Short Communication

# Epidemiological and Time Series Analysis of Tuberculosis with Prediction during COVID-19 Pandemic using ARIMA Model: A Study from Churu District of Rajasthan

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## Abstract

As Tuberculosis (TB) is a major public health problem in India and to achieve the goal of TB elimination, it is important to assess the trend of TB cases and the impact of lockdowns and other restrictions imposed for control of COVID-19 in India on the National TB Elimination Programme. Hence, the present study aims to study the temporal trend of TB cases and assess the impact of lockdown on TB detection. A retrospective record-based study was conducted in a tertiary care institute of India. A time series analysis of TB cases from April 2018 to May 2020 was carried out. An Auto-Regressive Integrated Moving Averages (ARIMA) model was used to forecast TB cases during the lockdown period and the result was compared with actual cases detected. The statistical analysis was accomplished with R software. The time series analysis showed that the projected TB cases in April and May 2020 were 67 and 86, respectively, while the observed cases in these months were 35 and 76. The trend of TB cases during the study period showed no steady increase or decrease and the detection of TB has declined during the COVID-19 lockdown period. The TB cases peaked from April to June and males constitute the majority of TB cases.

**Keywords:** COVID-19, India, tuberculosis

## Introduction

Tuberculosis (TB) is the most common infectious disease globally, affecting about ten million people annually, and is amongst the top ten causes of death globally. Geographically, India is the country with the maximum burden of TB cases, that is, 27%, and the burden of drug-resistant TB cases is high.[1] In 2019, there was a record-high notification of 24 lakh cases in India, which was 12% higher compared to 2018.[2] To fight TB and achieve targets set in the context of the Millennium Development Goals, efforts were made at the global level, and between 2000 and 2013 an estimated 37 million lives were saved.[3] After that, for the period 2016–2030, the Sustainable Development Goals (SDGs) and End TB Strategy for the period 2016–2035 were adopted by all World Health Organization (WHO) member states, including India. Under the SDGs, the targets till the year 2030 are a 90% reduction in deaths from TB and an 80% reduction in TB incidence compared with the levels in 2015. To achieve the SDG target for TB it is necessary to expand and intensify TB care services in all the high-burden countries, including India.[1] A novel coronavirus known as Severe Acute Respiratory Syndrome Corona Virus - 2 (SARS CoV-2), identified as the cause of coronavirus disease-19 (COVID-19), was reported from Wuhan, China in December 2019.[4] It spread rapidly across the world and the WHO declared it a pandemic on March 11, 2020.[5] In India, the growth curve of the COVID-19 pandemic shows regional variations.[6] The TB infection may increase susceptibility to COVID-19 and increase its severity.[7] The government of India announced a nationwide lockdown in a phased manner starting on March 25, 2020, to control the spread of COVID-19.[8] The government focused aggressively on controlling COVID-19

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and all other diseases were regarded as of less importance. The COVID-19 pandemic would affect public health programs, such as TB control programs, with serious consequences for known and unknown TB patients, particularly in developing countries where TB is endemic and health infrastructure is inadequate.[9] As TB is a major public health problem in India and to achieve the goal of TB elimination, it is important to assess the trend of TB cases and the impact of lockdown and other restrictions imposed for COVID-19 control in India on the National TB Elimination Programme (NTEP). Hence this study aims to study the temporal trend of TB cases and assess the impact of lockdown on TB detection. It also aims to study the epidemiological profile of TB cases.

## Subjects and Methods

- Study area: This study was conducted in a tertiary care institute in the Churu district. The district of Churu is situated in the Thar Desert region of Rajasthan State of India. It is divided into six blocks, caters to a total population of 2,039,547, and has a population density of 147 people per square kilometer.[10] The Churu district has six TB units (TU) and two cartridge-based nucleic acid amplification test (CBNAAT) sites. The TU Churu was purposively selected, as most cases of TB are reported by this unit, which has a CBNAAT site that is attached to a tertiary care center in Churu.
- Study Design: A retrospective record-based study was conducted by examining records from April 2018 to May 2020.
- Study Population: All TB patients (Pulmonary and Extrapulmonary TB) in the Churu district recorded in the CBNAAT register at TU Churu from April 2018 to May 2020 formed the study population.
- Data Collection: Information from the CBNAAT registers was collected on sputum smear results and CBNAAT results, along with demographic profiles of the patients.
- Data Analyzes: The data were entered in MS Excel by a skilled data entry operator under the observation of one of the investigators and were analyzed using R software and a *P*- value <0.05 was considered statistically significant.[11]

### ARIMA model

The ARIMA model was recommended by Box and Jenkins. It is a time series forecasting model and its general form is as follows: (p, d, q), where p and q represent the orders of auto-regressive (AR) and moving average (MA), respectively, while d represents the order of the differences. A series of monthly TB cases detected during the study period was constructed. The ARIMA model was built in the following stages: First, one of the unit root tests that is, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was used to determine whether the time series is stationary or required differencing. In addition, the stationary sequence should not be a white noise, and it was tested using the Ljung-Box test. Second, the model identification was done using auto.arima() function in R and values of P and q were determined. Third, the evaluation of the model was performed using autocorrelation function (ACF), partial autocorrelation (PACF) of the residuals as well as using Box. Test () to assess whether the residual sequence is white noise (i.e., *P*- value >0.05) that is, it does not contain any information which can be seen by testing the common statistical assumptions about the model residuals such as the mean is zero and the distribution which is normal and stationary.[12]

Fourth, the forecasting of data for the next two months and its comparison with the observed values was done.

- The study was carried out on the routinely gathered and accumulated data only and permission from the authorities concerned was obtained before the actual conduct of the study.

## Results

**Trend of TB cases and forecast of cases:** The confirmed TB cases data from April 2018 to March 2020 was used to execute the time series model fit. The confirmed TB cases identified in the periods from April 2018 to March 2019 and April 2019 to March 2020 were 1010 and 1074, respectively, and the trend of TB cases during the study period showed no steady increase or decrease. A seasonal variation in TB cases with the peak during the months from April to June was observed [Figure 1].

The time series was stationary (KPSS test: test statistic = 0.1273, *P*- value >0.05). In addition, the stationary sequence was not a white noise (*P*- value <0.01, Ljung-Box test). The best-fit model was selected using the auto.arima() function. The ARIMA (0,0,1) was identified as the most appropriate forecasting model and it was used for forecasting TB cases for April and May 2020. Residuals in the fitted ARIMA model were pure random sequences (white noises) as established by the Ljung-Box test (*P*- value >0.05) and residuals were normally distributed and their ACF plot showed all the spikes to be within the significance limits [Figure 2].

The time series sequence chart [Figure 1] shows that the projected TB cases in April 2020 and May 2020 were 67 (95% CI: 31–104) and 86 (95% CI: 40–132), respectively. Fewer TB cases were observed in April and May 2020 than the number of projected cases.

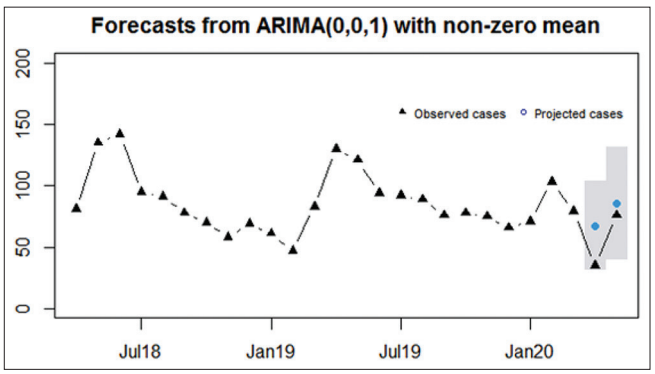


**Figure 1:** Forecast from ARIMA model of TB cases during April and May 2020

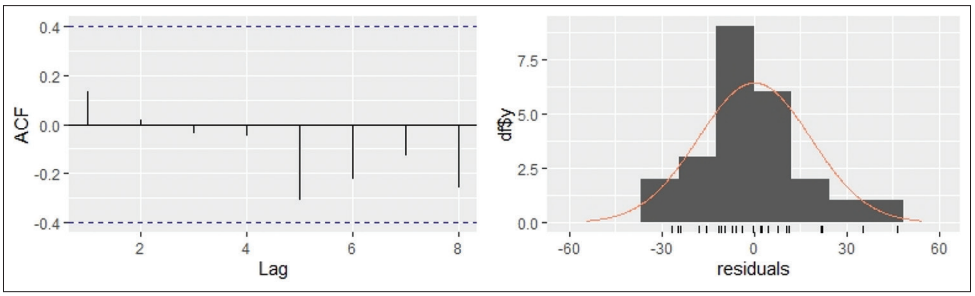


**Figure 2:** Plot of Residuals from ARIMA (0,0,1) model

**Profile of TB cases:** When the TB cases over the entire study duration were categorized according to age groups, it was found that the largest proportion (67.52%) of cases was in the age group of 20–60 years, followed by 20% cases of age above 60 years and those younger than 20 years constituted 12.5%. The majority of female TB patients were young, whereas the majority of male TB patients were old [Figure 3].

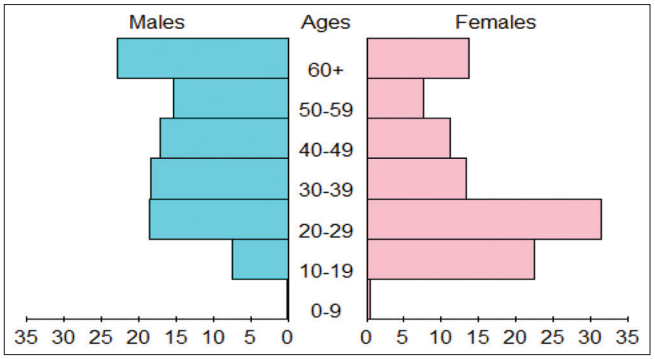


**Figure 3:** Age and gender-wise distribution of TB cases

## Discussion

India aims to achieve the elimination of TB by 2025, but the pandemic situation such as COVID-19 might lead to a change in priority. The Medical College in Churu district is a tertiary care referral center and accounts for 36% of TB notifications. The present study shows a decline in TB detection during the lockdown imposed to control of COVID-19 pandemic. A rapid assessment by the StopTB Partnership showed that during the lockdown period in India, there had been an about 80% decline in daily TB notifications.[13] An article published during the COVID-19 outbreak stated that the identification and treatment of TB and co-infection of TB and COVID-19 are likely to be compromised.[9] According to a study Tuberculosis control programs will be under severe stress owing to shifting of resources, overutilization of TB laboratories, more priority to COVID-19 care, issues related to the availability of human resources for TB care, restriction of the movement of patients and contacts, etc., with drug-resistant TB centers being taken over for COVID-related work due to change in the preferences of health care delivery.[14] People avoid going to hospitals and medical clinics for the apprehension of COVID-19 because of the lack of any personal protective measures and lack of adequate knowledge of COVID-19 infection prevention. The symptoms of COVID-19 and TB such as cough, fever, and breathlessness are similar, which might confuse people. As there is a social stigma associated with TB as well as with COVID-19, people may fear seeking health care if have symptoms that result from Tuberculosis. According to an article both these diseases have social impacts associated with stigma, discrimination, and isolation, as well as an economic impact resulting from loss of productivity and catastrophic costs to families and society.[9]

The present study, which forecasted TB cases during the lockdown period using the Auto ARIMA Model, showed fewer observed TB cases in April and May 2020 than projected cases. There was a decline in notified TB cases during the lockdown period and a sudden rise in the number of cases can be predicted after releasing the restrictions to handle the situation due to COVID-19. This leads to an extra burden on the already exhausted healthcare delivery system in India. This has been suggested in a modelling analysis that globally 6.3 million additional cases of Tuberculosis and 1.4 million additional deaths due to TB between 2020 and 2025 could be there due to a month's lockdown. In India alone, there will be 40,685 additional TB deaths between 2020 and 2025. This report also states that due to the COVID-19 pandemic, the incidence and death due to TB in 2021 will increase to the same level as seen between 2013 and 2016 and this could result in a delay of nearly five to eight years in TB control.[15] An article points out that predicting COVID-19 cases through convenient models may help to explain the potential spread in the country; hence appropriate actions can be taken in preventing the further spread of the disease and the healthcare system can be prepared for better management of the same.[14] More such models need to be implemented for various other diseases so that a major national health program such as NTEP is not affected. With the help of these models, routine services such as notification, diagnosis, and treatment can be carried out without any hindrance.

The present study found that TB cases peak from April to June, which is similar to the results of Thorpe *et al*.,[16] on the assessment of the seasonality of TB in India. They reported that TB cases peaked during April and June. In the present study, we found that males were more commonly affected by TB compared to females, which is similar to India's national

report for TB 2019.[17] Similar results were also found in other studies.[18-24] In the present study TB cases occurred predominantly in the 20–60 years age group; this is similar to India's national report for TB 2019.[17] In the present study, the elderly population (>60 years) was found to be more affected by TB compared to children. This could be due to increased risk among the elderly because of co-existing morbidities and protection among children due to BCG vaccination.[25,26]

### Limitation

The cases of TB diagnosed clinically and some extra-pulmonary cases whose samples could not be collected may have been missing from the study. Since it is a single-center record-based study and the data period is two years, hence findings may not be generalized beyond the study population.

## Conclusion

The trend of TB cases during the study period showed no steady increase or decrease and the detection of TB has declined significantly during the COVID-19 lockdown period. The TB cases peaked from April to June and males constitute the majority of TB cases. Efforts should be made to minimize the effect of epidemics or pandemics on major public health programs like TB.

### Key messages

The trend of TB cases showed no steady increase or decrease during the pre-pandemic period of two years and the seasonal variation was observed with the peak during the months from April to June.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

1. WHO | Global tuberculosis report 2019. World Health Organization. Available from: http://www.who.int/tb/publications/global_report/en/. [Last accessed on 2020 Jul 05].
2. Annual Reports: Central TB Division. Available from: https://tbcindia.gov.in/index1.php?lang=1&level=1&sublinkid=4160&lid=2807. [Last accessed on 2020 Jul 05].
3. The Millennium Development Goals Report 2015 | UNDP in India. UNDP. Available from: https://www.in.undp.org/content/india/en/home/library/mdg/themillennium-development-goals-report-2015.html. [Last accessed on 2020 Aug 10].
4. Lu H, Stratton CW, Tang Y-W. Outbreak of pneumonia of unknown etiology in Wuhan, China: The mystery and the miracle. J Med Virol 2020;92:401-2.
5. WHO Coronavirus Disease (COVID-19) Dashboard. Available from: https://covid19.who.int. [Last accessed on 2020 Jul 05].
6. MoHFW | Home. Available from: https://www.mohfw.gov.in/pdf/GuidelinesforInternationalarrivalsupdatedon10thFebruary2022.pdf. [Last accessed on 2022 Jul 26].
7. Stochino C, Villa S, Zucchi P, Parravicini P, Gori A, Raviglione MC. Clinical characteristics of COVID-19 and active tuberculosis co-infection in an Italian reference hospital. Eur Respir J 2020. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7263070/. [Last accessed on 2020 Jul 05].
8. Soni P. Effects of COVID-19 lockdown phases in India: An atmospheric perspective. Environ Dev Sustain 2021;23:12044-55.
9. Behera D. TB control in India in the COVID era. Indian J Tuberc 2021;68:128-33.
10. Churu District Population Census 2011-2020, Rajasthan literacy sex ratio and density. Available from: https://www.census2011.co.in/census/district/427-churu.html. [Last accessed on 2020 May 01].
11. R Core Team. R: A language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. 2021. Available from: http://www.R-project.org. [Last accessed on 2021 Dec 01].
12. Katoch R, Sidhu A. An application of ARIMA model to forecast the dynamics of COVID-19 epidemic in India. Glob Bus Rev 2021;0972150920988653. doi: 10.1177/0972150920988653
13. We did a rapid assessment: The TB response is heavily impacted by the COVID-19 pandemic. Available from: http://www.stoptb.org/news/stories/2020/ns20_014.html. [Last accessed on 2020 Jul 05].
14. Malavika B, Marimuthu S, Joy M, Nadaraj A, Asirvatham ES, Jeyaseelan L. Forecasting COVID-19 epidemic in India and high incidence states using SIR and logistic growth models. Clin Epidemiol Glob Health 2021;9:26-33.
15. Stop TB Partnership, Imperial College, Avenir Health, Johns Hopkins University, and USAID. The potential impact of the COVID-19 response on tuberculosis in high-burden countries: A modelling analysis. Available from: www.stoptb.org/assets/documents/news/Modeling%20Report_1%20May%202020_FINAL.pdf. [Last accessed on 2020 Jul 28].
16. Thorpe LE, Frieden TR, Laserson KF, Wells C, Khatri GR. Seasonality of tuberculosis in India: Is it real and what does it tell us? Lancet 2004;364:1613-4.
17. Central TB Division, Ministry of health and Family Welfare. India TB Report 2019.pdf. Available from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiPu4iH5o_rAhXwxzgGHRWnDlYQFjAEegQIARAB&url=https%3A%2F%2Ftbcindia.gov.in%2FWriteReadData%2FIndia%2520TB%2520Report%25202019.pdf&usg=AOvVaw3rSanmU6O4TAX0_OKAKJaf. [Last accessed on 2020 Aug 10].
18. Rao S. Tuberculosis and patient gender: An analysis and its implications in tuberculosis control. Lung India Off Organ Indian Chest Soc 2009;26:46-7.
19. Holmes CB, Hausler H, Nunn P. A review of sex differences in the epidemiology of tuberculosis. Int J Tuberc Lung Dis Off J Int Union Tuberc Lung Dis 1998;2:96-104.
20. Borgdorff MW, Nagelkerke NJ, Dye C, Nunn P. Gender and tuberculosis: A comparison of prevalence surveys with notification data to explore sex differences in case detection. Int J Tuberc Lung Dis Off J Int Union Tuberc Lung Dis 2000;4:123-32.
21. Horton KC, Hoey AL, Béraud G, Corbett EL, White RG. Systematic review and metaa-nalysis of sex differences in social contact patterns and implications for tuberculosis transmission and control. Emerg Infect Dis 2020;26:910-9.
22. Connolly M, Nunn P. Women and tuberculosis. World Health Stat Q Rapp Trimest Stat Sanit Mond 1996;49:115-9.
23. Hamid Salim MA, Declercq E, Van Deun A, Saki KAR. Gender differences in tuberculosis: A prevalence survey done in Bangladesh. Int J Tuberc Lung Dis 2004;8:952-7.
24. Jappar SB, Low SY. Tuberculosis trends over a five-year period at a tertiary care university-affiliated hospital in Singapore. Singapore Med J 2015;56:502-5.
25. Rajagopalan S, Yoshikawa TT. Tuberculosis in the elderly. Z Für Gerontol Geriatr 2000;33:374-80.
26. Lanckriet C, Lévy-Bruhl D, Bingono E, Siopathis RM, Guérin N. Efficacy of BCG vaccination of the newborn: Evaluation by a follow-up study of contacts in Bangui. Int J Epidemiol 1995;24:1042-9.