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Research Paper

# Captive bolt guns and suicides: a 15-year Swedish retrospective study

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ABSTRACT

*Background:* The captive bolt gun is a tool for stunning animals in the meat industry and is not considered a firearm under the Swedish firearm legislation. This study aimed to explore the involvement of such devices in human fatalities, with an emphasis on suicides. Epidemiological characteristics from a longitudinal perspective, as well as risk factors and injury patterns were analyzed.

*Method:* Suicides involving captive bolt guns in Sweden 2009–2023 were studied. Data, including demographics, circumstances of the incident, and autopsy reports, were collected from the National Board of Forensic Medicine.

*Results:* During the 15-year study period, there were 39 suicides involving captive bolt guns, accounting for an annual average of 2.6 suicides, or 0.3 suicides/1,000,000 living people. The incidence was relatively stable over the period. The county-level suicide rate increased with decreasing population density. Older males with mental health issues represented a high-risk group. Four cases were complex suicides, and in two cases, a victim sustained two separate bolt gun injuries in consecutive attempts. Injuries caused by modern captive bolt guns exhibited typical characteristics and could be distinguished from those involving older devices with projectiles. Brain injuries predominated as cause of death.

*Conclusion:* Suicides involving captive bolt guns are rare. Older males in rural areas, especially those with mental health issues and access to such devices, represented a high-risk group. Since access to these devices is unrestricted, prevention efforts should address individual risk factors, restriction of means and systemic measures aimed at promoting better mental health in rural communities.

## 1. Introduction

A captive bolt gun, also known as *humane killer, stunbolt gun* or *slaughterer's gun*, is a specialized shooting device primarily used in the meat industry for stunning animals prior to slaughter.[1] Invented in Germany in the early 20th century, it was designed to minimize animal suffering by delivering a rapid, controlled impact to the brain, rendering the animal immediately unconscious. A typical "true" captive bolt gun consists of a cylindrical metal tube housing a metal bolt, approximately 1 cm in diameter and with variable exit lengths (Fig. 1).[1] The device is placed against the animal's forehead, and a blank gunpowder cartridge is discharged, driving the bolt into the brain, causing a low-velocity brain injury. Some older models instead fire a projectile,[2] similarly to a conventional handgun. There are also other types of bolt guns with projectiles (nails), used in construction industry.

Unlike firearms, which are subject to extensive regulation and licensing, bolt guns for stunning animals do not require a license for possession or use in many countries, such as those within the European Union,[3] including Sweden.[4] This ease of access has led to some unintended consequences, including rare but noteworthy cases of human fatalities caused by these devices, most of which are suicides.[5–7]

Despite widespread use of captive bolt guns in the meat industry, fatalities involving these devices remain relatively underexplored. Most of the existing literature consists of isolated case reports.[8–14] The infrequency of such fatalities, combined with unusual nature of the injuries, can constitute a challenge in the death investigation and the interpretation of autopsy findings. Few studies have examined the broader epidemiological context and the prevalence of such deaths remains poorly documented.

This study aims to address these gaps by conducting a retrospective review of bolt gun-related deaths. The objective was to examine the demographics, circumstances, suicide risk factors and autopsy findings in relation to existing literature. The findings aim to inform forensic practices and highlight public health concerns surrounding unrestricted access to potentially lethal tools in both the occupational and private settings.

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## 2. Methods

All (suspected) unnatural deaths in Sweden are subject to a medico-legal autopsy, which includes toxicological screening for alcohol, pharmaceuticals and illicit drugs. The Swedish National Board of Forensic Medicine (NBFM) is responsible for conducting these medico-legal investigations. National data on all registered suicides involving bolt guns during the period 2009–2023 were collected from the NBFM database. Since the International Classification of Diseases (ICD) does not include a specific code for bolt gun injury, cases were collected by free word search for (the Swedish words for) *bolt gun* and *slaughterer's gun*. All suicides involving bolt guns were identified accordingly and included in the study. Three cases were excluded, one homicide and two cases with undetermined manner of death. No accidental bolt gun deaths were recorded during the study period.

The following variables were analyzed: sex and age of the deceased, time and place of death, cause of death, autopsy findings, toxicological results, injury location, circumstances surrounding the suicide, and known suicide risk factors. Data on firearm ownership were provided by the Swedish Police.

SPSS (version 30 for Windows) was used to perform statistical analyses, including a Poisson regression model that examined the relationship between the number of captive bolt gun related suicides and time (years), adjusted for the Swedish population size. The model's goodness-of-fit test did not indicate under- or overdispersion. A Spearman's rank-order correlation was also used to assess the relationship between county-level suicide rates and population density across all 21 Swedish counties. Information on population size and population density was sourced from Statistics Sweden.[15] Statistical significance was defined as a p-value $<0.05$.

The statistical programming language R (version 4.4.3; R Core Team, 2025) for Windows was used to implement a Bayesian beta-binominal model. This model estimated the probability that an individual who died by suicide involving a captive bolt gun had a particular mental health-related risk factor. A Beta (2,2) prior distribution was chosen to model the probability of the risk factor, and posterior distributions were derived from the observed data.

## 3. Results

### 3.1. Incidence and demographics

A total of 39 cases were identified, with an annual average of 2.6 suicides or 0.3 suicides/1,000,000 living people. The county-specific mortality rate (number of suicides per 1,000,000 people in a county) ranged from 1.8 to 17.1 during the study period, and was lower in large urban counties compared to the rest of the country (Fig. 2). Four counties had no cases. Poisson regression analysis (df = 1) showed that

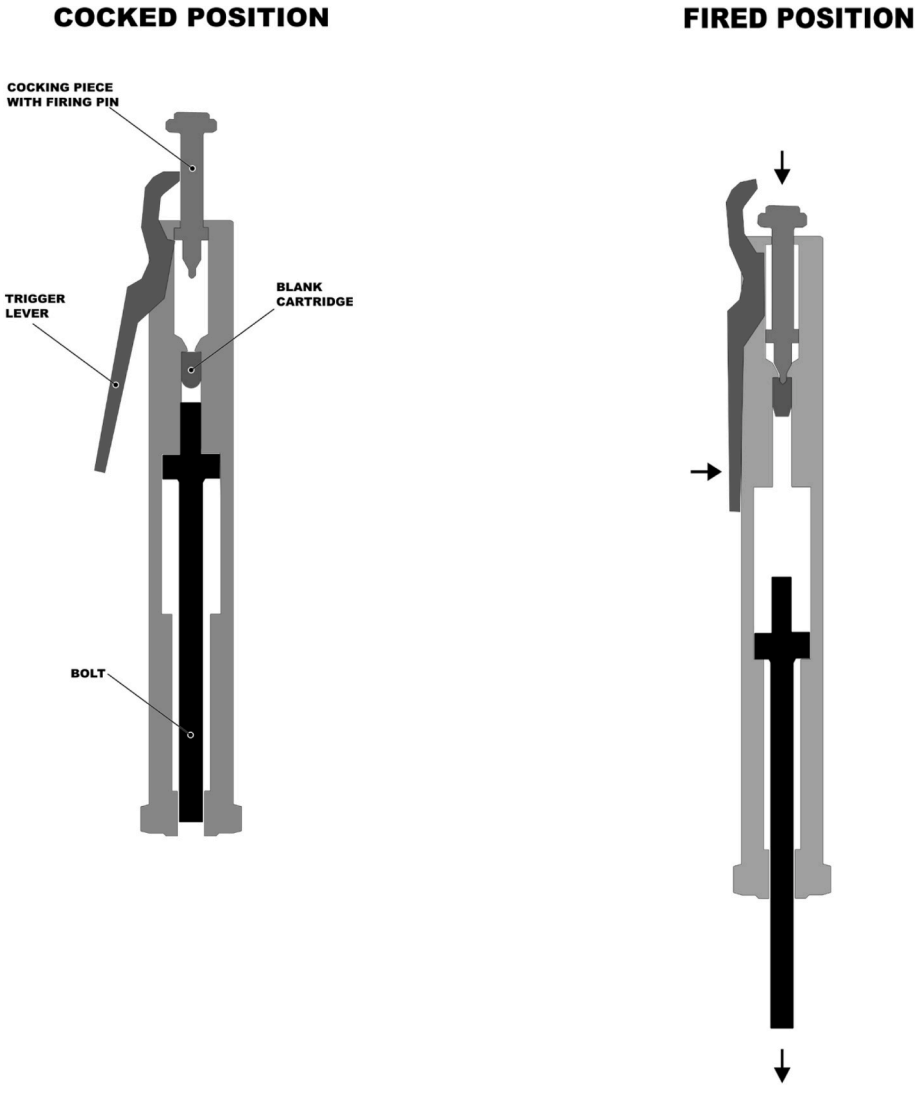


**Fig. 1.** A schematic of the captive bolt gun and its mechanism.

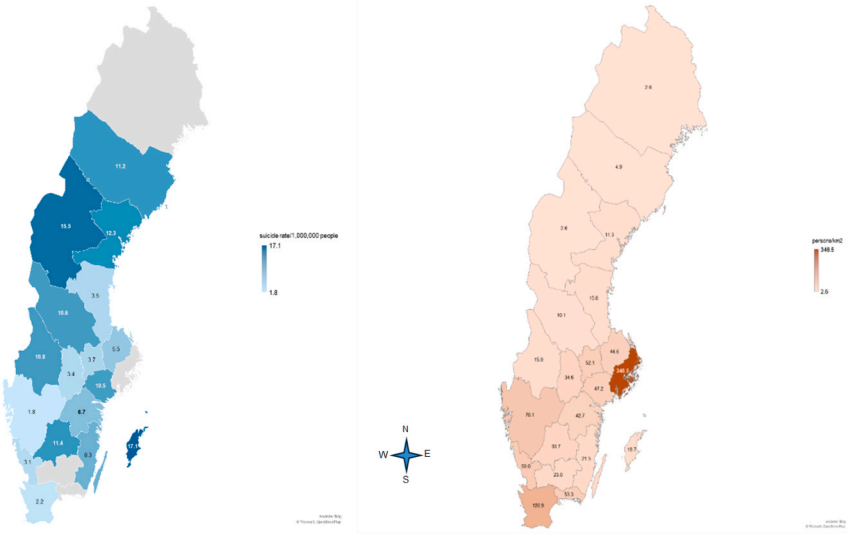

**Fig. 2.** Suicide rate in Swedish counties as the number of deaths involving bolt gun/1,000,000 people in 2009–2023 (left). Four counties (gray) had no cases during the study period. Population density in the counties (persons/km$^2$) (right).

the time (as years) was a negative predictor of the number of suicides, adjusted for population size; however, the result was not statistically significant (B = −0.014, S.E. = 0.0371, p = 0.0713). The incidence rate ratio (IRR = 0.986) indicates that there was a slight decrease (1.4 %) in the number of suicides by each successive year. The county-level suicide rate was negatively correlated with population density (r = - 0.541, p = 0.01), indicating a statistically significant, moderate inverse relationship.

The number of cases was highest during wintertime, December–February (n = 13), with the remaining cases distributed across March–May (n = 9), June–August (n = 9), and September–November (n = 8). The victim's age ranged from 29 to 87 years (mean = 63), and all but three were male. Almost half (49 %) of the victims were aged 60–79 years (Fig. 3).

### 3.2. Circumstances

There were in total 39 suicides with bolt gun injury, of which 35 as the underlying cause of death (COD): 32 with brain injury, 2 with chest injury, and 1 with abdominal injury. In 4 cases bolt gun injury to the head was reported as a contributing COD ("complex suicides"); in 3 of these was hanging, and in 1 drowning, the underlying COD.

Among all victims, 24 had at least one risk factor affecting mental health, including dementia and alcoholism. Mental health issues were reported in 20 cases, with an additional 2 cases involving victims with dementia. Alcoholism was present in 9 cases, and drug abuse was noted in 1 case. Somatic diseases were reported in 9 cases, including cancer, cardiovascular disease, and muscular disorders. The most common co-morbidity was mental health issues and alcoholism (n = 7), followed by mental health issues and somatic disease (n = 4). A history of previous suicide attempts was known in 3 cases. A suicide note was found in 10 cases (26 %). Social difficulties, such as separation or legal issues, were identified as possible contributing factors in 4 cases. Nearly one-fifth of the victims (18 %) initially survived the bolt gun injury but later died in the hospital due to their injuries.

Based on the observed data, the posterior distribution for the probability of an individual having the risk factor is a Beta (26, 17) distribution. The posterior mean of this distribution is estimated to be 0.60,

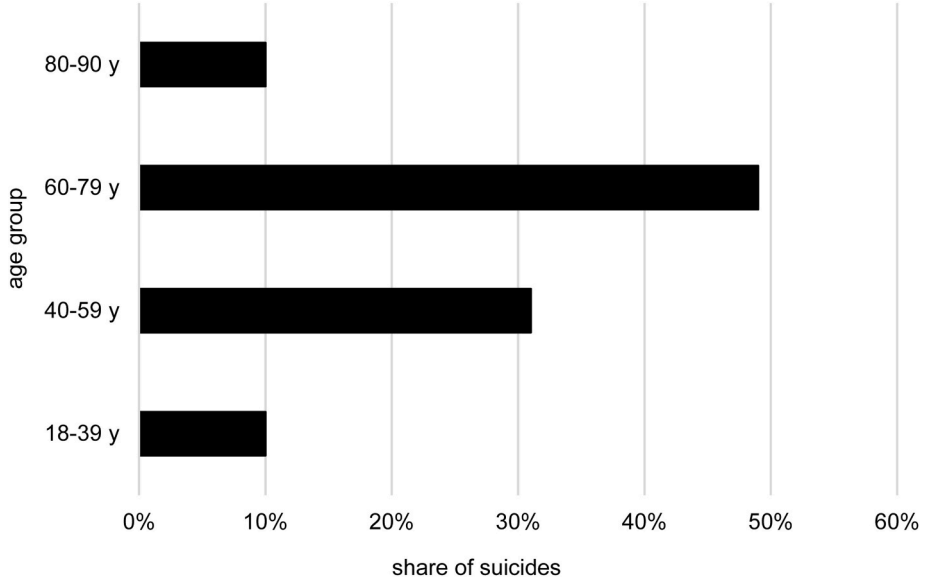


**Fig. 3.** Distribution of suicides involving bolt gun by age, Sweden 2009–2023.

suggesting that, after accounting for both the prior belief and observed data, the best estimate for the probability of an individual having the risk factor is 60 %. The 95 % credible interval for this probability is (0.454, 0.743).

In 25 of the cases, the shooting device used was a "true" captive bolt gun, while in the remaining 14 cases, the device fired a projectile (bullet). No case involved bolt gun for construction industry purposes. The projectile-firing devices were commonly described as old, and some were triggered by a claw hammer or a similar object. A significant proportion of the victims (64 %) had a history of licensed firearm ownership. In one-third of these cases (32 %), there had been a previous police investigation regarding the suitability for firearm ownership. However, information about firearm access and/or the status of licensed firearm ownership at the time of suicide was not available.

### 3.3. Autopsy findings

In cases involving a single captive bolt gun injury, the injury was most commonly located to the head (n = 34), particularly to a forehead (Table 1a–b). Two cases involved two bolt gun injuries (two attempts): one with both injuries to the head, and one with injuries to the chest and head.

Injury patterns are described in Table 1a–b. Entry wounds from the "true" bolt guns were, in most cases, circular in both the skin and the skull, often described as "punched out" or sharp edged. Skull fractures exceeding 1 cm radiating from the entry point and secondary fractures were rare (Table 1a). In some cases, the bolt reached the skull base and caused skull base fractures, while secondary fractures were all located in the thin roof of the orbital cavity. In several cases, a fragment of skull bone was found deep in the trajectory, with a punched-out appearance matching the entry site.

The injuries sustained from devices firing a projectile were similar in their core characteristics but exhibited some features resembling conventional gunshot wounds, such as stellate entry wound and, in 5 cases, the presence of an exit wound. Fractures emanating from the entry site in the skull were common (Table 1b), though bone fragments were found in the trajectory in only one case. Secondary fractures involved the middle cranial base.

In two cases where the cause of death was the chest injury, lacerations were found in the heart, lungs, and aorta. The abdominal injury fatality involved aorta and liver.

Post-mortem toxicological analysis was performed on all of victims except for three who died in hospital care. Blood alcohol concentration (BAC) was positive in 7 cases, ranging 0.29–2.04 g/L (mean 1.3 g/L). The majority (n = 5) of BAC-positive cases had a BAC >1.0 g/L. Antidepressants were detected in 10 of cases, benzodiazepines and sedatives in 6 cases (one related to hospital care) and neuroleptics in 3 cases. Opioids were detected in 5 cases, 2 of which linked to medical treatment. The most common other drugs were amlodipine (n = 4) and paracetamol (n = 4). In none of the tested cases, was the drug level considered toxic or lethal. No illicit drugs were detected.

**Table 1a**
Patterns and features in bolt gun injuries by captive bolt gun, N = 25.

| Injury patterns and features – bolt<br>Number of cases (% of 39 study cases) | | | | |
|---|---|---|---|---|
| Injury location | | Circular shape of the entrance (skin/bone) | Fractures emanating from the entrance | Secondary fractures |
| **Head** | 24 (61 %) | 24 (61 %) | 4 (10 %) | 4 (10 %) |
| Frontal | 9 | 9 | 3 (8 %) | 2 (5 %) |
| Parietal | 4 | 4 | 0 | 0 |
| Occipital | 6 | 6 | 1 (3 %) | 0 |
| Temporal | 5 | 5 | 0 | 2 (5 %) |
| Facial | 0 | 0 | 0 | 0 |
| **Chest** | 1 (3 %) | 1 (3 %) | 0 | 0 |
| **Total** | 25 (64 %) | 25 (64 %) | 4 (10 %) | 4 (10 %) |

**Table 1b**
Patterns and features in bolt gun injuries by projectile - firing devices, N = 14.

| Injury patterns and features – projectile<br>Number of cases (% of 39 study cases) | | | | |
|---|---|---|---|---|
| Injury location | | Circular shape of the entrance (skin/bone) | Fractures emanating from the entrance | Secondary fractures |
| **Head** | 12 (31 %) | 11 (28 %) | 9 (23 %) | 4 (10 %) |
| Frontal | 7 | 7 | 6 (15 %) | 3 (8 %) |
| Parietal | 3 | 3 | 2 (5 %) | 1 (3 %) |
| Occipital | 1 | 1 | 1 (3 %) | 0 |
| Facial | 1 | 0 | 0 | 0 |
| **Chest** | 1 (3 %) | 0 | 0 | 0 |
| **Abdomen** | 1 (3 %) | 1 (3 %) | 0 | 0 |
| **Total** | 14 (36 %) | 12 (31 %) | 9 (23 %) | 4 (10 %) |

## 4. Discussion

This represents the first national study encompassing all suicide cases within a broader series of bolt gun-related fatalities. The victims were predominantly older males with mental health issues and a history of firearm ownership. Mortality remained stable throughout the study period. Unique findings regarding geographic distribution, demographics and psychosocial risk factors may help inform future prevention strategies.

### 4.1. Frequency and geographical distribution

A suicide involving a bolt gun is rare. Firearm suicide is far more common in Sweden, with 112 cases annually during the study period,[16] vastly outnumbering the few bolt gun suicides. Notably, a significant proportion of victims had a history of firearm ownership and police investigation regarding the suitability for firearm ownership. Information regarding firearm access at the time of suicide was unavailable, but victims likely did not have access to a firearm. A Croatian study found no cases of captive bolt gun suicide attempts during wartime, when firearms were widely accessible, as opposed to peacetime.[6] This suggests that firearms would likely be preferred if available to the victim. In Sweden, police can revoke a firearm license if an individual is deemed unsuitable for ownership.[4] However, evidence on whether individuals shift to an alternative suicide method when firearms are restricted remains limited, as it is in restriction of other suicide means.[17] Nevertheless, restricting access to lethal means may save lives,[17] though this effort is complicated by relatively liberal availability of captive bolt guns. Since there are no regulations governing their purchase and use in Sweden, their distribution and availability is difficult to assess. Due to the rarity of these events and limited research, it remains unclear whether regulatory restrictions would reduce fatalities involving this tool in countries where such regulation exists. Several countries, a.o. the USA, Australia and the UK, require training or certification, despite a captive bolt gun is not classified as a firearm.

In suicides, the captive bolt gun's outcome on human body, availability, user's (occupational/practical) knowledge and experience and similarity to a conventional firearm in terms of usage[6] are plausible factors influencing its selection as a suicide method. Such factors have

been reported in studies on choice of firearms as suicide means.[18] Frontal head injury dominated, consistent with injuries that device is designed to inflict on animals, suggesting that victims were familiar to its use. Temporal region injuries were more common in suicide attempts with captive bolt guns in Croatia,[6] resembling the injury patterns seen in suicides with handguns.[19,20]

Previous studies have reported suicides involving captive bolt guns occurring primarily in rural areas.[5,6] In the present study, mortality rate decreased with increasing population density and was accordingly higher in the more rural northern counties. This pattern mirrors the distribution observed in overall suicide rates[21] and firearm-related suicide rates in Sweden.[22] One notable exception was the northernmost county, which had the lowest population density and the smallest proportion of agricultural land in the country,[23] yet no recorded cases of captive bolt gun suicides. In contrast, southern regions tended to have higher population density but also larger areas of agricultural land. Three southern counties had no recorded cases at all, whereas Gotland County, an island in the southeast of Sweden, had the highest rate of bolt gun related suicides. This county had a lower number of overall and firearm-related suicides than most other counties,[21,22] a moderately low population density, but a significant share of agricultural land and a high number of cattle and sheep.[24] The higher rates observed in rural regions may be attributed to several factors, elevated overall and firearm-related suicide rates, socioeconomic conditions, and limited access to mental healthcare.[25,26] However, regional differences warrant further investigation.

### 4.2. Demographics and risk factors

The male predominance and higher proportion of older victims were expected findings. Most agricultural workers are male,[23] and older males constitute the majority of suicide victims overall.[27] The mean age of the victims in the present study (63 years) was consistent with findings from a Slovenian study,[28] but higher than the ages reported in single-case studies.[8,9,11–13]

The estimated prevalence of mental health risk factors was high in this cohort, highlighting the need for targeted interventions. Similarly, psychiatric history was present in over 50 % of captive bolt gun injury cases in Slovenia, and cancer comorbidity was also observed.[28] Future studies could incorporate comprehensive data from healthcare contacts to better understand help-seeking behaviors and treatment patterns.

Swedish research in agricultural workers' mental health is very limited. However, a recent review of international literature identified key risk factors, including loneliness, adherence to masculine social norms, higher rates of depression and suicide attempts compared to other professions, and rising mental illness rates, particularly among older farmers.[25] Interestingly, in the Croatian study of self-inflicted captive bolt gun head injury, all cases involved males from rural areas with low level of education and no prior psychiatric history.[6] In general, many agricultural workers are reluctant to seek mental health services due to stigma and a lack of accessible resources in rural areas.[25]

### 4.3. Complex suicides

A complex suicide implies the use of at least two different suicide methods to ensure a fatal outcome.[29] Such cases are rare, accounting for only 1.5 %–5 % of all self-inflicted deaths.[30] Commonly, intoxication is combined with other methods,[29–31] and in one case, up to six different methods were reported.[32] A history of psychiatric illness is considered one of the key contributing factors in complex suicides.[33] In the present study, all complex suicide victims were males with mental health issues. Male predominance has been reported also in previous studies.[9,31–34] Three out of four complex suicides in the present study involved a combination of bolt gun injury and hanging, consistent with earlier findings.[8,9,34]

Distinguishing between homicide and complex suicide can be difficult, making it essential to conduct a thorough examination of the death scene, gather detailed background and circumstantial information, and perform a comprehensive forensic autopsy along with toxicological analysis.[31] Additionally, postmortem imaging may provide valuable insights and evidence of wound morphology.[35]

### 4.4. Injuries and toxicological findings

Captive bolt gun injuries are highly lethal, with a reported mortality rate exceeding 60 %.[6] Although most fatalities are classified as suicides, there have also been reports on homicides[7,34,36] and accidental injuries.[37] One homicide was also found in the NBFM database during the study period. While captive bolt gun injuries may initially resemble firearm wounds, they have distinct features, such as "punched out" entry wounds in the skin and bone (head injury), round skull defects, well-defined margins due to the bolt's cylindrical shape and concave tip, and no exit wound.[6,7,12,35] Secondary fractures are rare, usually occurring in thinner skull areas.[1,10] The bolt's low velocity results in a short wound channel (trajectory), with localized brain damage but significant hemorrhage and edema.[28,35] Severe brain vascular injury is a key factor in the high mortality rate.[6,28] The depth of the trajectory generally matches bolt length, as the dislodged skin and bone fragments have low velocity and do not function as secondary projectiles.[1] Injuries involving projectiles resembled those from conventional firearms, a bullet may exit the skull.[2]

Interestingly, atypical wound location was observed in three cases, two involving the chest and one the abdomen. While fatal chest injury has been reported elsewhere,[5,11] abdominal injury appears to be extremely rare. Previous studies have suggested that atypical injury location, the absence of a suicide note and previous suicide attempts, and a history of mental health issues may indicate impulsive and unplanned acts.[11] However, drawing such conclusions about impulsivity in the present cases remains difficult without thorough psychological autopsy.

As with suicides involving multiple firearm injuries, cases with multiple bolt gun injuries have raised questions about individual's ability to act after the first shot. A double bolt gun injury to the forehead inflicted by a single bolt gun has been previously reported,[13,34] as found in one case in the present study. Despite the potential pain caused by such injury, a victim may remain or regain conscious after the initial injury due to shallow injury without significant brain laceration[13] and may repeat a suicide attempt.

Nearly one-fifth of the victims were positive for blood alcohol, a slightly lower proportion than in firearm suicides (25 %), but aligns with findings showing that more than 60 % of BAC-positive victims had alcohol levels exceeding 1.0 g/L.[38] Acute alcohol consumption is associated with an increased risk of suicide attempts, particularly at higher levels of intake.[39]

### 4.5. Prevention

Preventing suicide requires a comprehensive, multi-level response that includes multidisciplinary collaboration, policy reform, organizational change and community engagement.[40] Future prevention must address systemic issues such as limited healthcare access, social isolation, cultural stigma, and economic stress.[40] Qualitative research is vital to understand the experiences of rural residents and tailor effective strategies. Recognizing the risk factors for psychological disorders and their impacts is crucial for alleviating the mental health burden in this population.[41] To further support mental well-being and aid in suicide prevention, there is a need for increased education, targeted training, and nationwide mental health awareness campaigns.[25] Additionally, restricting access to means, such as through family involvement or gun amnesty for old and unused firearms and bolt guns, can be a critical preventive measure. Given the widespread use of bolt guns in many countries, the varying regulations surrounding their availability, and

their potential use as a means of suicide, warrant greater attention. This calls for targeted prevention strategies at both national and regional levels.

## 5. Strengths and limitations

A strength of this study lies in its material, which encompass *all* cases of suicides involving a captive bolt gun, as all cases of (suspected) unnatural death in Sweden must undergo a medico-legal autopsy. A limitation in applying the findings of this study to preventive measures is, of course, the relatively small number of cases. Further studies in other countries would be beneficial. Detailed information about the type of bolt gun used, other than being some kind of captive bolt gun or slaughterer's gun, was often limited. This may reflect a lack of familiarity with these guns among both police and forensic pathologists.

## 6. Conclusions

Suicides by captive bot guns are rare events. Efforts to restrict access to this suicide means are challenged by the liberal availability and the absence of licensing requirements for their purchase and use in Sweden. Older males in rural areas, particularly those with mental health issues and access to such tools, represent a high-risk group. Increasing awareness of these risk factors could support the development of targeted health interventions, such as collecting of old and/or unused devices through weapon amnesty.

## Ethical statement

The study involved retrospective register data about decedents only, and therefore did not require ethical approval under Swedish law. Retrieval of register data for research purposes was approved by the Swedish Police and the NBFM (Dnr X24-90318).

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## Data availability statement

Data and material are available for researchers who meet the criteria for access to confidential data.

## Author contributions

All authors contributed to the study conceptualization, methodology, data collection, data analysis, writing, reviewing and editing. Corresponding author performed statistics.

## Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

## References

1. Geisenberger D, Giorgetti A, Glardon M, Große Perdekamp M, Pollak S, Pircher R. The punched-out tissue complex (skin-bone "imprimatum") in shots from captive-bolt guns: does it act as a secondary projectile? *Int J Leg Med*. 2020;134(3):1095–1102. https://doi.org/10.1007/s00414-020-02262-8.
2. Hunt AC, Kon VM. The patterns of injury from humane killers. *Med Sci Law*. 1962;2(3):197–203. https://doi.org/10.1177/002580246200200306.
3. EUR-Lex. Directive (EU) 2021/555 of the European Parliament and of the council. https://eur-lex.europa.eu/eli/dir/2021/555/oj/eng; 2021. Accessed June 20, 2025.
4. Firearms Act of 1996, SFS 1996:67. https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/vapenlag-199667_sfs-1996-67. Accessed June 20, 2025.
5. Capano D, Mercurio I, Fidenzi L, Landi G, Gabbrielli M. Suicides with captive bolt pistols in Siena province: entrance wound analysis. *Rom J Leg Med*. 2017;25(4):337–341. https://doi.org/10.4323/rjlm.2017.337.
6. Gnjidic Z, Kubat M, Malenica M, Sajko T, Radic I, Rumboldt Z. Epidemiological, forensic, clinical, and imaging characteristics of head injuries acquired in the suicide attempt with captive bolt gun. *Acta Neurochir*. 2002;144(12):1271–1277. https://doi.org/10.1007/s00701-002-1018-2.
7. Simic M, Draskovic D, Stojiljkovic G, Vukovic R, Budimlija ZM. The characteristics of head wounds inflicted by "humane killer" (captive-bolt gun) - a 15-year study. *J Forensic Sci*. 2007;52(5):1182–1185. https://doi.org/10.1111/j.1556-4029.2007.00519.x.
8. Viel G, Schröder AS, Püschel K, Braun C. Planned complex suicide by penetrating captive-bolt gunshot and hanging: case study and review of the literature. *Forensic Sci Int*. 2009;187(1-3):e7–e11. https://doi.org/10.1016/j.forsciint.2009.01.022.
9. Nikolić S, Zivković V, Juković F. Planned complex occupation-related suicide by captive-bolt gunshot and hanging. *J Forensic Sci*. 2011;56(1):248–251. https://doi.org/10.1111/j.1556-4029.2010.01507.x.
10. Große Perdekamp M, Kneubuehl BP, Ishikawa T, et al. Secondary skull fractures in head wounds inflicted by captive bolt guns: autopsy findings and experimental simulation. *Int J Leg Med*. 2010;124(6):605–612. https://doi.org/10.1007/s00414-010-0450-8.
11. Nikolić S, Atanasijević T, Živković V. Unusual suicidal penetrating heart injury by captive-bolt gunshot. *Forensic Sci Med Pathol*. 2022;18(3):260–263. https://doi.org/10.1007/s12024-021-00456-z.
12. Ventura F, Blasi C, Celesti R. Suicide with the latest type of slaughterer's gun. *Am J Forensic Med Pathol*. 2002;23(4):326–328. https://doi.org/10.1097/00000433-200212000-00004.
13. Fanton L, Karger B. Suicide with two shots to the head inflicted by a captive-bolt gun. *J Forensic Leg Med*. 2012;19(2):90–93. https://doi.org/10.1016/j.jflm.2011.07.010.
14. Pircher R, Geisenberger D, Große Perdekamp M, Neukamm M, Pollak S, Schmidt U. Thierauf-Emberger. A suicide with two makes of captive-bolt guns (livestock stunners) fired simultaneously to the forehead. *Int J Leg Med*. 2017;131(6):1557–1564. https://doi.org/10.1007/s00414-017-1539-0.
15. Statistics Sweden. Population and living conditions. https://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning-och-levnadsforhallanden/; 2025. Accessed June 20, 2025.
16. The National Board of Health and Welfare. National cause of death register. https://www.socialstyrelsen.se/en/statistics-and-data/registers/national-cause-of-death–register/; 2024. Accessed June 20, 2025.
17. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies, a systematic review. *JAMA*. 2005;294(16):2064–2074. https://doi.org/10.1001/jama.294.16.2064.
18. Houtsma C, Butterworth SE, Anestis MD. Firearm suicide: pathways to risk and methods of prevention. *Curr Opin Psychol*. 2018;22:7–11. https://doi.org/10.1016/j.copsyc.2017.07.002.
19. Canturk G, Canturk N, Odabasi AB, Erkol Z, Bosgelmez M. Autopsy findings of suicidal deaths committed by firearms in Ankara, Turkey. *Med Sci Law*. 2009;49(3):207–212. https://doi.org/10.1258/rsmmsl.49.3.207.
20. Blumenthal R. Suicidal gunshot wounds to the head: a retrospective review of 406 cases. *Am J Forensic Med Pathol*. 2007;28(4):288–291. https://doi.org/10.1097/PAF.0b013e318148bdca.
21. *National Centre for suicide research and prevention of mental lll-Health. Suicides in the Counties of Sweden*; 2024. https://ki.se/nasp/statistik/sjalvmord-i-varje-lan-i-sverige. Accessed June 20, 2025.
22. Junuzovic M. Firearm suicides in Sweden. *J Forensic Leg Med*. 2022;91, 102403. https://doi.org/10.1016/j.jflm.2022.102403.
23. The Swedish Board of Agriculture. Statistical database. https://jordbruksverket.se/om-jordbruksverket/jordbruksverkets-officiella-statistik/statistikdatabasen; 2024. Accessed June 20, 2025.
24. The Swedish Board of Agriculture. Agriculture in figures https://jordbruketisiffror.wordpress.com/2020/07/20/en-resa-genom-jordbruksmarkerna-i-sveriges-landskap/; 2020. Accessed June 20, 2025.
25. Lundqvist P, Håkansson C, Hakelius K. Farmers' psychosocial work environment and mental health, systematic literature review 2022:8. The Swedish Agency for Work Environment Expertise. https://sawee.se/publications/farmers-psychosocial-work-environment-and-mental-health/; 2023. Accessed June 20, 2025.
26. Judd F, Cooper AM, Fraser C, Davis J. Rural suicide-people or place effects? *Aust N Z J Psychiatr*. 2006;40(3):208–216. https://doi.org/10.1080/j.1440-1614.2006.01776.x.
27. The Public Health Agency of Sweden. *Statistics on suicide*; 2024. https://www.folkhalsomyndigheten.se/livsvillkor-levnadsvanor/psykisk-halsa-och-suicidprevention/suicidprevention/statistik-om-suicid/. Accessed June 20, 2025.
28. Pešak J, Porčnik A, Prestor B. Captive bolt gun-related vascular injury: a single center experience. *Diagnostics*. 2024;14(10):977. https://doi.org/10.3390/diagnostics14100977.
29. Gentile G, Galante N, Tambuzzi S, Zoja R. A forensic analysis on 53 cases of complex suicides and one complicated assessed at the Bureau of Legal Medicine of Milan (Italy). *Forensic Sci Int*. 2021;319, 110662. https://doi.org/10.1016/j.forsciint.2020.110662.
30. Paredes Rivera A, Dramé AS, Knight LD. A 3-year retrospective review of complex suicides with a review of the literature. *Am J Forensic Med Pathol*. 2024;45(4):308–313. https://doi.org/10.1097/PAF.0000000000000961.
31. Hösükler E, Hösükler B, Çoban İ, Koç S. Complex suicides: 21 cases and a review of the literature. *Egypt J Forensic Sci*. 2022;12:10. https://doi.org/10.1186/s41935-022-00269-3.

32. Petković S, Maletin M, Đurendić-Brenesel M. Complex suicide: an unusual case with six methods applied. *J Forensic Sci*. 2011;56(5):1368–1372. https://doi.org/10.1111/j.1556-4029.2011.01821.x.
33. Banchini A, Schirripa ML, Anzillotti L, Cecchi R. Planned and unplanned complex suicides: casuistry of the Institute of Legal Medicine of Parma (Italy). *Leg Med*. 2017;29:62–67. https://doi.org/10.1016/j.legalmed.2017.10.005.
34. Ondruschka B, Heil K, Schulz S, Dreßler J, Morgenthal S. Suizid oder Homizid? Eine rechtsmedizinische Auswertung letaler Bolzenschussverletzungen. *Rechtsmedizin*. 2018;28:413–419. https://doi.org/10.1007/s00194-018-0256-4.
35. Oikonomou A, Astrinakis M, Birbilis T, Pavlidis P, Prassopoulos P. Head trauma by captive bolt gun. *BMJ Case Rep*. 2011;2011, bcr0920114809. https://doi.org/10.1136/bcr.09.2011.4809.
36. Betz P, Pankratz H, Penning R, Eisenmenger W. Homicide with a captive bolt pistol. *Am J Forensic Med Pathol*. 1993;14(1):54–57. https://doi.org/10.1097/00000433-199303000-00013.
37. Tordrup PJ, Kjeldsen SR. Accidental injuries from captive-bolt guns (slaughterer's gun). *Injury*. 1994;25(8):497–499. https://doi.org/10.1016/0020-1383(94)90088-4.
38. Junuzovic M, Rietz A, Jakobsson U, Midlöv P, Eriksson A. Firearm deaths in Sweden. *Eur J Publ Health*. 2019;29(2):351–358. https://doi.org/10.1093/eurpub/cky137.
39. Borges G, Bagge CL, Cherpitel CJ, Conner KR, Orozco R, Rossow I. A meta-analysis of acute use of alcohol and the risk of suicide attempt. *Psychol Med*. 2017;47(5):949–957. https://doi.org/10.1017/S0033291716002841.
40. Kohlbeck S, Quinn K, deRoon-Cassini T, Hargarten S, Nelson D, Cassidy L. Toward a public health approach to farmer suicide prevention: the potential power of systems change. *J Agromed*. 2024;29(4):665–675. https://doi.org/10.1080/1059924X.2024.2388253.
41. Yazd SD, Wheeler SA, Zuo A. Key risk factors affecting farmers' mental health: a systematic review. *Int J Environ Res Publ Health*. 2019;16(23):4849. https://doi.org/10.3390/ijerph16234849.