




Multicenter analysis of dog bite injuries: Clinical patterns, demographics, and health outcomes for public safety enhancement

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ABSTRACT

Introduction: This study aimed to evaluate the factors influencing the severity of dog bite injuries, and subsequently, to determine whether there are differences depending on whether the dogs are owned or stray of patients admitted to the Emergency Departments (ED) of four roman hospitals due to dog-bites.

Materials and Methods: Data on clinical characteristics, accident timing, dog ownership status, type of injury and district involved were collected for ED patients involved in dog-bites from January 2014 to December 2023. Subsequently, dog-bite injury severity was assessed through Mcheick Classification. Descriptive, univariate, and logistic regression analyses were performed for the selected items.

Results: Over the study period, 4336 patients were admitted to the ED following dog-bites injuries. Multivariate analysis, based on dog-bite injury severity, revealed that the involved body region (OR 1.45, 95% CI: 1.03–2.04) and the risk of hospitalization (OR 6.04, 95% CI: 3.85–9.46) are predictive factors of greater injury severity, and that elderly individuals have a higher risk of experiencing more severe injuries (OR 1.90, 95% CI: 1.46–2.47). Moreover, multivariate analysis, based on dog ownership status, showed a lower probability of being bitten by a stray dog compared to an owned dog for children, teenagers and elderly (OR: 0.42, 95% CI: 0.31–0.55; OR: 0.58, 95% CI: 0.42–0.80; OR: 0.65, 95% CI: 0.50–0.84, respectively). Regarding the district involved, bites to the head and neck region were less frequent in cases involving stray/unknown dogs (OR: 0.28, 95% CI: 0.24–0.34).

Conclusions: This study revealed a rising trend in the number of cases until 2019, after which a decrease was observed. Injury severity increased with age, with children 35% less likely and those over 60 90% more likely to sustain severe injuries. Children, teenagers, and the elderly were less likely to be bitten by stray dogs, which were also less frequently associated with head and neck bites. These findings highlight the need for targeted prevention strategies, addressing both injury severity across age groups and the risks associated with owned versus stray dogs.

1. Introduction

Currently, dogs are the most popular pets worldwide. In 2023, the

largest number of domestic dogs live in the USA; instead, in the EU countries the largest population of domestic dogs were recorded in Germany, Spain and Italy (respectively: 10.3, 9.3 and 8.8 millions) [1].

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Since the late 1970s, scientific evidence has shown that pet ownership can have positive effects on people's physical and mental wellbeing [2]. Particular attention is paid to the health benefits of the elderly owning a dog [3].

However, dog bites are a significant global public health concern and represent the most common animal-related injury [4–6].

Dog bites pose a significant risk, affecting both pet owners and non-owners alike. Potential consequences range from minor scratches to severe injuries, including bacterial infections, tetanus, rabies, and even death. Globally, an estimated ten million injuries occur annually due to dog bites, with most being minor but some leading to serious or fatal outcomes [7,8]. In the U.S., approximately 4.5 million people are bitten each year, with 885,000 seeking medical treatment and 20 fatalities reported [9]. In the U.K., around 740 per 100,000 people experience dog bites annually [10]. Between 1995 and 2016, fatalities from dog attacks increased in Europe, with an estimated incidence of 0.0088 in 2016 across 30 European countries and 0.0048 in Italy [11]. In low- and middle-income countries (LMICs), dog bite injuries range from 1.03 to 25.7 per 1000 annually, with higher mortality rates due to rabies [9,12]. The disparity between high-income countries and LMICs is linked to the prevalence of stray dogs.

In cases of fatal or severe injuries, forensic pathologists investigate the crime scene, victim injuries, and suspected dog characteristics [13]. Literature suggests severe injuries from dog bites are relatively rare (4.9%), but socio-demographic and anatomical factors significantly influence severity. Older adults (≥ 60 years) have a 2.7-fold higher risk of severe trauma. The anatomical location also plays a key role, with increased risks for the head and neck (OR 2.63 [1.96–3.55]), upper extremities (OR 1.73 [1.32–2.26]), and multiple bite sites (OR 4.37 [2.96–6.45]) [14].

While several dog-bite events have been reported to the media and there has been growing interest in dog bites in recent years, no nationwide epidemiological report and forensic studies about dog-bite injuries has yet been made in Italy. A study conducted in Sicily, Italy, on 140 patients, highlighted an age-dependent distribution of injuries: children predominantly sustained injuries to the face, while adults were more likely to have injuries to the hands [14]. Furthermore, elderly patients were found to be at a higher risk of experiencing prolonged hospitalization [15].

However, the lack of systematic data makes it difficult to identify the associated risk factors and develop effective preventive strategies against dog-bite injuries. In fact, a topic that has never been discussed in the literature is whether there are differences in risk depending on whether the dog is stray or owned.

Consequently, the primary aim of the present study is to evaluate the factors influencing the severity of dog bite injuries, and secondly, to determine whether there are differences depending on whether the dogs are owned or stray.

2. Material and methods

2.1. Data collection

This retrospective observational study included all patients who had been admitted for a dog-bite injury to the 4 roman ED from 1 January 2014–31 December 2023.

2.2. EDs involved

The EDs included in the present study are Fondazione Policlinico Universitario "A. Gemelli" IRCCS, the "Gemelli Isola - Isola Tiberina Hospital", the "G.B Grassi" Hospital, and the "Sant' Eugenio" Hospital.

2.3. Inclusion and exclusion criteria

Inclusion criteria comprised all patients who presented to the ED for

a dog bite. Exclusion criteria included those who sought ED access for allergies, leash-related injuries, or trauma secondary to the presence of a dog.

2.4. Patient demographics, clinical characteristics, dog-related factors and ED disposition collection

Variables including patient data, including gender, age, injury circumstances, dog ownership status, type of injury and district involved, ED triage code, ED length of stay, mode of arrival, discharge status, date and time of admission, were collected and analyzed.

The final diagnoses, based on the 10th version of the International Classification of Diseases and radiology reports, were documented [16].

2.5. Assessment of dog-bite injury severity

The severity of dog bite injuries was assessed using the Mcheick Classification [17], which identifies 3 levels of injury severity:

- Level 1 (Mild): The bite resulted in a skin wound only.
- Level 2 (Moderate): The bite caused a skin laceration with muscle damage.
- Level 3 (Severe): The bite resulted in tissue loss with associated fractures.

2.6. Statistical analysis

Categorical variables are presented as frequencies and percentages and continuous variables as means and standard deviations (SDs). Univariate analyses were performed using the chi-square test, with Fisher's exact test if appropriate, or the *t*-test, depending on the type of data. For quantitative variables, a preliminary distribution analysis was performed. Logistic regressions were used to assess the influence of selected variables on the following outcomes: injury severity, assessed at the time of presentation to the ED, and dog ownership status.

For injury severity score, the categories were combined to generate a binary variable (severe injury = 3, non severe injury = 1–2). Multivariate models were built on univariate variables.

The significance level was set at 0.05.

Statistical analysis was performed with STATA 18.0 software (Stata Corporation, College Station, TX, USA) and SPSS V25® (IBM, Armonk, NY, USA).

3. Results

3.1. Study population

A comprehensive analysis of the database revealed a total of 5190 emergency room visits related to dogs injuries. However, 854 of these visits were excluded from the analysis as they were associated with either allergies, leash-related injuries, or other dog-related trauma not due to bites. Consequently, the study focused on 4336 patients admitted to the 4 EDs for dog-bites injuries.

Among these patients, 53.69% were male, and the mean age was 39.11 years (SD: 21.28) (Table 1). The most dog-bites injuries happened in the year 2019 with a slight decrease observed between 2019 and 2023 (Fig. 1). Analysis of medical records revealed that in most cases, the dog was either a stray or belonged to an unknown owner (57.5%) (Fig. 2). Moreover, most patients arrived at the ED via self-conveyance (90.08%). ED triage code was red in only 0.6% of cases, with an ED length of stay of 3.04 h (SD: 3.96). Only 129 patients were admitted to a hospital ward, of these, the majority were admitted to the Department of Orthopedics and Traumatology (45.7%) (Table 2).

Table 1
Patient demographics and clinical characteristics of 4336 patients presenting to the 4 ED with dog bite injuries between 2014 and 2023.

| Variable | Category | Subcategory | Number (%) | |
|-------------------|-------------------------|----------------|--------------|--------------|
| Age | Mean 39.11 (S.D. 21.28) | | | |
| Gender | Male | | 2328 (53.69) | |
| | Female | | 2008 (46.31) | |
| Injury Severity | Mild | | 2627 (60.59) | |
| | Moderate | | 1395 (32.17) | |
| | Severe | | 314 (7.24) | |
| | | | | |
| District involved | Face | | 704 (16.24) | |
| | Neck | | 10 (0.23) | |
| | Thoraco-Abdominal Wall | | | 104 (2.40) |
| | | Thorax | | 12 (11.54) |
| | | Back | | 19 (18.27) |
| | Breast | | 5 (4.81) | |
| | Abdomen | | 9 (8.65) | |
| | Side | | 27 (25.96) | |
| | External Genitalia | | 32 (30.77) | |
| | Upper Limb | | | 2097 (48.36) |
| | | Shoulder | | 26 (1.24) |
| | | Arm | | 270 (12.84) |
| | | Elbow | | 17 (0.81) |
| | | Forearm | | 219 (10.42) |
| | | Wrist | | 86 (4.09) |
| | | Hand + Fingers | | 1479 (70.52) |
| | Lower Limb | | | 1230 (28.37) |
| | | Gluteal | | 42 (3.41) |
| | | Thigh | | 513 (41.71) |
| | | Knee | | 75 (6.10) |
| | | Calf | | 458 (37.24) |
| | | Ankle | | 88 (7.15) |
| Foot + Toes | | | 54 (4.39) | |
| | | | | |
| Multiple | | | 191 (4.40) | |

3.2. Injury severity

Regarding injury severity, the majority of cases presented with mild severity, with the upper extremities most frequently involved (48.36%). Of these, the vast majority were due to dog bites to the hands or fingers (70.52%). The second most affected region was the lower extremities (28.37%), with the thighs (41.71%) and calves (37.24%) being the most common sites of injury. Of all patients presented in the ED, only 4.4% were multiply injured (Table 1).

Table 3 reports the severity characteristics of the injury. Overall, the mean injury severity was 1.46 [SD: 0.63], with a statistically significant

correlation between injury severity and the involvement of the face and neck. Moreover, a statistically significant association was found between injury severity and age, stray or unknown ownership, triage code, ED length of stay, emergency service admission and hospital admission. In the multivariate analysis, based on the univariate analysis, the risk of sustaining a more severe injury is directly proportional to increasing age: it is reduced by 35% in children and increases by 90% in individuals over 60 years old. Additionally, hospital admission and involvement of the face and neck are mild predictors of severe injuries. Finally, gender and the ownership status of the dog do not appear to be predictors of severe injuries. (Table 4)

3.3. Association between dog ownership status and risk factors

Out of 4336 dog bites, 2493 (57.5%) were inflicted by stray dogs or dogs of unknown ownership. The descriptive analysis is reported in Table 5. Multivariate analysis revealed a significant association between dog ownership status and victim's age ($p < 0.001$). Children (0–12 years), adolescents (13–18 years), and elderly patients (>60 years) showed a lower probability of being bitten by a stray dog compared to an owned dog (OR: 0.42, 95% CI: 0.31–0.55; OR: 0.58, 95% CI: 0.42–0.80; OR: 0.65, 95% CI: 0.50–0.84, respectively). A significant association was also found between dog ownership status and bite location ($p < 0.001$). Bites to the head and neck region were less frequent in cases involving stray/unknown dogs (OR: 0.28, 95% CI: 0.24–0.34). No significant associations were observed between dog ownership status and injury severity (OR: 1.13, 95% CI: 0.88–1.45), victim's gender (OR: 1.01, 95% CI: 0.89–1.15), or the need for hospital admission (OR: 0.99, 95% CI: 0.66–1.47). (Table 6)

4. Discussion

As the proportion of households with dogs in Italy is increasing, it is important for healthcare providers and families to be aware of the frequency and severity of dog-bite injuries. This study evaluated the trends and characteristics of dog-bites injuries in Rome, the most populous Italian city, and analyzed risk factors associated with severe injuries in a multicenter retrospective analysis that involves four EDs in the city in the last ten years that are the ED of Fondazione Policlinico Universitario “A. Gemelli” IRCCS, situated in an University teaching hospital, experiences an annual footfall of approximately 75,000 patients, with 20% seeking care for trauma. Functioning as a major trauma center, the hospital serves a catchment population of 1.8 million inhabitants. The ED at “Gemelli Isola - Isola Tiberina Hospital”, a Level I Trauma Center,

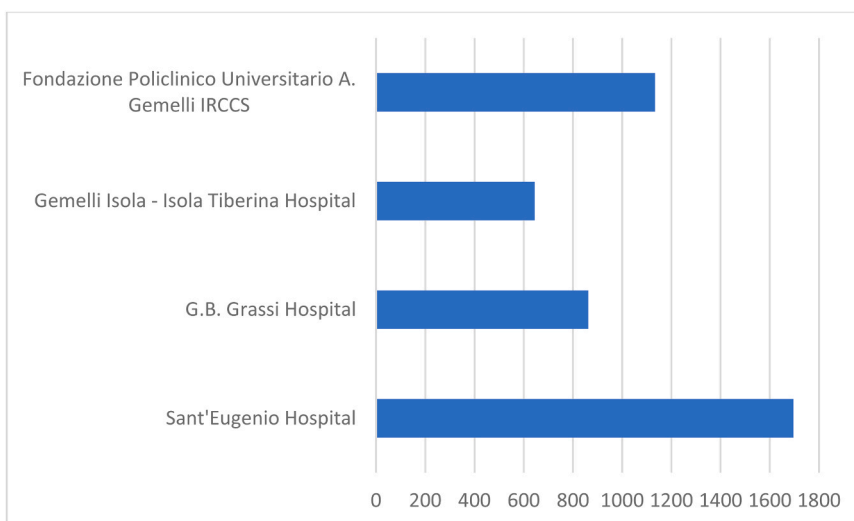


Fig. 1. Distribution of dog bite presentations across EDs.

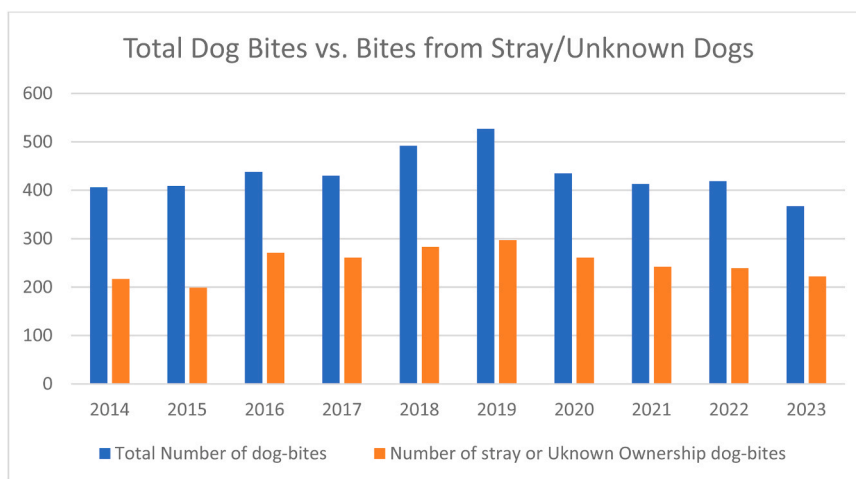


Fig. 2. Comparison of total dog bites vs. dog bites from strays or dogs of unknown ownership presenting to EDs between 2014 and 2023.

Table 2

Descriptive analysis of patient and dog-related factors influencing ED disposition following a dog bite.

| Variable | Category | Subcategory | Number (%) |
|----------------------|----------|------------------------------|--------------|
| Dog Ownership Status | | Owned by Owner or Family | 1843 (42.50) |
| | | Stray or Unknown Ownership | 2493 (57.50) |
| Triage | | White | 104 (2.40) |
| | | Green | 3657 (84.34) |
| | | Yellow | 198 (4.57) |
| | | Light Blue | 305 (7.03) |
| | | Orange | 46 (1.06) |
| | | Red | 26 (0.60) |
| ED Length of Stay | | Mean 3.04 h (S.D. 3.96) | |
| Mode of Arrival | | Emergency Service | 430 (9.92) |
| | | Ambulance | 417 (96.98) |
| | | Helicopter | 13 (3.02) |
| | | Self-arrival | 3906 (90.08) |
| Discharge status | | Discharge to home | 4207 (97.02) |
| | | Admitted to the Hospital | 129 (2.98) |
| | | Orthopedics and Traumatology | 59 (45.7) |
| | | Plastic Surgery | 19 (14.7) |
| | | Pediatrics | 14 (10.9) |
| | | Pediatric Intensive Care | 13 (10.1) |
| | | Intensive Care | 5 (3.9) |
| | | Pediatric Surgery | 5 (3.9) |
| | | Emergency Surgery | 5 (3.9) |
| | | Maxillofacial Surgery | 4 (3.1) |
| | | General Surgery | 2 (1.6) |
| | | Intensive Cardiology | 1 (0.8) |
| | | Urology | 1 (0.8) |
| Ophthalmology | 1 (0.8) | | |

serves a large and densely populated area in central Rome that encompasses the historic center. The "G.B. Grassi" Hospital in Ostia is a Level I Trauma Center with the that serves a diverse coastal area. Finally, the Sant'Eugenio Hospital in Rome houses a Level I ED, serving a significant portion of the city's southern quadrant.

The number of ED visits for dog bites has remained stable over the past decade, peaking in 2019 and gradually decreasing over the last five years, reaching its lowest point in 2023. The observed reduction was consistent over the study period and does not appear to be attributable to the lockdown measures implemented during the pandemic, as a similar decline was noted in bite incidents involving both familiar dogs and stray dogs.

Although no other studies in Italy have analyzed the epidemiological

Table 3

Descriptive analysis of the cohort by dog-bite injury severity.

| | Mild n. 2627 | Moderate n. 1395 | Severe n. 314 | p value |
|----------------------------|-------------------|---------------------|-------------------|---------|
| Age | 38.21 (SD: 21.29) | 39.54 (SD: 21.30) | 44.82 (SD: 20.22) | < 0.001 |
| Male | 1427 (54.30%) | 730 (52.30%) | 171 (54.5%) | 0.465 |
| Stray or Unknown Ownership | 1461 (55.6%) | 843 (60.4%) | 189 (60.2%) | 0.008 |
| ED Length of Stay | 2.81 (SD: 2.80) | 3.16 (SD: 4.78) | 4.48 (6.85) | < 0.001 |
| Emergency Service | 216 (8.2%) | 155 (11.1%) | 59 (18.8%) | < 0.001 |
| Hospital admission | 36 (1.4%) | 43 (3.1%) | 50 (15.9%) | < 0.001 |
| Face and Neck | 322 (12.3%) | 335 (24%) | 57 (18.2%) | < 0.001 |

Table 4

Multivariate analysis according to dog-bite injury severity.

| | | Injury Severity | | OR (CI) | p-value |
|----------------------|-----------------------------|-------------------|--------------|------------------|---------|
| | | Non Severe (4022) | Severe (314) | | |
| Age | Children (0–12) | 572 (14.22) | 27 (8.6) | 0.65 (0.43–0.99) | 0.048 |
| | Teenagers (13–18) | 207 (5.15) | 11 (3.5) | 0.74 (0.39–1.38) | 0.348 |
| | Adults (19–59) | 2567 (63.82) | 184 (58.6) | - | |
| | Elderly (>60) | 676 (16.81) | 92 (29.3) | 1.90 (1.46–2.47) | 0.001 |
| | Gender | Female | 1935 (46.4) | 143 (45.5) | - |
| | Male | 2157 (53.6) | 171 (54.5) | 1.09 (0.86–1.39) | 0.463 |
| Dog Ownership Status | Owned or owned by relatives | 1718 (42.72) | 125 (39.8) | - | |
| | Stray or Unknown Ownership | 2304 (57.3) | 189 (60.2) | 1.17 (0.91–1.51) | 0.233 |
| Hospital Admission | No | 3943 (98) | 264 (84) | - | |
| | Yes | 79 (2) | 50 (16) | 6.04 (3.85–9.46) | 0.001 |
| District involved | Other District | 3365 (83.7) | 257 (81.8) | - | |
| | Face and Neck | 657 (657) | 57 (18.2) | 1.45 (1.03–2.04) | 0.034 |

Table 5
Descriptive analysis of the cohort by dog ownership status.

| | Owned or owned by relatives n. 1843 | Stray or unknown ownership n. 2493 | p value |
|--------------------|--|---------------------------------------|---------|
| Age | 35.7 (SD:23.3) | 41.6 (SD: 19.21) | < 0.001 |
| Male | 993 (53.9%) | 1335 (53.5%) | 0.830 |
| Hospital admission | 59 (3.2%) | 253 (10.1%) | 0.563 |
| Red | 15 (0.8%) | 11 (0.5%) | 0.124 |
| ED Length of Stay | 2.8 (SD:3.6) | 3.2 (SD:3.1) | 0.004 |
| Emergency Service | 177 (9.6%) | 253 (10.1%) | 0.553 |
| Severe Injury | 125 (6.8%) | 189 (7.6%) | 0.316 |
| Face and Neck | 512 (27.8%) | 202 (8.1%) | < 0.001 |

trends of dog bite cases, these findings appear to contrast with international literature, which has shown a consistently increasing trend for such injuries in past decades [18]. The observed reduction could be attributed, on one hand, to increased awareness of the risks associated with interactions with dogs and more responsible behavior by dog owners, and on the other hand, to improved efforts in managing and reducing the phenomenon of stray dogs.

A total of 4336 patients sought care in the ED for a dog bite; of these 2.98% needed hospitalization, and 2.21% underwent under surgery. Previous studies in the US reported that the hospitalization rate for dog-bites injuries was 4% and 1.8% [19,20].

Age represents one of the risk factors associated with increased injury severity, as multivariate analysis has shown, on the one hand, that older individuals have a 90% higher risk of sustaining more severe injuries compared to younger individuals and, on the other hand, that children have a 35% lower risk of sustaining more severe injuries. This finding could be attributed to the increased frailty of older individuals and the presence of comorbidities and therapies, such as diabetes mellitus or anticoagulant therapies, which predispose them to a higher risk of sustaining more severe injuries regardless of the type of bite. The lower severity of injuries observed in children can likely be attributed to the context in which these bites occur. A majority of incidents involving children happen during playful interactions with family or owned dogs, where the bites are not driven by true aggression but are instead a reaction during play. This type of interaction typically results in less severe wounds.

In the analyzed cohort, a slight predominance of males was observed in cases of dog bites. However, contrary to findings reported in previous studies, this difference was not statistically significant, indicating that gender is not associated with a higher risk of sustaining more severe injuries [21].

Moreover, the upper limbs were the most frequently affected site of dog bites, followed by the lower limbs and the facial region. Specifically,

Table 6
Multivariate analysis based on the risk of Hospital admission after ED visits for dog-bites injuries.

| | | Dog ownership status | | OR (CI) | p-value |
|--------------------|-------------------|---------------------------------------|--------------------------------------|------------------|---------|
| | | Owned or owned by relatives (1843) | Stray or Unknown Ownership (2493) | | |
| Age | Children (0–12) | 404 (21.9) | 195 (7.8) | 0.42 (0.31–0.55) | 0.001 |
| | Teenagers (13–18) | 120 (6.5) | 98 (3.9) | 0.58 (0.42–0.80) | 0.001 |
| | Adults (19–59) | 992 (53.8) | 1759 (70.6) | - | |
| | Elderly (>60) | 327 (17.7) | 441 (17.7) | 0.65 (0.50–0.84) | 0.001 |
| Gender | Female | 850 (46.1) | 1158 (46.5) | - | |
| | Male | 993 (53.9) | 1335 (53.5) | 1.01 (0.89–1.15) | 0.864 |
| Severe Injury | No | 1718 (93.2) | 2304 (92.4) | - | |
| | Yes | 125 (6.8) | 189 (7.6) | 1.13 (0.88–1.45) | 0.354 |
| Hospital Admission | No | 1784 (96.8) | 2423 (97.2) | - | |
| | Yes | 59 (3.2) | 70 (2.8) | 0.99 (0.66–1.47) | 0.962 |
| District involved | Other District | 1331 (72.2) | 2291 (91.9) | - | |
| | Face and Neck | 512 (27.8) | 202 (8.1) | 0.28 (0.24–0.34) | 0.001 |

the hands and face emerged as the most commonly involved areas. This finding, consistent with previous results, can be explained by two main factors: on one hand, the hands are the first body part that comes into contact with the dog when attempting to pet it, and on the other hand, particularly with owned dogs, it is common for owners, especially children, to approach the dog's face, triggering an instinctive defensive reaction from the animal [15]. Multivariate analysis showed that patients with bites to the face and neck have a 45% higher chance of sustaining more severe trauma compared to those with injuries to other areas of the body. This may occur because the facial and neck regions contain a high concentration of blood vessels and vital organs, which are less protected compared to the structures in the thoracic region. The lack of adequate bony protection in these areas makes them particularly vulnerable to severe damage in the event of a bite, as dogs tend to deliver bites to these specific body regions, such as the neck and head. In fact, injuries involving the head and neck often require reconstructive procedures and can lead to disfiguring scars and long-term treatment. Several studies have shown an increased risk of infection in animal bites to the upper extremities compared to other anatomic sites [22,23].

In contrast to other studies published in the literature, our cohort showed a higher incidence of bites from dogs with unknown ownership or strays compared to bites from owned or familiar dogs [24]. Furthermore, although a statistically significant association was identified between injury severity and unknown dog ownership in the univariate analysis, this finding was not confirmed by the multivariate analysis, suggesting that this association is uncertain. This finding contradicts the results of Brogan TV et al., who reported that dog bites were more frequently caused by owned dogs [25]. The multivariate analysis showed no association between dog ownership status and injury severity, gender, or the risk of hospitalization.

The multivariate analysis demonstrated a significantly lower probability of bites from stray or unknown dogs in children and elderly individuals compared to owned dogs. This finding suggests greater parental attention in avoiding risky situations for children and adolescents, and greater vigilance among the elderly in avoiding dangerous situations. This element is also confirmed by the location of the injuries: children and elderly individuals are more likely to play with their own dogs, bringing their faces closer, compared to unknown dogs. This may explain the greater probability of bites to the head and neck region from owned dogs in these age groups.

This study has several limitations. First, the characteristics of the dog-bite injuries were analyzed based only on the pre-registered items in the ED medical records because this study is a retrospective observational study. Therefore, other potentially important data, such as dog size, dog breed, and rabies after dog bites, were not available, and these factors might affect the outcomes as potential confounders. Second, this study is based only on 4 hospitals. Additionally, these EDs which participated to the study provide a relatively higher level of emergency medical services (level 1 or 2). Because of this selection bias, the results

of this study may have a possibility of overestimation or underestimation. Third, we defined severe injury as Mcheich classification in this study. However, we could not extract these data from the database because this study is a retrospective study. Therefore, there is a possibility that some patients classified as having a non-severe injury according to the author's definition actually have serious injuries from a clinical viewpoint.

Ethical Declarations

The study protocol was approved by the Ethics Committee of the Policlinico Universitario A. Gemelli IRCCS (ID 5121).

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CRediT authorship contribution statement

Giulio Maria Ricciuto: Data curation. **Luigi Carbone:** Investigation, Data curation. **Marcello Covino:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Conceptualization. **Enrico Mirante:** Investigation, Data curation. **Giovanni Aulino:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Ersilia Castaldo:** Writing – review & editing, Writing – original draft. **Francesca Cittadini:** Writing – original draft, Methodology, Data curation, Conceptualization. **Davide Della Polla:** Data curation. **Martina Petrucci:** Writing – review & editing, Data curation. **Stefania Boccia:** Data curation, Conceptualization. **Francesco Franceschi:** Supervision, Data curation.

Declaration of Competing Interest

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