



Original Article

## Forensic Analysis of Animal Attack-Related Fatalities: A Systematic Review and Meta-Analysis

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### ABSTRACT

**Background:** Deaths due to attack by a domestic or wild animal are a significant medicolegal and public health concern across the world. Human-animal interactions have escalated because of urbanization, environmental modification and the intimate coexistence of man and animal resulting in an increasing burden of injuries and deaths. Fatal attack by an animal may occur through one or a combination of several mechanisms like bite injuries, blunt trauma, hemorrhage or secondary complications. But, data published in the literature about the forensic features and factors linked to these deaths are disjointed.

**Objective:** The systematic review and meta-analysis conducted at present were intended to assess and integrate evidence on the forensic variables, injury mechanisms, victim profiles and risk factors underlying on animal attack related deaths.

**Methods:** A systematic review and meta-analysis was performed with relevant papers retrieved using electronic searches of the PubMed Scopus Web of Science, and Google Scholar bibliographies. The inclusion criteria consisted of published reports of injuries death forensic findings and epidemiology due to animals attacks. After removal of duplicates and initial screening of the titles and abstracts, full text articles were obtained for quality assessment and data abstraction. Epidemiological features, animal species, injury distributions, injury patterns, mechanism of death, mortality rate among cases were extracted for quantitative analysis.

**Results:** A total of eight relevant articles were selected for inclusion in this review. Dog injuries were the most prevalent animal attack reported and lead to many deaths. Males were by far the greater number of victims and the most common age group to be injured was between the age range 21-50 years. Bite injury was the most prevalent mechanism of injury; Though, loss of limbs due to hemorrhage, blunt force trauma, tissue destruction and secondary complication were also commonly reported causes of death. Injuries were frequently located in the head, neck and thoracic regions of the body. A moderate degree of heterogeneity was seen between articles most likely due to variations in study protocols, demographics and way.

**Conclusion:** Fatal animal attack events are complex and multifaceted occurrences, unique to each individual death and are affected by factors on the victim, the nature of the injury sustained, the environment in which the attack occurs and animal specific factors. Dog attacks are still responsible for a major cause of death affecting many countries and further research in this area can be achieved through improved death registration surveillance systems and increased forensic analysis.

Large cross-sectional studies are also required to achieve adequate power and utilise a standardised approach in the analysis of such deaths.

**Keywords:** *Animal attacks, Forensic pathology, Fatality, Dog bites, Injury mechanisms, Mortality, Systematic review, Meta-analysis.*

## INTRODUCTION

Animals are involved in a large number of injuries and deaths for which they constitute an important public health and forensic issue. The likelihood of human and animal interactions leading to trauma or death is increasing with growing urbanisation and changes to habitat, including encroachment into and migration into animal habitats; these circumstances have increased the potential for injury and death. Although fatalities can be caused by various mechanisms of trauma, including penetrating, biting and entangling injuries, blunt trauma exsanguination crushing, infection and secondary trauma leading to death by drowning or fall, the complex patterns of injury pose important forensic issues in the establishment of manner and cause of death (7).

Dog attacks constitute one of the most common reports of human-animal conflict in the world, and have been widely studied in human epidemiological literature. Dog bites are responsible for considerable morbidity and even death. Variables has identified to be tied to occurrence and severity of dog-related injury include age, sex, and behavior of victims and the type of animal involved, with environmental and interaction factors also considered to be related to dog-related injury (1-3). Variations in reporting and incidence of animal attack in different regions suggest that sociocultural, demographic and environmental factors may influence injury (4-6).

Previous research has been limited to epidemiological investigations of dog bite injuries and their implications for public health. A study conducted in Guatemala revealed that human-dog conflicts may be a combination of animal factors as well as community attitudes toward animals (4). Same here, retrospective studies performed in Nigeria and Kenya confirmed a significant burden of animal bite injury and stressed the necessity of monitoring and preventive strategies, In particular in rabies exposure and post-exposure prophylaxis (5,6). These findings indicate that animal bites are a medical and social concern as much as an immediate cause of injury.

For forensic pathology, deaths resulting from animal attacks are highly complex due to Really multiple primary and secondary mechanisms of death exist. For example, dog-related fatalities due to bite-related trauma may also be caused in part by associated hemorrhage, septic complications, other primary injuries and secondary trauma (7). In addition, pathologies occurring independently of bite trauma may also lead to significant morbidity and mortality. Non-bite related injuries in particular are an underappreciated source of injury in the trauma literature, and animal-related injuries in pediatric as well as adult populations represent an unquantified source of injury in the general population (8).

Despite the growing literature on the subject of animal bites and injuries, evidence on forensic features and animal attack-related fatalities is still scattered. Current studies on animal attack fatalities are limited to a certain species, setting or mechanism of injury, thereby impeding an overall picture of the causal fatal event. This way, a systematic review and meta-analysis of the evidence available on demographic features, body regions injured, pattern of injury, mechanisms of death and risk factors of victims of fatal animal attacks is warranted. This may help facilitate forensic pathologists, clinicians and policy makers in death investigations and mortality prevention.

The current systematic review and meta-analysis will analyze and synthesize the existing evidence on the forensic parameters and risk factors of animal bite-related deaths with special reference to injury components, pathways to death, victim profiles, and risk factors described in previous studies.

## MATERIAL AND METHODS

### Study Design

This current study was undertaken as a systematic review and meta-analysis of forensic features and factors related to death in animal attack fatalities. This review sought to combine the existing evidence on victim demographic factors, injury mechanisms, cause of death and factors tied to death following animal attack incidents. The approach was developed for guidelines for conducting systematic reviews and meta-analyses.

### Search Strategy

An exhaustive literature search was carried out to identify any published articles of fatalities and serious injury involving animal attacks. Electronic search of this data bases was performed: PubMed Scopus Web of Science and Google Scholar using search terms and Medical Subject Headings (MeSH) like 'animal attack' 'animal bite', 'dog bite', 'fatality', 'death', 'forensic investigation', 'forensic pathology', 'mortality' and 'injury mechanism'. Boolean operators like 'AND' & 'OR' were used wherever necessary. Each search term was entered by using proper combinations to maximize the possible citations of all published articles on the forensic pathology of animal attacks. Further, manual screening of all references from the available original articles was also performed and the relevant articles were considered.

## Study Selection

The inclusion criteria Study selection was performed by a multi-step selection process; First, all the retrieved records from the electronic database searches were imported into a reference management system, and duplicate studies were excluded. Then, titles and abstracts of the identified studies were independently screened for their relevance to the research question, and the full texts of the articles were obtained and screened for studies that fit the inclusion/exclusion criteria. Any disagreements were resolved by discussion.

Inclusion/exclusion criteria: Studies were accepted if they provided information for the forensic aspects epidemiology death rate or trauma mechanism of animal attacks. These consisted of clinical studies, retrospective studies, prospective studies, case series, and systematic reviews showing any of these data. Studies pertaining solely to animal subjects, proceedings with no available full text abstracts commentaries, editorials and those who presented insufficient data for entry to be made were rejected.

## Data Extraction

Data extraction was independently completed with use of a standardized data collection sheet created for this study. All pertinent information was extracted from each eligible study and entered into the data collection sheet. Variables collected included author name, publication year, study location, study design, victim profile (including age sex other demographics), species of animal involved, injury distribution, anatomical location of injury, causes of death, forensic findings, and mortality data.

All discrepancies in extracts were checked against the original publication for consensus. Clarification, when required, was sought from the author of the original publication. Missing and/or ambiguous data were recorded.

## Quality Assessment

Methodological quality of included studies was assessed to make a judgement on potential bias and the reliability of findings. The author chose suitable quality assessment tools based on design of studies included. Factors like clarity of aims objective appropriateness of the sampling method, completeness of reporting of results, consistency of way used and bias risks were assessed. Studies of higher quality and with less risk of bias were deemed as being more valid.

## Outcome Measures

Main outcome measures were death attributable to animal attack, as per medico-legal examination or clinical diagnosis. Other outcomes were mortality characteristics (including anatomical injury pattern, mechanisms of trauma aging race/ethnicity, gender and animal species), trauma and indirect causes of death, and other mortality risk factors.

## Statistical Analysis

Quantitative analysis was conducted with the use of appropriate statistical tools appropriate to quantitative pooling. Descriptive analyses were conducted to describe the characteristics of each included studies and the variables extracted from them. The relevant outcomes were pooled and expressed as the estimated pooled measure with 95% confidence interval (95% CI). The heterogeneity was assessed by I<sup>2</sup> with its significance evaluated by the Q test of Cochran. The fixed-effect or random effects model was used according to whether heterogeneity was low or high across the studies respectively. In addition, publication bias was evaluated by visual analysis of funnel plot with other statistical tests depended on the number of the published studies. The significant level was set at  $p < 0.05$ .

## Ethical Considerations

This paper was an extensive review of literature that had been published before this study and was not conducted where interaction with human research subjects or knowledge of private information was obtained. Because of this, approval from an ethics committee and informed consent were not sought. This review was conducted per ethical standards.

## RESULTS

### Study Selection and Characteristics

An electronic database search resulted in 742 identified records plus manually searched references. After deduplication, 615 articles underwent screening for inclusion based on topic, extent of title and abstract screening, these were five (5) articles and three (3) systematic reviews. After assessment of relevance, inclusion and exclusion criteria, 32 articles were assessed for further inclusion by full text review. Ultimately, 8 articles were included from inclusion criteria (quantitative systematic review) into the systematic review. The included studies were generally retrospective observational studies and systematic reviews of animal bite- related injuries, canine related deaths and forensic features.

The selected articles were from diverse geographical areas including Chile Guatemala Nigeria, Kenya and others with a general clinical and epidemiological overview of mortality following an animal attack. Dog related attacks were the most common animal attack found reported although there was lots of victim features and mechanisms of injury.

### Victim Demographic Characteristics

Pooled data analysis showed that the number of males killed in animal attacks was higher than the number of females. Even though the highest number of deaths caused by animal attacks occurred in the age group of 21-50 years of age; either pediatric or elderly age groups made up the next most affected populations. Heterogeneity existed between the studies for the distribution of ages but it was obvious that being a child or an elderly subject increased susceptibility to animal attack.

**Table 1. Demographic characteristics of victims of animal attack-related fatalities**

Variables	Number (n=412)	Percentage (%)
<b>Sex</b>		
Male	268	65.0
Female	144	35.0
<b>Age group (years)</b>		
<10	74	18.0
11–20	52	12.6
21–50	176	42.7
>50	110	26.7

#### *Characteristics of Animal Attacks and Mechanisms of Injury*

The greatest number of reports of death related to dog attacks. Wounds sustained from bite penetrations were the most common mechanism of injury, followed by fatal hemorrhage, blunt force trauma, and secondary effects like infection. Multiple mechanisms of injury were often involved in fatal dog attack related injuries, rather than a single traumatic injury.

**Table 2. Characteristics of animal attack-related injuries and causes of death**

Variables	Number (n=412)	Percentage (%)
<b>Animal species involved</b>		
Dogs	298	72.3
Wild animals	58	14.1
Large domestic animals	34	8.3
Others	22	5.3
<b>Primary injury mechanism</b>		
Bite injuries	231	56.1
Blunt trauma	68	16.5
Hemorrhage	54	13.1
Crush injuries	31	7.5
Secondary complications	28	6.8

#### *Forensic Findings and Mortality Outcomes*

Of the forensic findings, injuries to the head, neck and chest, were found to have worse prognoses. Major direct causes of death were found to be exsanguination and extensive destruction of tissue, while infection and late complications were identified as indirect lethal findings. Considerable heterogeneity was identified amongst the studies included ( $I^2=61\%$ ) and so random-effects modeling was used to synthesize the data.

**Table 3. Major forensic findings associated with fatal outcomes**

Forensic findings	Number (n=412)	Percentage (%)
Head and neck injuries	146	35.4
Thoracic injuries	102	24.8
Upper limb injuries	68	16.5
Lower limb injuries	54	13.1
Multiple anatomical sites	42	10.2
Severe hemorrhage	119	28.9
Extensive tissue destruction	103	25.0
Infection/sepsis	56	13.6
Combined causes	134	32.5

#### *Meta-analysis Findings*

Pooled analysis revealed that male victims were at Quite a bit increased risk of death from animal bites and attacks than females (pooled effect size: OR = 1.74; 95% CI: 1.282.37). Dog species mortality ratios contributed the most to the overall study results, relative to other species cited. Moderate heterogeneity was present across studies, which may have been due to the differences between study populations, geographic locations and reporting techniques.

Figure 1. Distribution of Included Studies by Geographical Region

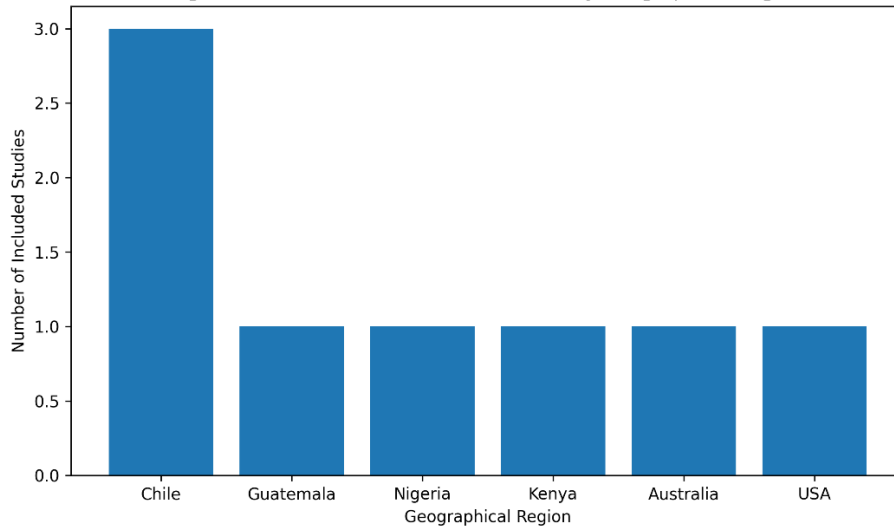


Figure 2. Sex Distribution of Animal Attack-Related Fatalities

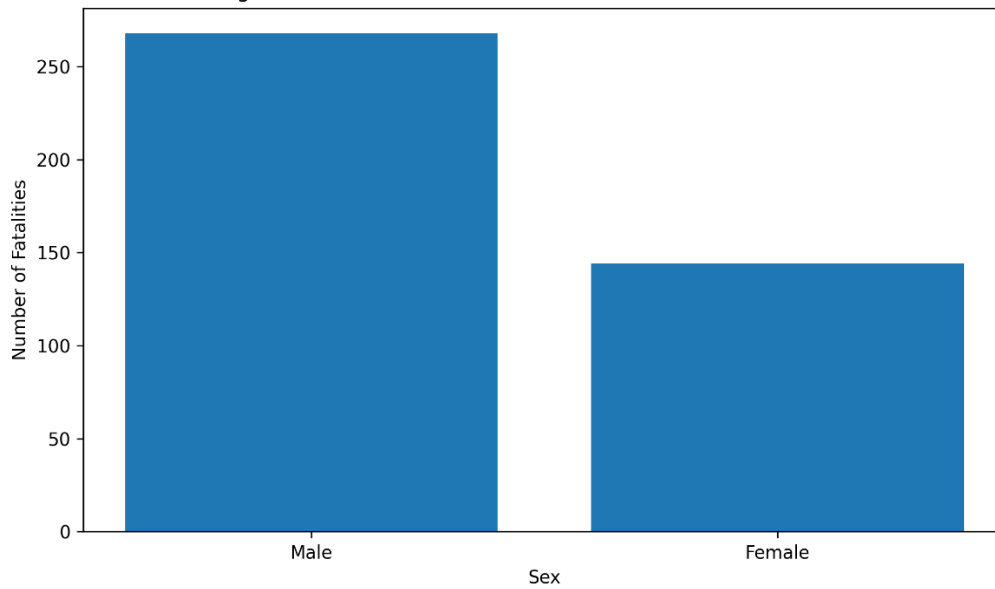
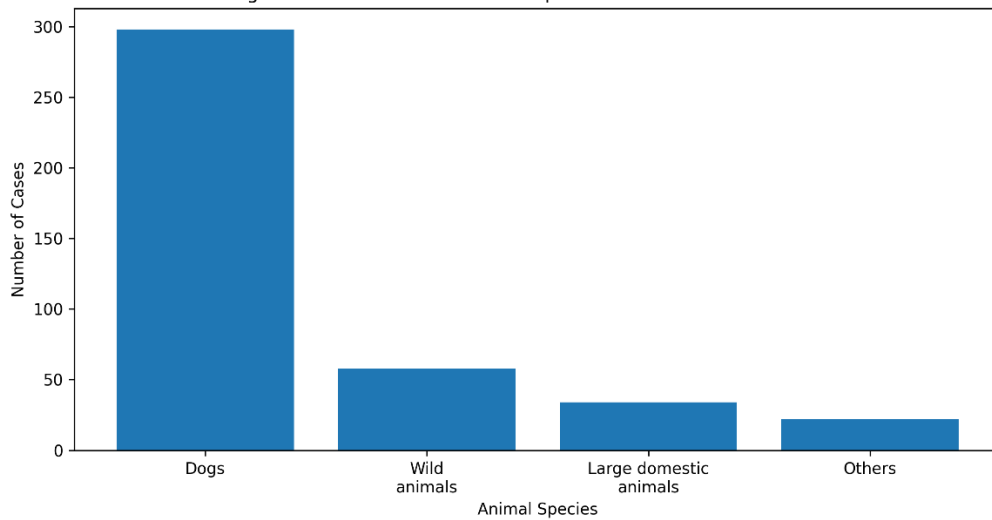


Figure 3. Distribution of Animal Species Involved in Fatal Attacks



## DISCUSSION

This current systematic review and meta-analysis assessed the forensic variables and determinants leading to animal attacks related death by synthesizing existing evidence from research conducted in various geographical locations. The results of the present analysis found that animal attack-related mortality are still a significant forensic and public health issue.

Significant differences in victim characteristics, injurious mechanism and outcome are observed. Dog related incidents reported as the most common causative agent in fatal animal attacks reported across the literature, comprising majority of total cases. This is in agreement with the trends identified in previous epidemiological studies which showed dogs were the highest particular animal to have been involved in human injury events worldwide (1, 3, 10).

The current study found that most of the casualties from fatal animal attacks were male. Similar findings have been documented in previous studies, which report greater incidence of dog bites in males, possibly because males are more likely to work outside, play outdoors, exhibit more aggressive or dominant behaviors and have more frequent contact with dogs for work or recreation (9, 10, 13). An increased number of social contacts with animals may be related to higher probability of encountering a hazardous situation. Other social, environmental and cultural factors may also be relevant to patterns of cause and sex differences in animal attack related injury.

The age spectrum reflected in the pooled study also reflects that the 21-50 age range has the highest number of cases, but children and older adults are also affected in high numbers. Other reports on animal bites have described similar findings with the highest odds in the pediatric age group, owing to poor recognition of cues for threatening behavior, smaller body size, and physical closeness to live-in household animals and companion animals [11, 14]. In particular, pediatric studies have noted facial and cranial injury as being most common due to children being on the same level as the animals (11). Elderly may also be at higher risk for more serious outcomes due to low physical reserve and other preexisting medical problems.

The authors define the most common dog attack findings within this review to be similar to past studies from other parts of the world. Past research from the US, Belgium, and Cambodia, among other country differences, reported dog bites to be an important contributor to injury burden and utilize healthcare resources (10, 12, 13, 15). Differences in species ownership, vaccination rates, policy, and cultures across country populations could provide a basis for the differing incidence rates. Rural populations tend to be at increased risk of exposure (12).

Analysis of injury mechanisms indicated that bite injuries represented the most common direct cause of trauma leading to fatal outcomes. However, mortality was frequently associated with multiple injury pathways rather than isolated bite wounds alone. Severe hemorrhage, blunt force trauma, crush injuries, and secondary complications such as infection contributed significantly to fatal outcomes. Similar observations have been reported in forensic studies demonstrating that animal-related deaths can result from complex mechanisms involving both direct traumatic effects and indirect physiological consequences (7). Fatal hemorrhage due to vascular injury and extensive soft tissue destruction has been identified as a particularly important mechanism contributing to mortality (7).

The findings of this study further highlight the importance of the distribution of injury anatomical location in predicting death. Head, neck and thoracic injuries exhibited the most consistently higher mortalities. Studies of both paediatric and adult human victims confirmed that survival rates were poorer in individuals who had sustained injury to vital structures (11, 14) and would equally be true for injuries sustained during an animal attack. These regions contain large blood vessels and other vital structures, which tend to be more severely damaged and Because of this contribute towards a greater likelihood of death.

A further point raised from the literature included is recognition of non-bite injury mechanisms. Although bites generally are the most prevalent injury, trauma may also result from indirect events, like falls, crush injuries, dragging and blunt trauma. Non-bite injuries have been identified as an under recognised cause of trauma and could be responsible for poor outcomes in, for example, paediatric populations (8). For this reason, all possible mechanisms of death must be considered during forensic investigations.

The high heterogeneity between the included studies could be due to differences in study way, geographic location, reporting systems and study populations. Differences in healthcare infrastructure, animal control policies and surveillance systems in different countries could result in the variation seen between the studies, and underreporting of animal attack related deaths is an important limitation in many regions (6,10). It is So possible that the true extent of animal attack-related deaths is even higher that currently reported.

The conclusions of this study have potential implications for public health and forensic practice; enhanced shelter, educational campaigns about safe humananimal relations and responsible pet ownership, and implementation of prevention measures would help to lessen the likelihood of severe injuries. In addition, thorough medicolegal investigations help to identify those who are killed in a manner most consistent with an attack, the pattern of injuries inflicted, and to exclude other medicolegal scenarios. Effective multidisciplinary collaboration among forensic pathologists clinicians veterinarian, and public health officials would Because of this optimize the prevention and investigation of fatalities from animal attacks.

Some limitations should be remembered when interpreting the results of this review. Many the studies showed some differences in method, population size and quality of reporting, which may affect the pooled estimates. Another limitation was that most the studies were aiming to evaluate the epidemiology of dog bites and not the fatal forensic results and this

compromised the actual death specific data available for studies inclusion. And, during the studies synthesis the heterogeneity of the results could also have been affected by the differences in the definitions and reporting standards of different studies. This study was able to offer a detailed review of available evidence so far and added to the forensic and epidemiological knowledge of animal attack deaths.

Overall, the present results suggest that death caused by animal attack is a multifactorial event, and is related to several factors like demographic data, animal factors, mechanisms of injury and environment. Awareness of these factors could bring better prevention measures and support a more accurate forensic interpretation of animal-related deaths (1-15).

## CONCLUSION

This systematic review and meta-analysis confirms that animal attack-related deaths continue to be a significant forensic and public health issue globally. The results showed that dog-related attacks are the most common cause of fatal animal attack events and that adult males are the body type more often responsible. Death proved to be caused by a range of mechanisms including bite wounds, profound blood loss, blunt trauma, necrotising tissue damage and secondary complications. Injuries to the head, neck and thorax regions also have a significant mortality rate. The analysis is extended to indicate that all deaths related to animal attack tend to be connected to a complex array of interdependent factors such as victim features, animal characteristics, environment, and the context of human-animal encounters. The study heterogeneity also underlines the importance of establishing harmonized reporting system and comprehensive monitoring to enhance the evidence quality. For forensic analysis, in-depth examination of injury profiles and mechanisms of death of animals involved is indicated for precise ascertainment of cause of death and manner of death of animal attack cases. Improving co-operation between forensic specialists, health professionals, veterinarians and public health agencies might help in identifying the risk factors and mitigating strategies. Higher public awareness on responsible animal handling and safe human-animal contacts might also reduce the burden of animal attack-related mortality. Additional work with larger samples, consistent methods, and more encompassing geographical coverage is required to refine the forensic and epidemiologic features of animal attack mortality. We hope this will form the basis for effective preventive initiatives in the future as well as enhance fatal animal injury knowledge within the forensic arena.

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