



Epidemiological characteristics, seasonality, trends of dog bite injuries, and relationship with meteorological data

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Abstract

Introduction and Objective. Animal bites are among the most critical in public health problems. Dogs are the leading cause of bite injuries. The study aimed to investigate the epidemiology and clinical features of dog bite cases admitted to an emergency department, as well as their temporal trends, seasonality, and relationship with meteorological data.

Materials and method. Study data comprised eight years (2012–2019) emergency room records of a tertiary center. Demographic characteristics of the cases, bite anatomical area, treatment applied, hospitalization, and death rates were determined. The incidence rates and distribution of meteorological data by years were examined using ANOVA and Kruskal Wallis tests. Seasonality and temporal trends were investigated for incidence rates using the additive decomposition technique. The temporal relationship of incidence rates with meteorological data was evaluated using the Autoregressive Distributed Delayed Boundary Test. Causality verification was performed using the Granger test.

Results. Dog bite cases consisted of 1,335 records of patients with a mean age of 26.6 ± 0.2 years. Bite cases were most common in the 20–44 age group (44.7%), males (76.4%), and lower extremities (48.2%). The frequency of hospitalization was 4.1%. Annual incidence rates ranged from 52.7–49.9/100,000, with a non-significant increasing trend. The incidence of bites had two peaks, in June and August. A co-integration relationship was observed between incidence rates and air temperature and humidity levels ($p < 0.001$).

Conclusions. Effective implementation of prevention programmes is needed for high-risk demographic groups. In addition, a national monitoring and reporting system could evaluate the effectiveness of any prevention programme and reduce the incidence of dog bites.

Key words

dog bite injury, dog bite incidence, trend, epidemiology, emergency department, meteorological data

INTRODUCTION

Animal bites are an important cause of morbidity and mortality worldwide [1]. The main animal species with the potential to bite humans are snakes, dogs, cats, and monkeys [1]. The animal most frequently involved in bite-related injuries is the dog, responsible for 76% – 94% of injuries [2, 3].

The estimated annual incidence of dog bites among those presenting to the United States emergency services is 1.1 per 1,000 [4], with reported incidence rates from European countries being similar [5]. The precise incidence of dog bite injuries in Turkey, however, is not known. According to the Ministry of Health of the Republic of Turkey, approximately 250,000 cases of suspected rabies contact are reported annually, most of which are from dog bites [6].

The incidence and epidemiological characteristics of dog bite injuries may vary depending on geographical location, income level, industrialization, and cultural factors [5, 7]. Most bite cases are children, and the incidence of dog bites is high in mid-late childhood [1]. Men are more also often exposed to dog bites than women [1]. People can experience

significant health consequences and financial losses from dog bite injuries [8]. Although bite cases have been evaluated from many aspects, studies examining temporal trends and their relations with meteorological data (MD) are in the minority. Besides the epidemiological characteristics of the cases, the relationship with natural variables, such as MD, can provide additional information on bite control [9]. On the other hand, MD has also been used in modelling studies to estimate the incidences of various health events, especially infectious diseases [9]. Although various studies on dog bite cases have been carried out in the study area to date, to the best of the authors' knowledge, the temporal trend, seasonality and relationship of the cases with MD, have not been addressed.

This study aimed to investigate the epidemiological and clinical features of dog bite cases admitted to an emergency department, as well as their temporal trends, seasonality, and relationship with MD.

MATERIALS AND METHOD

The study was planned as cross-sectional. Within the scope of the research, dog bite cases were not physically examined in any way, no questions were asked, no drugs were administered; only recorded data were examined. Therefore,

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Figure 1. Map of Turkey with Erzurum province marked in red [27]

the study was deemed exempt from Ethics Committee review. The data were compiled from the emergency room records of a tertiary centre in Erzurum, a city in eastern Turkey with a population of approximately 757,000 (2021) [10]. Compared to the western part of the country, the city is relatively underdeveloped, has cold climatic conditions prevail, and where agriculture and animal husbandry are mainly conducted. In terms of area, it is Turkey's fourth largest province (25,000 km²) and is at an altitude of about 1,900 m above sea level. Figure 1 [11], demonstrates the location of Erzurum on the map of Turkey.

The cases comprise 96 months (1 January 2012–31 December 2019) of emergency service applications exposed to dog bites in Erzurum city centre. Data were compiled from hospital information management system records by scanning with the ICD code (W54.0) (application date, address, age, gender, anatomical site of bite, treatment, hospitalization, death). The book in which the rabies prophylaxis records were kept was also examined. All accessed records are anonymized. Cases referred from outside the province, encountering dogs (no bite), injuries caused by non-dog animals, and cases with lost records, were excluded from the study. Between 2012–2019, the total number of emergency polyclinic applications amounted to 2,561,075, and the number of dog bite cases – 1,335. Population data of the province were obtained from the Turkish Statistical Institute [monthly average temperature (°C), precipitation (mm/day), relative humidity (%) and wind speed (m/sec)].

Statistical Package for the Social Science (version 22), EViews (version 10), and Tableau Public (version 2022.4) programs were used for data analysis and visualizations. Analyses were carried out in the stages of descriptive statistics, annual incidence information (trend and forecast), evaluation of variables by year, and application of time series techniques (stationary tests and lag length selection, cointegration tests, and modeling of bite cases). Descriptive statistics are presented using mean, standard error, number, percentage, and ratio. Incidence rates were calculated by dividing the number of cases by the mid-year population of the city center (100,000 people). ANOVA, Kruskal Wallis, and Mann Whitney U tests with Bonferroni correction were used for post-hoc analyses to evaluate incidence rates and MD by

years. A partial correlation technique was used to evaluate the relationship between monthly incidence rates and MD.

Using the additive decomposition method, monthly incidence rates were adjusted according to seasonality and trend components, and estimates calculated. In order to avoid misinterpretations due to random movements of the variables, co-integration analysis was preferred instead of classical regression. Augmented Dickey-Fuller (ADF) was used as the unit root test and the lag length was determined according to the Schwarz information criterion. In the co-integration analysis, the Autoregressive Distributed Delayed Boundary Test (ARDL) approach was used, since the variables were stationary at that level. Ramsey Reset, CUSUM and CUSUM of squares, Jarquera-Bera, Breusch-Godfrey performance tests were used to investigate possible model problems. Finally, the relationships between incidence rates and MD were confirmed by the Granger causality test. Results were significant when $p < 0.05$ was obtained in all analyses.

RESULTS

Demographic and clinical characteristics of bite cases are presented in Table 1, and their distribution by age group and anatomical region in Table 2. 1,335 dog bite cases were included in the study. The mean age of patients was 26.6 ± 0.2 years. Bite frequency was higher in the 20–44 age group (44.7%), and in men (74.6%) than in women. In all age groups, the lower extremities were the anatomical region most frequently exposed to bite. Most of the cases (82.6%) comprised injuries requiring simple medical intervention. The general hospitalization frequency of bite cases was 4.1%. No deaths occurred.

In Table 3, the mid-year populations of the study area, annual number and incidence rates of bite cases, and annual averages of MD are given. The overall annual incidence of bites was 40.5/100,000. The incidence of dog bites was calculated as a minimum in 2015 (27.2/100,000, 95% CI: 21.5 – 32.9) and a maximum in 2012 (52.7/100,000). ANOVA (2012–2015 and 2015–2019) ($p = 0.001$), there was no significant difference between the distribution of MD by years ($p > 0.05$). Figure 2 indicates the seasonality, estimates and trend of dog bite incidence by

Table 1. Distribution of dog bite cases according to demographic and clinical characteristics

| Variables | Mean / Cont | SE / % |
|---------------------------|-------------|--------|
| Age (year) | 26.6 | 0.5 |
| Age groups | | |
| 0-9 | 264 | 19.8 |
| 10-19 | 279 | 20.9 |
| 20-44 | 597 | 44.7 |
| 45 and above | 195 | 14.6 |
| Gender | | |
| Female | 339 | 23,6 |
| Male | 996 | 76.4 |
| Bitten anatomical area* | | |
| Head/Neck/Face | 83 | 6.1 |
| Body | 99 | 7.3 |
| Upper extremity | 523 | 38.4 |
| Lower extremity | 656 | 48.2 |
| Treatment applied | | |
| Suture/Complex operations | 232 | 17.4 |
| Dressing | 1103 | 82.6 |
| Hospitalization | | |
| Yes | 55 | 4.1 |
| No | 1280 | 95.9 |
| Death | | |
| Yes | - | - |
| No | 1335 | 100.0 |

* total exceeds the number of participants, in some cases due to bites located in more than one anatomical region

Table 2. Distribution of dog bite cases by age group and anatomical regions

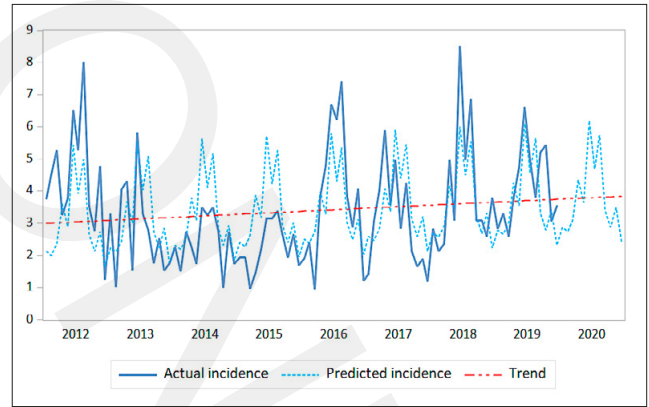
| Anatomical area | 0-9 years | 10-19 years | 20-44 years | 45 years and above |
|----------------------------|--------------------|--------------------|--------------------|--------------------|
| | n (%) ^a | n (%) ^a | n (%) ^a | n (%) ^a |
| Lower extremity | 86 (44.3) | 176 (46.3) | 290 (50.5) | 104 (48.8) |
| Upper extremity | 81 (41.8) | 144 (37.9) | 221 (38.9) | 77 (36.2) |
| Body | 10 (5.1) | 38 (10.0) | 37 (6.4) | 14 (6.5) |
| Head/Neck/Face | 17 (8.8) | 22 (5.8) | 26 (4.5) | 18 (8.5) |
| Total ^b [n (%)] | 194 (14.2) | 380 (27.9) | 574 (42.2) | 213 (15.7) |

^a Column percentage; ^b total exceeds the number of participants, as some cases have bites in more than one anatomical region

Table 3. Mid-year population, bite case numbers, bite incidence and annual distribution of weather components

| Years | Mid-year population | Number of cases | Crude Incidence (per 100.000) (Sum±SE) | Temperature(°C) (Mean±SE) | Precipitation (mm/day) (Mean±SE) | Relative humidity (%) (Mean±SE) | Wind speed (m/sec) (Mean±SE) |
|-------|---------------------|-----------------|--|---------------------------|----------------------------------|---------------------------------|------------------------------|
| 2012 | 398.368 | 210 | 52.7 (39.1-66.3) ^a | 5.6±3.4 | 2.6±0.3 | 68.4±4.0 | 2.8±0.2 |
| 2013 | 394.684 | 133 | 33.7 (22.9-44.5) | 5.3±3.3 | 2.6±0.3 | 66.3±4.2 | 2.9±0.2 |
| 2014 | 399.683 | 116 | 29.0 (22.9-35.2) | 6.9±3.0 | 2.6±0.3 | 66.5±4.5 | 2.9±0.2 |
| 2015 | 412.326 | 112 | 27.2 (21.5-32.9) ^{ab} | 6.1±3.2 | 3.5±0.5 | 66.8±4.5 | 2.7±0.2 |
| 2016 | 417.385 | 193 | 46.2 (30.0-62.5) | 5.5±3.1 | 4.3±0.7 | 66.5±3.5 | 3.4±0.2 |
| 2017 | 422.389 | 156 | 36.9 (25.5-48.4) | 5.6±3.5 | 4.8±1.5 | 63.3±4.7 | 3.0±0.3 |
| 2018 | 422.164 | 204 | 48.3 (33.3-63.3) | 7.6±2.6 | 3.3±0.5 | 69.2±3.7 | 3.1±0.2 |
| 2019 | 422.832 | 211 | 49.9 (40.6-59.2) ^b | 6.2±3.1 | 3.3±0.5 | 65.9±4.2 | 2.8±0.2 |

^{ab} significant difference between groups with the same character ($p=0.001$)

**Figure 2.** Seasonality, trend and forecasts of bite cases by year

year. The incidence of dog bites indicated a non-significant increasing trend over the eight-year period ($p>0.05$).

Figure 3 presents the monthly trends of dog bite incidence rates and MD. The incidence rates, which increased in March when the temperatures rose regionally, had two separate peaks – in June and August. The lowest incidence rates were recorded in December. There was a positive correlation between monthly mean incidence rates and only air temperature ($r=0.470$; $p<0.001$). Precipitation, relative humidity, and wind speed were not significantly correlated with monthly incidence rates ($p>0.05$).

Time series analyzes were used to evaluate possible relationships between incidence rates and MD. ADF test results of the variables used in time series analyzes are presented in Table 4. stationary testing using the ADF test with a maximum lag length of 11 showed that all the variables were stationary on the level ($p<0.05$ for all). Time series graphs of weather components are given in Figure 4.

Table 5 presents the time series analysis results. Long- and short-term relationships between incidence rates and MD were evaluated with the ARDL approach. Because of the analysis, the ARDL (2, 0, 0, 1, 0) estimation model was

Table 4. ADF test results of incidence rates and weather components

| Variables | t-Statistics | Critical Value (%) | p Value |
|-------------------|--------------|--------------------|------------------|
| Incidence | -3.69 | -3.50 | 0.006 |
| Temperature | -9.33 | -3.50 | <0.001 |
| Precipitation | -7.95 | -3.50 | <0.001 |
| Relative humidity | -7.86 | -3.50 | <0.001 |
| Wind speed | -8.06 | -3.50 | <0.001 |

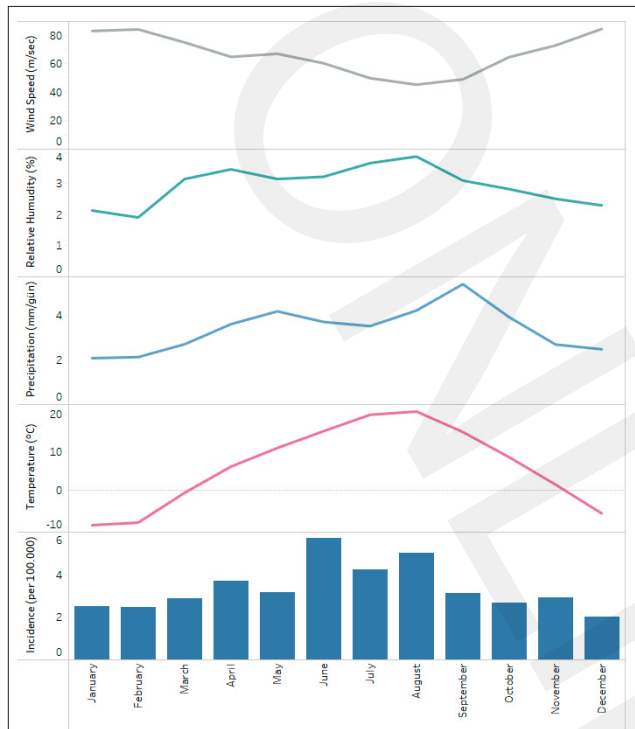


Figure 3. Incidence rates of cases and distribution of meteorological data by months

determined ($R^2=0.472$, $F=11,009$; $p<0.001$). According to the model, there was a positive long-term co-integration relationship between the number of cases and air temperature, and a negative relationship with humidity levels. The error correction coefficient of the model showed that the effect of a deviation in the relationship between the variables could reach equilibrium within 2.1 months [CointEq(-1): -0.472 , $p<0.001$]. This showed the low variance in estimates caused by previous incidence rates, temperature and humidity shocks.

Table 6 presents the results of MD's Granger causality test. The causality for the temperature and humidity variables associated with the incidence rates as a result of the ARDL test was confirmed by the Granger test ($\chi^2=12.046$; $p=0.002$ and $\chi^2=6.208$; $p=0.044$, respectively).

Table 5. Time series analysis results for annual incidence rates and meteorological data

| Variables | Coefficient | SE | t-Statistics | p Value |
|------------------------|-------------|-------|--------------|------------------|
| Incidence (-1) | 0.165 | 0.097 | 1.694 | 0.094 |
| Incidence (-2) | 0.363 | 0.094 | 3.845 | <0.001 |
| Temperature | 0.049 | 0.018 | 2.666 | 0.009 |
| Precipitation | -0.004 | 0.032 | -0.134 | 0.893 |
| Relative humidity | 0.004 | 0.013 | 0.321 | 0.749 |
| Relative humidity (-1) | -0.030 | 0.009 | -3.443 | <0.001 |
| Wind speed | 0.163 | 0.168 | 0.970 | 0.334 |
| Constant | -2.221 | 1.097 | -2.024 | 0.046 |

R^2 0.472; Adjusted R^2 0.429; F - 11.009, Schwarz Criterion - 2.391; Durbin-Watson - 2.036; $p<0.001$; CointEq (-1): -0.472.

Table 6. Granger causality test results of meteorological data

| Variables | χ^2 | df | p Value |
|-------------------|----------|----|---------|
| Temperature | 12.046 | 2 | 0.002 |
| Precipitation | 0.410 | 2 | 0.814 |
| Relative humidity | 6.208 | 2 | 0.044 |
| Wind speed | 0.529 | 2 | 0.767 |

DISCUSSION

Tes study identifies the main epidemiological and clinical features of dog bite cases admitted to the emergency department of a tertiary hospital between 2012 – 2019, investigates their seasonality, and explains their temporal trends and relationship with MD. The results of the study could help to develop local control and prevention policies for dog bite cases, as well as provide data comparable to other parts of the world.

Age is an important demographic determinant of dog bite injuries [4]. Almost half of the victims (44.7%) in this study were in the young-middle age group, and the findings are consistent with some studies [4, 12–14]. However, most studies have reported that dog bites are more common in the paediatric age group [2, 5, 12–15]. This may be related to

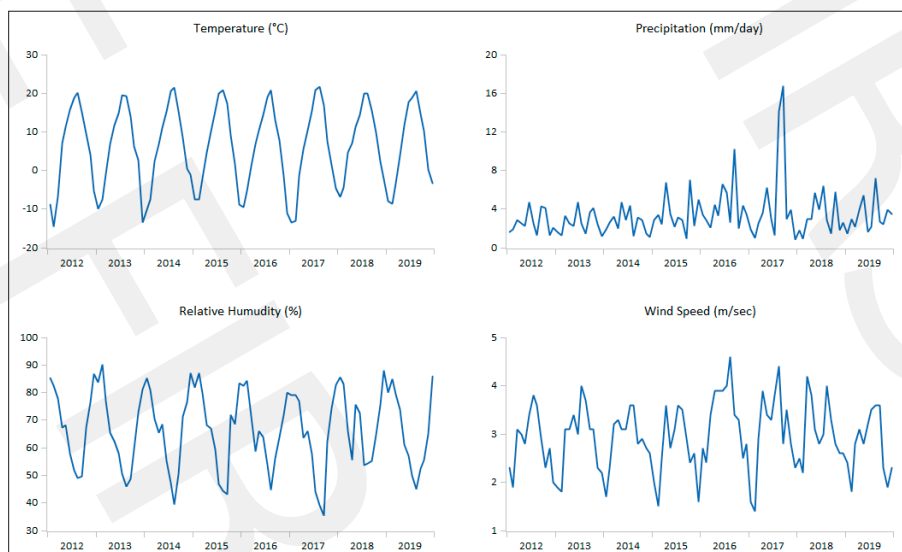


Figure 4. Time series graphs of meteorological data by year.

the demographic structure and dog ownership rates in the research groups.

Men are more often affected by dog bites [2, 15–18]. The current study found that bites are almost three times more common in men than in women, which is consistent with the literature. Being involved in agricultural activities and spending a lot of time outdoors may increase the likelihood of males being bitten. However, there are also studies reporting that incidences of dog bites are higher in women [5, 19, 20]. This contradiction may be because of socio-cultural reasons and, therefore, behavioural differences.

This study is compatible with the literature, and the lower extremities were determined as the anatomical region most frequently exposed to dog bites [2, 16, 12, 21, 22]. However, in some studies, hand and upper extremity bites were observed more frequently [14, 15, 17, 18, 23]. The high rate of dog ownership in some regions and the intensity of activities such as interaction with animals and games can explain this situation. It is known that children are frequently exposed to dog bites in the head, neck and face areas [2, 18]. Their short stature and vulnerability may explain the burden of head bites in children. Contrary to expectations, incidences of head injuries were low (14.6%) in the 0–19 age group in this study. This suggests that children in the region may have been bitten by an aggressive animal while playing or running, causing provocation.

Depending on the characteristics of the biting animal and the victim, dog bites can cause substantial physical injury and hospitalization [3, 18]. However, hospitalizations and deaths are not comparable, as they are usually reported for developing rabies cases [18, 24]. The current study showed that almost one-fifth of bite victims underwent sutures or other complex treatment procedures, and 4.1% were hospitalized. The incidence of hospitalization was the same as in regional studies, and no deaths occurred [22].

Reported incidence rates of dog bites vary widely (1.5 to 650/100,000) [5, 16, 4, 12–14, 17–19]. Various factors, such as geographical location, number of uncontrolled animals, industrialization and socio-cultural structure, can affect incidence rates. The likely unregistered nature of most minor and self-treated cases causes estimates to be limited to hospital admissions [25]. In the presented study, the crude incidence was calculated between 52.7–49.9/100,000. In addition, significant fluctuations in incidence rates were observed between years. Calculated incidence rates are higher than studies conducted with regional data [15, 22]. In this study, a non-significant upward trend in bite incidence was found. This may be a sign of a real increase, but may also be caused by population movements, the effectiveness of studies on stray dogs, improvements in reporting and changes in bite survivors' demand for healthcare.

Understanding the seasonal distribution of health problems and their relationship with MD can guide control studies [9]. However, it is reported that MD rarely acts alone, and its combinations, together with other factors, provide optimum conditions [26–28]. In the current study, consistent with the literature [17, 18, 20, 19, 21–23], the distribution of bite cases throughout the year increased almost in parallel with the air temperature, and made two separate peaks in June and August. This may be because of the increase in people's outdoor activities and dog activity in warmer weather.

In the current study it was found that air temperature and humidity levels simultaneously predicted the incidence of

bites. Studies conducted in the Ezurum region [22] and in the Philippines [9] have also associated high temperature, low precipitation and humidity with mammalian bites. The fact that animals are more mobile and travel longer distances in hot and dry weather may increase the likelihood of encounters and people being bitten.

This study provides up-to-date information on the epidemiological features and public health burden of dog bite injuries. Bite records created through the hospital automation system in the emergency department are reliable.

Limitations of the study. It is acknowledged that this study has some limitations. First, the study data included only cases of dog bites that occurred in the city centre and presented to the emergency room. There may be victims who do not seek medical help or receive treatment in primary and secondary care centres. It is therefore possible that the study provides lower incidence estimates for dog bite injuries. In addition, a reporting bias may have arisen because of severe cases that were more likely to seek medical attention. Second, there are significant fluctuations in incidence rates from year to year. In the years when dog bite injuries were observed, the issues of how the cases were handled in the emergency department and how they were reflected in the records came to the fore. Studies conducted by local governments, lack information on bite cases, such as whether they occurred in the countryside or in the city centre, and whether the animal had an owner or was a stray dog.

CONCLUSIONS

This study determined that dog bite injuries were especially more common in the child-adolescent and young-middle-aged adult groups, as well as during the hot and low humidity seasons. To reduce the incidence of bites, it is important to intervene before appropriate climatic conditions in age groups where bite cases are common. Educating children and teenagers about how to treat dogs and signs of aggression can reduce bite injuries. An effective trauma surveillance system, in which emergency room conditions are also observed, is important to define risk groups and planning interventions. Finally, introducing national control programmes for stray dogs can provide long-term control of dog bite incidents.

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