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Research Paper

Single stab injuries to the trunk in assault cases—A comparative study of female and male victims in clinical forensic medicine

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ABSTRACT

Background/aim: Determining the causation of an injury in living individuals is a key task for forensic pathologists. However, little is known about sex-based differences in injury characteristics. The study aims to examine sex-based differences in single stab injuries to the trunk among assault survivors, to potentially identify injury patterns that could aid forensic assessment and help in the management of these patients in emergency care.
Methods: Using the Swedish National Board of Forensic Medicine's registry, we identified 385 survivors of single stab injuries to the trunk (361 men, 24 women). Case characteristics were collected and analyzed using Mann-Whitney U tests, chi-square tests, and univariate logistic regression analyses.
Results: Psychiatric illness was more frequent in women than in men (26% vs. 11%, $p < 0.05$). Women were more often assaulted at home (42% $_{female}$, 21% $_{male}$, $p < 0.05$), while men were mostly attacked outdoors (56% $_{male}$, 29% $_{female}$, $p < 0.05$). In 50% of female cases, the assault object was found at the crime scene, while in majority of male cases no object was identified (66%, $p < 0.05$). Horizontal wound directions were more common in women (59% vs. 29%, $p < 0.05$). Injury severity, based on the New Injury Severity Score, did not differ between sexes (median 8 $_{male}$, median 9 $_{female}$, $p = 0.76$).
Conclusion: Differences in demographics, injury characteristics, and circumstances may help guide forensic assessments by improving injury profiling and assessment accuracy. It can also help emergency caregivers provide appropriate support to assaulted patients. Further research is needed to explore whether these findings reflect underlying patterns of domestic violence.

1. Introduction

Forensic pathologists have several important tasks; one is determining the causation of injuries on a living person based on medical findings, such as injuries and scars, anatomic location, and, to some extent, the context of the case. Accordingly, forensic pathologist assessments can be based on medical records, photographs, clinical forensic medical examinations, and the case context as described in police reports, including victim and witness statements and results of police forensic examinations, such as damage to clothes. It should be noted that the role of forensic pathologists varies internationally. In Sweden, forensic pathologists are involved in the assessment of both fatal and non-fatal injuries within a forensic medical context, whereas in other jurisdictions assessments of injuries in living individuals are commonly performed by other forensic medical practitioners.

Most studies in the field of forensic medicine have been conducted on autopsy populations, and research on surviving individuals is limited. Furthermore, few studies on assaults inflicted by sharp force violence

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have focused on examining victim characteristics and forensic findings to help identify specific patterns in assault-related cases[1–3].

In some studies, the peak of sharp force violence is seen around the age of 30 years, regardless of sex,[2,4] but in one study the peak in men was described as occurring before 30 years of age, and in women, after the age of 30[1]. Domestic violence has been described to particularly affect young adults aged 15–19 years, especially women.[5]

Discrepancies are also found when analysing injury severity expressed via an Injury Severity Score (ISS), with some studies reporting higher ISS scores in women while others suggest higher scores in men[1,2]. The sex-related difference regarding the anatomical location of sharp force injuries has also been debated. In one study, males demonstrated a pattern of chest and lower body injuries, while females suffered mostly head, chest, and abdominal injuries, often involving multiple sites.[1] In another study, female victims of intimate partner violence (IPV) had injuries to the axial skeleton, especially ribs and injuries at the right side of the body.[3] In another study from 2020, most IPV-related injuries were localised in the face, upper trunk, and fingers.[6] In some studies, women had high blood alcohol levels and were more prevalent with a psychiatric history.[2,3] Females were more likely to be assaulted at home compared to men, possibly due to domestic violence.[1] It has been demonstrated that in cases of domestic violence, most perpetrators were identified as intimate partners.[2]

Single stab injuries to the trunk represent a challenging injury when assessing the manner of death.[7] To guide the assessment, multiple factors can be taken into consideration, including injury characteristics, injury severity, and context. To the best of our knowledge, no current study has explored how sex may influence injury severity, injury patterns, and circumstances in assault cases involving a single stab wound to the trunk. This highlights the need for research in this area to increase the evidence base for the forensic assessment of assault cases, as well as to increase the knowledge of the various patterns of violence inflicted on women versus those inflicted on men.

The purpose of this study is to examine sex differences in single stab injuries to the trunk among survivors of assault. The objectives are to examine sex differences in the injury pattern, injury severity, and to assess how the circumstances (location at the time of injury, influence of alcohol or narcotics) may differ between sexes. This can contribute to identifying specific patterns in assault-related cases, making them easier to recognise in future forensic assessments and clinical care, providing important information for public health in the prevention of violence in general as well as violence aimed at women.

2. Material and method

2.1. Study population

Cases reviewed in this study included surviving individuals of assault with a single stab to the trunk between 2016 and 2021. Data were collected from the clinical registry of the Swedish National Board of Forensic Medicine. The registry included police-reported assault cases assessed by forensic pathologists at the Swedish National Board of Forensic Medicine, all of which have forensic reports based on either forensic examination, medical records, photographs documenting the injuries, or a combination thereof. In some cases, no forensic examination was conducted, and the assessment relied solely on photographs and/or clinical documentation.

Using keywords such as “stab wound”, “knife cut”, and “knife stab”, we were able to identify 9162 cases. Individuals <15 years of age were excluded, as were reports involving more than a single stab to the trunk. Cases that were included involved stab wounds located anywhere between the clavicle and the pelvic bone. Cases involving both incisions and stabs, and cases with stab wounds of more than one direction were still classified as single stab wounds and were therefore included in the study. Additional blunt force trauma after the stabbing did not represent an exclusion criterion, and therefore such cases were also included. Cases of self-inflicted, accidental, or non-assessable stab injuries were excluded.

2.2. Collection of variables

Demographic data and information on crime scenes and injury characteristics were collected from forensic reports, police reports, and medical records.

Age was expressed in years and treated as a continuous variable whereas sex was categorised as female/male. In this paper, the term 'sex' refers specifically to sex assigned at birth, and is therefore limited to a binary categorisation with only two options: male and female.

Psychiatric diagnosis and the abuse of alcohol/narcotics were categorised as present or absent based on the information available in any of the available medical records. Data were categorised as missing if no medical records were available.

Information on the crime scene was categorised into victim's residency, other indoor location (other than the victim's house), or outdoor location.

Information about the weapon's position after the crime was subdivided into: object found in situ of the body of the victim upon the arrival of the police or ambulance, object found on the crime scene, object found by the suspect, or object missing.

Injuries to clothing were categorised as injury through clothing, no injury through clothing, or no clothing worn during stabbing.

Substance use at the time of the stabbing was assessed upon arrival at the hospital through appropriate testing. If the tests yielded positive results or if the victim admitted to being under the influence of substances at the time of the stabbing, this was documented in the medical records and interpreted as confirmed intoxication. The subdivision in this group consisted of the influence of alcohol and the influence of illicit/licit/non-specified narcotics. Illicit drugs were defined as the following: tetrahydrocannabinol, amphetamine, cocaine, and heroin.

The entrance wound was categorised based on the anatomical location and divided into anterior trunk, right axillar region, left axillar region, and posterior trunk. The anterior and posterior parts of the trunk were furthermore subdivided into right, left, and vertical midline. Stab injuries could implicate the thoracic or abdominal cavity or be categorised as non-penetrating. In case of penetration to the thoracic wall, stab injuries were categorised as injuries to the bones of the ribcage or injuries to the intercostal space. The orientation of the entrance wound was defined as vertical, horizontal, or diagonal down right/left.

The length of the injury channel, expressed as a continuous constant, was recorded in centimetres. The orientation of the injury channel was classified as either caudal/cranial/straight horizontal or medial/lateral/straight sagittal. Defensive injuries were expressed as present or absent. These injuries were described as superficial sharp injuries to the palms or ulnar sides of the forearms that could have occurred when the victim tried to fight off the assault.

Injury severity was defined using the Abbreviated Injury Score (AIS) from 2005. The three most severe scores were used to calculate the New Injury Severity Score (NISS), according to the following formula: $NISS = AIS^2 + AIS^2 + AIS^2$[8].

Based on the results, injuries were categorised as minor if NISS ≤8, moderate if NISS = 9–15, severe if NISS = 16–24, and critical if NISS ≥25. A forensic pathologist (Berg von Linde M) rated injuries according to the NISS scale. To assess reliability, 20 randomly chosen cases were independently scored by an emergency medicine physician (Khoshnood A M). Inter-rater reliability (ICC) was 0.73 (95% CI 0.32–0.89). After discussion of discrepancies and the development of standardised scoring criteria in consultation with an AIS instructor, a second independent assessment of 20 other cases was performed. This yielded an ICC of 0.87 (95% CI 0.68–0.95), indicating good agreement between raters. Details of the scoring procedure and definitions are presented elsewhere.[9]

2.3. Statistics

Categorical variables were presented in numbers and percentages. Continuous variables were expressed as medians and ranges, as the data were not normally distributed. Chi-square tests were used to assess p-values for nominal variables (e.g., sex), while Mann-Whitney U tests were used to compare whether differences were significant between two independent, continuous, not-normally distributed variables (e.g., age). A p-value <0.05 was considered statistically significant.

Additionally, univariate logistic regression analyses were performed to assess differences in demographics, circumstances, and injury characteristics between female victims and male victims (reference). Odds ratio (OR) were reported with 95% confidence intervals (CI).

IBM SPSS Statistics Premium 28 was used to analyse statistical data.

2.4. Ethics approval

The Swedish Ethical Review Authority approved the study (Dnr 2022–04847–01). No informed consent was collected, as the study was retrospective, containing data that had already been collected by public authorities or registry holders.

3. Results

3.1. Study population

The study population consisted of 385 cases (Fig. 1), the majority of whom were men (n = 361, 94%, Table 1). The median age was similar between the two groups, with a slightly wider range for males. A significantly higher frequency of females had a psychiatric diagnosis compared to males (26%$_{female}$ vs. 11% $_{male}$, $p = 0.035$). Although not statistically significant, females had higher rates of alcohol and narcotic intoxication.

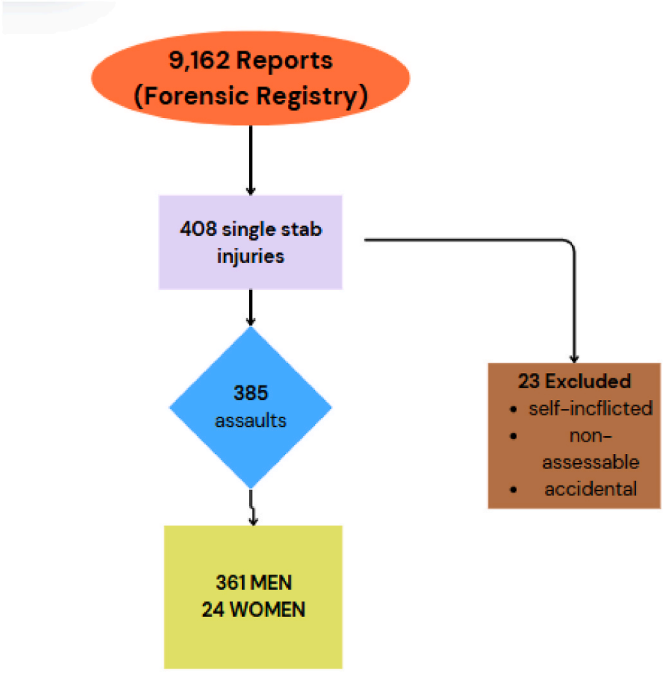

Fig. 1. Flowchart of case inclusion. Data were selected from the Swedish National Board of Forensic Medicine's registry between 2016 and 2021. The figure illustrates the inclusion process in the study. Using keywords related to sharp force violence, 9162 reports were selected from the registry, of which only 408 cases were classified as single stab injuries to the trunk. Following an exclusion of 23 cases, 385 cases were included in the study.

Table 1
Demographic characteristics of the study population.

	Males	Females	Difference (p-value)
Number of cases	361 (100)	24 (100)	
Age in years (median, range)	30.0 (15–79)	30.5 (20–67)	P = 0.874
Valid	n = 360	24	
Psychiatric diagnosis*	40/356 (11.2)	6/23 (26.1)	p = 0.035
Alcohol abuse¤	30/356 (8.4)	4/23 (17.4)	p = 0.145
Narcotic abuse#	68/356 (19.1)	6/23 (26.1)	p = 0.413

Age was presented as median age (years) with range. Age information for one male was missing. Mann-Whitney *U* test was used to assess the difference between sexes in age at assault. Psychiatric diagnosis, alcohol and narcotic abuse were expressed as numbers and percentages. *¤#Information was missing for five males and one female. Chi-squared test was used to evaluate sex differences between these variables.

3.2. Circumstances of the scene of death

A significantly higher proportion of assaults on females occurred at home (42%$_{female}$ vs. 21%$_{male}$, $p = 0.022$) while the majority of assaults on men occurred outdoors (56%$_{male}$ vs. 29%$_{female}$, $p = 0.022$), as depicted in Table 2. In assaults against females, the object related to the crime were more frequently found at the scene of the crime (50%$_{female}$ vs. 23%$_{male}$) while among cases involving men, the object was missing in

Table 2
Circumstances at the scene of assault.

	Males	Females	Difference (p-value)
Injury inflicted at home*, n (%)	70/338 (20.7)	10 (41.7)	-
Other indoor location*, n (%)	80/338 (23.7)	7 (29.2)	-
Outdoors*, n (%)	188/338 (55.6)	7 (29.2)	0.022
Object found in situ, n (%)	8 (2.2)	0 (0)	-
Object found at the scene, n (%)	84 (23.3)	12 (50)	-
Object found within possession of the suspect, n (%)	31 (8.6)	<3 (8.3)	-
No object found, n (%)	238 (65.9)	10 (41.7)	0.029
Injury in clothing¤, n (%)	41/44 (93.2)	8/8 (100)	-
No injury in clothing¤, n (%)	3/44 (6.8)	0/8 (0)	-
No clothing¤, n (%)	0 (0)	0 (0)	0.447
Influence of alcohol#, n (%)	93/359 (25.9)	6 (25)	0.922
Illicit narcotics#, n (%)	22/359 (6.1)	<3 (4.2)	0.695
Licit narcotics#, n (%)	9/359 (2.5)	0 (0)	0.432
Unspecified narcotics#, n (%)	6/359 (1.7)	0 (0)	0.523

All variables in Table 2 were presented as numbers and percentages. Sex differences were analyzed with Chi-Squared test. *Information on location at the time of the crime was missing for 23 male cases. ¤Data on injury clothing were missing for 317 males and 16 females. #In two male cases there was missing information on alcohol and narcotic influence at the time of the crime.

a larger proportion (66%$_{male}$ vs. 42%$_{female}$). This result was statistically significant ($p = 0.029$). Almost all victims where data on clothing was registered had sustained injuries through clothing in both groups (93% $_{male}$ and 100% $_{female}$). However, a substantial number of cases were missing data (317 for men and 16 for women). No difference was observed between the sexes regarding injury through clothing. No significant differences between the sexes were found with respect to the influence of alcohol and narcotics (Table 2).

Table 3
Injury characteristics.

	Males	Females	Difference (p-value)
NISS (median, range)	8 (1–50)	9 (1–27)	0.762
Penetrating thoracic cavity*, n (%)	114/360 (31.7)	5 (20.8)	-
Penetrating abdominal cavity*, n (%)	83/360 (23.1)	19 (41.7)	-
Penetrating thoracic and abdominal cavity*, n (%)	53/360 (14.7)	<3 (8.3)	-
Non-penetrating*, n (%)	110/360 (30.6)	7 (29.2)	0.193
Penetrating the bones of the ribcage[¤], n (%)	44/113 (38.9)	<3/7 (28.6)	-
Penetrating the intercostal space[¤], n (%)	69/113 (61.1)	5/7 (71.4)	0.584
Vertical entrance wound[#], n (%)	54/197 (27.4)	0/17 (0)	0.026
Horizontal entrance wound[#], n (%)	58/197 (29.4)	10/17 (58.8)	0.026
Downward right[#], n (%)	39/197 (19.8)	4/17 (23.5)	-
Downward left[#], n (%)	46/197 (23.4)	3/17 (17.6)	-
Length of the injury channel, median[¨] (range) (cm)	5.0 (0.3-23.0)	6.0 (5.5-17.5)	0.126
Valid data	n = 73	n = 3	
Cranial injury channel[§], n (%)	21/74 (28.4)	<3/3 (33.3)	-
Caudal injury channel[§], n (%)	52/74 (79.3)	<3/3 (66.7)	-
Straight horizontal injury channel[§], n (%)	<3/74 (1.4)	0/3 (0)	0.965
Medial injury channel[@], n (%)	68/80 (85)	5/5 (100)	-
Lateral injury channel[@], n (%)	11/80 (13.8)	0/5 (0)	-
Straight sagittal injury channel[@], n (%)	<3/80 (1.3)	0/5 (0)	0.646
Defensive injuries, n (%)	27 (7.5)	<3 (4.2)	0.545

The length of the injury channel and NISS were expressed in median values with range. Sex differences on the length of injury channel and NISS were analyzed with Mann-Whitney *U* test. All the other examined variables in Table 3 are expressed as numbers and percentages. Differences between sex in these cases were assessed with Chi-Squared test.
Missing values: *penetrating injury to the thoracic/abdominal cavity n = 1 in men, [¤]injury to ribcage/intercostal space n = 248 in men and 17 in women, [#]direction of the entrance wound n = 109 in men and 7 in women, [¨]length of the injury channel n = 233 in men and 21 in women, [§]orientation of the injury channel in vertical plane n = 232 in men and 21 in women and [@]horizontal plane n = 226 in men and 19 women.

3.3. Characteristics of the injuries

As shown in Table 3, most comparisons between males and females did not show statistically significant differences, including injury severity (NISS), presence of perforating injuries, penetrating injuries involving bones of the ribcage or intercostal space, injury channel length and trajectory, or the location and presence of defensive injuries. However, there was a higher significant frequency of horizontal injuries in females (59%$_{female}$, vs. 29%$_{male}$; *p*-value = 0.026) whereas men were more often attacked with vertical injuries in comparison to women. (27%$_{male}$ vs. 0%$_{female}$; *p*-value 0,026).

3.4. Anatomical location

None of the anatomical site data showed any statistical significance (Table 4). Frontal injuries dominated in both the male and female group (50% $_{male}$ vs. 67%$_{female}$). Abdominal injuries were more common among women (54%$_{female}$ vs. 35%$_{male}$), while thoracic injuries were far more common in men (65%$_{male}$ vs. 46%$_{female}$). The left side of the body appeared to be injured in most cases, regardless of sex (63% $_{male}$ vs. 50% $_{female}$).

3.5. Factors associated with male versus female assaults

The forest plot shown in Fig. 2 presented information on demographic data, circumstances, injury characteristics, anatomical location, injury severity, and their association with female sex. Injury inflicted at home (OR 3.8, 95% CI 1.4–10.5) and object found at the scene (OR 3.4, 95% CI 1.7–8.2) were statistically significant, suggesting higher odds for women to be attacked at home with an object that is later found in the home-setting. While not being statistically significant, some variables were less associated with assault of females: influence of alcohol (OR 0.9, 95% CI 0.4–2.5), narcotics (OR 0.4, 95% CI 0.1–2.9), injuries to the back (OR 0.5, 95% CI 0.2 –1.5) or left axillary region (OR 0.2, 95% CI 0.1–1.5), caudal injury channel (OR 0.8, 95% CI 0.1–9.4), defensive wounds (OR 0.5, 95% CI 0.1– 4.1), and moderate injuries according to the NISS score (OR 0.9, 95% CI 0.1–1.1).

4. Discussion

We observed that the peak age for assault with sharp force to the trunk was around 30 years of age for both women and men. Female victims were also diagnosed with psychiatric illness to a higher extent compared to male victims. Most women were assaulted at home, commonly with objects that were later found at the crime scene. In terms of injury characteristics, women have a higher frequency of horizontal wounds in comparison to men. There were no significant differences in NISS scores, implying similar patterns of injury severity in single stabs to the trunk between the sexes.

In the study population, men and women were shown to be subjected

Table 4
Anatomical location of the injuries.

	Males	Females	Difference (p-value)
Frontal, n(%)	180 (49.9)	16 (66.7)	-
The back, n(%)	103 (28.5)	5 (20.8)	-
Axillar right, n(%)	20 (5.5)	<3 (8.3)	-
Axillar left, n(%)	58 (16.1)	<3 (4.2)	0.250
Thorax, n(%)	234 (64.8)	11 (45.8)	-
Abdomen, n(%)	127 (35.2)	13 (54.2)	0.061
Left side, n(%)	228 (63.3)	12 (50)	-
Middle line, n(%)	28 (7.5)	<3 (8.3)	-
Right side, n(%)	105 (29.2)	10 (41.7)	0.400

All variables are expressed in numbers and percentages. Differences between sexes were studied using Chi-Squared test.

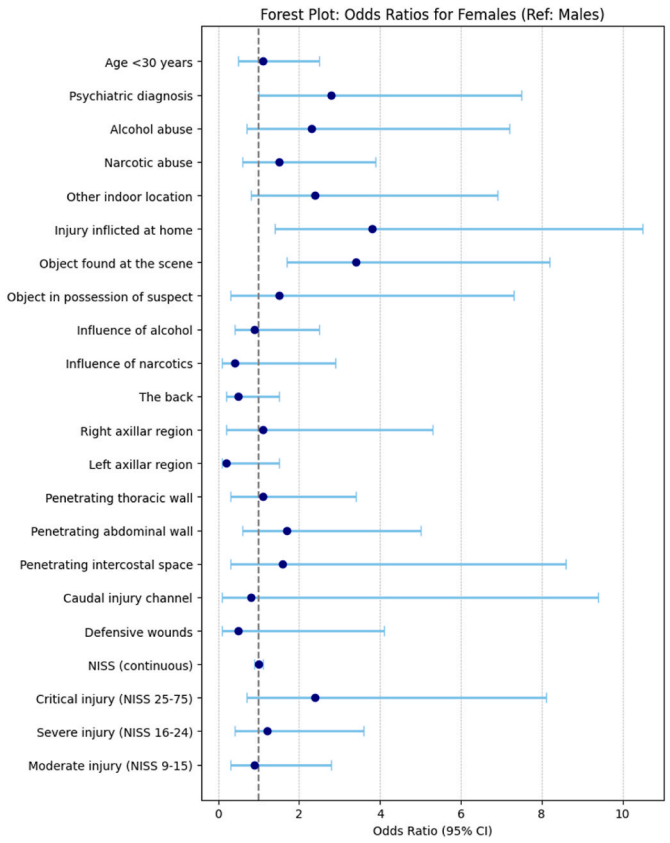

Fig. 2. Associations between demographics, circumstances, injury characteristics, anatomical location, injury severity and females.
Forest plot with univariate logistic regression analysis illustrating associations between variables and female using men as a reference group. The red dots illustrate the odds ratio (OR) values for every single variable while the vertical line represents OR = 1. The horizontal line shows the 95% confidence interval (CI). The variables presented are: age<30 (reference = age ≥30), psychiatric diagnosis (reference = no psychiatric diagnosis), alcohol and narcotic abuse (reference = no alcohol and narcotic abuse), injury inflicted at home or other indoors (reference = outdoors), object found at scene or within possession of the suspect (reference = no object found), influence of alcohol or narcotics at the time of the crime (reference = no alcohol and narcotics influence at the time of the crime), injuries in the back, right/left axillary region (reference = frontal trunk injuries), penetrating thoracic/abdominal wall (reference = non-penetrating injuries), penetrating the intercostal space (reference = penetrating the bones of the ribcage), caudal injury channel (reference = cranial injury channel), defensive wounds (reference = no defensive wounds), NISS (continuous variable), critical/severe/moderate injury (reference = minor injury).
*Note that some data is missing because logistic regression analysis was not possible in some groups considering the small proportion of included cases. Such groups are injury in clothing, object found in situ, direction of wound entrance, straight horizontal direction of injury channel and sagittal direction of injury channel. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

to assaults at a similar age which is around 30 years. This aligns with previous research where a general peak in violence was seen at 30 years, independent of sex.[2,4,10] This indicates that young adults have the highest risk of violent victimisation. While our results replicate previous studies in respect to a sex-independent peak in violence, our findings do not align with a previous publication by Rozenfeld et al.[1] where females were found to be a few years older than males. The lack of significance could depend on sample size limitations or variability in our cohort. Of note is the wide interquartile range (IQR) regarding age, which supports the idea that such violence can be age-independent.

We found that females suffer from psychiatric disorders to a significantly higher extent compared to men, which corresponds positively to previous studies[2,3,11,12]. No meaningful variation in substance use was proven, which is in discordance with previous studies, where substance abuse was more commonly seen in women[2,3]. This could depend on sample size limitations, underreporting or missing data (records were missing for 5 men and 1 woman). The lack in significant differences in substance abuse could also depend on the fact that the study was performed in Sweden, where gender norms and substance use patterns could differ from the ones in other countries. A hypothesis that could explain why women suffer from a psychiatric disorder more frequently than men has been proposed in a study published in 2017, where it was suggested that the greater exposure to traumatic events, hormonal influence, genetic factors, and social stress in life that women experience could play an important role in the development of psychiatric conditions.[13] It could also be speculated that psychiatric illness is overrepresented among women because of a male tendency to avoid seeking medical care, as suggested in a previous publication by Thompson et al.[14]

Our findings are aligned with the previous study conducted by Rozenfeld et al.,[1] which examined stabbing victims. This could suggest that women are often victim of domestic violence, which is why their homes may represent the location for the assault. IPV victimisation is experienced to a greater extent by women who are attacked at home, as seen in different studies[3,15–17]. From a situational perspective, these findings may reflect difficulties in conflict resolution within family or intimate relationships, where interpersonal tensions may escalate into violence. From a forensic point of view, this distinction is important, as injuries resulting from impulsive escalation in interpersonal conflicts may present differently compared to those arising from planned acts of violence. In addition, violence occurring within family or intimate partner contexts may also reflect underlying social and cultural norms, including gender-related power imbalances. From a forensic perspective, awareness of these underlying dynamics is important, as they may affect not only the interpretation of violence with corresponding injury patterns observed but also the credibility of reported circumstances.

In future studies, it could be interesting to complete the database with whether or not IPV is reported by the victim itself, whether there are other injuries on the body (often, victims of IPV have multiple injuries on the body), what time of the day/year the assaults peak in frequency (we speculate that a peak of domestic violence can be seen during holidays, nights/mornings, and winters; times where people are confined at home)[1,18–20].

The tendency towards street-related violence seen among men can be linked to rising gang-related criminality in Sweden[21] and behavioural factors in men in the context of conflict resolution, such as aggressive personalities and risk-taking behaviour, which, when combined with night life, can increase the likelihood of physical fights.[22] From a forensic perspective, this contextual understanding may assist in interpreting the circumstances surrounding an injury, as violence occurring in public environments may be more consistent with impulsive encounters or group-related conflicts, rather than domestic or relational violence.

In our study, we demonstrated a statistically significant difference between men and women in the location of the sharp force weapon. The weapon used to commit the assault was missing in majority of male-related assaults, while in half of the female cases, the object was found at the victim's home. This could reflect the setting of the assault, reinforcing the link between women and IPV-related assaults. We hypothesised that in male-related assaults, which usually occur outside of the home, spontaneous altercations can happen, leading to immediate discharge of possible weapons from the scene of the crime. Among women, IPV is usually not premeditated, which means that weapons are often everyday household objects, such as knives, tools, or other household items.[23]

Based on our material, we observed that NISS did not differ between sexes, suggesting that the severity of the injuries was the same. This contrasts with the study by Rozenfeld et al.,[1] where women with stab

wounds were found to have higher ISS with higher hospitalisation rates and longer stays. The result also does not align with another previously mentioned study published in 2013, where it was observed that men suffered greater injuries with higher ISS and higher mortality rates.[2] The lack of differences to the present study could depend on population characteristics, such as a selected group with single stab wounds to the trunk and healthcare access. For instance, one of the articles we compared to our NISS was conducted in Israel, where healthcare access may differ from that in Sweden.

Furthermore, gender-related patterns of violence may also vary across countries depending on sociocultural context and legal frameworks. For example, the relative contribution of domestic and public violence, access to weapons, and reporting practices may differ internationally, potentially influencing both injury patterns and observed sex differences. Therefore, while our findings reflect a Swedish context, caution should be taken when generalising these results to other settings, and comparative studies across countries are warranted.

No difference was demonstrated in distribution of injury type regarding penetrating injuries and injuries involving the bones of the ribcage and intercostal space. This does not align with the study from Rozenfeld et al.,[1] which showed a higher frequency of penetrating abdominal injuries among women and a predominance of thoracic injuries in men. In contrast to a study published in 2023,[3] where a predominance of rib fractures was seen, we could not demonstrate a difference between penetrating intercostal injuries and penetrating injuries at the bone of the ribcage. Based on our results, it is possible to assume that underlying mechanisms and contexts for assaults may be similar for sexes in a Swedish setting, but since previous studies have shown a difference in injury pattern,[1,3] it is more plausible that our results are more likely the result of a small sample size causing a low statistical significance rather than absence of real variation.

We could, however, demonstrate a significant difference in injury pattern between sexes when describing the orientation of the entrance wound. We concluded that the majority of females and almost 30% of men had horizontal entrance wounds. This may shed light on the circumstances surrounding the assault. The observed gender-based differences in wound direction may reflect variations in the dynamics of the assault, including positioning between victim and perpetrator and the force application. For example, horizontal wounds may be more consistent with close-range interactions, such as those occurring in domestic settings, whereas vertical wounds may be associated with different attack dynamics, including more forceful thrusts. In a previous study from our research group,[7] where deaths resulting from homicides and suicides following a single stab wound to the trunk were compared, it was found that homicides were positively associated with vertical entrance wounds, which may suggest that the prevalence of horizontal entrance wounds in our cohort could present a true difference in our population of victims, possibly reflecting less lethal violence, as the population actually survived the stab wound; however, it could also represent a misclassification of cases—not actually representing assaults but possibly self-inflicted injuries.

Due to a substantial proportion of data being missing, only a limited number of cases could be analyzed for injury channel length and orientation, making comparisons difficult. No significant sex differences were found, and no previous studies have examined these variables in surviving assault victims by sex. No statistically significant difference was proven in defensive injuries between the two sexes. This may suggest similar attempts from both sexes to defend themselves during the assaults. It could also depend on the fact that we only included cases with a single stab wound, representing another assault setting in which defensive wounds might not be relevant.

When comparing the anatomical location of the injuries, no statistically significant difference was observed. Our study results were not in line with previous studies showing a predominancy of abdominal injuries in women with a tendency of right-sided wounds.[1,3] In other previous research conducted on single stab injuries, wounds were primarily found on the left anterior thorax.[16,24] A reason for why the female population in the study registry was small could possibly depend on the fact that women involved in assaults are usually injured at multiple sites, which is something we excluded from our inclusion criteria.[1] This study specifically focuses on injuries to the trunk, which may further contribute to differences compared to studies including injuries to other anatomical regions. Consequently, the restriction to trunk injuries, while methodologically intentional, limits direct comparability with broader trauma studies and may partly explain the discrepancies observed in injury patterns between studies. It could also be because penetrating trauma is generally less common in women compared to men.[1,2] In the future, it could be of interest to study how sex could affect injury patterns in multiple stab trauma cases.

This study provides new insights that can be valuable in forensic assessments, particularly in injury profiling, evidence interpretation, and the consideration of psychiatric comorbidity. Since women have a higher likelihood of being attacked at home with the assault object being found at the scene and more frequently present with horizontal wounds than men, these findings can assist forensic pathologists in building more accurate injury profiles. The observed patterns make it possible to hypothesise the connection to specific contexts, such as domestic violence. Circumstantial factors and specific injury patterns can strengthen the evidence interpretation in legal settings. Importantly, exploring gender-based differences is relevant as they may reflect underlying variations in violence context, mechanism, and intent, which are central to forensic interpretation. Identifying such differences may therefore improve the ability to distinguish between assault-related and self-inflicted injuries, as well as contribute to a more nuanced assessment of the circumstances surrounding the event.

In this regard, the findings of the present study contribute to problem-solving in both forensic and clinical settings. By linking injury characteristics, contextual factors, and victim profiles, the results may assist professionals in forming more evidence-based hypotheses regarding the circumstances of injury, thereby reducing uncertainty in assessments and supporting more consistent conclusions.

The high psychiatric illness frequency seen among women may highlight vulnerabilities that forensic pathologists should take into consideration when interpreting behaviours and answers received from the victims but also prompt the pathologist to objectively assess injury characteristics for potentially self-inflicted wounds. However, this is the case for both men and women.

Our study also presents findings that can have implications in emergency medicine. By identifying specific patterns in assault-related cases, it becomes easier to recognise them in future assessments. When a woman presents with a single stab wound to the trunk, especially if the injury occurred at home with the weapon present at the crime scene, it should raise concerns of possible domestic violence. Therefore, questions on the specific topic should be asked. Eventually, connections to IPV could, in an emergency setting, imply contact with social services, mental health evaluations, and safety planning, including a mandatory report to child protective services if children are involved. The findings of the study also contribute to the knowledge that injury features are more important than injury severity in the assessment of victims of physical assaults.

4.1. Strengths and limitations

A strength of our study is the use of a large, national, population-based registry with data collected over several years (2016–2021). A total of 361 men and 24 women were included, which must be considered a limited sample size resulting in low statistical power. Additionally, a significant proportion of the data was missing. This led to several non-statistically significant findings, and limited the ability to complete certain analyses, such as univariate logistic regression analyses for some factors. The low statistical power and the poor replicability of results from previous studies make it difficult to draw conclusions that can be

generalised to the whole population of survivors of single stab injuries to the trunk. Another strength is the study design. We consider the choice of study design appropriate regarding our research purpose since it made it possible to examine sex differences with pre-collected data and examine exposures (sex, circumstances) and outcomes (injury pattern and severity) without the time or expense that a prospective study would have required. All research questions have been answered using this methodology. However, the retrospective design imposes limitations on case selection, as inclusion depends on the availability of previously recorded data. As a result, not all relevant cases may be captured or fully represented, introducing a potential selection bias. This reflects the nature of data collected in routine forensic practice rather than under controlled research conditions.Another strength of this study is the large panorama of variables examined, unlike previously conducted research. However, as mentioned previously, a large proportion of data on injury characteristics (e.g., entrance wound direction, length and trajectory of the injury channel) was missing. An additional strength lies in the register itself. All cases included in the study were subjected to a forensic assessment. Each case was assessed by two physicians, one of whom was always a board-certified forensic pathologist. However, it is important to note that not all cases were examined by a forensic pathologist. In such cases, the assessment relied on images, police reports, and medical journals, increasing the risk of misinterpretation.

A limitation when analysing substance use was due to our methodology. We relied on available medical records to retrieve information on substance use. We cannot exclude the possibility that eventual substance use was underreported because of shame, stigma, or incomplete medical records. Missing data and sample size limitations could also have contributed to the lack of significance in regard to substance use.

Since the study is based on survivors, we did not compare data with the results in non-surviving victims, which could have led to valuable insights into the mortality risk of different injuries. However, we attempted to address this by using the NISS score, which was used to determine the severity of the injuries. By restricting our study population to survivors of single stab injuries, we may also have inadvertently excluded more aggressive forms of violence, such as multiple or fatal stab wounds. This selection could bias the sample toward less severe cases, therefore negatively influencing the NISS score.

For future research, it would be proper to use a larger database. It would also be interesting to include more information on the circumstances of the assaults, such as information on the perpetrator and whether a prior relationship with the victim existed, to study possible connections to domestic violence. Furthermore, it would also be interesting to study whether the results obtained in this study hold true when analysing multiple stab injuries, which seem to be more common in cases of female assaults.

5. Conclusion

In this study, female victims of physical assaults with a single stab injury to the trunk were associated with higher frequencies of psychiatric illness, injuries inflicted at home, the assault object being found at the scene of the crime, and horizontal entrance wounds. Additional findings showed no difference in injury severity. The median age for assaults showed no sex-dependent tendency with a median of 30 years for both men and women. All these findings may reflect differences and similarities in circumstances surrounding the assaults, suggesting that assaults on women may be potentially linked to domestic violence. Future research should include larger database with more proportioned male-to-female ratio. Furthermore, it could be of interest to examine whether IPV is documented and whether the results would differ if multiple stab injuries were taken into consideration.

Credit authorship contribution statement

GD: Writing—original draft, formal analysis, investigation. MBvL: Visualisation, project administration, methodology, investigation, formal analysis, conceptualisation. SA: Writing—review & editing, formal analysis, conceptualisation. CJW: Writing—review & editing, resources, project administration, formal analysis, conceptualisation. AMK: Writing—review & editing, project administration, validation, formal analysis, supervision, conceptualisation.

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Declaration of competing interest

None.

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