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ORIGINAL ARTICLE

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Antibiotic prophylaxis in pediatric dog bite injuries: Infection rates and prescribing practices

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Abstract

Objective: Pediatric dog bite injuries are a major public health concern and antibiotic prophylaxis is often prescribed due to concern about the development of infection. The Infectious Diseases Society of America recommends 3–5 days of antibiotic prophylaxis for high-risk dog bites. The purpose of our study was to compare infection rates among patients receiving antibiotic prophylaxis and those who did not receive antibiotic prophylaxis.

Methods: We conducted a retrospective cohort study of children aged 3 months to 17 years enrolled in the healthcare systems' affiliated accountable care organization (ACO). Eligible children with a dog bite injury presented at an urgent care center or emergency department between 2016 and 2019. We excluded children who were immunosuppressed or had bites that required closure by a surgeon. An electronic health record review was completed and ACO claims data were used to determine if a prescription was filled. Patients with an International Classification of Diseases (ICD)-10 code concerning for infection within 7 days of injury were recorded as having a bite infection.

Results: A total of 2653 non-immunosuppressed children presented for care of dog bite injuries and 672 children met eligibility criteria. Thirty-five children developed an infection of their injury. Of the 539 children who received antibiotic prophylaxis, 5.8% developed an infection and 3.0% of the 133 children who did not receive antibiotic prophylaxis developed an infection ($p = 0.28$).

Conclusion: The overall infection rate for pediatric dog bite injuries was 5.2%. In our single-center study, no difference in infection rates was found between those receiving and not receiving antibiotic prophylaxis.

KEYWORDS
antibiotic prophylaxis, dog bite, infection, pediatric

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1 | INTRODUCTION

1.1 | Background

Dog bites are a frequent cause of emergency department (ED) visits, accounting for more than 316,000 visits and over $1 billion in national payments for ED services annually.[1,2] Analysis of these visits revealed that 42% of dog bites occur in children under 14 years of age, indicating a significant pediatric public health problem.[3] Due to shorter stature, young children are more likely to sustain dog bites on the face, head, and neck.[3–6]

1.2 | Importance

Of concern after dog bites is the risk of subsequent wound infection. In a 1994 meta-analysis, Cummings estimated a reduction in risk of infection with antibiotic prophylaxis compared with standardized wound irrigation.[7] A subsequent meta-analysis by Medeiros and Saconato revealed found no benefit.[8] The included randomized controlled studies were limited by sample sizes, loss to follow-up rates as high as 58%, and heterogeneity in patient inclusion and infection rates (3.2%–45.8%).[9–14] A multi-centered observational study in 2015 showed that the infection percentage for patients receiving antibiotic prophylaxis was about 5.2%[15]; however, the study was limited by lack of standardized wound care, antibiotic prescribing practices, and enrollment of very few pediatric patients.

Areas of special consideration for antibiotic prophylaxis include wound closure and anatomic region variation. Three studies suggested that closure does not increase the risk of infection,[11,16,17] but a multi-centered observational study showed that head and neck wounds were more likely to be closed and to become infected.[18] Multiple studies have also shown the strongest benefit of antibiotic prophylaxis for hand wounds.[9–11,13,14]

1.3 | Goals of this investigation

With mixed evidence supporting antibiotic prophylaxis in dog bite injuries and limited pediatric specific dog bite literature, the need for antibiotic prophylaxis must be discussed. The primary aim of this study was to determine the infection rate in pediatric dog bite injuries and to determine if there is a difference in infection rates between children who receive antibiotic prophylaxis and those who do not receive antibiotic prophylaxis. Secondary aims of this study include describing the epidemiology and treatment practices of pediatric dog bite injuries in a large pediatric health care system.

2 | METHODS

2.1 | Study design

A retrospective cohort study of children ages 3 months to 17 years presenting with dog bite injuries who were enrolled in the health-care systems' affiliated accountable care organization (ACO) was performed. Eligible children with a dog bite injury presented at one of the urgent care centers (UCs) or EDs between 2016 and 2019. This study was approved by the hospital's institutional review board.

The Bottom Line

Dog bite injuries are common in children. Antibiotics are commonly prescribed in children after dog bite injuries. This study assesses the utility of antibiotics in children after a dog bite and demonstrates that antibiotics do not change the rate of infection. Therefore, it is important to further study this as it will change current standard of practice.

2.2 | Selection of participants

Children were excluded if they had an immunosuppressive diagnosis such as sickle cell disease, neutropenia, an immunodeficiency, HIV, cancer, or diabetes. Additionally, children receiving chemotherapy agents, insulin, erythropoietin, enzyme replacements, immune suppressants, immunizing agents, glucocorticoids longer than 14 days, and/or immunomodulators were excluded. These children were excluded as they are more vulnerable to infection and more likely to be prescribed antibiotics. Children less than 3 months of age were excluded as these young infants are more susceptible to bacterial infection.

Children were excluded if they were found to not have a dog bite or if they presented more than 24 h after their injury as delayed presentations have been found to have higher rates of infection.[19] Wounds closed by a surgeon were excluded as the hospital has trained suture technicians who follow a pre-closure irrigation protocol and complete most of the wound care in both the ED and UC settings. Wounds managed by trained suture technicians are irrigated with 30–100 mL saline/cm of wound with or without povidone-iodine using a 30–35 mL syringe with either a splash shield or 18–19-gauge catheter to create an adequate pound per square inch. Wound irrigation has been shown to be an important factor in preventing infection[7,20] and children with wound closure by a surgeon are often treated in an operating room where general anesthesia would allow for more thorough wound irrigation. Each treating provider determined antibiotic prophylaxis without standardization within the healthcare system. Children transferred from a referring institution were not excluded from the study unless their bite wounds were closed elsewhere.

Eligible subjects were identified by querying an electronic health record database for children presenting to the healthcare systems' EDs or UCs with a diagnosis code of "open bite." A keyword analysis isolated children presenting for a dog bite. A manual chart review was then completed for children with public insurance, as these children may be eligible for enrollment in the ACO. The hospital-affiliated ACO is the largest pediatric ACO in the United States and is responsible for the care of more than 470,000 children covered by Medicaid Managed Care across 47 counties. The ACO database has information related to the healthcare of these children and contains claims information allowing for access to information from visits both within and outside of the hospital network.

2.3 | Exposure/outcome

Physician notes from each chart were reviewed to determine bite wound characteristics and treatment practices. These were completed by two trained reviewers and all information was obtained as documented in the note; no assumptions of care were made. It was noted if oral antibiotics were prescribed. If a patient presented for more than one bite wound during this period, each bite was included as a separate encounter in the analysis.

For the cohort of children eligible for enrollment in the hospitals' ACO, all prescription insurance claims within 7 days of the visit were obtained and compared to the prescribed antibiotic to determine if the antibiotic was filled by the patient. If the antibiotic was filled, the patient was considered to have received antibiotic prophylaxis. If an antibiotic was not prescribed or filled, the patient was considered to not have received antibiotic prophylaxis. If a patient received a dose of antibiotics in the ED but did not fill their antibiotic prescription, they were considered not to have received antibiotic prophylaxis. Additional prescribed antibiotics were noted. All diagnosis codes from visits within 7 days of the initial visit were obtained. These codes were reviewed and children with diagnosis codes indicating a skin or wound infection were noted to have an "infected bite." Seven days was chosen for the development of infection, as the median time from bite injury to infectious symptoms in prior literature was reported to be 24 h,[21] and almost all bite wound infections showed signs of infection by 72 h.[19]

2.4 | Data analysis

We described the demographics and clinical characteristics by calculating percentages for each cohort. To study the bi-variate association between infection and potential risk factors, we conducted chi-square tests (for 2 by 2 contingency tables, we used Fisher's exact test). Specifically, we compared the infection rates between antibiotic and non-antibiotic cohorts, by demographic and other clinical characteristics. p-Values less than 0.05 were considered statistically significant. All statistical analyses were conducted according to SAS Enterprise Guide 8.1.[22]

To compare the two proportions, we assumed an infection rate of 18% in the no antibiotics group and an infection rate of 8% in the antibiotics group. If 155 patients were placed in each group and we used Fisher's exact test, there would be an 80% chance that the difference between the two groups was statistically significant ($p < 0.05$). We did not have missing data on key variables of the study sample.

3 | RESULTS

3.1 | Characteristics of study subjects

A total of 2653 non-immunosuppressed children presented to one of two ED or seven UC locations from 2016 to 2019 with a diagnosis code containing "open bite." After limiting to children with public insurance and excluding dog bites requiring surgical management and children presenting greater than 24 h from injury, 925 children remained (Figure 1). Seven children presented for two separate bite encounters. A total of 672 dog bite encounters were reviewed with all healthcare claims data available from the ACO.

Four hundred and twelve children presented to an ED and 260 presented to an UC location. A total of 91.5% of children were prescribed an antibiotic and it was confirmed that 87.6% of these children filled their antibiotics within 7 days of the injury. The antibiotic fill rates and infection proportions by visit location are shown in Table 1. A total of 539 children received antibiotic prophylaxis and 133 children did not receive antibiotic prophylaxis. Table 2 describes the demographics, bite characteristics, and management of children by antibiotic prophylaxis status. This study was not powered to detect differences in management, but in this sample, 34% of bites receiving antibiotic prophylaxis were described as a puncture and 24.8% of those not receiving antibiotic prophylaxis were described as a puncture ($p = 0.05$). A total of 52.5% of the wounds receiving antibiotic prophylaxis were sutured, and 34.6% of the wounds not receiving antibiotic prophylaxis were sutured ($p < 0.001$). None of the included patients had concerns about tendon or joint involvement of the bite wound.

3.2 | Main results

Thirty-five children had diagnosis codes concerning for a bite wound infection within 7 days of the injury. Patterns of infection by patient demographics and bite characteristics are shown in Table 3. Infection rates by management at the initial visit are shown in Table 4. Of children receiving antibiotic prophylaxis, 5.8% had International Classification of Diseases (ICD)-10 codes concerning infection, while 3.0% of the children not receiving antibiotic prophylaxis had diagnosis codes consistent with infection ($p = 0.28$). Of bites sutured with absorbable sutures 3.8% developed an infection and 8.1% of bites sutured with non-absorbable sutures developed an infection ($p = 0.17$).

A total of 638 antibiotic prescriptions were written, with a mean duration of 6.62 days. A dose of antibiotic was given during the initial visit in 295 bite encounters, with only nine given intravenously. Table 5 describes antibiotic prescribing practices in children presenting with dog bite injuries. Amoxicillin-clavulanate was the most frequently prescribed antibiotic and accounted for 91.2% of antibiotic prescriptions. Clindamycin and sulfamethoxazole-trimethoprim were the next most frequent at 3.9% and 3.1%, respectively. These were usually prescribed together. A total of 2.2% of children receiving 1–5 days, 7.7% receiving 6–7 days, and 10.2% receiving 9–14 days of antibiotics developed an infection ($p < 0.001$).

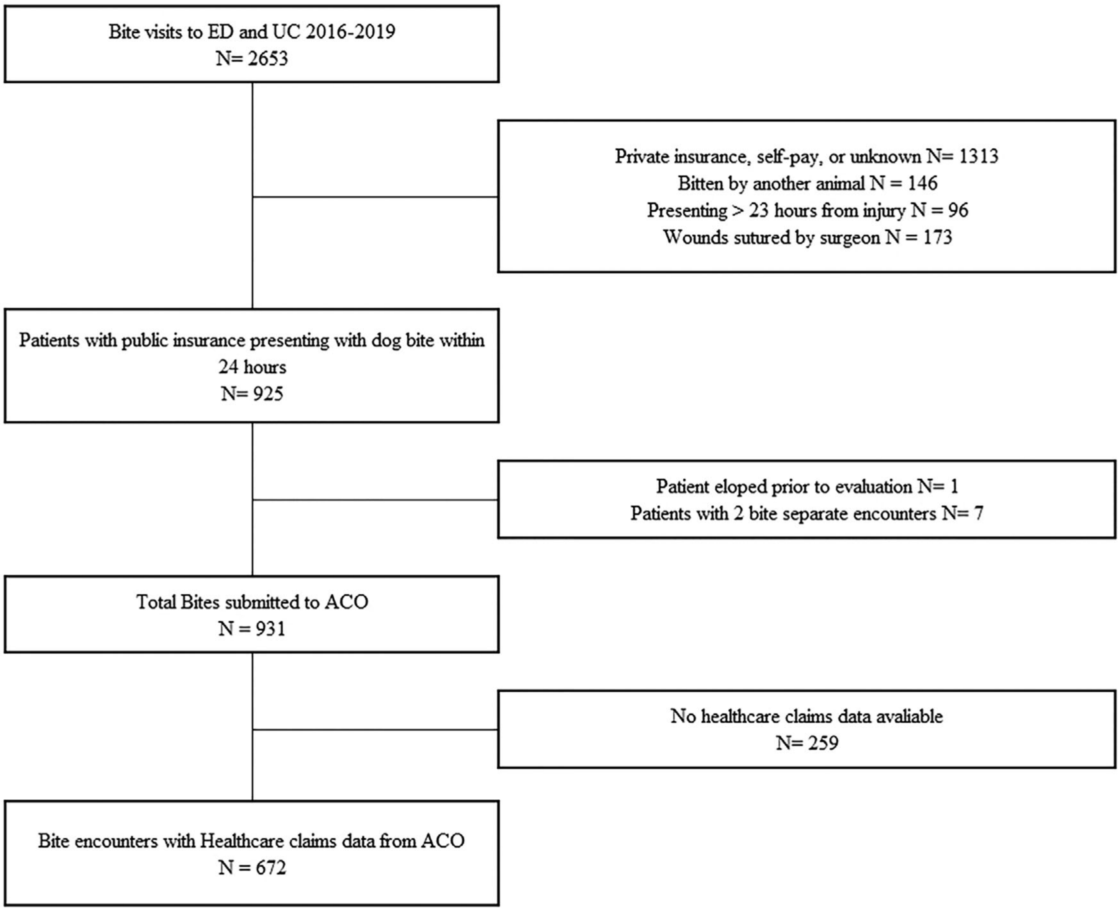

FIGURE 1 Dog bites presenting to two emergency departments (EDs) and seven urgent care (UC) locations in a large pediatric healthcare system from 2016 to 2019. ACO, accountable care organization.

TABLE 1 Antibiotic fill rates and infection rates by visit location.

	Urgent care ($N = 260$, 38.7%), n (%)	Emergency department ($N = 412$, 61.3%), n (%)
Antibiotics		
Did not receive antibiotics	63 (24.2)	70 (17.0)
Not prescribed	38 (60.3)	19 (27.1)
Not filled	25 (39.7)	51 (72.9)
Received antibiotics	197 (75.8)	342 (83.0)
Infections[a]	12 (4.6)	23 (5.6)

[a] p-Value comparing infection rate between urgent care and emergency department encounters = 0.72.

4 | LIMITATIONS

During our data collection, about 70% of patients with public insurance had all healthcare claims data available for analysis. Patients without healthcare claims data available may have had out of state coverage, not been enrolled in the ACO, or had the 7-day data collection timeframe across a month transition and the patient was not enrolled in the ACO for both consecutive months. To avoid underestimating infections, these patients were excluded from analysis. In addition, the infection rates of our cohort did not conform with the assumed rates during sample size calculation; therefore, the power of the study sample was lower than expected.

To create a cohort large enough for analysis, both ED and UC presentations were considered as suture technicians are present at both locations. By excluding bites requiring surgical closure, the most severe bites were excluded; however, this standardized the patient population to differences in resource availability and closure technique. Among children who did not receive antibiotics, 60.3% were cared for in the UC versus only 27.1% in the ED. There was no difference in wound infection rates between these settings (5.6% vs. 4.6%, $p = 0.72$); however, the proportions of children receiving antibiotic prophylaxis in the UC and ED were different (75.8% and 83.0%, respectively, $p = 0.03$). More data needs to be collected on wound size and characteristics to be able to adequately compare bites between these two healthcare settings.

Another limitation of this study is that children who were not prescribed an antibiotic were grouped with children who did not fill their antibiotic, creating the “no antibiotic prophylaxis” group, as only a small number of children were not prescribed antibiotics.

TABLE 2 Antibiotic prophylaxis by demographics, bite characteristics, and bite management.

	No antibiotic prophylaxis ($N = 133$, 19.8%) *n* (%)	Antibiotic prophylaxis ($N = 539$, 80.2%), *n* (%)	*p*-Value[a]
Gender			
Female	48 (36.1)	241 (44.7)	0.08
Male	85 (63.9)	298 (55.3)	
Age			
<1 year	0 (0)	8 (1.5)	0.47
1–4 years	41 (30.8)	179 (33.2)	
5–9 years	53 (39.8)	197 (36.6)	
10–14 years	27 (20.3)	119 (22.1)	
15–17 years	12 (9.0)	36 (6.7)	
Bite characteristics			
Head	62 (46.6)	289 (53.6)	0.18
Neck	0 (0)	9 (1.7)	0.22
Torso	10 (7.5)	43 (8.0)	1.00
Arm	21 (15.8)	99 (18.4)	0.53
Hand	19 (14.3)	90 (16.7)	0.60
Leg	33 (24.8)	102 (18.9)	0.15
Foot	2 (1.5)	8 (1.5)	1.00
Puncture	33 (24.8)	183 (34.0)	0.05
Fracture	2 (18.2)	3 (4.8)	0.16
Management			
Imaging	11 (8.3)	64 (11.9)	0.23
Sutured	46 (34.6)	284 (52.8)	<0.001

[a]*p*-Values calculated using chi-squared tests comparing groups with antibiotic prophylaxis and those without antibiotic prophylaxis.

Providers may have felt that children who were not prescribed antibiotics had minor wounds that were at a lower risk of infection, leading to a lower impact of not having antibiotic prophylaxis in this group. Our study grouped patients who filled their antibiotic prescriptions in the received antibiotics group; however, patients who filled a prescription does not ensure that they completed the antibiotic course. We allowed patients up to 7 days to fill their antibiotic prescription to be considered to have received antibiotic prophylaxis to ensure that all children receiving antibiotics were included; however, antibiotics given further from the injury are less likely to provide appropriate antibacterial prophylaxis. Infection rates were determined based on ICD-10 codes from subsequent visits, as clinical notes were not available to confirm all wound infections. ICD-10 codes were chosen as the outcome measure as these codes were available for all subsequent visits both within and outside of our hospital network.

This was also a single healthcare system with a high prescription fill rate. The presence of hospital-trained suture technicians provides standardized wound irrigation but may limit generalizability. A thorough wound irrigation process is needed to apply these results since irrigation can reduce wound infection rates.[19]

TABLE 3 Infections by demographics and bite characteristics.

	No infection ($N = 637$, 94.8%) *n* (%)	Infection ($N = 35$, 5.2%), *n* (%)	*p*-Value[a]
Gender			
Female	279 (96.5)	10 (3.5)	0.08
Male	358 (93.5)	25 (6.5)	
Age			
<1 year	7 (87.5)	1 (12.5)	0.52
1–4 years	205 (93.2)	15 (6.8)	
5–9 years	240 (96.0)	10 (4.0)	
10–14 years	140 (95.9)	6 (4.1)	
15–18 years	45 (93.8)	3 (6.3)	
Bite location			
Head	330 (94.0)	21 (6.0)	0.39
Neck	9 (100)	0 (0.0)	1.00
Torso	52 (98.1)	1 (1.9)	0.51
Arm	114 (95.0)	6 (5.0)	1.00
Hand	102 (93.6)	7 (6.4)	0.49
Leg	131 (97.0)	4 (3.0)	0.19
Foot	10 (100)	0 (0.0)	1.00
Puncture	203 (94.0)	13 (6.0)	0.58
Fracture	5 (100)	0 (0.0)	1.00

[a]*p*-Values calculated using chi-squared tests comparing infections by demographics and bite characteristics.

TABLE 4 Infections by bite management.

	No infection ($N = 637$, 94.8%), *n* (%)	Infection ($N = 35$, 5.2%) *n* (%)	*p*-Value[a]
Imaging	69 (92.0)	6 (8.0)	0.27
Sutured	315 (95.5)	15 (4.5)	0.49
Sutured by physician[b]	25 (100)	0 (0.0)	0.62
Subcutaneous sutures	95 (94.1)	6 (5.9)	0.41
Absorbable sutures	255 (96.2)	10 (3.8)	0.17
Dermabond	0 (0.00)	1 (100)	0.05
Antibiotic prophylaxis	508 (94.2)	31 (5.8)	0.28
Antibiotic dose given in urgent care/emergency department	272 (94.8)	15 (5.2)	1.00

[a]*p*-Values calculated using chi-squared tests comparing infections by bite management.
[b]Bites not sutured by a physician were sutured by a hospital-trained suture technician.

TABLE 5 Antibiotic prescribing practices in the emergency department and urgent care locations of a large pediatric healthcare system for patients presenting with dog bite injuries.

	Mean in days (SD)	Range (days)
Outpatient prescriptions (*N* = 638)	6.62 (2.05)	1–14
Antibiotic dose given in emergency department/urgent care, *n* (%)		
Intravenous	9 (3.1)	
Oral	286 (97.0)	
Outpatient prescription, *n* (%)		
Amoxicillin-clavulanate	582 (91.2)	
Cefdinir	2 (0.3)	
Cephalexin	4 (0.6)	
Clindamycin	25 (3.9)	
Doxycycline	3 (0.5)	
Metronidazole	1 (0.2)	
Sulfamethoxazole-trimethoprim	20 (3.1)	
	No infection (*N* = 603), *n* (%)	**Infection (*N* = 35), *n* (%)**
Antibiotic prescription duration[a]		
1–5 days	311 (97.8)	7 (2.2)
6–7 days	169 (92.4)	14 (7.7)
9–14 days	123 (89.8)	14 (10.2)

Abbreviation: SD, standard deviation.

[a]*p*-Value comparing infections by antibiotic prescription duration ≤ 0.001.

5 | DISCUSSION

There was no difference in the infection rates among children with dog bite injuries who received and those who did not receive antibiotic prophylaxis at the time of injury in our single-center cohort (5.8% vs. 3.0%, $p = 0.28$). Although a prior meta-analysis[7] showed that 16.1% of patients with dog bites become infected without antibiotic prophylaxis, our analysis showed that only 3.0% developed infections in this group. This difference may be explained by standardized high-pressure irrigation, as it has been reported that irrigation can reduce the infection rate from 69% to 12%.[19] Most wounds in the children in our study were irrigated and sutured by technicians. A total of 5.8% of children who received antibiotic prophylaxis developed an infection, which is consistent with an observational study from 2015 showing a 5.2% infection rate.[18]

Although not powered to detect statistical significance, our population showed no difference in receipt of antibiotic prophylaxis or infection based on bite location, which is consistent with prior literature.[23] Particular attention should be paid to bites involving the hands. A prior study showed that 30% of hand bites become infected and noted this difference was significant compared to all other wounds.[19] In our population, 6.4% of patients with hand wounds developed an infection, but this difference was not significant compared to that in children without hand wounds ($p = 0.49$).

The role of closure in the development of dog bite wound infection is unclear. Some studies have shown that closure of a dog bite wound is an independent predictor of infection[15]; however, others have shown a decreased infection risk with closure.[19,24] This finding was thought to be due to better irrigation, which may be attributable to the use of local anesthetic with suturing. Primary closure results in better cosmetic outcomes,[17] which is important to consider in children as many bites occur on the face. We found that patients receiving antibiotic prophylaxis had a higher rate of wound closure (52.8% vs. 34.6%, $p < 0.001$), but there was no difference in infection rate in children receiving primary wound closure (4.6% vs. 5.9%, $p = 0.49$).

Our study showed that patients receiving antibiotic prophylaxis were more likely to have a wound described as a puncture by the treating provider (34% vs. 24.8%, $p = 0.05$). Previous literature suggested that puncture wounds have a higher rate of infection[15,19]; therefore, this increase may be accounted for by providers having a higher concern for development of infection in these children. Interestingly, there was no difference in the infection rate among children with wounds described as a puncture compared to those where the wound was not described as a puncture (6.0% vs. 4.8%, $p = 0.58$).

Most children in our study received Amoxicillin-clavulanate, which is the antibiotic of choice after a dog bite as *Pasteurella* is the most common pathogen.[25,26] Trimethoprim-sulfamethoxazole and clindamycin were the second most common prescriptions, which is consistent with current recommendations for penicillin-allergic children.[27] The mean duration of antibiotics prescribed was 6.62 days. At this time, no recommendation is made for antibiotic prophylaxis in low-risk dog bites, yet 91.5% of all bites were prescribed an antibiotic. Interestingly, the mean duration in our study exceeds the current Infectious Diseases Society of America's recommendation of 3–5 days for dog bites if the patient is immunocompromised, on immunosuppressive drugs, or for bites involving the face, hands, or feet.[28] However, a European review article recommends amoxicillin-clavulanate for 7–14 days for these bites.[29]

The length of antibiotic prescription was found to be associated with infection as children who were prescribed a longer duration of antibiotics at the initial visit were more likely to develop infections ($p < 0.001$). This may reflect that providers prescribing a longer duration of antibiotics in wounds they felt were more at risk of infection. A previous study revealed that the median time for signs of a wound infection to develop is 24 h[21]; therefore, some wounds may have already shown signs of infection at presentation, resulting in a longer course of antibiotics.

Although pediatric ED prescription fill rates have been shown to be as high as 92.7%,[30] a prior study examining healthcare claims data showed a fill rate of 57% in a Medicaid population.[31] Our children had an 87.6% fill rate when confirmed using healthcare claims data. This difference is likely due to an on-site pharmacy at the main ED accounting for 61.3% of the children in our study; therefore, a lower prescription fill rate would be expected in the community.

In summary, since antibiotics are implicated in 67% of pediatric adverse drug reactions[32] and there are concerns of antimicrobial resistance affecting pediatric patients globally,[33] the need for antibiotic prophylaxis in pediatric dog bite injuries should be discussed. We found that the infection rates after pediatric dog bite injuries did not differ between those receiving and not receiving antibiotic prophylaxis, but our study had notable limitations given its retrospective single-center design. A large, multi-centered prospective study would allow for bite characteristics and infections to be more accurately documented for a stronger statistical analysis. It is also important to note that antibiotics are not recommended for low-risk dog bites; however, over 90% of children received a prescription for antibiotic prophylaxis and many of these children are prescribed antibiotics for longer than recommended, demonstrating a tendency to prescribe antibiotics outside of current guidelines.[28]

AUTHOR CONTRIBUTIONS

Courtney Coyle and Julie C. Leonard conceptualized and designed the study. Courtney Coyle, Junxin Shi, and Julie C. Leonard participated in developing methodology and data curation. Courtney Coyle completed the investigation, created the visuals, and wrote the original draft of the manuscript. Junxin Shi provided the statistical software and completed the formal analysis. Junxin Shi and Julie C. Leonard helped with review and editing of the manuscript and Julie C. Leonard provided supervision for the study.

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

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