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Original Article

Public Health Section

Seasonal Variation and Time Trend Analysis of Dog Bite Cases Attending the Anti Rabies Clinic in Delhi using ARIMA Model Forecasting

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ABSTRACT

Introduction: Rabies is a fatal viral disease which is transmitted to humans through animal bites, most commonly via dogs. Fortunately, this disease is preventable through timely pre and postexposure vaccination.

Aim: To study the seasonal predisposition and trend analysis of dog bite cases attending the anti rabies clinic.

Materials and Methods: This retrospective cross-sectional study was conducted in the anti rabies clinic of a government hospital in Delhi. Enumeration and inclusion of all dog bite cases were made. An Autoregressive Integrated Moving Average (ARIMA) model was used to analyse the available data of dog bites, from 2011 to 2018. In this study, the least Bayesian Information Criterion (BIC) value was 12.2 and the corresponding model is ARIMA (1, 0, 0) with the goodness of fit 2 (R^2=44%). The model verification was done by noise residual check. The model was applied for time series analysis and forecasting of rabies cases in subsequent years.

Results: Total number of dog bite cases were 1,46,344 in last eight years (2011-2018). The maximum number of cases being 27961 in the year 2014 followed by 22385 in the year 2013. A seasonal predisposition of dog bite cases was seen for the month of February to April. The trend analysis forecasting for 2019, 2020, 2021, 2022 and 2023 predicted 11317, 11676, 10157, 8639 and 7120 cases, respectively.

Conclusion: Although the dog bite cases will be on a decline in the future, adequate measures need to be strengthened further to sensitise the community about rabies prevention and timely reporting to anti rabies clinic for prophylaxis.

Keywords: Autoregressive integrated moving average, Rabies prevention, Rabies reservoir, Vaccination, Viral disease

INTRODUCTION

Rabies is one of the oldest recognised diseases affecting humans. It is primarily a disease of terrestrial and airborne mammals, including dogs, wolves, cats, bats, monkeys, and humans [1]. It's been previously documented that dogs are still the most common reservoir of rabies in India [2]. The disease itself is caused by a fatal neurotropic virus that belongs to the genus Lysa virus from family Rhabdoviridae. This virus is introduced through the injuries or cuts into the skin and mucosa most typically via bites of rabid animals [3]. The zoonotic disease virus is typically present in the saliva of the rabid animal and is transmitted from animal to human or animal to other animals [4].

Rabies is absolutely preventable. The disease is still an important public health problem in South-eastern Asia. An estimated 45% of all deaths from rabies occur in this part of the world [2]. Globally, a total of 59,000 human deaths occur due to rabies and, over 3.7 million disability-adjusted life years annually [5]. In India, the annual incidence of human rabies was found to be 17,137 (95% Confidence Interval (CI) 14,109-20,165) [6]. In the absence of an obvious declining trend, the unvarying incidence of rabies for the last decade in India is, in all probability, an underestimation of the true incidence as rabies still fails to make it to the list of notifiable diseases in India [6].

Forecasting the diseases can be done by applying mathematical models which can be linear and non linear. Few models were artificial neural network and Susceptible, Infected, Recovered and Dead (SIRD) Models. The ARIMA model is a linear model based on adjusting observed values and it works by reducing the difference between the values generated in the model and the observed to zero value. This model has the advantages of both statistical value web box and Jenkins method for building the models [7].

General lack of awareness of preventive measures, insufficient dog vaccination, an uncontrolled canine population, poor knowledge of proper postexposure prophylaxis and an irregular supply of anti rabies vaccine and immunoglobulin, particularly in primary healthcare facilities, have led to this situation. This is of concern as India is keen to achieve the target of zero human death from dog-mediated rabies by 2030 [8]. As there are effective rabies prevention guidelines, like the use of a reduced (4-Dose) vaccine schedule for postexposure prophylaxis to prevent Human Rabies [9], available to healthcare officials and policy makers, but it is still very important to improve the management of the same. Therefore, the aim was to study the seasonal predisposition and trend analysis of dog bite cases visiting the anti rabies clinic.

MATERIALS AND METHODS

This retrospective cross-sectional study was conducted at North DMC Medical College and Hindu Rao Hospital, Delhi, India with high patient load and having an exclusive anti rabies clinic. Institutional Ethical Committee Clearance was attained before the commencement of the study under IHEC no. 2019/000122. Data were collected from the animal bite registers maintained at the anti rabies clinic from January 2011 to December 2018 and analysed.

Inclusion criteria: All cases of dog bites reported in the registers were included in the study.

Exclusion criteria: No exclusion criteria was applied.

Data collection: Data from the records was collected after obtaining permissions from the institutional board. No personally identifying information was collected and the data so collected was solely used for the purpose of research.

In this study, data regarding total number of all dog bite cases, that were treated at that particular government hospital in Delhi was used.

Study Procedure

An ARIMA model was used to fit with the data of dog bites available during the year 2011 to 2018. The model was proposed to the general ARIMA process to apply time series analysis, forecasting, and control. ARIMA was deemed to be the ideal model for data analysis in the present scenario as the data in question is not stationary. The model specification was confirmed by the Ljung-Box (modified Box-Pierce) test and residual noise check [10].

The application of ARIMA models constitutes of four phases:

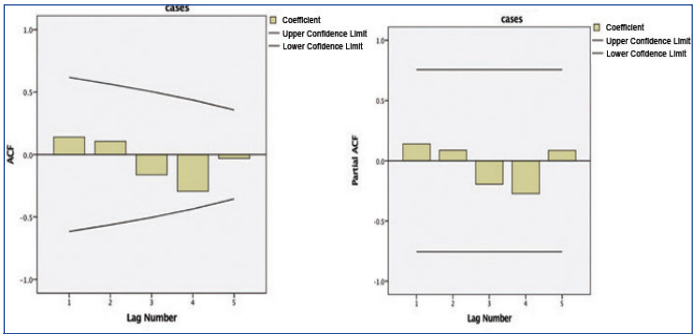
1. Choosing a model: In this phase selecting the most appropriate lags for the Autoregression (AR) and Moving Average (MA) is done. In addition, variable requiring first difference for induction of stationery is determined. For identification of the best model, the Autocorrelation Function (ACF) and Partial ACF (PACF) are utilised.

2. Estimation: The least-squares estimation process is done for estimation.

3. Diagnostic testing: For testing autocorrelation, diagnostic testing is done. Analysis at this stage is done to check the failure, then the process is started from the beginning and other variables also added.

4. Forecasting: The ARIMA models are specifically used for forecasting with the use of lagged variables.

P and Q values were determined from the plotting of values of ACF and PACF. The spikes that are above the time axis are the estimates for p-value. Spikes below the time axis are used for estimating 'Q' value. In AR (p) model, the spikes of ACF exponentially decay or a sine wave pattern is observed. The spikes of PACF are around zero beyond the time lag p. In MA (q) model the spikes at ACF end to zero beyond the time lag q. The spikes of PACF decay exponentially or a sine wave pattern is observed. After the identification and estimation of the model parameter, the model is determined with different sets of parameters. Once the model was identified and the model parameter can be estimated, then the model is determined with a different set of parameters. The assumption made about the random error (e) is satisfied. Selection of model can also be based on values of some criteria such as normalised BIC [Table/Fig-1] [7,11].



[Table/Fig-1]: ACF and Partial autocorrelation function.

Using an ARIMA specification to select a particular tentative model and the general term of it was as follows [12-14]:

$$Yt=b0+b1\ Yt-1+b2\ Yt-2+b3\ Yt-3+\ldots+\varepsilon t$$

Where:

Yt represented the number of animal bite cases at time t

Yt-1 represented the number of animal bite cases at time t-1

Yt-2 represented the number of animal bite cases at time t-2

εt represented the error

STATISTICAL ANALYSIS

Data analysis was done with the software Statistical Package for the Social Sciences (SPSS) IBM (version 21.0).

RESULTS

Model fit: ACF and PACF shows an irregular increasing pattern of dog bite cases. Thus, ARIMA models (p, d, q), was applied for such situation [Table/Fig-1]. The best suitable model was selected based on minimal BIC value. In this study, the least BIC value is 12.2 and the corresponding model is ARIMA (1, 0, 0) [Table/Fig-2] with the goodness of fit 2 (0.446). The model verification is done by noise residual check [Table/Fig-3].

ARIMA (p, d, q)	BIC	R^2
1, 1, 1	18.2	0.232
1, 1, 2	17.4	0.311
0, 0, 1	16.9	0.389
0, 1, 1	17.2	0.321
1, 0, 0	12.2	0.446

[Table/Fig-2]: ARIMA Model selection.
Stationary data over time staying close to zero; ARIMA: Autoregressive integrated moving average; BIC: Bayesian information criterio

Parameter	Stationary R^2	Ljung-Box Q Statistics	DF	p-value
Quarterly dog bite cases	0.500	21.320	17	0.212

[Table/Fig-3]: Model statistics for dog bite cases.

Forecast of cases: The total number of reported dog bite cases from the institution was found to be 1,46,344 extending from 11,390 cases in the year 2011 to 12,707 cases in 2018 [Table/Fig-4]. The Ljung-Box (modified Box-Pierce) test indicated that the ARIMA (1, 0, 0) model was correctly specified [Table/Fig-3] and that there were no outliers in the data as detected by expert modeller. The predicted numbers for the years 2013, 2015 and 2017 coincide with the actual reported cases suggesting the aptness of the model selection.

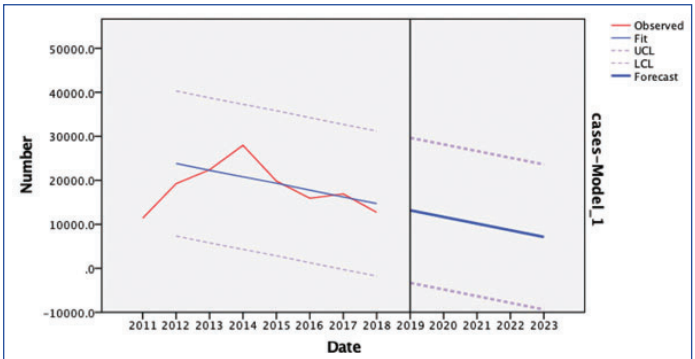
Year	Actual dog bite cases- N	Forecasted dog bite cases- N_0	95% Confidence interval	
			Lower limit	Upper limit
2011	11390	-	-	-
2012	19251	23824	7337	40311
2013	22385	22262	4475	38748
2014	27961	20788	4302	37274
2015	19827	19338	2852	35824
2016	15921	17756	1269	34242
2017	16902	16214	-271	32700
2018	12707	14720	-1766	31206
2019	-	11317	-3310	29661
2020	-	11676	-4810	28163
2021	-	10157	-6329	26644
2022	-	8639	-7847	25126
2023	-	7120	-9366	23607

[Table/Fig-4]: Forecasting of cases as per ARIMA model (1,0,0).

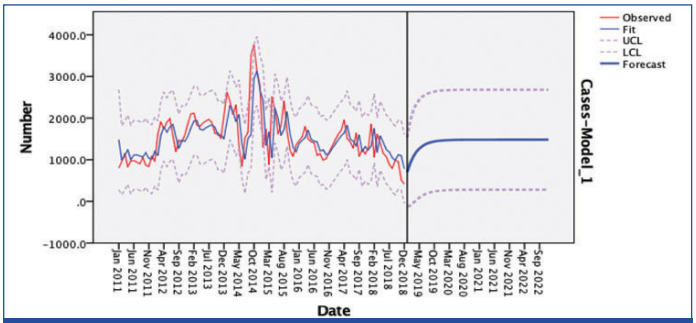
The number of reported cases from 2011 to 2018 was plotted and analysed using ARIMA to obtain the dog bite cases forecasting for the years 2019 to 2023 which showed a decreasing trend when plotted. [Table/Fig-4] tabulates the values obtained for forecasted dog bite cases (N_0) with 95% confidence limits for each year starting from 2011 up to the year 2023 [Table/Fig-5]. The values forecasted point towards a decreasing trend in dog bite cases in Delhi predicting 11,317 cases in 2019 and going down to 7120 cases in 2023. Peak of forecasted cases was noted in 2020 with 11,676 cases being predicted.

Trend analysis: Despite the fact that the yearly forecast of dog bites cases showed a sluggishly declining trend for the year 2019-2023 [Table/Fig-5], a quarterly forecast of dog bite cases using ARIMA showed an initial slow increase in the May 2019 quarter followed by a somewhat stationary trend from October 2019 to September 2022. A

seasonal predisposition of dog bite cases was observed where peak in number of cases and subsequent dip was noted [Table/Fig-6].



[Table/Fig-5]: Annual forecast of dog bite cases.



[Table/Fig-6]: Quarterly forecast of dog bite cases.

DISCUSSION

A total of 1,46,344 dog bite cases attended anti rabies clinic of the government hospital in Delhi from 2011 till 2018. This cross-sectional study estimated the seasonal variations and trend analysis of dog bite cases attending the anti rabies clinic. The data for seasonal variation of dog bite cases was available for 8 years i.e., (2011-2018).

It was observed that the frequency of dog bite cases was less in winter months viz., November, December, January. These three months are usually the coldest months of the year. The cause behind the decreased frequency of the dog bite cases in these months may be attributed to decreased outdoor activities of the people, especially during morning hours when dogs are more prone to attack [15]. A similar finding was reported in other studies where a reduction of the dog bite cases in winter months of the year was documented [16]. Saleem SM et al., reported a decrease in cases during winter months and an increase along with the onset of spring [17]. Monroy A et al., observed in their study that dog bite cases peaked during the summer months when people spent more time outdoors [18].

Furthermore, the frequency of dog bite cases increases with the arrival of spring i.e., month of February to April. This can be attributed to the fact that people prefer morning walks with the arrival of spring months and schools start operating after winter breaks, which eventually leads to the increased number of dog bite cases among children and people who go for walks in the morning hours as explained earlier. These findings were also reported in a number of other studies [18-20]. In a previous study by Acharya R et al., January showed highest incidence of 11.11%, and the least cases reported in September (5.81%) [21].

The data for the last 8 years were analysed using trend analysis. There was an increasing trend of dog bite cases over the years. The trend for the upcoming five years was derived. The trend analysis forecasting for 2019, 2020, 2021, 2022 and 2023 showed 11317, 11676, 10157, 8639 and 7120 cases, respectively. This is contrary to the pattern reported by other studies as well [17,22]. The declining trend can be because of the increased vaccination of dogs who are most often responsible for rabies in India [23]. In this context, attention should also be given to the vaccination of dogs against rabies as it can prove to be an essential component of disease control activities. The rationale behind vaccinating dogs against rabies is to institute pre-exposure immunity in animals, thereby protecting them from contracting rabies. Some of the major factors which influence the probability of success of rabies vaccination of dogs include type of vaccine used, number of doses of rabies vaccinations, breed and size of the dog, age at vaccination, and number of days after vaccination when the antibody titres are tested. A booster vaccination regimen has also been recommended for larger breeds of dogs [24].

Limitation(s)

Since the retrieved participant data included in the study was only from one particular government teaching hospital, external validity is limited.

CONCLUSION(S)

Although the dog bite cases will be on a decline in the future, adequate measures need to be strengthened further to sensitise the community about rabies prevention and timely report to anti rabies clinic for prophylaxis. In order to achieve target by 2030, correct information and education regarding rabies prevention needs to be imparted. Municipal administrative policies need to be Improved to contribute to a rabies free community.

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