Dog bite injuries to the face: Is there risk with breed ownership? A systematic review with meta-analysis

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ABSTRACT

Introduction: Dog bite injuries to the face are a serious, yet modifiable public health concern. This study explores the relationship between dog breed and the risk of biting and injury. The objective of this study is to determine the relative risk and severity of dog bite injuries to the face by breed.

Methods: Retrospective chart review of facial dog bite injuries presenting to the University of Virginia Health System and Nationwide Children's Hospital. Additionally, descriptive data was collected from 240 patients over the last 15 years. Bite risk by breed was assessed by a literature search from 1970 to current. A composite measure was used to determine the severity of injury, and characterize each patient into an ordinal scale of bite severity. An average of each breed bite rate within each study was calculated and combined to create an empiric bite risk by breed. Dog breeds were also further characterized morphologically.

Results: Bite risk by breed from the literature review and bite severity by breed from our case series were combined to create a total bite risk plot. Injuries from Pitbull's and mixed breed dogs were both more frequent and more severe. This data is well-suited for a bubble plot showing bite risk on the x-axis, bite severity on the y-axis, and size of the bubble by number of cases. This creates a 'risk to own' graphic for potential dog owners.

Conclusion: Breeds vary in both rates of biting and severity. The highest risk breeds had both a high rate of biting and caused significant tissue injury. Physical characteristics can also help determine risk for unknown or mixed-breed dogs. Potential dog owners can utilize this data when assessing which breed to own.

1. Introduction

Dog bites are a significant yet modifiable public health concern, but the true magnitude is difficult to estimate with such wide ranges in reporting, severity of injury and varieties of breeds that bite. According to the Centers for Disease Control and Prevention (CDC) data [1], 4.7 million people in the United States are bitten by dogs annually and 20% of these victims require medical care for injuries sustained. Bite injuries to children remain an underreported public health problem and it has been estimated that nearly 50% of children will sustain a dog bite in their lifetime [2]. Children are also disproportionately represented with fatal bite injuries involving the head and neck [3,4].

Although dog bites are a longstanding problem with potential for significant functional, aesthetic and psychosocial sequelae, incomplete and inconsistent data requisition has hindered meaningful conclusions regarding dog ownership and the associated risks [5]. Despite national attention to these issues, and likely other benefits, dog ownership has continued to increase in the U.S. It has been estimated that as of 2012 there are nearly 83 million owned dogs in the U.S. with an average of 1.7 owned dogs per household [6].

Multiple factors may account for the prevalence and severity of facial dog bites. Injuries range in severity from superficial wounds requiring minimal care, to complex injuries requiring advanced reconstructive surgery or even death [7]. The force generated from dog bites can be significant enough to fracture bone and the damage created from the bite is dependent on the patient, site of bite and dog breed [8,9]. Breed specific information may shed light on the risk to own certain types of dogs, but this has not currently been substantiated as a
single predictive factor. With over 400 recorded breeds and widely varying morphology [10], we investigated the risk of biting based on dog breed as well as average bite severity. To assess the bite severity, we performed a multi-institutional retrospective review of facial trauma caused by dogs over a 15-year period. Lastly, we evaluated general morphology of each breed grouping as a predictor of bite severity.

2. Materials and methods

This study was performed at Nationwide Children’s Hospital (NCH) in Columbus, Ohio, and the University of Virginia Health System in Charlottesville, Virginia, two tertiary care medical centers with level I trauma designations. This study was approved by the IRB at both locations.

Bite risk by breed was assessed by a literature search for studies reporting dog bites and breed from 1970 to current. We required a minimum of 40 reported bites. Forty-three studies met the criteria [11-52]. The relative bite percentage by breed was tabulated for each study. These percentages were averaged for each breed, the standard deviation calculated, then ordinal variables for bite frequency were assigned to each breed.

An electronic search was used to create a database between the years of 2002 and 2017 for all patients who presented to the emergency department with a chief complaint of “dog bite”. Upon reviewing charts, this study selected for patients with dog bites to the head and neck. Charts were furthered reviewed for dog breed, facial trauma consulting service, extent of tissue damage, treatment, and management.

Using the composite measure of wound size and tissue avulsion to determine the severity of injury, we characterized each dog bite patient into an ordinal scale of bite severity. Measurements in the scale reflect incremental changes in the most current Common Procedural Technology (CPT) codes that described wound repair of increasing complexity (Table 1).

The bite risk variable (as calculated by meta-analysis) and the bite severity variable (as calculated by our patient population) were then combined into a plot to create an overall relative risk of injury visual.

Dog Morphology (height, weight and dog head shape) was also evaluated as a way to describe and group breeds by similarities, which may be useful when specific breed is not known. Data on the average adult height and body weight for each breed was determined using the latest weight and height breed charts from the American Kennel Club (AKC). When a range was listed, the median was calculated and the mean obtained if the height or body weight differed for the male and female within a breed. Dog breeds were assigned to characteristic head shape ( dolichocephalic, brachycephalic, and mesocephalic) based on previously established “Cephalic Index”. The cephalic index (CI) is calculated by measuring the skull at its widest point, multiplied by 100, which is then divided by the maximum length of the skull [53].

3. Results

For assessment of bite risk by breed, 43 studies were identified that reported greater than 60 dog bites and reported bite by breed. Each study was individually tabulated into number of bites attributed to a certain breed. Of the 26,000 bites reported, 39.9% were attributable to a specific breed and the remaining were either unknown or mixed breed. The preponderance of non-specific bite information was due to large volume survey studies. To equalize each study’s breed bite prevalence and dampen the effect of the large volume surveys, each study was broken down into percentage of bites by breed, these numbers then averaged across the 43 studies for each breed, the standard deviation calculated, and the breeds listed in decreasing order in Fig. 1. After this meta-analysis by breed, Pit-bulls were responsible for the highest percentage of reported bites across all the studies (22.5%) followed by mixed breed (21.2%), and German Shepherds (17.8%).

For assessment of bite severity by breed, the cohort of 240 bites reported over the last 15 years at our two institutions was reviewed for extent of injury in each case. As photographs were not consistently available, an ordinal scale of severity was created dependent on length of laceration, need for complex vs simple closure, presence of bony fracture, and presence of tissue avulsion (Table 1). This ordinal scale was then averaged for each breed. The combined variables of bite risk and bite severity were then combined into a scatter plot (Fig. 2) by breed. Mixed breed and the Pit-bull were found to have the highest relative risk of biting, as well as the highest average damage per bite. Breeds like the Great Dane and Akita were found to have lower relative risk of biting, however, the average damage from these bites were high. Lastly, breeds such as the Jack Russell terrier, Border collie, and Cocker spaniel had increased risk of biting with lower tissue damage compared to the other breeds.

The number of bites attributable to each breed in our cohort was superimposed as bubble size in a bubble plot (Fig. 3). Breeds like the Pit-bull and Akita were distributed evenly amongst our two institutions, whereas, breeds like the German shepherd and Border collie were represented entirely by one institution. This was performed to show the more specific, regional risk of dog ownership as breed popularity varies from location to location.

Further analysis of bite risk and bite severity was analyzed by average dog size (height and weight) as well as breed head shape (Fig. 4). This was categorized in a similar scatter plot, however, the risk of biting in the x-axis uses units generated from the y-axis in Fig. 1 to adjust for outliers in biting percentages. Physical characteristics like brachycephalic head shape and weight between 66 and 100 pounds were found to have both the highest bite risk and highest average tissue damage per bite. Dogs with the head shape of dolichocephalic were found to have a lower biting risk and lower average tissue damage per bite.

4. Discussion

Dog bites are a preventable problem affecting approximately 1.5% of the US population annually [11]. To better understand these traumatic events we performed an extensive literature search for dog bites that reported breed and retrospectively evaluated patients who suffered bites to the head and neck from two, regionally distinct, level I trauma centers. With a reported 83.3 million dogs living in more than 50 million households [12] this study cannot represent all dog bite injuries. A significant number of bites are assessed and treated by those who first evaluate bite victims including emergency physicians, primary care providers, and parents [12]. Although many injuries are untreated or managed by others, the volume of patients requiring expert care continues to be in demand as the American Society of Plastic Surgeons reported that nearly 29,000 dog bite repairs were performed in 2016 [54].

Despite increasing public awareness of dog bites, the problem persists and magnitude of the problem cannot be overstated. According to the CDC, those who require treatment after dog bites are predominately children ages 5–9 years [55]. From 1993 to 2008 there was an 86% increase in hospitalizations and from the 1980s to 2012 there was a reported 82% increase in fatal injuries [56]. Although the risk of this occurring remains relatively low in relation to the total number of dogs,
children younger than 12 and adults older than 70 years are overrepresented as victims and most vulnerable to lethal attack [57]. Not only are dog bites a serious public health concern from the standpoint of substantial physical and emotional trauma, the economic cost cannot be ignored and may also shed light on the significance of this problem. Bini et al., reported dog bites as the second most costly public health problem in the United States [11]. According to the Insurance Information Institute and State Farm, dog bites and dog related injuries accounted for $600 million in homeowner's liability claims in 2016 alone; this represented more than one-third of all homeowners insurance liability claims dollars paid during that time period. Since 2006 there has been nearly a 24% increase in the number of claims made [58].

Bite statistics describe a broad range of injuries and these statistics may be misleading because minor bites are recorded the same way as a mauling. In this study, 240 bite injuries were analyzed specifically using a bite severity scale that was generated as compositive measure of wound size, tissue avulsion, and/or internal derangement to determine the severity of injury. These were injuries deemed severe enough to warrant consultation by a facial trauma and reconstructive surgeon.

Secondly, to assess risk of biting, a meta-analysis was performed to obtain data on bite rate and breed. Similar to previous studies, we found that there are clearly predominant biting breeds and additionally, breeds that cause significant damage when they do bite [6–8,59,60].

As seen in Fig. 1, we were able to determine a relative risk of biting for a certain breed after analyzing more than 26,000 bites from the literature over the last 30 years. Of the cases in which the breed was known, the Pit-bull was responsible for the highest percentage of reported bites across all the studies followed by mixed breed and then German Shepherds. Currently, no prior studies exist that examine bite severity by breed. Therefore, the relative risk of biting and average tissue damage of bite, calculated using the 240 cases seen at our institutions, was used to determine an overall “risk to own” (Fig. 2). Mixed breed and Pit bulls were found to not only have the highest relative risk of biting, but were also found to have the highest average tissue damage per bite. Although caution should be taken with breeds found to have an increased risk of biting and high average tissue damage, it is also important to note breeds like the Great Dane who although have the lowest relative risk of biting, are seen to have the highest average bite damage. In our series, 240 cases required consultation from a facial
plastic and reconstructive surgeon. This data may not be a general representation of all dog bites and represents more severe bites to the head and neck.

Controversy exists in identifying "problem" breeds or breeds that may be prone to biting. Breed report most commonly relies on the perception of someone involved with a traumatic event and research has indicated that validity of breed identification may be lacking; more specifically, visual identification has been shown to match a DNA analysis for breed in as few as 25% of dogs [14]. That being said, the existing literature indicates that between 27% and 45% of bites the family dog is the cause of injury and one may conclude that most dog owners know the breed whether specific or mixed [11,15,16]. Golinko et al., in a large study of over 1600 dog bite injuries, reported that in only 12.7% of cases the dog was unknown. Secondly, breed popularity over a given time frame may cause certain breeds to appear more or less prone to biting based on their representation in given population. Using compiled data over many years may not account for shifts in popularity, but may account for differences in breed popularity and ownership by location, as seen in Fig. 3. The two tertiary care centers from this study differ between urban and rural patient populations and differences in breed ownership trends can be seen. Notably, a large amount of German Shepherd bites were treated at NCH in Columbus, whereas, none were reported at University of Virginia. This highlights the complexity of assessing bite risk by breed and the difficulty in making broad generalizations from one population to another.

In our sample, mixed breeds were amongst the most prone to biting and causing damage, yet we have little insight into what types of breeds were mixed. This presents difficulty in finalizing a conclusion based on breed alone because further study is required to determine whether a breed category could be applied. Furthermore, the term "pit-bull" is generic and descriptive of a type of dog that includes the American Pit Bull terrier, American Staffordshire terrier and the Staffordshire Bull terrier rather than a pure breed [60]. It is possible that people are describing the physical nature of the dog rather than a distinct breed. Neither the AKC, nor the United Kennel Club (UKC), acknowledges the "pit-bull" as a breed or group [61]. Certain physical characteristics, especially those that make a dog appear physically aggressive, may cause people to identify a dog as a "pit-bull". Because of this broad generalization, and lack of registration as a "pure breed" it is not possible to know how many dogs in a given region would fall into the category of a pit-bull [62]. It is impossible to know how many mixed breed dogs were pit-bulls, pit-bull mixes, or fell into this category by physical description alone. Perhaps it is the described physicality of the dog rather than the DNA confirmed breed assignment that is most predictive of severe injury.

In the 26,000 bites reviewed from the literature, 60.1% of the time a breed was not identified, which is consistent with other reports [12]. This accounts for several scenarios including those designated as mixed breed. This is also consistent with the previous statement that roughly 40% of dog bites are from the family dog in which the breed is most likely known. Because the majority of bites were from breeds we could not identify we explored morphological characteristics including weight and height of the breeds as well as the general classification by skull anatomy using the CI as way to identify dogs prone to aggression. The CI is calculated a ratio of maximum skull width to maximum skull length and is used to characterize canines and organize them into three groups, brachycephalic, mesocephalic, and dolichocephalic. Dolichocephalic characterizes "long-headed" dogs, such as the Afghan hound and greyhound, where the length of the skull is greater than the width. Brachycephalic characterizes "short-headed" dogs, such as the pug and
Fig. 3. Risk of breed ownership represented by the relative risk of biting and bite severity adjusted for both location (shade), and number of dog bites by breed (bubble size).

Fig. 4. Risk to own represented by the relative risk of biting, bite severity and dog morphology (weight, height, and skull anatomy). Each quadrant represents a combination of bite risk and bite severity.
chow chow, where the width of the skull is greater than the length. Mesopolichic characteristics "square-headed" dogs, such as the golden retriever and Siberian husky, where the measurement of skull width and length is relatively equal. Studies have shown an association with behavior body size and CI [53,63]. Our study demonstrates that canines with brachycephalic skull anatomy, as well as large dogs between 66 and 100 pounds, have an increased risk of biting as well as an increased risk for causing severe tissue damage (Fig. 4).

The circumstances causing a dog to bite are multifactorial and may have been influenced by behavioral and/or situational factors as much as genetics. The occurrence of a bite is influenced not only by breed behavior tendencies, but also the behavior of the victim (most commonly a child), the parents, and the dog owner [7,15]. Specific risk factors beyond breed are numerous, but should be acknowledged as detailed by Gurunluogulu et al., to include male dog, chained dog, sexually intact dog, unrestrained dog on owner's property, a dog that has been "rescued," insufficient physical exercise, history of aggression, summer months, children and more specifically male children [5-7,11-15].

There is no perfect way to mitigate the risk of a dog bite and unfortunately all dogs have the potential for harm, but it's important to recognize the increased potential for damage with various types of dogs and that most are preventable injuries. The purpose of this paper is to provide information to dog owners (or those considering ownership) about the types of dogs who may bite more frequently and/or cause more damage; with this information one can determine their risk tolerance for injury before an event occurs and potentially prevent a severe facial injury.

5. Conclusion

Dog bite injuries to the head and neck remain a significant public health problem. While there is a significant range in severity from superficial and unreported wounds to fatal injuries, we have analyzed bites from patients requiring consultation from a facioanatomical and reconstructive surgery service. We conclude that bite frequency and severity can be attributed to certain breeds, if the breed is known. Our study also acknowledges the significant risk of biting with the mixed breed population, which creates a dilemma with identification. Alternating physical characteristics such as height, weight, and head shape as were factors for bite risk and risk of severe tissue injury. We recommend separating children from high-risk breeds and high-risk phenotypes reported in this study. Selecting for animals with low risk for biting and tissue damage may lower the risk injury.

References