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Characteristics of severely injured trauma patients transported by helicopter emergency medical services in Switzerland: a retrospective cohort study

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Summary

BACKGROUND: Information on severely injured patients transported by helicopter emergency medical services (HEMS) in Switzerland is scarce. This study, with a special focus on sex differences, aimed to gain insights into the demographics, injury characteristics and outcomes of these patients and to provide data that could help improve prehospital trauma care.

METHODS: This is a retrospective multicentre cohort study analysing data collected by the Swiss Trauma Registry. Patients aged 16 or older, who were admitted by helicopter emergency medical services to a level 1 trauma centre in Switzerland between 2018 and 2022, with an Injury Severity Score (ISS) of ≥16, were included.

RESULTS: Overall, 2714 trauma patients were analysed in the present study. The majority of these patients were male (73.7%). Blunt trauma was the main cause of injury (93.6%), with traffic accidents (43.5%) and falls (43.3%) being the most common accident mechanisms. A greater percentage of male patients than female patients were involved in motorcycle crashes (16.5% vs 6.9%, p <0.001). Female patients were more frequently involved in accidents as pedestrians (6% vs 2.7%, p <0.001) and experienced more falls below 3 metres of height (22.9% vs 14.7%, p <0.001). The median ISS of our cohort was 24 (interquartile range [IQR]: 19–30). The most common injuries were thoracic trauma (67%), head trauma (66.7%) and spine trauma (50.3%). Men suffered more thoracic injuries (68.9% vs 61.9%, p = 0.001) and their median Abbreviated Injury Score (AIS) Thorax was significantly higher (3.0 [IQR: 0–3] vs 2.0 [IQR: 0–3], p <0.001). Women had a higher prevalence of pelvic fractures (29.3% vs 21.5%, p <0.001) and suffered more fractures of long bones in their upper extremities (22.2% vs 15.7%, p <0.001). There was no significant difference in in-hospital mortality between women and men (15.7% vs 14.6%, p = 0.493), nor in other outcome parameters.

CONCLUSION: To our knowledge, this is the first analysis of data on severely injured trauma patients transported by helicopter emergency medical services in Switzerland. While there were notable differences between women and men in terms of accident mechanisms and injury characteristics, no significant differences in outcome parameters were observed.

Introduction

Background

Helicopter emergency medical services (HEMS) are a cornerstone of trauma care in most Western countries and have been shown to reduce mortality after trauma and shorten rescue time, particularly in rural or geographically challenging areas like the alpine regions of Switzerland, which cover over 50 percent of the country [1–8]. Due to these challenging geographical conditions, fast and efficient rescue is often only possible by helicopter. As a result, helicopter emergency medical services are more established in Switzerland than in many other European countries and respond to around 6% to 10% of all emergency calls [9, 10]. This is also reflected in the finding that a smaller proportion of patients were transported by helicopter emergency medical services in Europe. In Switzerland, around 35% of seriously injured people are transported to a hospital by helicopter [11]. Differences in trauma outcomes according to sex have already been identified, with most studies showing that women appear to be relatively advantaged compared to men when looking at over-

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all mortality [12]. Researchers are increasingly exploring new sex-specific perspectives in acute care medicine, particularly in the fields of trauma and resuscitation. However, systematic reviews and meta-analyses of sex-based disparities in trauma sample only a small proportion of the published literature, which biases conclusions. Few studies on trauma outcomes present data by sex, and the bias against publishing negative studies persists. It is therefore important to address sex-specific issues in trauma and resuscitation.

Recent papers from the Netherlands and Denmark have reported data on patients transported by helicopter emergency medical services, looking into the characteristics of trauma- and non-trauma patients, and comparing the characteristics of trauma patients by mode of transportation (helicopter emergency medical services vs ambulance) [13, 14]. To our knowledge, there exists no similar information on trauma patients transported by helicopter emergency medical services in Switzerland.

Objective

The aim of this study was to provide an overview of severely injured trauma patients transported by helicopter emergency medical services in Switzerland, with a particular focus on differences between men and women. This information can help to better understand trauma patients transported by helicopter emergency medical services and to further improve prehospital trauma care.

Methods

Study design and setting

In Switzerland, deployment of helicopter emergency medical services is organised either by regional medical emergency call centres or directly by the national operation centre of the Rega (Rettungsflugwacht/Guarde Aérienne). The entire Swiss helicopter emergency medical services operation area is accessible within 15 minutes of flying time day and night by a helicopter at one of the four main Swiss helicopter emergency medical services providers: Rega, Air-Glaciers, Air Zermatt and Alpine Air Ambulance. A helicopter emergency medical services team comprises at least a pilot, a paramedic and an emergency physician, usually an anaesthetist or intensive care doctor with a specialisation in prehospital emergency medicine. All helicopter emergency medical services providers conduct primary missions to aid patients in need of emergency medical treatment, search and rescue missions and in addition offer rapid transfer of critically ill patients between hospitals.

In this retrospective multicentre cohort study, we analysed data from the Swiss Trauma Registry (STR) on severely injured trauma patients transported by helicopter emergency medical services. The Swiss Trauma Registry plays a crucial role in the advancement of trauma care by collecting, providing and reviewing data on critically injured trauma patients. All twelve level 1 trauma centres in Switzerland are obliged to document trauma patients aged ≥16 years with an Injury Severity Score (ISS) ≥16 and/or Abbreviated Injury Score (AIS) Head ≥3 in the Swiss Trauma Registry [15, 16]. The Swiss Trauma Registry excludes patients with isolated burns or in whom the burn is the clear primary injury, as well as patients who have experienced suffocation, hanging or drowning without any accompanying injuries. Patients who reached the emergency department without signs of life are also excluded if either no or only very limited diagnostic or treatment measures have been performed. Patients who meet the criteria mentioned above are then registered by the trauma centres in the Swiss Trauma Registry, which forms the basis for coordinated clinical care and research in Switzerland by, in return, providing participating clinics with data on severely injured trauma patients for further research [17].

The Swiss Trauma Registry has been systematically collecting a wide range of trauma data in a pseudoanonymous manner since 2015 [15]. The registry includes detailed demographics, injury characteristics, prehospital and admission parameters, medical interventions and various outcome measures. Data entry follows standardised protocols, ensuring consistency across all participating level 1 trauma centres in Switzerland. Clinicians and trained registry personnel collect patient data from health records, prehospital emergency reports and hospital documentation. To ensure data integrity and accuracy, the Swiss Trauma Registry performs regular internal validation checks [15].

The present review is published in accordance with Swiss Trauma Registry publication guidelines under STR-ID 19 and uses STROBE reporting guidelines [18, 19].

Eligibility criteria

For our study, we identified all patients in the Swiss Trauma Registry admitted by helicopter emergency medical services between January 2018 and December 2022. This starting point was selected because we believe that from this time onward, data quality in the Swiss Trauma Registry is sufficiently high to ensure reliable analysis. The endpoint was determined by the latest fully available year of data at the time of study initiation.

We excluded all open cases, all non-primary admissions, all cases with an unknown accident date or where the accident date was more than one day prior to admission, and all cases without a documented ISS. We also excluded all patients with an ISS <16 to ensure that only severely injured patients were analysed.

Statistical methods

All statistical analyses were conducted using STATA 18.1 (StataCorp, College Station, TX, USA). Descriptive statistics for categorical variables are presented as frequencies and corresponding percentages. For continuous variables, either medians with interquartile ranges (IQR) or means with standard deviations (SD) are reported, depending on the results of normality testing (Shapiro-Wilk test). P-values were calculated using the Wilcoxon rank-sum test for non-normally distributed data and the unpaired t-test for normally distributed data. For categorical variables, p-values were obtained using the chi-squared test. A p-value of <0.05 was considered statistically significant.

Creation of graphical cohort description

To visually represent the Swiss helicopter emergency medical services severe trauma cohort, a 3D deformed human figure – referred to as the Swiss helicopter emergency medical services severe trauma “traumunculus” (a portmanteau word formed from trauma and homunculus) – was constructed, inspired by the well-known 3D sensory/motor male and female homunculus [20, 21]. The traumunculus integrates various cohort trauma characteristics, including the proportion of males, mean age, trauma severity, relative frequency of injuries to each body region and trauma type (e.g. penetrating trauma). Its construction is detailed in the appendix.

Ethics approval and consent to participate

The cantonal ethics committee of St. Gallen (EKOS) reviewed the study design, classified it as a quality evaluation analysis and granted permission for using patient data without individual consent (BASEC Nr. Req-2022-01540 EKOS 22/198).

Results

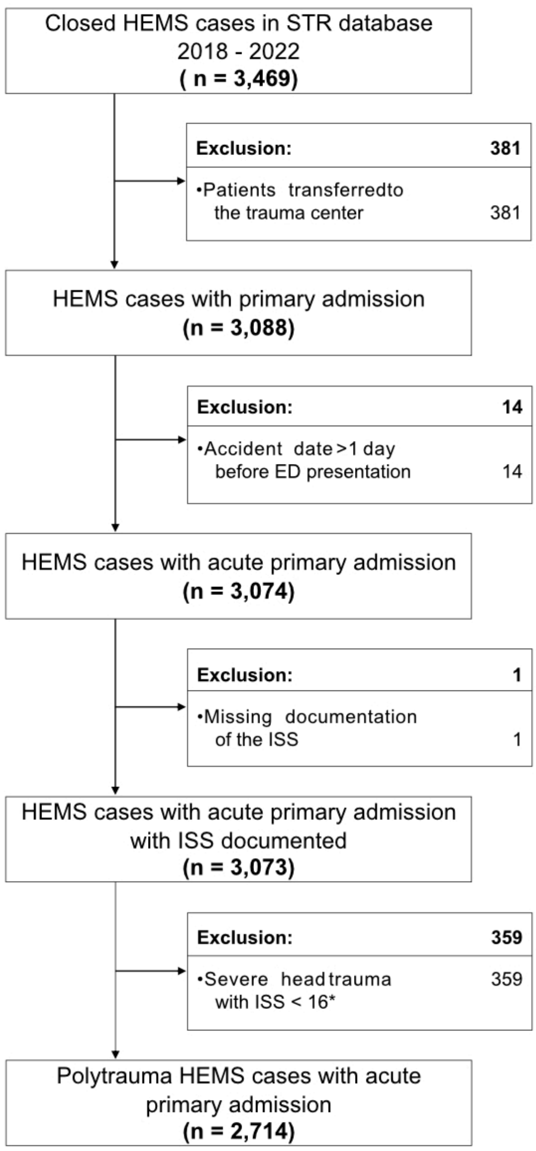
Study population

In total, 3652 primary helicopter emergency medical services cases were identified in Swiss Trauma Registry database between January 2018 and December 2022, of which 3469 were closed cases. After applying the previously stated exclusion criteria, 2714 cases were analysed in the present study (figure 1).

Baseline characteristics and admission data

Table 1 shows patient demographics, trauma characteristics and vital signs at hospital admission for men, women and the entire cohort. The median age of all patients was 54 years (IQR: 35–67). Patient numbers declined with increasing age, from 1022 in the youngest age group to 363 aged 75 years or over. Women accounted for approximate-

Figure 1: Study flowchart. * Excluding patients with an Injury Severity Score (ISS) of less than 16 results in the omission of individuals with severe head trauma (Abbreviated Injury Score [AIS] Head ≥3) who have an overall ISS below 16. ED: Emergency Department; HEMS: Helicopter Emergency Medical Service; STR: Swiss Trauma Registry.



ly one-quarter of patients across all age groups except those aged >75 years, where the percentage of female patients rose to 36.6%. Overall, male patients were slightly younger than female patients (median age 53 years [IQR: 35–66] vs median age 55 years [IQR: 36–70], p = 0.007).

Most injuries originated from blunt trauma (93.6%) with traffic accidents (43.5%) or falls of any height (43.3%) being the predominant causes of injury. Further analysis of traffic accidents revealed that 14% of all patients had been involved in a motorcycle crash, 11.8% in a car or truck accident, 10.4% in a bicycle accident, 3.6% had been a pedestrian at the time of the accident and 1.3% were involved in an e-bike or e-scooter accident. Falls were further divided into three groups according to height: 22% of all patients fell from a height greater than 3 metres, 16.8% from a height less than 3 metres and 2% fell at ground level. In 68 patients, a fall was reported but no specific height documented.

Men were more frequently involved in motorcycle accidents (16.5% vs 6.9%, p <0.001), whereas women were relatively more often involved in accidents as pedestrians (6% vs 2.7%, p <0.001) and were more likely to experience a fall from a height below 3 metres (22.9% vs 14.7%, p <0.001).

When comparing vital signs at hospital admission between the two sex groups, statistically significant differences in systolic blood pressure, respiratory rate, temperature and oxygen saturation were noted.

Injury characteristics

The most common and severe injury among all patients was trauma to the thorax (67%, median AIS: 3.0 [IQR:

Table 1:
Demographics, accident characteristics and vital signs at hospital admission according to sex. The p-values are across all age categories and accident characteristics. Vitals were obtained at hospital admission.

		Total (n = 2714)		Female (n = 713)		Male (n = 2001)		p-value
Demographics			[%]		[%]		[%]	
Age groups	16–45 years, n (%)	1022	[37.7%]	259	[36.3%]	763	[38.1%]	
	>45–65 years, n (%)	950	[35.0%]	227	[31.8%]	723	[36.1%]	
	>65–75 years, n (%)	379	[14.0%]	94	[13.2%]	285	[14.2%]	
	>75 years, n (%)	363	[13.4%]	133	[18.7%]	230	[11.5%]	<0.001
Age in years		54.0	[35.0–67.0]	55.0	[36.0–70.0]	53.0	[35.0–66.0]	0.007
Accident characteristics								
Type of injury*	Blunt trauma	2540	[93.6%]	672	[94.2%]	1868	[93.4%]	
	Penetrating injury	95	[3.5%]	22	[3.1%]	73	[3.6%]	
	Blunt & penetrating injury	77	[2.8%]	18	[2.5%]	59	[2.9%]	
Type of injury, detail	Traffic – car, truck	319	[11.8%]	94	[13.2%]	225	[11.2%]	
	Traffic – motorcycle crash	379	[14.0%]	49	[6.9%]	330	[16.5%]	
	E-bike/E-scooter	34	[1.3%]	10	[1.4%]	24	[1.2%]	
	Bicycle	281	[10.4%]	64	[9.0%]	217	[10.8%]	
	Pedestrian	98	[3.6%]	43	[6.0%]	55	[2.7%]	
	Traffic, other	66	[2.4%]	21	[2.9%]	45	[2.2%]	
	Fall over 3 metres	596	[22.0%]	145	[20.3%]	451	[22.5%]	
	Fall below 3 metres	457	[16.8%]	163	[22.9%]	294	[14.7%]	
	Fall at ground level	54	[2.0%]	18	[2.5%]	36	[1.8%]	
	Fall of unknown height	68	[2.5%]	22	[3.1%]	46	[2.3%]	
	Other – blow	111	[4.1%]	29	[4.1%]	82	[4.1%]	
	Gunshot wound	27	[1.0%]	4	[0.6%]	23	[1.1%]	
	Stab wound	13	[0.5%]	3	[0.4%]	10	[0.5%]	
	Explosion	2	[0.1%]	0	[0.0%]	2	[0.1%]	
	Avalanche, landslide, spillage	25	[0.9%]	5	[0.7%]	20	[1.0%]	
	Other	175	[6.4%]	42	[5.9%]	133	[6.6%]	
	Unknown	9	[0.3%]	1	[0.1%]	8	[0.4%]	<0.001
Vitals			**[IQR or %]**		**[IQR or %]**		**[IQR or %]**	
Systolic blood pressure [mm Hg]		130	[110–147]	123	[106–140]	130	[111–149]	<0.001
Systolic blood pressure <90 mm Hg		267	[9.8%]	72	[10.1%]	195	[9.7%]	0.786
Pulse clinical [/min]		86	[72–101]	85	[71–100]	87	[72–102]	0.057
Pulse <60/min		193	[7.1%]	50	[7.0%]	143	[7.1%]	0.905
Pulse >100/min		701	[25.8%]	165	[23.1%]	536	[26.8%]	0.056
Glasgow Coma Scale (GCS)**		14.0	[3–15]	14.0	[3–15]	14.0	[3–15]	0.833
Glasgow Coma Scale (GCS) <9**		876	[33.3%]	229	[33.3%]	647	[33.3%]	0.993
Respiratory rate [/min]***		16.0	[14–20]	16.0	[14–20]	16.0	[14–21]	0.010
Bradypnoea <10/min***		54	[3.2%]	15	[3.6%]	39	[3.0%]	0.557
Tachypnoea >30/min***		60	[3.5%]	10	[2.4%]	50	[3.9%]	0.156
Temperature [° C]#		36.3	[35.6–36.8]	36.2	[35.5–36.7]	36.3	[35.7–36.9]	0.001
Oxygen saturation [%]##		98.0	[95–100]	99.0	[96–100]	98.0	[95–100]	0.001

* 2712, ** 2629, *** 1713, #2340, ##2353 non-missing values.

0–3]), followed closely by head trauma (66.7%, median AIS: 2.0 [IQR: 0–4]) and spine trauma (50.3%, median AIS: 1.0 [IQR: 0–2]). The median ISS in our cohort was 24.0 (IQR: 19–30).

Men suffered relatively more thoracic injuries than women (68.9% vs 61.9%, p = 0.001) and the median AIS Thorax for male patients was significantly higher than for female patients (3.0 [IQR: 0–3] vs 2.0 [IQR: 0–3], p <0.001). A considerably higher proportion of men than women had concomitant lung injuries (30.1% vs 23.6%, p = 0.001), haemo- or pneumothorax (38.8% vs 34.5%, p = 0.041) and rib fractures (55.5% vs 51.2%, p = 0.046).

Women suffered more pelvic fractures than male patients (29.3% vs 21.5%, p <0.001), as well as more fractures of long bones of the upper extremities (22.2% vs 15.7%, p <0.001), with more fractures of the humerus (9% vs 5.3%, p <0.001) and fractures of forearm bones (16% vs 11.9%, p = 0.005). There was no significant difference in the median ISS between men and women (24.0 [IQR: 19–30] vs 25.0 [IQR: 18–30], p = 0.780) (table 2).

Traumunculus

Figure 2 visualises the Swiss helicopter emergency medical services severe trauma traumunculus as described in the "Methods" section based on a 52-year-old (mean of cohort) with a 72% male appearance (proportion of males) base mesh. The size of its body parts reflects the prevalence of injury, the colour reflecting mean AIS and black holes denoting penetrating injury per body region (one percent per hole).

Outcome

Overall, 405 of 2714 patients (14.9%) died during their hospital stay, and 14 patients died after discharge but within 28 days after trauma. The lowest mortality rate was observed in the population aged 16–45 years (8.7%). The rate of mortality increased with age, reaching 38% in the group of individuals aged over 75 years (appendix table S1).

There was no statistically significant difference between male and female patients in hospitalisation length, intensive care unit (ICU) stay, duration of mechanical ventilation, 28-day mortality or in-hospital mortality (table 3, appendix table S2).

Discussion

To our knowledge, this is the first analysis of severely injured trauma patients transported by helicopter emergency medical services in Switzerland. In our cohort, these patients are predominantly male, and although some trauma

Table 2:
Injury characteristics according to sex.

	Total (n = 2714)		Female (n = 713)		Male (n = 2001)		p-value
Injury characteristics		[%]		[%]		[%]	
…Any head trauma	1810	[66.7%]	479	[67.2%]	1331	[66.5%]	0.747
…Any face trauma	940	[34.6%]	233	[32.7%]	707	[35.3%]	0.201
…Any neck trauma	134	[4.9%]	38	[5.3%]	96	[4.8%]	0.573
…Any thorax trauma	1819	[67.0%]	441	[61.9%]	1378	[68.9%]	0.001
…Any abdomen trauma	733	[27.0%]	199	[27.9%]	534	[26.7%]	0.527
…Any spine trauma	1365	[50.3%]	359	[50.4%]	1006	[50.3%]	0.972
…Any upper extremity trauma	1262	[46.5%]	330	[46.3%]	932	[46.6%]	0.893
…Any lower extremity (incl. pelvis) trauma	1228	[45.2%]	340	[47.7%]	888	[44.4%]	0.128
…Any external trauma	112	[4.1%]	24	[3.4%]	88	[4.4%]	0.234
Abbreviated Injury Scale (AIS)							
…AIS Head	2.0	[0.0–4.0]	3.0	[0.0–4.0]	2.0	[0.0–4.0]	0.192
…AIS Face	0.0	[0.0–1.0]	0.0	[0.0–1.0]	0.0	[0.0–1.0]	0.182
…AIS Neck	0.0	[0.0–0.0]	0.0	[0.0–0.0]	0.0	[0.0–0.0]	0.568
…AIS Thorax	3.0	[0.0–3.0]	2.0	[0.0–3.0]	3.0	[0.0–3.0]	<0.001
…AIS Abdomen	0.0	[0.0–1.0]	0.0	[0.0–2.0]	0.0	[0.0–1.0]	0.472
…AIS Spine	1.0	[0.0–2.0]	1.0	[0.0–2.0]	2.0	[0.0–2.0]	0.700
…AIS Upper Extremity	0.0	[0.0–2.0]	0.0	[0.0–2.0]	0.0	[0.0–2.0]	0.708
…AIS Lower Extremity (incl. pelvis)	0.0	[0.0–3.0]	0.0	[0.0–3.0]	0.0	[0.0–3.0]	0.036
…AIS External	0.0	[0.0–0.0]	0.0	[0.0–0.0]	0.0	[0.0–0.0]	0.234
Severe body region trauma*							
…Head	1325	[48.8%]	358	[50.2%]	967	[48.3%]	0.387
…Face	139	[5.1%]	31	[4.3%]	108	[5.4%]	0.275
…Neck	63	[2.3%]	19	[2.7%]	44	[2.2%]	0.478
…Thorax	1463	[53.9%]	346	[48.5%]	1117	[55.8%]	0.001
…Abdomen	420	[15.5%]	121	[17.0%]	299	[14.9%]	0.199
…Spine	531	[19.6%]	134	[18.8%]	397	[19.8%]	0.545
…Upper extremity	62	[2.3%]	21	[2.9%]	41	[2.0%]	0.169
…Lower extremity	750	[27.6%]	212	[29.7%]	538	[26.9%]	0.144
…External	3	[0.1%]	1	[0.1%]	2	[0.1%]	0.781
Injury severity		[IQR]		[IQR]		[IQR]	
…Injury Severity Score (ISS)	24.0	[19.0–30.0]	25.0	[18.0–30.0]	24.0	[19.0–30.0]	0.780

* Defined as AIS ≥3

mechanisms and injury characteristics vary between male and female patients, outcome parameters are similar between the two groups.

Sex distribution of accidents

We can only hypothesise why men make up almost three quarters of the patients in this cohort. Past and ongoing research assumes that men tend to engage in riskier activities and behaviours than women, especially in younger years [22]. This has led to the term "young male syndrome", although it has been questioned by more recent studies [23, 24]. They also suffer more injuries with potentially grave consequences during work in hazardous jobs such as construction work or when handling heavy machinery [25]. According to one paper, men's higher prevalence of risk-taking behaviour results in an overall non-fatal injury incidence of 10.1/100 for men in the United States, compared with 8.5/100 for women. Age-adjusted mortality rate from trauma was three times higher for men than for women [26]. According to a publication in 2024 by the Momentum Institute, relying on data from the Austrian national statistical system, male drivers caused two-thirds of all traffic accidents in 2023, of which almost a quarter occurred under the influence of alcohol or drugs, compared with 9% of accidents with female drivers [27]. We agree that riskier behaviour and greater activity in potentially hazardous

Figure 2: Swiss helicopter emergency medical services (HEMS) severe trauma traumunculus.

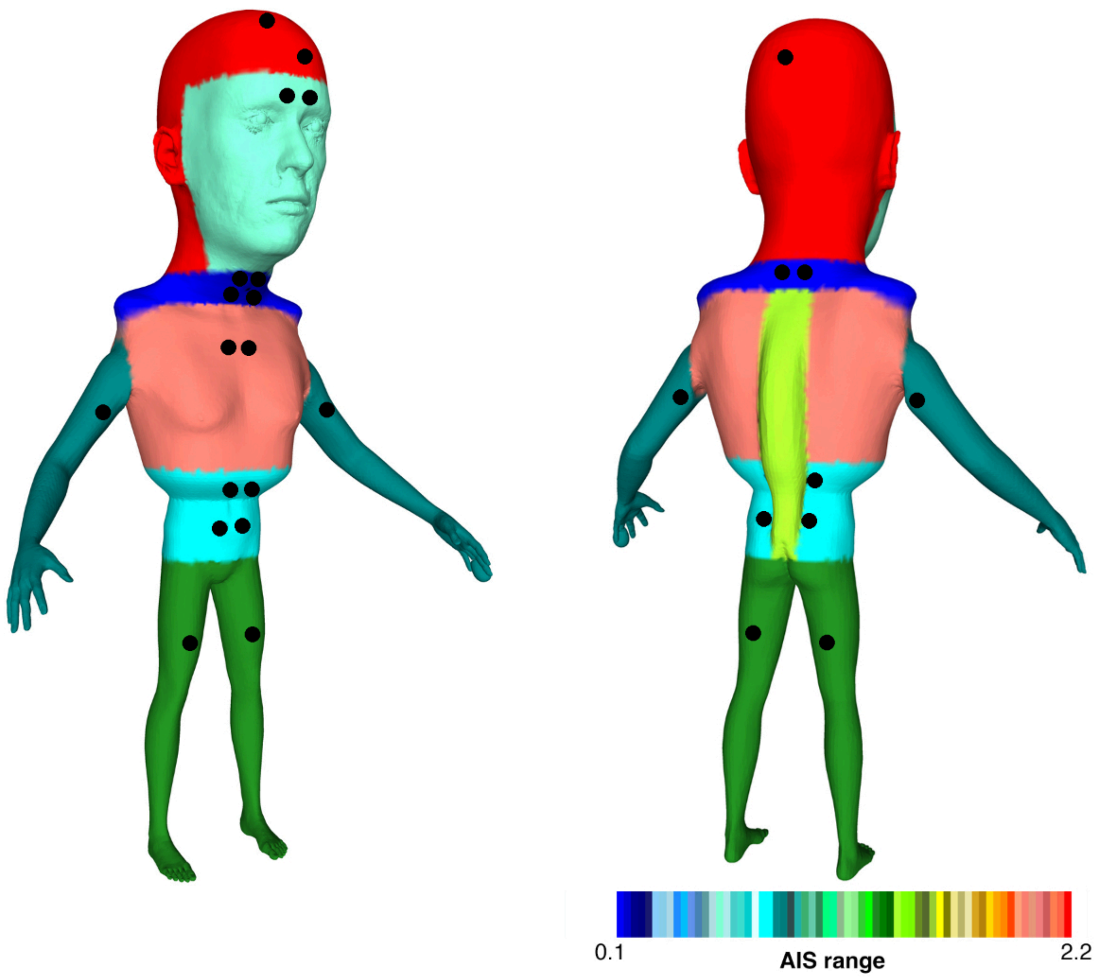


Table 3:
Outcome according to sex.

	Total (n = 2714)		Female (n = 713)		Male (n = 2001)		p-value
Outcome		**[IQR or %]**		**[IQR or %]**		**[IQR or %]**	
Length of hospital stay [days]	11.0	[6–18]	11	[6–17]	11	[6–18]	0.295
Length of ICU stay [hours]	48	[19–149]	46	[20–133]	48.0	[19–155]	0.435
Mechanical ventilation*	1176	[47.0%]	300	[46.0%]	876	[47.4%]	0.541
Duration of mechanical ventilation [hours]**	8	[0.0–69]	6	[0.0–53]	9.0	[0–72]	0.155
28-day mortality (from accident)***	419	[18.0%]	115	[18.8%]	304	[17.7%]	0.545
In-hospital mortality	405	[14.9%]	112	[15.7%]	293	[14.6%]	0.493

ICU: Intensive Care Unit.

* 2500, ** 2136, *** 2326 non-missing values.

jobs, along with other factors, may contribute to higher numbers of male patients in our study. We found that men were more involved in motorcycle crashes, which could underline more involvement in hazardous activities. The Swiss Council for Accident Prevention (Beratungsstelle für Unfallverhütung [BFU]) highlighted in its 2021–2025 action programme that motorcycles are particularly popular among young men and that, despite accounting for only 2% of all vehicles on the road, motorcyclists (both male and female) represent 30% of all severely injured road users – a figure that closely aligns with our own findings. The BFU also addresses the role of peer pressure among young men as a contributing factor to risk-taking behaviour. With numerous action plans and programmes, the BFU aims to prevent non-work-related severe injuries in Switzerland and to mitigate the impact of this major public health concern. Non-work-related accidents account for approximately one million incidents annually, leading to 36,000 severely injured patients, 2400 fatalities and 12 billion Swiss Francs in material damage [28].

Our study's results further emphasise the need for targeted prevention campaigns to reduce the burden of severe injuries, particularly among young men. Potential preventive strategies might include (a) traffic safety campaigns, (b) mandatory advanced rider training, (c) peer-driven interventions, (d) further enforcement of traffic laws, (e) infrastructure improvements (road safety modifications) and (f) early public health education starting as early as primary school.

Injury characteristics

Regarding the consequences of trauma, men seemed to experience thoracic trauma more frequently and with a significantly higher Abbreviated Injury Score (AIS) Thorax, including greater incidence of lung injuries, rib fractures and haemo- or pneumothoraxes. Severe thoracic injuries can originate from high-energy trauma, possibly reflecting men's higher prevalence in motorcycle accidents. Women in our cohort suffered pelvic and upper extremity fractures, including humerus and forearm fractures, more frequently. While pelvic fractures are also associated with high-energy trauma, another factor increasing the fracture rate in women may be underlying osteoporosis, which is most prevalent in older female patients [29, 30]. After the age of 50, women are five times more likely to develop osteoporosis than the general population. This, coupled with the effects of ageing, frailty and more frequent falls, can significantly increase the likelihood of hip fractures in women over 70 years of age. The incidence of forearm fractures also rises, but not as sharply [31, 32].

Sex-based differences in quality of care

Published data suggests that the quality of prehospital care varies between men and women due to sex-related factors. A 2012 retrospective cohort analysis of severely injured patients in Canada looked at sex-based differences in direct transport by emergency medical services to trauma centres, as well as secondary transfer from non-trauma centres to trauma centres. The study revealed that female patients were less likely to be directly admitted or transferred to a trauma centre than male patients [33]. A 2016 retrospective observational study from Stockholm underlines these results. The study showed that severely injured female trauma patients were given less priority in prehospital care and more often did not receive direct transport to a trauma centre compared to their male counterparts [34]. In accordance with our study, they also reported that women suffered more injuries from falls than men and that mortality between the male and female groups did not differ significantly.

A possible explanation for this sex gap in triage and admission might be that elderly female patients more frequently suffer from "less spectacular" mechanisms of trauma, such as falls, and despite being severely injured, may be more likely undertriaged due to the apparent "low-energy" mechanism of trauma. Men, who more often suffer serious injuries from eye-catching high-energy trauma mechanisms such as motorcycle crashes might be more likely to be directly transported to a trauma centre because of the obvious accident mechanism. However, it is important to point out that diagnosis in the prehospital setting, particularly during helicopter emergency medical services missions, can be very challenging. Evidence without regard to sex groups shows that even trained professionals can miss severe chest and pelvic injuries in these situations [35, 36].

There is conflicting data on patient outcomes when focusing on sex in emergency medicine. The evidence so far does not indicate a difference in mortality when male and female trauma patients are compared [34, 37–39]. On the other hand, research has shown that sex can influence medical treatment and outcome in various conditions such as myocardial infarction, stroke care and triage to the ICU [40–50]. A recent nationwide registry study from Switzerland with 41,733 cardiac arrest patients, 34.9% of whom were women, concluded that female patients were less frequently admitted to an ICU after cardiac arrest. In addition, fewer advanced treatment measures were taken, and their risk of ICU mortality was higher compared to their male counterparts, especially after out-of-hospital cardiac arrest [50].

In our study, there were no significant differences between the two sex groups in terms of outcome parameters; mortality was similar between men and women, as was their duration of hospital stay and other outcome data. Nevertheless, more and more data with a special focus on sex differences is emerging and future research will play an important role in unearthing or denying inequality in medical care between male and female trauma patients. It is important for helicopter emergency medical services crew members to acknowledge this potential sex bias and to keep it in mind on missions, ensuring that all patients receive equal high-quality care regardless of their sex.

Limitations

Our cohort does not represent all patients admitted to Swiss level 1 trauma centres with comparable injury severity as helicopter emergency medical services tend to operate in more remote regions than ground emergency medical services (GEMS). In Switzerland, ground emergency medical services provide emergency medical aid in more densely populated areas. Here helicopter emergency medical services are mostly dispatched for additional support of ground emergency medical services, for example if a physician is needed on-site, to provide rapid transport to

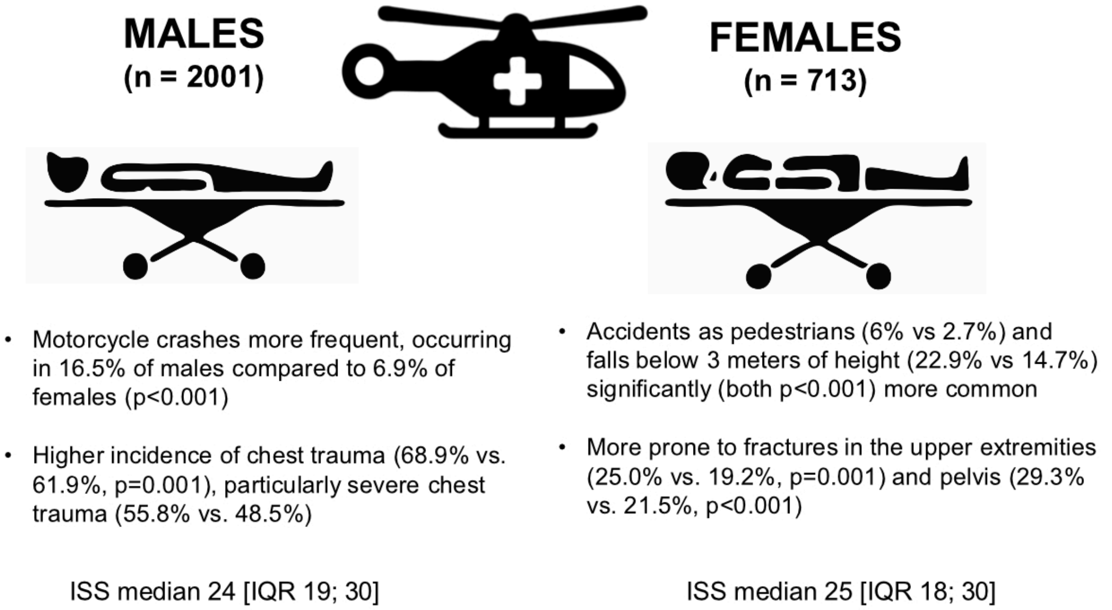


Figure 3: Summary of the results. ISS: Injury Severity Score.

a medical centre further away or if no ground emergency medical service is available. Further research comparing Swiss trauma patients transported by helicopter emergency medical services and ground emergency medical services, such as that published by Blok et al. with data from a Danish helicopter emergency medical services provider, would be needed to gain insight into potential differences [31].

Furthermore, this study only analysed severely injured trauma patients, excluding those with a lower Injury Severity Score (ISS), which limits its significance for all trauma patients. We also excluded patients who were transferred to a trauma centre after primary admission to a non-trauma centre, thus not enabling us to provide data on the correct triage of male and female trauma patients by the crews on the scene as has been described in other studies and mentioned in our discussion. Another limitation of this study is of course its retrospective design and analysis of data. Due to the summarised nature of the dataset, we were not able to compare the baseline characteristics of the two sexes with their injuries, mechanisms of accidents and outcomes, preventing us from drawing conclusions about relationships between these variables such as injuries or injury mechanisms suffered predominantly in certain age groups of the two sexes.

Conclusion

The data provided by the Swiss Trauma Registry enabled us to present an overview of the patients encountered by medical professionals on their helicopter emergency medical services missions in Switzerland. Although differences between women and men were observed in terms of trauma mechanisms and injuries, no significant differences in outcome parameters were noted.

An illustrative and short summary of the results can be found in figure 3.

Data sharing statement

The complete and deidentified dataset used to create any tables and figures in the current study is available from the corresponding author upon reasonable request.

Acknowledgments

Author contributions: UP designed the study. MM built the database. PM, MM and SJ analyzed the data. All authors performed the literature search. MM and DAJ wrote the structure of the manuscript. PM, SJ and DAJ wrote the first draft of the manuscript. All authors contributed to the interpretation of the data and writing of the final manuscript and approved the final version of the manuscript.

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Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflict of interest related to the content of this manuscript was disclosed.

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Appendix

Supplement 1. Creation of the traumunculus

Step 1: Creation of the three-dimensional base mesh

The software “MakeHuman” (http://www.makehumancommunity.org/, version 1.2.0) was used to create a three-dimensional base mesh. The mesh was adjusted to reflect the cohort's characteristics, such as the percentage of male appearance and average age (Figure S1). Weight and height were not further adjusted as this information was unavailable in the database.

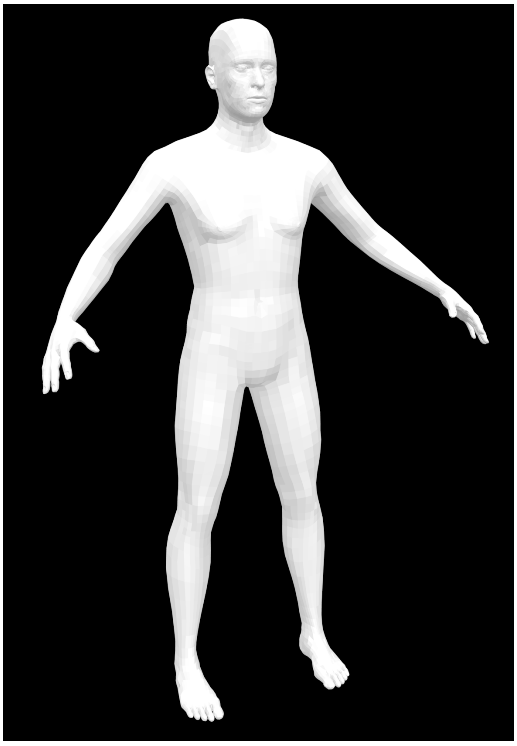

Figure S1. Base mesh obtained by MakeHuman; male 72%, age 52 years (mean age of cohort)

Step 2: Mesh refinement

The base mesh was imported into MeshLab (Version 2022.02, built on February 23, 2022, using Clang 13.0.0 and Qt 5.15.2). The density of the mesh was increased using the subdivision surfaces filter (Catmull-Clark).

Step 3: Point adjustment in Stata

The mesh points were exported and processed in Stata. For each body region (head, face, neck, spine, thorax, abdomen, upper extremity, lower extremity), the following adjustments were made: First, the percentage share of the total body surface area for each region was determined based on the Wallace rule of nines [51]. Second, the percentage of cases in which each body region was affected by trauma was calculated. Third, under the simplified assumption that a body region is affected by trauma proportionally to its share of the total body surface area, the surface area of each region was scaled by a factor derived from the ratio of injuries in that region to its initial surface area. For instance, the head, which accounts for approximately 5% of the total body surface area, was injured in 66.7% of cases. As a result, the surface area of the head was scaled up by a factor of 13.3 (66.7/5).

Step 4: Final traumunculus construction

The adjusted mesh was re-imported into MeshLab. The surface of the traumunculus was reconstructed using the screened Poisson surface reconstruction method after computing normals for the point sets and cleaning the mesh (merging vertices).

Step 5: Coloring

The regions were colored based on the mean Abbreviated Injury Scale (AIS) score of each body region, using a predefined color gradient. The proportion of penetrating trauma for each injured body part was visually represented by the number of holes in the region, with each hole representing 1% of penetrating trauma.

Supplement 2.

	Total	In-hospital mortality		P-value
	(n=2714)	No (n=2309)	Yes (n=405)	
DEMOGRAPHICS				
Age groups				
16-45	1022 [37.7]	933 [40.4]	89 [22.0]	
>45-65	950 [35.0]	847 [36.7]	103 [25.4]	
>65-75	379 [14.0]	304 [13.2]	75 [18.5]	
>75	363 [13.4]	225 [9.7]	138 [34.1]	<0.001
Age [years]	54 [35; 67]	52 [33; 60]	67 [49; 79]	<0.001
Gender				
Female	713 [26.3]	601 [26.0]	112 [27.7]	
Male	2001 [73.7]	1708 [74.0]	293 [72.3]	0.493
ACCIDENT CHARACTERISTICS				
Type of injury				
Blunt trauma	2540 [93.6]	2173 [94.1]	367 [90.6]	
Penetrating injury	95 [3.5]	69 [3.0]	26 [6.4]	
Blunt & penetrating injury	77 [2.8]	66 [2.9]	11 [2.7]	
Unknown	2 [0.1]	1 [0.0]	1 [0.2]	0.003
Type of injury, detail				
Traffic - car, truck	319 [11.8]	287 [12.4]	32 [7.9]	
Traffic - MCC	379 [14.0]	348 [15.1]	31 [7.7]	
Bicycle	281 [10.4]	247 [10.7]	34 [8.4]	
Pedestrian	98 [3.6]	68 [2.9]	30 [7.4]	
Fall over 3m	596 [22.0]	522 [22.6]	74 [18.3]	
Fall below 3m	457 [16.8]	346 [15.0]	111 [27.4]	
Fall of unknown height	68 [2.5]	58 [2.5]	10 [2.5]	
Traffic other	66 [2.4]	53 [2.3]	13 [3.2]	
Other - Blow	111 [4.1]	100 [4.3]	11 [2.7]	
Gunshot wound	27 [1.0]	14 [0.6]	13 [3.2]	
Stab wound	13 [0.5]	10 [0.4]	3 [0.7]	
Other	175 [6.4]	159 [6.9]	16 [4.0]	
E-bike/E-scooter	34 [1.3]	29 [1.3]	5 [1.2]	
Fall at ground level	54 [2.0]	41 [1.8]	13 [3.2]	
Explosion	2 [0.1]	1 [0.0]	1 [0.2]	
Avalanche, landslide, spillage	25 [0.9]	17 [0.7]	8 [2.0]	
Unknown	9 [0.3]	9 [0.4]	0 [0.0]	<0.001
Penetrating injury	172 [6.3]	135 [5.8]	37 [9.1]	0.012
VITALS				
SBP [mmHg]	130.0 [110; 147]	130.0 [112.0; 147]	119.0 [90; 145]	<0.001
SBP <90mmHg	267 [9.8]	172 [7.4]	95 [23.5]	<0.001

Pulse clinial [/min]	86.0 [72; 101]	86.0 [72.0; 100]	91.0 [71; 110]	<0.001
Pulse <60/min	193 [7.1]	151 [6.5]	42 [10.4]	0.006
Pulse >100/min	701 [25.8]	545 [23.6]	156 [38.5]	<0.001
GCS	14.0 [3; 15]	14 [9; 15]	3.0 [3; 3]	<0.001
GCS <9	876 [33.3]	535 [24.0]	341 [85.0]	<0.001
Respiratory rate [/min]	16 [14; 20]	16 [14; 21]	15.0 [12; 19]	<0.001
Bradypnea <10/min	54 [3.2]	34 [2.3]	20 [8.7]	<0.001
Bradypnea >30/min	60 [3.5]	51 [3.4]	9 [3.9]	0.716
Temperature[°C]	36.3 [35.6; 36.8]	36.4 [35.8; 36.9]	35.8 [35.0; 36.5]	<0.001
Oxygen saturation [%]	98 [95; 100]	98 [96; 100]	98 [93; 100]	0.001
INJURY CHARACTERISTICS				
Any Head trauma	1810 [66.7]	1455 [63.0]	355 [87.7]	<0.001
Any Face trauma	940 [34.6]	782 [33.9]	158 [39.0]	0.045
Any Neck trauma	134 [4.9]	108 [4.7]	26 [6.4]	0.135
Any Thorax trauma	1819 [67.0]	1566 [67.8]	253 [62.5]	0.035
Any Abdomen trauma	733 [27.0]	636 [27.5]	97 [24.0]	0.133
Any Spine trauma	1365 [50.3]	1192 [51.6]	173 [42.7]	0.001
Any UE trauma	1262 [46.5]	1114 [48.2]	148 [36.5]	<0.001
Any LE (incl. pelvis) trauma	1228 [45.2]	1074 [46.5]	154 [38.0]	0.002
Any External trauma	112 [4.1]	99 [4.3]	13 [3.2]	0.315
INJURY SEVERITY				
ISS	24.0 [19.0; 30.0]	22.0 [18.0; 29.0]	29.0 [25.0; 41.0]	<0.001
AIS head	2.0 [0.0; 4.0]	2.0 [0.0; 3.0]	4.0 [3.0; 5.0]	<0.001
AIS face	0.0 [0.0; 1.0]	0.0 [0.0; 1.0]	0.0 [0.0; 2.0]	0.011
AIS neck	0.0 [0.0; 0.0]	0.0 [0.0; 0.0]	0.0 [0.0; 0.0]	0.130
AIS thorax	3.0 [0.0; 3.0]	3.0 [0.0; 3.0]	2.0 [0.0; 3.0]	0.281
AIS abdomen	0.0 [0.0; 1.0]	0.0 [0.0; 2.0]	0.0 [0.0; 0.0]	0.196
AIS spine	1.0 [0.0; 2.0]	2.0 [0.0; 2.0]	0.0 [0.0; 2.0]	<0.001
AIS UE	0.0 [0.0; 2.0]	0.0 [0.0; 2.0]	0.0 [0.0; 2.0]	<0.001
AIS LE (incl. pelvis)	0.0 [0.0; 3.0]	0.0 [0.0; 3.0]	0.0 [0.0; 2.0]	<0.001
AIS external	0.0 [0.0; 0.0]	0.0 [0.0; 0.0]	0.0 [0.0; 0.0]	0.322
SEVERE BODY REGION TRAUMA				
Head	1325 [48.8]	989 [42.8]	336 [83.0]	<0.001
Face	139 [5.1]	107 [4.6]	32 [7.9]	0.006
Neck	63 [2.3]	48 [2.1]	15 [3.7]	0.045
Thorax	1463 [53.9]	1261 [54.6]	202 [49.9]	0.078
Abdomen	420 [15.5]	360 [15.6]	60 [14.8]	0.690
Spine	531 [19.6]	474 [20.5]	57 [14.1]	0.003
Upper extremity	62 [2.3]	57 [2.5]	5 [1.2]	0.125
Lower extremity (incl. pelvis)	750 [27.6]	667 [28.9]	83 [20.5]	<0.001
External	3 [0.1]	2 [0.1]	1 [0.2]	0.371
OUTCOME				
Dur. of hospitalization [days]	11.0 [6.0; 18.0]	12.0 [7.0; 19.0]	3.0 [2.0; 7.0]	<0.001
Dur. intensive care [h]	48.0 [19; 149]	48.0 [20; 156]	41.0 [10; 122]	<0.001
Dur. of MV [h]	8.0 [0.0; 69.0]	5.0 [0.0; 60.4]	30.0 [6.0; 97.0]	<0.001

Mortality 28 days after accident	419 [18.0]	32 [1.7]	387 [97.0]	<0.001
In-hospital mortality	405 [14.9]	0 [0.0]	405 [100.0]	<0.001
HEAD/FACE INJURY				
TBI contusion	370 [13.6]	285 [12.3]	85 [21.0]	<0.001
TBI concussion	430 [15.8]	411 [17.8]	19 [4.7]	<0.001
TBI bleeding	25 [0.9]	17 [0.7]	8 [2.0]	0.016
Skull fracture	823 [30.3]	616 [26.7]	207 [51.1]	<0.001
Face fracture	728 [26.8]	596 [25.8]	132 [32.6]	0.004
SPINE INJURY				
Spine fracture	1365 [50.3]	1192 [51.6]	173 [42.7]	0.001
C-spine injury	580 [21.4]	486 [21.0]	94 [23.2]	0.328
Thoracic spine injury	725 [26.7]	652 [28.2]	73 [18.0]	<0.001
Lumbal spine	655 [24.1]	574 [24.9]	81 [20.0]	0.035
THORAX INJURY				
Lung injury	770 [28.4]	669 [29.0]	101 [24.9]	0.097
Haemo-/pneumothorax	1023 [37.7]	890 [38.5]	133 [32.8]	0.029
Heart injury	207 [7.6]	192 [8.3]	15 [3.7]	0.001
Thoracic aorta injury	36 [1.3]	29 [1.3]	7 [1.7]	0.443
Rib fracture	1476 [54.4]	1269 [55.0]	207 [51.1]	0.152
Sternum fracture	231 [8.5]	191 [8.3]	40 [9.9]	0.286
ABDOMINAL INJURY				
Diaphragmatic injury	33 [1.2]	30 [1.3]	3 [0.7]	0.344
Solid organ injury	533 [19.6]	469 [20.3]	64 [15.8]	0.035
Liver injury	263 [9.7]	227 [9.8]	36 [8.9]	0.554
Spleen injury	267 [9.8]	238 [10.3]	29 [7.2]	0.050
Pancreas injury	29 [1.1]	28 [1.2]	1 [0.2]	0.081
Hollow organ injury	69 [2.5]	61 [2.6]	8 [2.0]	0.432
Esophageal injury	3 [0.1]	2 [0.1]	1 [0.2]	0.371
Stomach	9 [0.3]	8 [0.3]	1 [0.2]	0.748
Small intestine	38 [1.4]	35 [1.5]	3 [0.7]	0.221
Colon	38 [1.4]	32 [1.4]	6 [1.5]	0.880
Kidney injury	162 [6.0]	143 [6.2]	19 [4.7]	0.239
Bladder injury	26 [1.0]	25 [1.1]	1 [0.2]	0.111
Retroperitoneal hemorrhage	25 [0.9]	21 [0.9]	4 [1.0]	0.879
PELVIC INJURY				
Pelvic fracture	639 [23.5]	558 [24.2]	81 [20.0]	0.068
EXTREMITY INJURY				
UE fracture	563 [20.7]	501 [21.7]	62 [15.3]	0.003
Clavicle fracture	317 [11.7]	270 [11.7]	47 [11.6]	0.959
Scapula fracture	385 [14.2]	333 [14.4]	52 [12.8]	0.400
UE long bone fracture	472 [17.4]	415 [18.0]	57 [14.1]	0.056
Humerus fracture	170 [6.3]	144 [6.2]	26 [6.4]	0.888
Radius/ulna fracture	352 [13.0]	314 [13.6]	38 [9.4]	0.020
Hand fracture	168 [6.2]	157 [6.8]	11 [2.7]	0.002
LE fracture	627 [23.1]	561 [24.3]	66 [16.3]	<0.001
Femur fracture	330 [12.2]	297 [12.9]	33 [8.1]	0.007

Tibia/fibula fracture	348 [12.8]	306 [13.3]	42 [10.4]	0.110
Foot fracture	153 [5.6]	145 [6.3]	8 [2.0]	0.001

Supplement 3. Detailed injury characteristics according to sex

	Total (n=2714)	Gender Female (n=713)	Male (n=2001)	P-value
HEAD/FACE INJURY				
TBI contusion	370 [13.6]	97 [13.6]	273 [13.6]	0.979
TBI concussion	430 [15.8]	109 [15.3]	321 [16.0]	0.636
TBI bleeding	25 [0.9]	5 [0.7]	20 [1.0]	0.474
Skull fracture	823 [30.3]	223 [31.3]	600 [30.0]	0.520
Face fracture	728 [26.8]	180 [25.2]	548 [27.4]	0.268
SPINE INJURY				
Spine fracture	1365 [50.3]	359 [50.4]	1006 [50.3]	0.972
C-spine injury	580 [21.4]	160 [22.4]	420 [21.0]	0.417
Thoracic spine injury	725 [26.7]	190 [26.6]	535 [26.7]	0.963
Lumbal spine	655 [24.1]	181 [25.4]	474 [23.7]	0.363
THORAX INJURY				
Lung injury	770 [28.4]	168 [23.6]	602 [30.1]	0.001
Haemo-/pneumothorax	1023 [37.7]	246 [34.5]	777 [38.8]	0.041
Heart injury	207 [7.6]	50 [7.0]	157 [7.8]	0.472
Thoracic aorta injury	36 [1.3]	6 [0.8]	30 [1.5]	0.187
Rib fracture	1476 [54.4]	365 [51.2]	1111 [55.5]	0.046
Sternum fracture	231 [8.5]	61 [8.6]	170 [8.5]	0.961
ABDOMINAL INJURY				
Diaphragmatic injury	33 [1.2]	5 [0.7]	28 [1.4]	0.144
Solid organ injury	533 [19.6]	152 [21.3]	381 [19.0]	0.189
Liver injury	263 [9.7]	77 [10.8]	186 [9.3]	0.244
Spleen injury	267 [9.8]	78 [10.9]	189 [9.4]	0.250
Pancreas injury	29 [1.1]	7 [1.0]	22 [1.1]	0.793
Hollow organ injury	69 [2.5]	12 [1.7]	57 [2.8]	0.090
Esophageal injury	3 [0.1]	2 [0.3]	1 [0.0]	0.112
Stomach	9 [0.3]	3 [0.4]	6 [0.3]	0.630
Small intestine	38 [1.4]	9 [1.3]	29 [1.4]	0.715
Colon	38 [1.4]	3 [0.4]	35 [1.7]	0.010
Kidney injury	162 [6.0]	35 [4.9]	127 [6.3]	0.164
Bladder injury	26 [1.0]	7 [1.0]	19 [0.9]	0.940
Retroperitoneal hemorrhage	25 [0.9]	7 [1.0]	18 [0.9]	0.844
PELVIC INJURY				
Pelvic fracture	639 [23.5]	209 [29.3]	430 [21.5]	<0.001
EXTREMITY INJURY				
Clavicle fracture	317 [11.7]	90 [12.6]	227 [11.3]	0.361
Scapula fracture	385 [14.2]	80 [11.2]	305 [15.2]	0.008
UE fracture	563 [20.7]	178 [25.0]	385 [19.2]	0.001
UE long bone fracture	472 [17.4]	158 [22.2]	314 [15.7]	<0.001
Humerus fracture	170 [6.3]	64 [9.0]	106 [5.3]	<0.001
Radius/ulna fracture	352 [13.0]	114 [16.0]	238 [11.9]	0.005

Hand fracture	168 [6.2]	38 [5.3]	130 [6.5]	0.267
LE fracture	627 [23.1]	153 [21.5]	474 [23.7]	0.225
Femur fracture	330 [12.2]	84 [11.8]	246 [12.3]	0.719
Tibia/fibula fracture	348 [12.8]	83 [11.6]	265 [13.2]	0.272
Foot fracture	153 [5.6]	42 [5.9]	111 [5.5]	0.733