At Times, Hunters Should Beware. Trauma from Wild Boar Encounters During Hunting: A Nationwide Survey in Germany with a Systematic Literature Review

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Article

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Abstract

Background/Objectives: Wild boar (Sus scrofa) populations have expanded markedly across Europe, increasing human–wild boar encounters and hunting-related injuries. Existing knowledge derives mainly from isolated case reports or fatality analyses. This nationwide study characterizes injury patterns, management pathways, outcomes, and contextual risk factors associated with wild boar attacks during organized hunting in Germany and complements these data with a systematic literature review. **Methods:** Injured hunters were recruited via major German hunting journals. Structured physician-led telephone interviews captured demographics, hunting exposure, event characteristics, anatomical injury patterns, management strategies, complications, outcomes, and post-injury adaptations. Injuries were categorized as closed, open outpatient, or open inpatient. Descriptive statistics, Chi-square tests, linear regression models, and ANCOVA were applied. A systematic literature review (PRISMA 2020) supplemented the primary dataset. **Results:** A total of 101 hunters were included, predominantly experienced male dog handlers injured during close-range tracking operations. Lower-extremity penetrating injuries dominated. Significant associations with injury severity included situational context ($p = 0.028$), sex of the injuring boar ($p = 0.023$), and time to first help ($p = 0.036$). Open injuries requiring inpatient care frequently involved extensive soft-tissue destruction, vascular injury, surgical intervention, infectious complications, and prolonged recovery. Treatment duration strongly predicted work absenteeism across all injury categories, with progressively steeper regression slopes in more severe injuries (interaction $p < 0.001$). No fatalities occurred, and all participants resumed hunting. Most participants expressed need for improved first-aid training. **Conclusions:** Hunting-associated wild boar attacks constitute a distinct form of penetrating trauma with deceptively small external wounds and substantial underlying tissue damage. This study provides the largest structured clinical dataset to date and, combined with a systematic literature review, informs prevention strategies, first-aid preparedness, and surgical management in modern trauma systems.

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1. Introduction

Wild boars (*Sus scrofa*) are one of the most widely distributed large mammals globally, and have undergone a marked numerical expansion over recent decades, particularly in Europe. Once largely confined to forested and rural landscapes, wild boar populations have progressively increased in density and geographic range, recolonizing previously unoccupied territories and expanding into peri-urban and urban environments [1]. This population growth has been attributed to a combination of biological and anthropogenic factors, including high reproductive capacity, landscape changes favoring edge habitats and agriculture, supplementary feeding, reforestation, absence or reduction of large predators, and milder winters enhancing juvenile survival [1–3].

The demographic characteristics of wild boar are exceptional among ungulates. The species exhibits early sexual maturity, high fecundity and marked plasticity in reproductive timing and output, allowing rapid population growth even under substantial hunting pressure.3 Long-term hunting data demonstrate that harvest numbers have increased across Europe while hunter populations have remained stable or declined, suggesting that traditional recreational hunting may be insufficient to control population growth [1]. At the same time, hunting remains the primary source of mortality in most European wild boar populations [1,4].

As wild boar populations have expanded, human–wild boar conflicts have intensified. These conflicts include agricultural damage, vehicle collisions, disease transmission risks, ecological impacts and increasingly frequent direct encounters with humans [1,3]. Urban synurbization, defined as the adaptation of wildlife species to urban environments, has been documented in several European cities, where wild boars now exploit anthropogenic food sources and green corridors [5]. Such proximity increases the likelihood of aggressive interactions, particularly when animals are habituated, wounded, cornered or accompanied by offspring.

Attacks by wild pigs on humans have been documented historically across multiple continents and ecological contexts. A comprehensive synthesis of 412 attacks worldwide identified both hunting and non-hunting circumstances as triggers, with wounded animals representing a major cause during hunting scenarios [2]. Most victims were adult males, often traveling on foot and alone, and lower extremity injuries predominated [2]. Injury patterns were typically lacerations and puncture wounds, reflecting tusk-inflicted penetrating trauma [2]. Although attacks are considered rare relative to overall human–wildlife interactions, fatalities do occur. A global review of fatal wild pig attacks between 2000 and 2019 documented 172 human deaths across 29 countries, most frequently under non-hunting circumstances but also during hunts involving provoked or wounded animals [6]. Exsanguination and severe thoracoabdominal injury were among the most common causes of death [6].

From a forensic and pathological perspective, fatal attacks by large mammals including wild boar display characteristic injury patterns that can assist in species attribution. In contrast to carnivores, wild boar attacks are dominated by penetrating tusk injuries rather than bite-associated crushing or tearing patterns [7]. Large mammals may also inflict combined blunt and sharp trauma, including crush injuries and deep incised wounds, occasionally mimicking assault-related trauma in forensic contexts [8]. Fatal outcomes may result from hemorrhage, internal organ disruption or secondary complications such as sepsis [8,9]. In wilderness or remote settings, delayed evacuation and limited access to immediate medical care may exacerbate injury severity and mortality risk [10].

The management dimension of wild boar hunting further complicates the risk landscape. Hunting practices vary between individual and team-based methods, and may selectively target specific sex or age classes, influencing both population structure and encounter dynamics [4]. Modern hunting is increasingly shaped by sociopolitical, ethical and demographic changes within hunting communities, potentially affecting hunting effort, harvest efficiency and animal behavior [3]. Under

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sustained hunting pressure, wild boar may modify spatial behavior, increase nocturnality and alter escape responses, potentially affecting both encounter frequency and attack circumstances [3].

Despite the documented global occurrence of wild boar attacks and the recognized expansion of wild boar populations in Europe, clinical data characterizing injury patterns within defined hunting populations remain limited. Existing literature is largely composed of ecological syntheses, forensic reviews and global attack compilations rather than systematic clinical analyses within modern trauma systems [2,6,7]. Consequently, while the ecological and epidemiological framework of human–wild boar interactions is increasingly well described, the clinical spectrum, management strategies and outcomes of hunting-associated injuries in contemporary European settings have not been comprehensively characterized.

In regions where wild boar populations continue to grow and hunting remains a major management tool, understanding the clinical implications of these interactions is essential. A precise characterization of injury mechanisms, anatomical distribution, therapeutic strategies and outcomes provides an evidence base for prevention strategies, hunter education, emergency preparedness and trauma care planning in landscapes shaped by expanding wild boar populations. Against this ecological, epidemiological and forensic background, a detailed clinical evaluation of hunting-associated wild boar injuries within a contemporary European healthcare setting is warranted. Global syntheses have outlined circumstances and general injury patterns of wild pig attacks, but they offer limited insight into structured trauma management, complication profiles, functional recovery and behavioral consequences within defined hunting populations. To address this gap, the present nationwide exploratory study systematically examines wild boar–related injuries sustained during organized hunting in Germany, integrating exposure characteristics, anatomical injury patterns, treatment pathways, complications, long-term outcomes and post-injury adaptations to provide a comprehensive clinical perspective that complements existing review-based literature and informs prevention and surgical management strategies.

2. Materials and Methods

The first part of this project was a monocentric, exploratory, observational study aiming to systematically document injuries associated with wild boar hunting in Germany. The objective was to gather detailed, structured information from affected hunters to characterize injury mechanisms, clinical features, treatment pathways and outcomes. The study was conducted in accordance with the Declaration of Helsinki and applicable German data protection regulations. It was approved by the Ethics Committee of Ludwig-Maximilians-University of Munich (Munich, Germany; reference 24-0377; date of approval 05 June 2024). Participation was voluntary, withdrawal was possible at any time without disadvantage, and no interventions, risks or burdens beyond the interview time were involved.

Participants were adults aged 18 years or older who hunted in Germany, were actively engaged in wild boar hunting within Germany, and had sustained at least one injury in direct association with such hunting activities. Individuals were eligible only if they were able to answer the study questionnaire completely and truthfully and had no conditions that interfered with participation. Recruitment was carried out on a voluntary basis following an announcement of the study in several of the most widely read German hunting journals (“Wild und Hund”, “Pirsch”, “Nachrichtenblatt des Deutschen Jagd Terrier – Club e.V.”) and hunting social media channels. Interested individuals contacted the study team directly and received further study materials.

After expressing interest, each potential participant was provided with an information sheet and the required consent documents. Written informed consent was obtained. Data acquisition took place via structured telephone interviews conducted by the first author of this study, who is an experienced physician with expertise in orthopedics, trauma medicine and hunting practice. During these interviews, the structured questionnaire was completed manually on paper. Each interview lasted approximately one hour.

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The questionnaire comprised four major domains: demographic characteristics; hunting experience and exposure to wild boar; detailed information on the injury event, including anatomical location, injury type, circumstances and characteristics of the involved wild boar; and medical management, recovery and subjective impressions. If a single event resulted in multiple injuries, each injury was documented separately. Injury characterization included whether the injury was open or closed, the affected body region, the specific anatomical structures involved and the presence of fractures, vascular injuries or nerve damage. Participants provided detailed information on temporal and environmental conditions at the time of injury – including hunting method and lighting – as well as the sex and measured weight of the wild boar involved. Medical treatment pathways were recorded, including pre-hospital care, outpatient or inpatient management, surgical interventions, rehabilitation, total duration of medical treatment and duration of work absenteeism. Self-reported healing outcomes and the presence or absence of persistent functional impairment were documented at the time of data collection.

To ensure data protection and confidentiality, a two-part pseudonymization system was used. Each paper questionnaire comprised an upper section with identifying information and a lower section containing only a sequential identification number. After the interview, a physical copy of the completed questionnaire was produced; the identifying section was removed from the copy and destroyed, and only the pseudonymized section was retained for analysis. The original questionnaire was stored securely in the clinic of the first author of this study in accordance with standard clinical documentation procedures.

All pseudonymized data were manually entered into Excel files (Microsoft, Redmond, WA, USA). Given the exploratory nature of the study, analyses were descriptive and conducted by predefined injury groups (closed injuries, open injuries treated on an outpatient basis and open injuries requiring inpatient treatment). Continuous variables (e.g., age, anthropometric data, hunting experience, measured wild boar weight) were summarized using means and ranges, while categorical variables (e.g., sex, hunting role, protective equipment use, injury characteristics, treatment pathways and outcomes) were reported as absolute numbers and percentages. Participants were counted once per variable unless otherwise specified; injuries involving multiple anatomical regions or characteristics were documented accordingly.

Statistical analyses were performed using GraphPad Prism (Version 11; GraphPad Software, Boston, MA, USA). Continuous variables were summarized using descriptive statistics, including mean, standard deviation, median, interquartile range and range, as appropriate. Categorical variables were reported as absolute numbers and corresponding percentages. Group comparisons of categorical variables were performed using Chi-square tests. Associations between continuous variables were assessed using simple linear regression analyses conducted separately within predefined injury categories. For each regression model, the slope, coefficient of determination (R2) and p value testing deviation of the slope from zero were calculated. Differences between regression slopes across injury categories were evaluated using analysis of covariance (ANCOVA) with interaction terms. All statistical tests were two-sided, and a p value < 0.05 was considered statistically significant. No data were missing. All results were presented in tabular form to provide transparent and comprehensive reporting of the collected data.

The second part of this project was a systematic literature search performed in PubMed and Ovid/Embase (including all resources) using the terms summarized in Table 1 from database inception through February 12, 2026, in accordance with the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11].

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Table 1. Terms used in the systematic literature search performed in accordance with the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11]. Abbreviation: NR, number of records retrieved.

Search No.	PubMed search	NR	Ovid/Embase search	NR	
1	("wild boar"[Title/Abstract] OR "Sus scrofa"[Title/Abstract]) AND (injur*[Title/Abstract] OR attack*[Title/Abstract] OR trauma*[Title/Abstract] OR bite*[Title/Abstract]) AND (human*[Title/Abstract] OR patient*[Title/Abstract])	100	((wild boar OR Sus scrofa).ti,ab.) AND (injur*.ti,ab. OR attack*.ti,ab. OR trauma*.ti,ab. OR bite*.ti,ab.) AND (human*.ti,ab. OR patient*.ti,ab.)	140	
2	(("pig"[Title/Abstract] OR "boar"[Title/Abstract]) AND (bite*[Title/Abstract])) AND (infection[Title/Abstract] OR injur*[Title/Abstract] OR trauma*[Title/Abstract])	83	((pig OR boar).ti,ab. AND bite*.ti,ab.) AND (infection.ti,ab. OR injur*.ti,ab. OR trauma*.ti,ab.)	86	
3	("animal attack"[Title/Abstract]) AND (boar[Title/Abstract] OR pig[Title/Abstract])	8	(animal attack).ti,ab. AND (boar OR pig).ti,ab.	3	
4	wild boar case report	336	(wild boar).ti,ab. AND (case report OR case study).ti,ab.	36	
5	wild boar attack	104	(wild boar AND attack*).ti,ab.	38	
6	(("Wild boar"[tiab] OR "Sus scrofa"[tiab]) AND ("Wound"[tiab] OR "Injury"[tiab] OR "Attack"[tiab]))	147	((wild boar OR Sus scrofa).ti,ab.) AND ((wound OR injury OR attack).ti,ab.)	214	Also used in [5]
7	("wild" OR "feral") AND ("pig" OR "boar") AND ("attack") AND ("fatal" OR "died" or "killed")	8	(wild OR feral).ti,ab. AND (pig OR boar).ti,ab. AND (attack*).ti,ab. AND (fatal* OR died OR kill*).ti,ab.	14	Also used in [6]
Sum of records retrieved		786		531	

The assessment strategy for the identified records is summarized in Figure 1.

The numbers of retrieved records are presented in Table 1. A total of 1,317 records were identified across both databases, of which 554 duplicates were removed prior to screening. No automated tools were used to identify or exclude ineligible records.

Of the remaining 763 records, 734 were excluded because they did not address injuries caused by wild boars or pigs (details in the Appendix). The 29 eligible records [5,12–39] were classified as Category 1 records (i.e., studies retrieved through the systematic literature search) and are referred to as such in the following text.

Screening the reference lists of related reviews [1–10] yielded five additional articles [40–44]. One of these articles [40] was indexed in PubMed and Ovid/Embase but had not been retrieved by the

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systematic search strategy; it was therefore designated as a Category 2 record. The remaining four articles [41–44] were not indexed in PubMed or Ovid/Embase and were consequently not captured by the systematic search; these were designated as Category 3 records.

In addition, seven articles [45–51] were identified through the first author's private literature database. Five of these [45–49] were indexed in PubMed and/or Ovid/Embase but had neither been retrieved by the systematic search nor cited in the screened reviews [1–10]; these were designated as Category 4 records. The remaining two articles [50,51] were not indexed in PubMed or Ovid/Embase and were also not cited in the screened reviews [1–10]; these were designated as Category 5 records.

The final dataset comprised 41 articles. None were excluded based on study outcome. Publications in languages other than English were translated using ChatGPT (version 5.2; OpenAI OpCo, San Francisco, CA, USA). Owing to substantial heterogeneity in the reporting and characterization of case descriptions across studies, a quantitative meta-analysis was not performed.

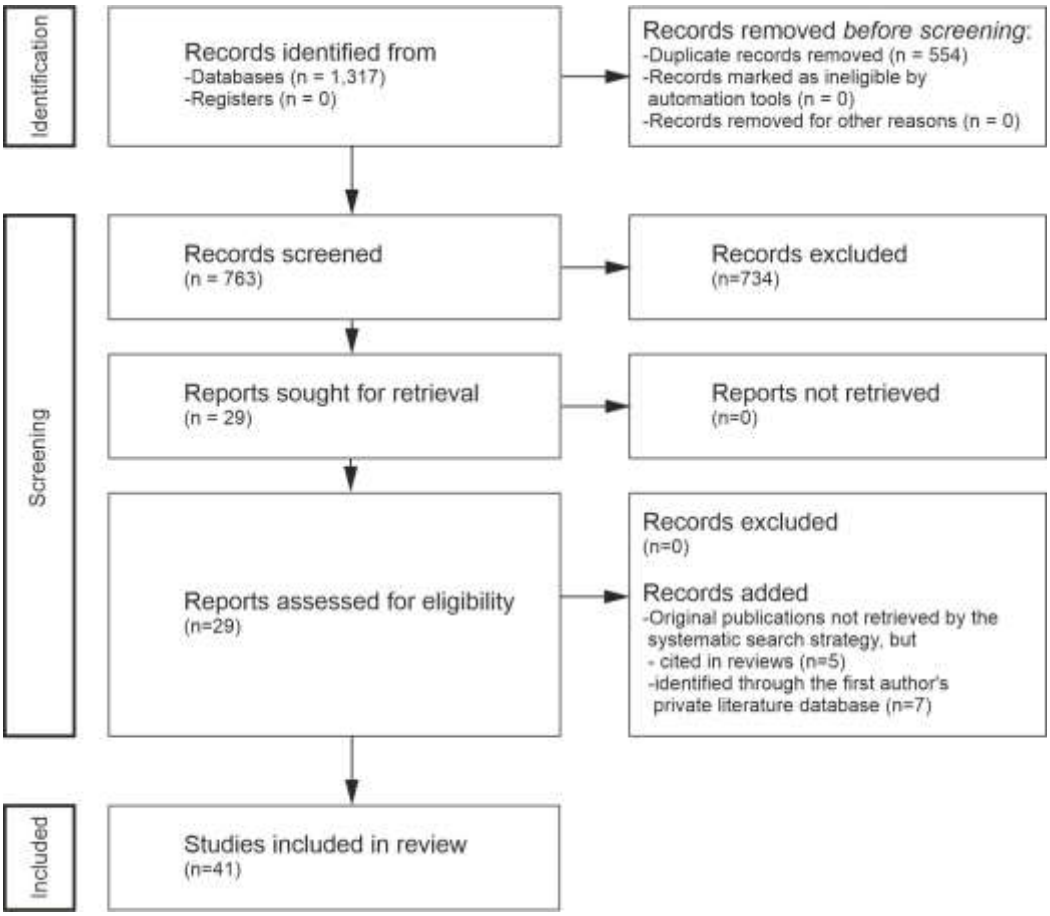

Figure 1. Systematic review flow chart of the literature search performed according to the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11] on February 12, 2026.

3. Results

3.1. Demographic Characteristics

A total of 101 individuals (participants in this study) who sustained wild boar–related injuries during hunting activities were included and categorized into three groups (injury categories): closed injuries, open injuries treated on an outpatient basis, and open injuries requiring inpatient treatment.

Across all groups, the study population was overwhelmingly male, with only a very small proportion of female participants (Table 2).

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Table 2. Demographic characteristics of the study population.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Sex (male)	22 (95.6%)	44 (95.7%)	31 (96.9%)
Sex (female)	1 (4.4%)	2 (4.3%)	1 (3.1%)
Mean age at injury (years)	49.1	50.2	47.0
Age range (years)	26–74	22–74	24–75
Mean height (cm)	180.6	180.6	180.8
Height range (cm)	170–196	165–200	165–200
Mean weight (kg)	84.3	83.5	91.0
Weight range (kg)	63–102	64–120	63–125
BMI (men)	26.0	25.7	28.0
BMI (women)	21.8	24.1	22.9
Hunting experience (years), mean	25.3	30.6	24.4
Hunting experience range (years)	4–57	4–56	3–50

The mean age at the time of injury was similar across groups, with participants predominantly in middle adulthood, ranging from young adulthood to advanced age (Table 2). Body height and weight were comparable between groups, and most participants were within the overweight BMI category, particularly in the inpatient open-injury group (Table 2).

3.2. Hunting Experience and Exposure

Participants reported extensive hunting experience, with most participants having hunted for several decades at the time of injury. All participants reported frequent annual contact with wild boar.

Exposure to tracking operations varied between groups. In the closed-injury group, 6 of 23 (26.1%) participants reported fewer than 50 tracking events per year, 7 (30.4%) reported 50–100, 4 (17.4%) reported 101–200 and 6 (26.1%) reported more than 200 tracking events annually. In the outpatient open-injury group, 17 of 46 (37.0%) participants reported fewer than 50 tracking operations, 10 (21.7%) reported 50–100, 6 (13.0%) reported 101–200 and 13 (28.3%) reported more than 200 per year. In the inpatient open-injury group, 16 of 32 (50.0%) participants reported fewer than 50 tracking operations, 7 (21.9%) reported 50–100, 5 (15.6%) reported 101–200 and 4 (12.5%) reported more than 200 annually (Table 3).

Table 3. Hunting exposure and hunting roles. *, multiple selections possible.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Dog handlers	22 (95.7%)	44 (95.7%)	29 (90.6%)
Registered tracking teams	15 (65.2%)	13 (28.3%)	16 (50.0%)
>5 wild boar contacts/year	23 (100%)	46 (100%)	32 (100%)
Tracking operations <50/year	6 (26.1%)	17 (37.0%)	16 (50.0%)
Tracking operations 50–100/year	7 (30.4%)	10 (21.7%)	7 (21.9%)
Tracking operations >100-200/year	4 (17.4%)	6 (13.0%)	5 (15.6%)
Tracking operations >200/year	6 (26.1%)	13 (28.3%)	4 (12.5%)
Hunting methods* – Stand hunting	18 (78.3%)	34 (73.9%)	29 (90.6%)
Hunting methods* – Stalking	13 (56.5%)	32 (69.6%)	31 (96.9%)
Hunting methods* – Driven hunt	17 (73.9%)	38 (82.6%)	30 (93.8%)

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Hunting methods* – Tracking	19 (82.6%)	42 (91.3%)	31 (96.9%)

The Chi-square test showed no significant difference between the groups (p = 0.520), indicating that tracking frequency had no impact on injury category. From a broader perspective, this finding suggests that cumulative tracking exposure alone did not appear to determine injury severity; rather, situational factors at the time of encounter may be more decisive than overall hunting routine.

3.3. Hunting Regions, Roles and Techniques

Participants were active in numerous German federal states. Most individuals were dog handlers at the time of injury, and a substantial proportion were registered tracking-dog teams (Table 3).

With regard to hunting techniques, multiple methods were commonly used (Table 3). In the closed-injury group, 18 of 23 (78.3%) participants reported stand hunting, 13 (56.5%) stalking, 17 (73.9%) driven hunts and 19 (82.6%) tracking. In the outpatient open-injury group, 34 of 46 (73.9%) participants reported stand hunting, 32 (69.6%) stalking, 38 (82.6%) driven hunts and 42 (91.3%) tracking. In the inpatient open-injury group, 29 of 32 (90.6%) participants reported stand hunting, 31 (96.9%) stalking, 30 (93.8%) driven hunts and 31 (96.9%) tracking (Table 3). The Chi-square test showed no significant difference between injury category and hunting technique (p = 0.968). From a broader operational perspective, this suggests that severe injuries were not confined to a specific hunting modality but may occur across all commonly practiced techniques, reflecting the inherently unpredictable nature of close-range wild boar encounters rather than a method-specific risk profile.

3.4. Protective Equipment and Weapons

Use of protective equipment differed between groups. In the closed-injury group, 4 of 23 (17.4%) participants wore no protective clothing, 13 (56.5%) wore protective trousers only and 6 (26.1%) wore both protective trousers and jacket. In the outpatient open-injury group, 9 of 46 (19.6%) participants wore no protective clothing, 27 (58.7%) wore protective trousers only and 10 (21.7%) wore both items. In the inpatient open-injury group, 10 of 32 (31.3%) participants wore no protective clothing, 21 (65.6%) wore protective trousers only and 1 (3.1%) wore both items (Table 4).

Table 4. Protective equipment and weapons used at the time of injury. *, multiple selections possible.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
No protective clothing	4 (17.4%)	9 (19.6%)	10 (31.3%)
Protective trousers only	13 (56.5%)	27 (58.7%)	21 (65.6%)
Protective trousers + jacket	6 (26.1%)	10 (21.7%)	1 (3.1%)
Carried rifle*	22 (95.7%)	42 (91.3%)	30 (93.8%)
Carried shotgun*	1 (4.3%)	1 (2.2%)	0 (0%)
Carried handgun (in addition to long gun)*	2 (8.7%)	6 (13.0%)	3 (9.4%)
Carried knife*	23 (100%)	46 (100%)	32 (100%)

The Chi-square test showed no significant difference between groups (p = 0.129), indicating that protective clothing type had no impact on injury category. In a broader preventive context, this suggests that currently used protective garments may not reliably mitigate injury severity, highlighting a potential need for improved protective standards or alternative safety strategies.

With regard to weapons, almost all participants carried a long gun, predominantly rifles. A minority additionally carried a handgun, and all participants carried a hunting knife (Table 4).

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3.5. Temporal Distribution of Injuries

Injuries across all groups occurred over several decades, with most reported in recent years. Seasonal clustering was observed, particularly in late autumn and winter, while some injuries also occurred in summer months. Nearly all incidents occurred during daylight; only very few incidents occurred in darkness (Table 5).

Table 5. Circumstances of injury events.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Tracking operations	18 (78.3%)	42 (91.3%)	24 (75.0%)
Driven hunts	3 (13.0%)	4 (8.7%)	8 (25.0%)
Other activities	2 (8.7%)	0 (0%)	0 (0%)
Daylight	23 (100%)	45 (97.8%)	30 (93.8%)
Darkness	0 (0%)	1 (2.2%)	2 (6.3%)
Male wild boar (Keiler)	14 (60.9%)	35 (76.1%)	30 (93.8%)
Female wild boar (Bache)	8 (34.8%)	10 (21.7%)	2 (6.3%)
Unknown	1 (4.3%)	1 (2.2%)	0 (0%)
Mean boar weight (kg)	76.9 (Keiler) / 69.1 (Bache)	82.2 (Keiler) / 85.3 (Bache)	72.0 (Keiler) / 95.0 (Bache)

3.6. Situational Context and Characteristics of the Injuring Wild Boar

Tracking operations represented the predominant context in all groups (Table 5). In the closed-injury group, 18 of 23 (78.3%) injuries occurred during tracking; in the outpatient open-injury group, 42 of 46 (91.3%); and in the inpatient open-injury group, 24 of 32 (75.0%). Additional injuries occurred during driven hunts and other hunting-related activities (Table 5). The Chi-square test showed a significant difference between groups ($p = 0.028$), indicating that situational context exerted an impact on injury category. This finding suggests that the specific operational scenario – particularly active tracking – may influence not only exposure but also injury severity, likely reflecting close-range encounters with wounded or cornered animals.

Most injuries were inflicted by male wild boar (Table 5). In the closed-injury group, 14 of 23 (60.9%) injuries were caused by male animals; in the outpatient open-injury group, 35 of 46 (76.1%); and in the inpatient open-injury group, 30 of 32 (93.8%). When excluding cases with unknown animal sex, the Chi-square test demonstrated a significant difference between groups ($p = 0.023$), indicating that animal sex influenced injury category (Table 5). From an ethological standpoint, the predominance of male animals in inflicting injuries may reflect greater body mass, tusk size and aggressive defensive behavior, which could translate into higher trauma potential during encounters.

3.7. Injury Distribution and Patterns

Lower-extremity injuries predominated across all groups. In the closed-injury group, 16 of 23 (69.6%) participants involved only the lower extremity, 3 (13.0%) involved both upper and lower extremities, 2 (8.7%) involved only the upper extremity, and 2 (8.7%) involved the trunk. In the outpatient open-injury group, 32 of 46 (69.6%) participants were confined to the lower extremity, 4 (8.7%) involved both upper and lower extremities, 7 (15.2%) involved only the upper extremity, and the remainder involved other regions. In the inpatient open-injury group, 21 of 32 (65.6%) participants affected the lower extremity only, 7 (21.9%) affected both upper and lower extremities, and 3 (9.4%) affected only the upper extremity (Table 6).

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Table 6. Anatomical distribution and type of injuries. *, multiple selections possible.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Lower extremity only	16 (69.6%)	32 (69.6%)	21 (65.6%)
Lower + upper extremity	3 (13.0%)	4 (8.7%)	7 (21.9%)
Upper extremity only	2 (8.7%)	7 (15.2%)	3 (9.4%)
Thorax	1 (4.3%)	0 (0%)	1 (3.1%)
Abdomen/pelvis	1 (4.3%)	2 (4.3%)	0 (0%)
Face	0 (0%)	1 (2.2%)	0 (0%)
Open injuries	0 0%)	46 (100%)	32 (100%)
Closed injuries	23 (100%)	0 (0%)	0 (0%)
Fractures*	3 (13.0%)	1 (2.2%)	3 (9.4%)
Vascular injuries*	0 (0%)	0 (0%)	6 (18.8%)
Nerve injuries*	0 (0%)	0 (0%)	2 (6.3%)
Soft-tissue injuries*	21 (91.3%)	46 (100%)	32 (100%)

The Chi-square test showed no significant difference between injury category and injury distribution ($p = 0.669$). From a broader biomechanical perspective, the uniform predominance of lower-extremity involvement across all severity categories reflects the typical upward tusk motion of a charging wild boar, and indicates that anatomical location alone does not determine clinical severity; rather, the depth of penetration and associated structural damage appear to be more decisive determinants of outcome.

3.8. Tissue Affected by Injury

In the closed-injury group, 21 of 23 (91.3%) participants sustained soft-tissue injuries, while 3 (13.0%) sustained fractures. In the outpatient open-injury group, all 46 (100%) participants sustained open soft-tissue injuries, and 1 (2.2%) sustained a fracture. In the inpatient open-injury group, all 32 (100%) participants sustained open soft-tissue injuries; 3 (9.4%) sustained fractures, 6 (18.8%) sustained vascular injuries, and 2 (6.3%) sustained nerve injuries (Table 6). The Chi-square test showed no significant difference between injury category and tissue type affected by injury ($p = 0.968$). Although more complex structural injuries were observed in severe cases, the absence of statistical association suggests that tissue type alone did not fully account for clinical classification, and that overall trauma burden may better reflect injury severity.

3.9. Time to First Help

In the closed-injury group, 16 of 23 (69.6%) participants received help within one hour, 6 (26.1%) within one to six hours, and 1 (4.3%) after more than 24 hours. In the outpatient open-injury group, 16 of 46 (34.8%) participants received help within one hour, 28 (60.9%) within one to six hours, and 2 (4.3%) within six to 12 hours. In the inpatient open-injury group, 18 of 32 (56.3%) participants received help within one hour, 13 (40.6%) within one to six hours, and 1 (3.1%) within 12 to 24 hours (Table 7).

Table 7. Time to first help and treatment pathways. *, multiple selections possible.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
<1 hour to first help	16 (69.6%)	16 (34.8%)	18 (56.3%)
1–6 hours	6 (26.1%)	28 (60.9%)	13 (40.6%)
6–12 hours	0 (0%)	2 (4.3%)	0 (0%)
12–24 hours	0 (0%)	0 (0%)	1 (3.1%)
24–48 hours	1 (4.3%)	0 (0%)	0 (0%)
Self-treatment only	16 (69.6%)	0 (0%)	0 (0%)
Outpatient only	4 (17.4%)	46 (100%)	0 (0%)

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Hospital admission	3 (13.0%)	0 (0%)	32 (100%)
Operative treatment*	2 (8.7%)	35 (76.1%)	32 (100%)
Rehabilitation (any)*	3 (13.0%)	5 (10.9%)	10 (31.3%)

The Chi-square test showed a statistically significant difference between groups ($p = 0.036$), indicating that time to first help influenced injury category. From a trauma-systems perspective, this underscores the importance of rapid on-site assistance and evacuation logistics, as early intervention may play a critical role in limiting progression from moderate to severe clinical courses.

3.10. Treatment Duration, Functional Recovery and Work Absenteeism

Treatment pathways reflected the predefined injury categories, with closed injuries frequently managed conservatively or on an outpatient basis, outpatient open injuries often requiring operative wound management, and inpatient open injuries uniformly necessitating hospital admission and surgical intervention (Table 7). However, when examining total treatment duration, the descriptive statistics revealed a less intuitive distribution than expected from injury severity alone (Table 8).

Table 8. Healing outcomes and work absenteeism.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Complete healing with no functional impairment	22 (95.7%)	45 (97.8%)	24 (75.0%)
Persistent impairment	1 (4.3%)	1 (2.2%)	8 (25.0%)
Total treatment time [days]			
Minimum	3	7	2
25% percentile	14	14	14
Median	21	29	14
75% percentile	30	57	29.5
Maximum	1000	365	180
Mean	72.8	50.7	27.4
Standard deviation	205.6	70.4	27.4
Work absence [days]			
Minimum	0	0	0
25% percentile	0	0	0
Median	7	21	0
75% percentile	30	42	19.3
Maximum	180	120	90
Mean	23.2	27.1	13.2
Standard deviation	41.2	29.9	21.0

In particular, mean and median treatment times did not increase linearly across injury categories, and variability was considerable, especially in the closed-injury and outpatient groups. This dispersion likely reflects heterogeneity in soft-tissue damage, secondary complications and individual recovery trajectories rather than misclassification of injury severity.

Healing outcomes were generally favorable (Table 8). Complete recovery without persistent functional impairment was reported by nearly all participants in the closed and outpatient open groups, whereas a substantial minority in the inpatient open-injury group (8 of 32 (25.0%) participants) reported lasting impairment. These findings underscore that although most hunting-associated wild boar injuries were survivable within a structured trauma system, severe open injuries

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carried a measurable risk of long-term functional limitation, particularly when associated with vascular or complex soft-tissue involvement.

At first glance, work absenteeism appeared not to parallel injury severity in a straightforward manner (Table 8). Notably, the inpatient group did not demonstrate the longest average absence from work. This apparent discrepancy is most plausibly explained by heterogeneity in occupational status and interpretation of "work absenteeism." Retired participants reported no absence regardless of treatment duration. Similarly, freelancers, self-employed participants and company owners may have resumed professional activities in a modified or partial capacity without formally defining this as absenteeism, in contrast to salaried employees and civil servants whose absence is structurally documented. Consequently, absolute work-absence figures must be interpreted with caution and cannot be regarded as a pure surrogate marker of injury severity.

To further explore the relationship between clinical burden and occupational impact, linear regression analyses were performed separately within each injury category. In all three groups, treatment duration showed a strong positive linear association with work absenteeism (Figure 2).

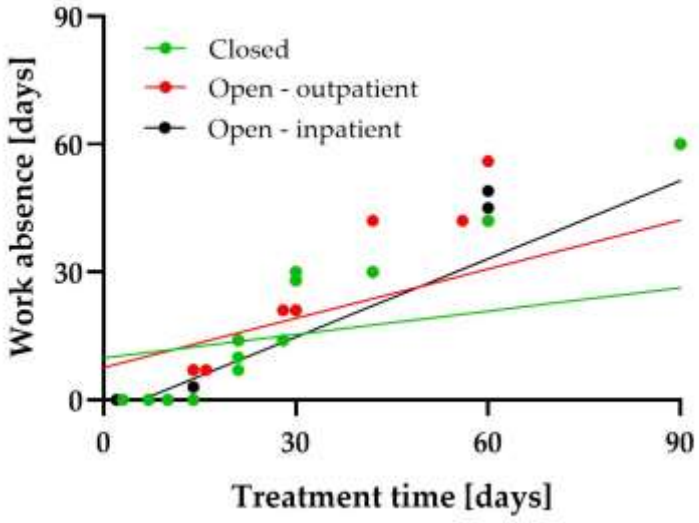

Figure 2. Relationship between total treatment duration and work absenteeism stratified by injury category. Each dot represents one participant (outliers with higher values not shown). Linear regression lines are shown separately for closed injuries (green), open injuries treated on an outpatient basis (red) and open injuries requiring inpatient treatment (black). A positive association between treatment time and work absence was observed in all groups, with progressively steeper slopes in the outpatient and inpatient open-injury groups, indicating an increasing occupational impact with rising injury severity.

In the closed-injury group, the slope was 0.183 ($R^2 = 0.83$; $p < 0.001$); in the outpatient open-injury group, the slope was 0.384 ($R^2 = 0.82$; $p < 0.001$); and in the inpatient open-injury group, the slope was 0.611 ($R^2 = 0.90$; $p < 0.001$). In each category, the slope differed highly significantly from zero, indicating that longer treatment duration was consistently associated with longer work absenteeism.

Importantly, comparison of slopes using an interaction model (analysis of covariance) demonstrated that the regression slopes differed significantly between the three groups ($p < 0.001$ for the interaction term). The progressive increase in slope magnitude from closed to outpatient to inpatient injuries indicates that, as injury severity rose, each additional day of treatment translated into a disproportionately greater occupational impact.

From a broader health-economic perspective, these findings reconcile the initially counterintuitive descriptive statistics. Although absolute absenteeism values were influenced by socio-occupational factors, the internal association between medical burden and occupational limitation was robust and became increasingly pronounced with injury complexity. Particularly in

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severe open injuries requiring inpatient care, prolonged medical management was closely mirrored by extended work absence, reflecting tangible functional and socioeconomic consequences.

Taken together, these results suggest that injury severity in this context should not be assessed solely by anatomical classification or need for hospitalization. Rather, the combined evaluation of treatment intensity, duration of care, functional outcome and the strength of the treatment–absence relationship provides a more nuanced and clinically meaningful assessment of overall impact

3.11. Preparedness, First-Aid Knowledge, and Training Needs

Self-reported first-aid knowledge varied. While most participants in all groups stated that they possessed first-aid knowledge, self-assessed competence differed, with a notable proportion of participants in the inpatient open-injury group rating their knowledge as insufficient. The large majority of all participants – ranging from 87% to 96% - expressed the need for additional first-aid training. At the moment of injury, between one third and one half of participants felt prepared, while up to two thirds in the inpatient group felt unprepared (Table 9).

Table 9. Preparedness, first-aid knowledge and behavioral changes. *, multiple selections possible.

Variable	Closed Injuries (n=23)	Open Injuries, Outpatient (n=46)	Open Injuries, Inpatient (n=32)
Felt prepared	10 (43.5%)	24 (52.2%)	11 (34.4%)
Felt unprepared	13 (56.5%)	22 (47.8%)	21 (65.6%)
First-aid knowledge rated “good”	12 (52.2%)	23 (50.0%)	13 (40.6%)
First-aid knowledge rated “adequate”	9 (39.1%)	20 (43.5%)	11 (34.4%)
First-aid knowledge rated “insufficient”	2 (8.7%)	3 (6.5%)	8 (25.0%)
Additional training considered necessary	22 (95.7%)	44 (95.7%)	28 (87.5%)
Changed protective equipment*	6 (26.1%)	24 (52.2%)	24 (75.0%)
Changed weapons*	3 (13.0%)	11 (23.9%)	8 (25.0%)
Changed tactics*	6 (26.1%)	16 (34.8%)	16 (50.0%)
Changed strategy*	2 (8.7%)	5 (10.9%)	6 (18.8%)
Stopped hunting*	0 (0%)	0 (0%)	0 (0%)

3.12. Post-Injury Behavioral Changes

In the closed-injury group, 6 of 23 (26.1%) participants changed protective equipment; in the outpatient open-injury group, 24 of 46 (52.2%); and in the inpatient open-injury group, 24 of 32 (75.0%) did so (Table 9). The Chi-square test showed no significant difference between injury category and post-injury behavioral changes ($p = 0.988$). Accordingly, although behavioral adaptations were frequent, their statistical independence from injury category suggests that post-event risk perception and precautionary change may be driven more by subjective experience than by objective injury severity.

No participant in any group ceased hunting as a result of the injury.

3.13. Qualitative Statements

Qualitative responses from all 101 participants revealed consistent themes emphasizing the unpredictability and inherent danger of wild boar encounters, particularly during tracking operations. Many participants described their experiences as sudden, surprising or unavoidable. Participants repeatedly highlighted the importance of caution, daylight tracking, maintaining visual awareness in dense vegetation, reliance on experienced hunting companions and the essential role of dogs and protective equipment. Several accounts reflected errors attributed to distraction, routine or

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overconfidence, while others were framed as formative or life-changing experiences. Despite the severity of some injuries, all individuals expressed continued commitment to hunting.

3.14. Systematic Literature Review of Wild Boar– and Swine-Related Human Injuries

The systematic literature search identified 41 articles addressing injuries caused by wild boar or closely related swine species in human subjects. The majority of publications were single case reports, followed by small case series and a limited number of autopsy-based investigations and epidemiological datasets. Most reports described penetrating trauma caused by tusks, frequently involving the lower extremities, but thoracic, abdominal, maxillofacial and neurological injuries were also documented. Fatal outcomes were predominantly associated with major vascular disruption or delayed recognition of intra-abdominal injury.

Five reports [36,38–40,49] were included despite the fact that it was unclear whether the described injuries were caused by domestic pigs or wild boar. These reports were retained because their microbiological findings – particularly regarding polymicrobial contamination and species such as Pasteurella spp. and Actinobacillus suis – remain clinically relevant for the management of penetrating swine-related injuries.

Given the substantial heterogeneity in study design, case characterization and outcome reporting, quantitative synthesis was not feasible. Instead, the identified publications were analyzed descriptively and are summarized in Table 10.

Table 10. Overview of all studies included in the systematic literature review on wild boar– and swine-related human injuries, including study characteristics, confirmation of wild boar involvement and core clinical patterns. Abbreviations: Y, year of publication; R, reference; C, category (as defined in Section 2); C/S, country/setting; D/N, design/number of cases; CS, case series; CR, case report; CWB?, confirmed wild bore?; CCP, core clinical pattern (very short); CCTS, closest comparison vs this study.

Y	R	C	C/S	D/N	CWB?	CCP	CCPS
2026	This study		Germany; hunting-related	CS; N=101	Yes	Hunting-associated trauma from tusks/bites; broad injury spectrum	Reference cohort
2026	[12]	1	(Case report; wild boar tusk knee)	CR; N=1	Yes	Knee arthrotomy from tusk	Similar mechanism (tusk trauma), different context (not a hunting cohort)
2025	[45]	4	(ED/trauma)	CR; N=1	Yes	Open digital fractures from boar bite	Similar (bite injury), different (single hand/digit focus)
2024	[46]	4	(Clinical case)	CR; N=1	Yes	Wild boar injury with need for acute management (case-based)	Mechanistically similar, but single-case clinical course
2024	[13]	1	(Trauma)	CR; N=1	Yes	Traumatic injury from wild boar attack (case-based)	Mechanistically similar, but not a hunting cohort

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2024	[14]	1	(Wilderness/trauma)	CR; N=1	Yes	Common fibular nerve injury after boar attack	Similar (extremity trauma), highlights peripheral nerve outcome
2024	[05]	1	Spain (Barcelona area); human–wild boar interface	CS; N=34	Yes	Urban/peri-urban interface injuries from boars	Differs (non-hunting; urban/peri-urban)
2023	[15]	1	Korea	CR; N=1	Yes	Severe head/brain injury after boar encounter (single case)	Differs (non-hunting single severe head injury emphasis)
2023	[16]	1	Japan; farm setting	CR; N=1	Yes	Penetrating chest injury with retained tusk fragment → traumatic pneumothorax → VATS removal	Comparable penetrating mechanism, but thoracic focus; rare foreign body retention
2023	[50]	5	Sri Lanka	CS; N=3	Yes	Series of attacks (regional context); management themes	Smaller, community context vs hunting cohort
2023	[17]	1	Turkey; forest setting	CR; N=1	Yes	Penetrating lower extremity wound → common fibular nerve compression → acute foot drop; surgical neurolysis + grafting with partial recovery	Comparable extremity mechanism, but rare isolated common fibular nerve palsy
2022	[47]	4	Turkey; traumatic animal-attack deaths	Autopsy series; multi-species	Mixed (includes wild boar)	Autopsy patterns: intrathoracic bleeding common; blunt/crush trauma common	Outcome-severity skewed (fatalities)
2022	[18]	1	Turkey; land-hunting deaths	Autopsy series; N=26	Wild boar subset present	Hunting fatalities: mostly firearms; 3.8%	Closest hunting comparator, but outcome =

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				total deaths		wild boar attacks (vascular injury)	fatalities focus vs injury cohort
2021	[51]	5	India	CR; N=1	Yes	Fatal exsanguination after boar attack	Highlights fatal hemorrhage; hunting context may differ
2021	[48]	4	India; major trauma center	Brief trauma-center series	Mixed animals	Mechanisms/patterns of animal injuries in trauma admissions	Partially comparable (hospital trauma lens), but not boar-specific
2021	[19]	1	(Trauma/animal injury context)	Mixed (not boar-only)	Mixed animals	Animal-related injuries (not boar-restricted)	Limited comparability (not boar-specific)
2020	[20]	1	Nepal (Chitwan NP)	Spatial/eco analysis	Mixed species; includes wildlife attacks	Spatial concentrations of attacks	Differs (eco-spatial; not hunting trauma cohort)
2018	[21]	1	(Europe; trauma)	CR; N=1	Yes	Major soft-tissue injury; emphasizes severity/management	Similar (tusk soft-tissue trauma), single-case
2018	[22]	1	Japan; rural coastal setting	CR; N=1	Yes	Wild boar attack → fall from 10 m cliff → near-fatal drowning with aspiration pneumonia; minor external trauma	Differs (secondary trauma mechanism—fall/drowning rather than primary penetrating extremity injury)
2018	[23]	1	Japan	CR; N=1	Yes	Penetrating anorectal trauma; severe contamination issues	Differs (rare anorectal penetrating mechanism vs typical hunting extremity/trunk injuries)
2018	[41]	3	Brazil; surveillance/registry context	Dataset study (attacks & rabies PEP focus)	Mixed/depends on reporting (wild boar vs "javaporco" noted)	Epidemiology + rabies PEP adherence issues	Differs strongly (public health registry vs hunting trauma cohort)

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2018	[42]	3	(Clinical case)	CR; N=1	Yes	Chest trauma from wild boar attack	Similar (thoracic trauma), single-case
2017	[24]	1	Japan	CR; N=1	Yes	Bite wounds; infection-prevention approach discussed	Similar (bite management issues), single-case
2017	[43]	3	Nepal (Chitwan NP)	Epidemiology of wildlife attacks	Mixed species; wild boar included	When/where/whom patterns in park setting	Differs (wildlife-attack ecology vs hunting-case clinical cohort)
2017	[25]	1	India; animal-attack fatalities	Autopsy series; wild boar n=6 (within multi-species)	Mixed (boar subset explicit)	Fatality distribution includes wild boar; context includes "fields"	Fatality dataset; not comparable to nonfatal hunting-injury series
2016	[26]	1	India	CR; N=1	Yes	Perineal injury → recto–vesico–cutaneous fistula; surgical management	Differs (rare urogenital/colorectal fistula vs typical hunting injuries)
2015	[44]	3	India	CR; N=1	Yes	Fatal penetrating laceration by tusk (referenced in series)	Fatal hemorrhage/penetration emphasis
2015	[27]	1	India	CR/forensic note	Yes	Fatal tusk injuries (fatality-focused)	Differs (fatality-focused)
2014	[28]	1	Croatia	CR; N=1	Yes	Wild boar inflicted injury + treatment	Comparable (hunting region context plausible), single-case
2013	[29]	1	Croatia; hunters	Retrospective hunter attacks (13-year)	Yes (game-animal attacks; includes boar)	Hunter-focused attack patterns + management/infection discussion	Highly comparable context (hunters), but not Germany-only
2011	[30]	1	India	CR; N=1	Yes	Maxillofacial injury (boar inflicted)	Differs (maxillofacial focus)
2011	[31]	1	Turkey	CR; N=1	Yes	Wild boar wound management; vaccination/anti	Comparable management themes

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						biotic considerations	(tetanus/rabies/antibiotics)
2011	[32]	1	India; rural agricultural setting	CR (forensic); N=1	Yes	Lower extremity lacerations + blunt abdominal trauma → small bowel & mesenteric perforations → peritonitis → death (delayed diagnosis)	Highlights delayed intra-abdominal injury and fatal outcome
2008	[33]	1	India	CR; N=1	Yes	Fatal craniocerebral injury from boar attack	Highlights fatal head injury
2007	[34]	1	Turkey	CS (small; details not extracted here)	Yes	Wild boar attacks; often cited for clinical patterns	Likely comparable trauma type
2006	[35]	1	(Forensic/clinical)	CR; N=1	Yes	Fatal attack with multiple lesions / abdominal organ injury (as summarized in their table)	Highlights fatal abdominal trauma
1996	[36]	1	France; clinical microbiology case	CR; N=1	Unclear (pig bite)	Actinobacillus suis infection after pig bite; microbiological characterization; infection-focused	None – unclear whether domestic pig or wild boar
1992	[37]	1	(Clinical microbiology)	CR; N=1	Yes (wild boar bite)	Pasteurella multocida infection after wild boar bite (infection focus)	Adds infection dimension
1991	[49]	4	USA; farm setting	CR; N=1	Unclear (domestic swine/boar in pen)	Swine bite of the hand in farm worker; deep penetrating hand injury; surgical debridement emphasis;	None – unclear whether domestic pig or wild boar

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						infection risk from swine oral flora	
1990	[38]	1	USA; clinical microbiology	CR; N=1	Unclear (pig bite; petting-zoo context)	Hand infection after pig bite; unusual Flavobacterium isolate; microbiological + antimicrobial susceptibility focus	None – unclear whether domestic pig or wild boar
1988	[39]	1	UK; pig farming region	CS; N=7	Unclear (pig/boar injuries; farming context)	Pig bite/goring injuries with high infection rates; polymicrobial flora; emphasizes severe wound infection despite antibiotics	None – unclear whether domestic pig or wild boar
1988	[40]	2	Papua New Guinea; rural/provincial hospital	Hospital CS; N=20	Unclear (domestic + feral pigs mixed)	Severe penetrating injuries from pigs; abdominal evisceration, thoracic wounds, vascular injuries; mixed domestic/feral context	None – unclear whether domestic pig or wild boar

4. Discussion

This study is the largest dedicated cohort of hunting-associated wild boar injuries published to date, and provides a level of clinical granularity that has been largely absent from the existing literature. Previous publications on confirmed wild boar attacks [5,12–35,37,41–48,50,51] have been dominated by isolated case reports, small case series, fatality analyses or wildlife ecology datasets. Consequently, the clinical understanding of wild boar–related trauma has historically been shaped by anecdotal evidence and highly selected severe cases rather than systematic cohort-based evaluation. The present series of 101 injuries sustained during organized hunting in Germany therefore fills a substantial gap, and allows meaningful contextualization of previously published findings within a structured trauma-system framework.

Most available reports in the literature described single patients with dramatic injury patterns. Examples include knee arthrotomy after tusk penetration [12], open digital fractures following a wild boar bite [45], common fibular nerve injury [14] and isolated foot drop following fibular nerve compression requiring neurolysis [17]. Complex anorectal trauma requiring surgical reconstruction [23], recto-vesico-cutaneous fistula formation after perineal injury [26], thoracic trauma with pneumothorax and retained tusk fragment necessitating thoracoscopic removal [16], and fatal

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craniocerebral injury [33] further illustrate the broad anatomical spectrum of potential injury. While these reports provide important insights into the severity and diversity of tusk-inflicted trauma, they inevitably overrepresent unusual or catastrophic presentations. In contrast, the present cohort captures the entire clinical spectrum of hunting-associated injuries, from less complex soft-tissue wounds to injuries requiring operative intervention and rehabilitation.

Across virtually all publications, the predominant mechanism is penetrating trauma caused by tusks, frequently accompanied by secondary blunt force from body impact. The tusk functions as a sharp, upward-projecting weapon capable of producing deep puncture wounds with limited external skin disruption but extensive underlying tissue damage. Case reports repeatedly emphasized the discrepancy between superficial wound appearance and internal injury extent, particularly in extremity wounds [24,31]. The present findings confirm the predominance of penetrating extremity trauma, particularly involving the lower limb, consistent with the biomechanical dynamics of a charging boar striking upward toward the hunter's legs.

However, injury mechanisms are not restricted to primary tusk penetration. A near-fatal case involving a fall and subsequent aspiration pneumonia after a wild boar attack [22] illustrates the relevance of secondary trauma mechanisms. Similarly, fatal delayed intra-abdominal complications following apparently minor wounds [32] emphasize that small external lesions may conceal severe visceral injury and that delayed diagnosis can be fatal. These observations reinforce the need for thorough clinical assessment beyond the immediately visible wound.

Fatality-focused series provide an important complementary perspective. Autopsy-based investigations from Turkey and India [18,25,47] identified catastrophic vascular disruption and massive thoracoabdominal penetration as primary mechanisms of death. Individual fatal case reports [32,33,44,51] similarly highlighted exsanguination and delayed recognition of internal injury. The absence of mortality in the present cohort likely reflects differences in emergency response systems, evacuation logistics, structured team-based hunting practices and rapid access to surgical care. Early hemorrhage control and timely operative management appear decisive determinants of survival.

Exposure context further differentiates injury patterns. Wild boar trauma occurs in organized hunting, agricultural settings and urban interface encounters. Urban synurbic injuries described in one report [5] involved civilians rather than hunters, whereas ecological datasets from Nepal [20,43] primarily addressed environmental correlates without detailed clinical outcome reporting. The present cohort represents a homogeneous population injured during organized hunting, enabling clearer conclusions regarding risk patterns and management within this specific occupational-recreational setting.

Neurological injury, although infrequent, deserves particular attention. The detailed report of common fibular nerve injury following a wild boar bite [17] underscores the vulnerability of neurovascular structures in lateral knee trauma. The present series confirms that even apparently limited extremity wounds require systematic neurovascular assessment, though permanent nerve deficits were rare.

Thoracic injuries, although less frequent, may be life-threatening. A retained tusk fragment embedded in the chest wall with traumatic pneumothorax requiring thoracoscopic intervention [16] illustrates the capacity of wild boar tusks to generate penetrating thoracic trauma with retained foreign bodies.

Infection risk has been emphasized in microbiological case reports, particularly older publications in which differentiation between wild boar, feral pig and domestic swine was not always clear [36,38–40,49]. Polymicrobial contamination including Pasteurella species and Actinobacillus suis was repeatedly documented. Although some cases involved domestic pigs, the microbiological implications remain relevant for penetrating swine-related trauma. Contemporary reports [24,31] stressed early debridement and antimicrobial prophylaxis, and the present findings confirm that deep penetrating injuries carry infection risk, though severe septic complications are uncommon within structured trauma systems.

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An additional aspect of direct practical and medico-legal relevance concerns the occupational dimension of hunting-associated wild boar trauma. Severe injury sustained during organized hunting may qualify as an occupational accident ("Arbeitsunfall" in German language), not only for professional hunters but also for recreational hunters who are formally insured through statutory accident insurance systems during licensed hunting activities. In Germany, the legal obligation under animal protection legislation to conduct tracking of wounded game ("Nachsuche" in German language) after a non-lethal shot further institutionalizes exposure to close-range encounters with potentially injured and aggressive wild boar. Tracking operations represented the predominant context of injury in the present cohort and were significantly associated with injury severity. Thus, the risk of wild boar trauma is not merely recreational but is structurally embedded within regulatory hunting frameworks. Comparable legal or ethical obligations to track wounded game may exist in other countries, suggesting that the occupational and quasi-occupational relevance of these findings extends beyond the German context. This perspective reinforces the necessity of structured prevention strategies, standardized safety protocols and targeted first-aid training as elements of occupational health within hunting practice.

Methodological heterogeneity in prior reviews further complicated interpretation of incidence and severity patterns [2,5–7,10]. The PRISMA-based strategy [11] employed in the present study combined database searches, reference tracking and supplementary identification, yielding 41 relevant publications. In contrast, earlier reviews varied substantially in scope. Gudmannsson et al. (2019; [7]) restricted analysis to fatal Nordic mammal attacks; Mayer (2013: [2]) synthesized global attacks from scientific and non-scientific sources; Mayer et al. (2023; [6]) focused exclusively on fatalities between 2000 and 2019; Pujol et al. (2024; [5]) used narrower database terms; and Freer (2004; [10]) provided a narrative review. These methodological differences directly influence reported case numbers, geographic representation and perceived severity. Fatality-focused or media-based reviews may overemphasize catastrophic presentations, whereas broader structured searches reveal a more heterogeneous but largely survivable injury spectrum.

A striking discrepancy between the present dataset and prior publications concerns the scope of reported clinical variables. Most earlier reports concentrated on singular aspects of trauma – neurovascular complications [17], infection [49], anorectal reconstruction [23] or forensic reconstruction [27,35] – without structured documentation of exposure characteristics, protective equipment use, treatment duration, functional outcome or occupational impact. Even larger epidemiological analyses [19,20,41] primarily described mechanisms and anatomical distribution rather than therapeutic pathways and long-term consequences.

By contrast, the present study integrates anatomical injury distribution, severity stratification, operative versus conservative pathways, rehabilitation, treatment duration, functional recovery, work absenteeism, hunting technique and protective equipment use. Variables such as work absenteeism and treatment duration – together with their regression-based association – have not been systematically quantified in prior publications. This methodological expansion reframes wild boar trauma from an isolated surgical curiosity to a definable subset of hunting-associated occupational injury with measurable clinical and socioeconomic endpoints.

The absence of standardized reporting parameters in earlier literature limits cross-study comparability and hinders evidence-based prevention. Infection risk was frequently discussed, yet interactions between injury morphology, operative management and long-term impairment were rarely examined systematically. Similarly, neurological complications [17] were described without broader incidence context. Fragmented disciplinary perspectives – from forensic pathology [7,8] to wildlife ecology [3] – have prevented development of a unified analytical framework.

Taken together, and accounting for methodological heterogeneity, the available evidence confirms that wild boar attacks during hunting most commonly produce penetrating lower extremity injuries but may also result in thoracic, abdominal, neurological and secondary blunt trauma. Fatal outcomes are predominantly associated with uncontrolled hemorrhage or delayed recognition of internal injury, whereas structured trauma care substantially mitigates mortality risk.

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In the context of expanding wild boar populations across Europe and continued regulatory emphasis on active hunting as a management tool [1,3], the present findings underscore the need for standardized reporting criteria, evidence-based prevention strategies and integration of hunting-related trauma into occupational health considerations. By combining a large homogeneous cohort with a comprehensive literature synthesis, this study provides a balanced and clinically grounded framework for understanding hunting-associated wild boar trauma beyond anecdotal or fatality-focused narratives.

5. Conclusions

Wild boar attacks during organized hunting represent a distinct form of penetrating trauma characterized predominantly by tusk-inflicted extremity injuries with the potential for significant underlying structural damage. Previous literature has largely been shaped by isolated case reports and fatality-focused analyses; a broader and methodologically structured synthesis revealed a more heterogeneous but predominantly survivable injury spectrum.

The present nationwide cohort demonstrates that, within a modern trauma system, most hunting-associated wild boar injuries can be effectively managed with early surgical assessment, systematic neurovascular evaluation and appropriate infection prophylaxis. Major vascular disruption remains the principal life-threatening mechanism, while delayed recognition of internal injury represents a critical risk factor for adverse outcomes.

Beyond the immediate clinical dimension, severe trauma sustained during wild boar hunting may constitute an occupational accident for both professional and recreational hunters. In Germany, the legal obligation to conduct tracking (“Nachsuche”) of wounded game institutionalizes close-range encounters with potentially aggressive animals, and thereby structurally embeds exposure risk within regulated hunting practice. Similar regulatory frameworks may exist in other countries. Accordingly, wild boar–related trauma should be recognized not merely as a rare wildlife incident but as a definable occupational and recreational hazard requiring structured preventive strategies, standardized reporting and targeted first-aid preparedness.

Differences in literature search strategies and case ascertainment have substantially influenced reported incidence, severity distribution and mortality estimates in prior reviews. By integrating a comprehensive evidence base with a large, homogeneous hunting cohort, this study provides a balanced clinical characterization of wild boar–related trauma and supports the development of evidence-based recommendations for hunter education, preventive measures, emergency response planning and standardized management pathways in regions experiencing continued expansion of wild boar populations.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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