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An Investigation on the Epidemiology of Dog Bite Prevalence using Time series Prediction

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Abstract

The study elaborates on the cases of dog bite in the Coimbatore district of Tamil Nadu. The primary data collected was from a Primary Health Centre at Coimbatore till October 2016. Based on the retrieved data from 5 cluster of villages in Coimbatore it was evident that the cases of dog bite prevalence in males was much dominant than that of female population. Now the primary data was subjected to a statistic model employing SPSS software and the module for operation was time series. The time series data was further again analyzed and a forecast was performed accordingly. The forecast model had its peak starting from November 2016. Linear Regression was performed to know the trend line of infection. This trend line and the forecasting were based on LCL and UCL values of the primary data. The study clearly embarks the forecasting of dog bite infections on a future scale, the need for a forecasting method enables to understand predictions of a data based on a past trend line of the primary data. This forecasting method can be applied for systems with data following a consistent trend line approach.

Keywords: LCL-Lower Count Limit and UCL-Upper Count Limit, forecasting, trend line

INTRODUCTION

Rabies is a zoonotic viral disease, causing acute inflammation of the brain, in humans and other warm-blooded animals. Although, the rabies virus targets the central nervous system, eventually affecting the brain and leading to death, the effect of the disease could be prevented by timely and right post-exposure treatment, through, proper wound toilet, PEP and / or passive immunization.

The incidence and distribution of rabies at the global level and at local levels have been the subject of epidemiological studies. A study in India conducted in 18 states, in 2003, revealed a high incidence of animal bites in rural areas and the children and the poor/low income group were the most affected. This observation prompted us to take up epidemiological studies in Coimbatore region.

A WHO-sponsored epidemiological study on animal bites in India in 2003, covering 18 states, including a population 52,731 from randomly chosen 8500 households revealed that “the annual incidence of animal bites was high 1.7% and it was more in rural areas,1.8%, children 2.6% and poor/ low-income group 75%”. The dog was the major biting animal (91.5%) with the cat taking the second place at 4.7%. (Sudarshan et al.,2006).

In the sixteenth century, Fracastoro, an Italian physician, poet, and scholar, strengthened the concept of rabies as a contagious disease. John Hunter in 1793 initiated an experimental, scientific approach to rabies by studying rabies transmission through the inoculation of a rabid animal’s saliva or human saliva into dogs. (Zuckerman et al.,2009).

Global scenario of Prevalence of Rabies

Globally three main areas of rabies have been demarcated. According to De Serres et al.(2008), they are:

(i) Rabies-free countries (mostly islands, including England, Australia, and Japan)

(ii) Countries in which canine rabies has been brought under control and wildlife rabies predominates (Western Europe, Canada, and the United States); and

(iii) Countries with enzootic canine rabies (all of Latin America, Africa, and Asia).

MATERIALS AND METHODS

Prevalence of rabies infection in Coimbatore: A survey was carried out to evaluate the prevalence of dog-bites and rabies in Pooluvapatti, Coimbatore. Our study area was divided into 5 village clusters and they are as follows: I Karunya, II Alandurai, III Boluvampatti, IV Thondamuthur and V Pooluvapatti. The data of the dog-bite victims, among these 5 clusters during the study period, from August 2010 to October 2016, are analysed and discussed.

Time Series forecasting: In recent years, time series forecasting research has exploded in popularity. Time series forecasting is gathering and analyzing historical data in order to create a model that can extrapolate those data into the future. Future event forecasting is useful in a variety of sectors to aid decision-making since it reduces future uncertainty.

The major goal of the time series analysis is to fit the data to the appropriate model under consideration. Let us model the following using Time Series Analysis based on Linear Regression and forecast.

Linear Trend Model:

We first looked at the time series data by plotting its series across time, and then we created a sample descriptive measure of the series' major features. A description of the series, outliers, troughs, and the existence of turning points that were pronounced on the time plot were done using graphical depiction of the series of observed dog bite injury dataset versus time. The trend, seasonal movement, cyclical movement, irregular variation, and forecasting attributes of the series were all established using the time plot. Because numerous time-trend curves in all human efforts have the propensity to expand or decrease in absolute terms or fluctuate during the time period in question, such trend series may be represented using proper mathematical models known as trend models. For this research, we concentrated on linear, quadratic, and exponential trend models. The general direction in which the graph of a series of successful observations taken in time (typically at equal intervals) tends to travel over a lengthy period of time is referred to as a trend.

When the trend follows a straight line, a linear trend curve may be used to estimate the dataset The equation $Y = A + Bt + E$ $Y = A + Bt + E$represents a straight line model, where Y is the trend value of the dog bite case at time period t, A and B are constants, and E is the randomly distributed error throughout the time series. The linear trend line is thus$Y = A + Bt$ $Y = A + Bt$ and the sum of squares of deviations from the trend line is minimized. (Ojo et al., 2010)

The method of least squares (Nyblom., 1986, Shangodoyin., 2012) has been employed to estimate the parameters A and B usually. The two normal equations are $\sum_{i=1}^{n} Y_i = nA + B\sum_{i=1}^{n} t_i$ and $\sum_{i=1}^{n} t_i Y_i = A\sum_{i=1}^{n} t_i + B\sum_{i=1}^{n} t_i^2$

The residual is given by $E = \sum_{i=1}^{n} e_i^2 = (Y_i - A - Bt)^2$. It is minimized by $\frac{\partial E}{\partial A} = 0$ and $\frac{\partial E}{\partial B} = 0$

Thus the fitted trend line is given by $Y = A + Bt$

RESULTS AND DISCUSSION

1.1 Prevalence of dog bite in Coimbatore

The results of the study of the prevalence of dog-bite in Coimbatore - South, is given below. The month-wise data on the victims of dog-bite, both male and female, who visited the public health centre for treatment from the year 2010 to 2016, are given in Tables 4.1 a to 4.1 g , 4.2 to Figure 4.1

Table 4.1 a Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2010

2010	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	-	-	-	-	-	-	-	9	7	8	9	5
Female	-	-	-	-	-	-	-	7	0	1	3	4
Total	-	-	-	-	-	-	-	16	7	9	12	9

Table 4.1 b Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2011

2011	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	6	1	8	4	5	9	4	9	8	7	8	9
Female	3	2	2	3	3	3	3	8	1	6	3	7
Total	9	3	10	7	8	12	7	17	9	13	11	16

Table 4.1 c Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2012

2012	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	3	19	10	17	16	7	12	17	20	17	20	23
Female	6	5	8	7	4	2	12	10	5	5	9	10
Total	9	24	18	24	20	9	24	27	25	22	29	33

Table 4.1 d Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2013

2013	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	16	12	19	22	18	26	13	15	14	17	19	12
Female	5	7	10	13	16	9	9	17	13	7	12	6
Total	21	19	29	35	34	35	22	32	27	24	31	21

Table 4.1 e Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2014

2014	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	9	12	14	11	20	19	14	19	12	17	13	15
Female	5	3	4	6	15	5	7	9	6	8	5	9
Total	14	15	18	17	35	24	21	28	18	25	18	24

Table 4.1 f Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2015

2015	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec
Male	12	10	9	21	22	15	20	27	14	12	15	30
Female	13	14	9	11	9	8	12	8	6	5	16	10
Total	25	24	18	32	31	23	32	35	20	17	31	43

Table 4.1 g Prevalence of dog-bite in Coimbatore - South: Month-wise frequency of male and female victims of dog-bites in the year 2016

2016	j Jan	Fe b	Mar	April	May	June	July	August	Sept	Oct
Male	28	27	28	27	30	29	24	14	19	19
Female	10	9	13	12	9	12	14	11	10	10
Total	38	36	41	39	39	41	38	25	29	29

Tables 4.1a to 4.1 g give the month-wise numbers of male and female victims of dog-bites every year from 2010 to 2016

Table 4.2 Total no of male and female victims of dog-bites from 2010-2016

Year	2010	2011	2012	2013	2014	2015	2016	Total
Male	38	71	175	206	177	207	245	1121
Female	15	51	89	124	80	124	110	591
Total	53	122	264	330	257	331	355	1712

The above data has been consolidated, year-wise, 2010 to 2016 in Table 4.2. The perusal of Table 4.2 makes us understand that there has been a gradual increase in the number of patients visiting the Pooluvapatti PHC over the years. Probably there has been a growing awareness among the villagers regarding the need for the treatment of dog-bites.

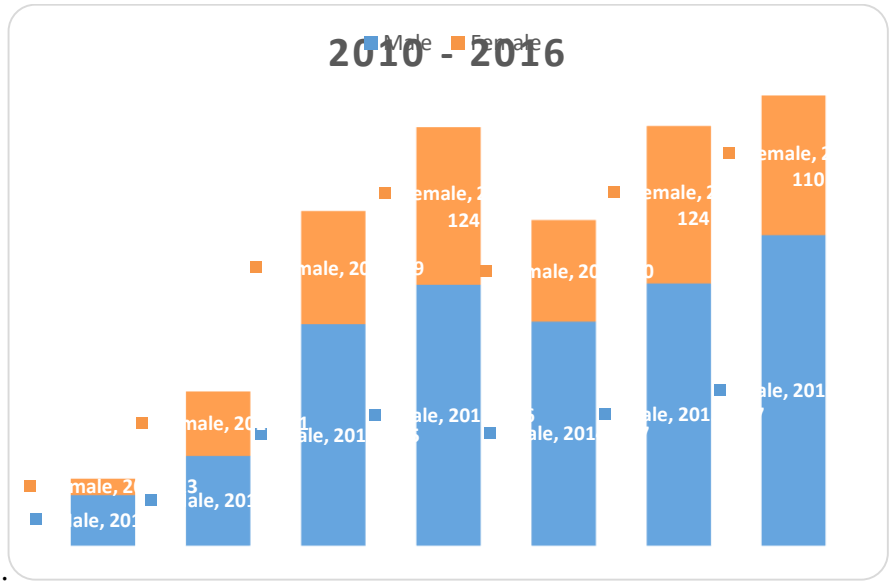

Figure 4.1 .Total no of male and female victims of dog-bites from 2010-2016

A gender-wise analysis of the dog-bite victims reveals that the number of males affected is greater than the number of females, every year. Out of the total number of 1712 persons covered in this study, 1121 i.e. 65% were men and the remaining 591, that is 35% were female. This may be due to greater exposure and encounter with dogs by men more than by women. The provocation too may be more in the case of men. The total dog-bite victims among male and female are represented in the Figure 4.1

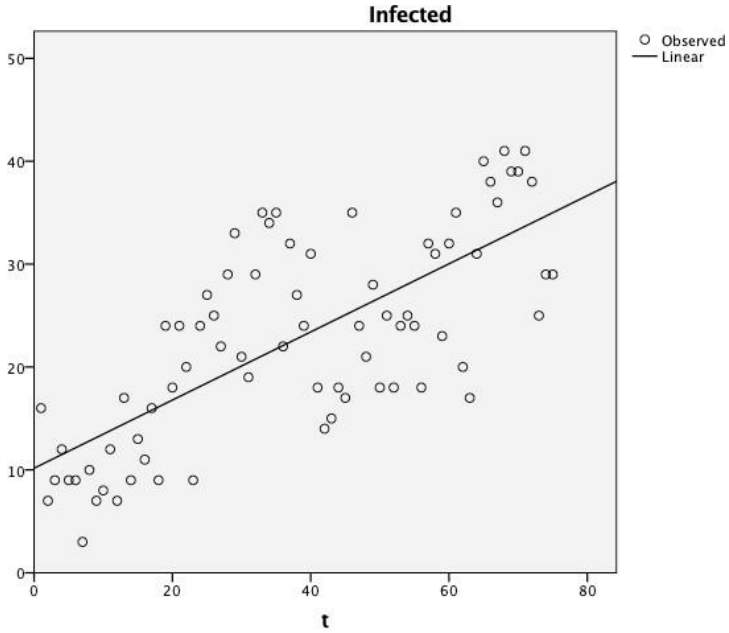

Figure 4.2 Linear Regression

The Figure 4.2 depicts Linear Regression. This linear regression model was made employing a statistical tool like SPSS. An inference made reveals a trend line stating linear regression of the data based on the months and prevalence of the infection, also stating the need of regression to clearly visualize that the data fit for regression which was taken over a time period variable as months and the dense population data.

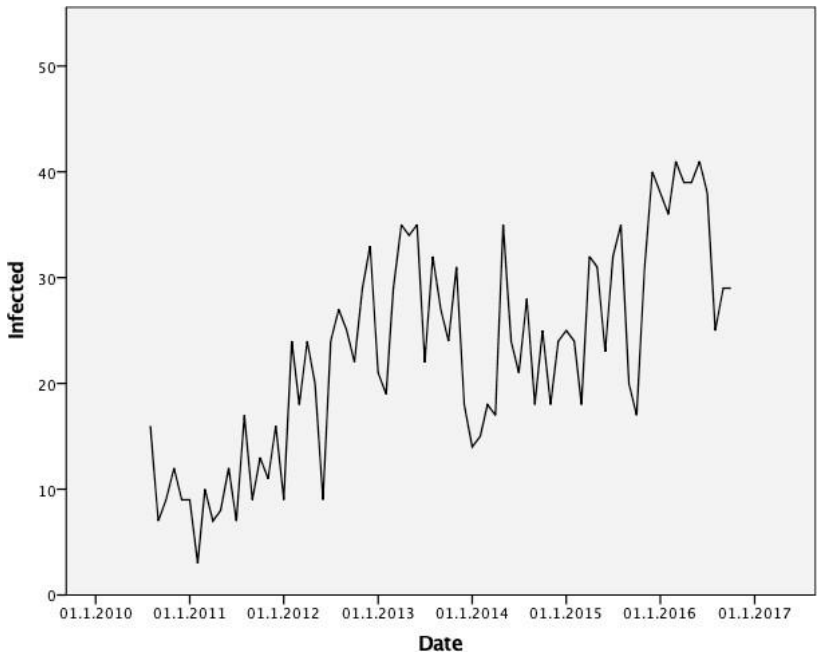

Figure 4.3 Time varying behavior and seasonality

The representation of the time varying behavior and seasonality of the rabies virus infection in relation to the months of the infection is up to January 2017 is portrayed in the Figure 4.3. The figure as observed also denotes the rate of infection takes peak fluctuations at maximal progression.

Regression analysis is also done based on the time series behavior thereby equating to a time series equation as $y(t)= 0.331t+10.165$. This equation paves a way to fit the variable data to the appropriate model.

Table 4.3 : Forecast of the trend line infection

Model		Nov 2016	Dec 2016	Jan 2017	Feb 2017	Mar 2017
Infected	Forecast	31	32	28	29	31
-Model_1	UCL	43	45	42	43	46
	LCL	19	20	15	15	17

	Apr 2017	May 2017	Jun 2017	Jul 2017	Aug 2017
Forecast	35	37	33	33	35
UCL	50	53	50	50	53
LCL	19	21	16	16	17
	Sep 2017	Oct 2017	Nov 2017	Dec 2017	
Forecast	28	29	31	32	
UCL	47	48	51	53	
LCL	10	10	11	12	

As seen from the Table 4.3, the forecast starts after the last non-missing range of the requested estimation period. The non-missing values of all the predictors are available at the end of the requested forecast period. In our study we have made clear by justifying the upper and lower limit scales pertaining to the development of the forecast model.

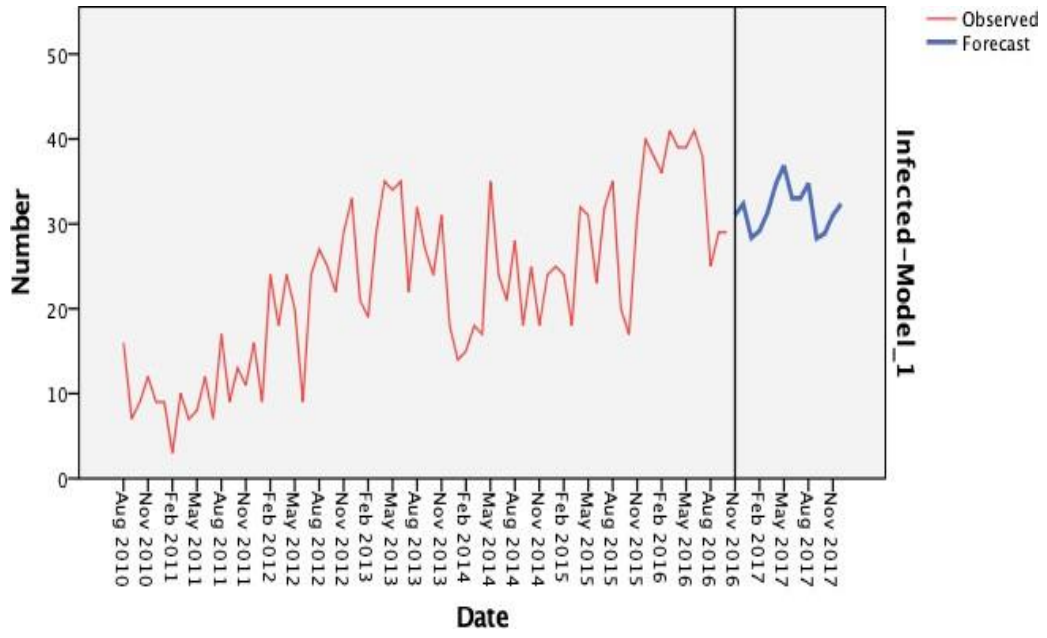

Figure 4.4: Forecast done post November 2016 using time series

The observed time series trend line was fit based on a said equation

y(t)= 0.331t+10.165. The peaks in blue indicate the forecast made based on the data already projected from red colored peak. These peaks are clearly elucidated in figure 4.4.The peaks in blue also indicate post Nov 2016 , the infected number increases with respect to the data incorporated.

Table 4.4: Gender Based Test

Year	Male	Female
2010	38	15
2011	71	51
2012	175	89
2013	206	124
2014	177	80
2015	207	124
2016	245	110

Based on the primary data of bite cases taken from the village clusters there was equally bitten cases of both males and females on an average scale which can be seen from table 4.4

Table 4.5: Independent Sample Test

T-Test

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Infected	Male	7	159.86	76.233	28.813
	Female	7	84.71	40.339	15.247

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Infected	Equal variances assumed	2.868	.116	2.305	12	.040	75.143	32.599	4.116	146.169
	Equal variances not assumed			2.305	9.116	.046	75.143	32.599	1.542	148.744

As represented in Table 4.5, the independent sample test states the highest bitten cases were in males compared to the female population. The p value obtained was based on data fit in the model and was found to be 0.04 less than 0.05; this indicates the rejection of null hypothesis making the scope of the objective precise on males being largely bitten than females.

SUMMARY AND CONCLUSION

Stray dog menace, the incidence of dog-bites and hence the necessity to regulate the population of dogs in India, have been recently topics of much debate (Levin et al.,2017) The fall out of this kind of a situation has been the increasing incidence of dog-bites in rural as well as urban areas and the need for the treatment with anti-rabies vaccine in such cases.

A lot of discussion is going on in the country on the stray dog population menace and its control. There is an urgent need felt among the public to contain the dog population as it could be the carrier of the dreaded disease causing rabies virus. Hence, an epidemiological study of the frequency of dog -bite and treatment in Coimbatore was carried out along with a forecasting model based on this primary data.

Out of a total number of 1712 persons covered in this study, 1121 i.e. 65% were men and the remaining 591, that is, 35% were female this data was again verified by the linear regression model and t-tests stating it very clear that the number of dog bites in male was more than that of females. The forecasting model also reveals the time varying behavior and seasonality of the rabies virus infection in relation to the months of the infection is up to January 2017 and was portrayed clearly in the study. Therefore this forecasting model is efficient, avoids redundancy of primary data and can be employed in data analytics for biological systems and prevent rabies viral infections occurring to a greater extent through forecasting.

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