellermann AL. Physical and psychological outcomes 8 months after serious gunshot injury. J Trauma 2002; 53: 709-716. https://doi.org/10.1097/00005373-200210000-00015