Review Article

The impact of COVID-19 on tuberculosis in most populated state of India: A geospatial meta-analysis

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Abstract

Background: Tuberculosis is one of the major burdens to developing nations. India is among the countries categorized by the World Health Organization (WHO) as experiencing a significant burden of TB, HIV-associated TB, and MDR/RR-TB within the context of low- and middle-income nations. Globally South East Asian and African region alone accounted for 82% of death (HIV negative), where India accounts for 36% of TB fatalities. **Materials and Methods:** The data was extracted from NIKSHAY web portal on TB notification cases in UP, India. The random effects meta-analysis was performed to estimate pooled proportion of TB cases in public and private notified during both the periods. Spatial analysis was used to display the spread of TB cases across the state, during both the periods. **Results:** A total 75 districts data on TB notified cases were available for current investigation. The pooled proportion of TB cases were 0.24 (0.21, 0.27) and 0.76 (0.73, 0.79) during COVID-19 period for private and public hospitals, respectively. Similarly, the pooled proportion of TB cases were 0.26 (0.23, 0.29) and 0.74 (0.71, 0.77) post-COVID-19 for private and public hospitals, respectively. **Conclusion:** The proportion of TB cases were more in public hospital as compared to private hospitals during COVID-19 period. Similarly, result was obtained in post-COVID-19 period.

Keywords: COVID-19, infectious diseases, meta-analysis, spatial analysis, tuberculosis

Background

Tuberculosis is the first infectious disease to be identified in history[1] that originates from the genus Mycobacterium.[2] Mycobacterium tuberculosis is the communicable disease that majorly affects pulmonary and extrapulmonary parts of body.[3] The Mycobacterium tuberculosis has exceptionally potent pathogen that has caused morbidity and mortality worldwide, accounting 9.6 million new cases.[4] Tuberculosis spreads through bronchial tree (bronchogenic spread) lymphatics or blood stream, lymph-haematogenous spread and intracanalicular spread (e.g., bronchi to trachea to larynx to gastro intestinal tract). The M. Bacterium mainly induced through inhalation of bacilli containing droplet nuclei and polymorphonuclear granulocytes and alveolar macrophages absorb but it outlives.[5] The risk factors associated with TB infection are patient factor (recipient), pathogens factor and environmental factor.[6] Undernutrition, alcohol use, disorder, smoking, diabetes and HIV are the major causes of getting affected from the infection.[7] The disease recurrently happens more inside the household or within the community, resulting into lopsided spatial patterns over the specific region. The population variation has significant impact on its areal clustering, reflecting continuous transmission and co-location of risk factors for spread of tuberculosis.[8]

Tuberculosis is one of the major burdens to developing nations. Majorly population with TB infection found in low- and middle-income countries.[7] Southeast Asian and African region alone accounts for 82% of death (HIV negative), where India accounts for 36% of TB fatalities. According to WHO there

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is 8.6% increase in TB related deaths from 2015 to 2020 in Southeast Asian and 6.6% increase in India[9] The infection is significant in the areas with a high proportion of the population, and it can be a challenge with latent TB infection among millions of people which can reoccur at any moment of time.[10]

The spread of COVID-19 became the biggest encounter of 2020, as it has impacted the treatment of tuberculosis patient, its investigation and prevention because of the lockdown.[11] There has been downturn in diagnosis of people with TB during COVID-19 globally from pretrend of 2020.[7] Tuberculosis cases supersede leaving behind the previous reported cases, and there is an increase in the mortality due to Tuberculosis, as there is interruption caused by COVID-19.[12] The TB notification cases as per the daily record from NIKSHAY portal of Health Ministry of India reveals that there is a drastic decrease in the notification of TB cases during COVID outbreak and the period of lockdown.[13] So as to maintain an adequate and consistent high-quality service of healthcare facility, it is essential to address the gap and need of region in combatting the Tuberculosis disease.[14] Efficient strategy to control together with socio-economic development while considering low- and moderate-income countries the disease is still a biggest health crisis yet to be resolved.[15] We did investigation to estimate the pooled prevalence of TB in Uttar Pradesh, notified during and after pandemic, in private and public hospitals simultaneously. Additionally, the significant difference between during and post-COVID-19 period was checked in private and public hospitals separately. Also, the trends in TB reported cases in 75 districts of TB were checked, during and after pandemic separately.

Materials and Methods

Data sources

The data for TB notification cases are collected by the Ministry of Health and Family Welfare NIKSHAY web portal, from the period of lockdown to July 2023 (for Uttar Pradesh). The population density of U.P. district has been collected from Census of India and the availability of doctors per district discussed in relation to notified cases in district acquired from Department of Medical Health and Family Welfare.

Study setting

The selected region for the study is Uttar Pradesh, India. The state is most fertile region and well-irrigated land, attracting high population. UP has the highest number cases of TB. The notification rate per 1,00,000:230 in UP is highest among all the states of India. UP accounts for 7,54,533 doctors and availability of 3,388 Public Hospital Centres with highest number in Prayagraj and lowest in Shrawasti.

Outcome

The proportion of TB cases notified in public hospitals and private hospitals during COVID-19 period and post-COVID-19 period, respectively.

Statistical analysis

We used z-proportion test to check the statistically significant difference between proportions of TB cases in public notified during COVID-19 and public notified post-COVID-19 period, in 75 districts of UP. We used P value <0.05 as a threshold for significance, i.e., if P value is less than 0.05, the result is statistically significant. Similarly, the same test is used to compare the proportions of private notified cases of TB during COVID-19 and private notified cases of TB post-COVID-19 period, of same places. We used the technique of meta-analysis to estimate the pooled proportion of public notified and private notified cases of TB during COVID-19 and post-COVID-19 period separately. The Q-statistic and I^2-statistic were used to identify heterogeneity between proportions of TB cases reported by districts of UP. If the degree of heterogeneity in effect size was significantly high (i.e., $I^2 > 30\%$), random effect model was used; otherwise, fixed effect model is used.[16]

We constructed forest plots which displayed individual proportions of each district (along with 95% CI) and pooled proportion at the end of graph (along with its 95% CI). We constructed line diagram was to compare the trend between public notified and private notified cases of TB during COVID-19 and post-COVID-19 separately.

We also used Arc GIS to map the spatial distribution of the notified cases in public and private hospitals. Here, dot density has been used for representing proportion of cases during the COVID-19 and post-COVID-19 period (in both public and private). Choropleth method used to show density of population depicted by intensity of colour in district of U.P. giving the clear picture of the expanse of the notification of tuberculosis. The density has been divided into five classes from the very high to very low density of population shown merged with layer of notification of TB cases during the time of COVID-19 and post-COVID-19 period in public and private hospitals in overall Uttar Pradesh.

Results

Trends in TB cases

The trend line [Figure 1a] was made for the TB cases reported in private vs public hospital during COVID-19. The trend line suggests that notified cases of TB were more in public hospitals as compared to private hospitals. Similarly, the trend line [Figure 1b] was made for the TB cases reported in private vs public hospital post-COVID-19. Here, the trend line suggests that notified cases of TB were more in public hospitals as compared to private hospitals.

Proportion dissimilarity

We observed significant difference between 65 number of districts of UP, in public hospitals during COVID-19 and post-COVID-19 period, whereas 10 districts of state have shown no significant difference for same period in public

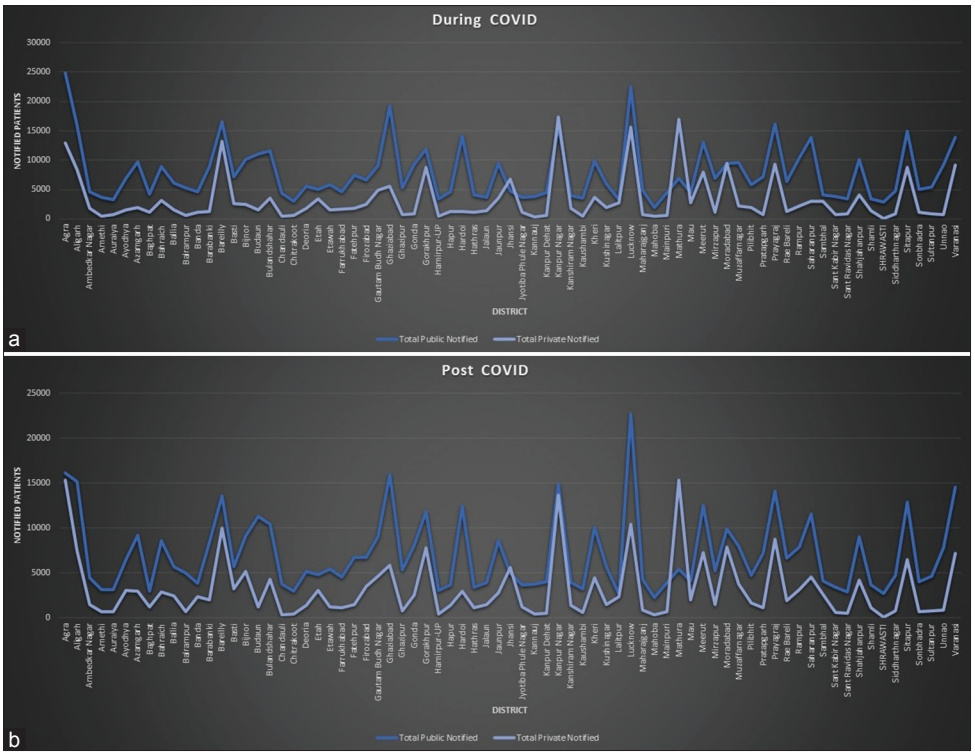

Figure 1: Trend lines between private notified patients vs public notified patients of TB (a) during COVID-19 and (b) post-COVID-19

hospitals. Similarly, 69 and 06 districts have shown significant difference and no significant difference in proportion of TB cases reported from private hospitals cases before COVID-19 and post-COVID-19. Tables 1 and 2 show the proportions and comparisons of all districts.

Meta-analysis of TB cases during COVID-19

The heterogeneity between proportion of different districts was statistical significance (*P* value <05). The I^2 obtained for private and public (both) notified cases of TB during COVID-19 period was 100%; therefore, we used random-effects model to estimate the pooled proportion of TB cases during COVID-19. The pooled proportion of TB cases in private notified during COVID-19 was 0.24 with 95% CI 0.21 to 0.27. Similarly, the pooled proportion of TB cases in public notified during COVID-19 was 0.76 with 95% CI 0.73 to 0.79. The forest plots [Figure 2a and b] display the result of current meta-analysis.

Meta-analysis of TB cases post-COVID-19

The heterogeneity between proportion of TB cases for different districts was statistical significance (*P* value <05). The I^2 obtained for private and public (both) notified cases of TB post-COVID-19 period was 100%; therefore, we used random-effects model to estimate the pooled proportion of TB cases post-COVID-19. The pooled proportion of TB cases in private notified post-COVID-19 was 0.26 with 95% CI 0.23 to 0.29. Similarly, the pooled proportion of TB cases in public notified post-COVID-19 was 0.74 with 95% CI 0.71 to 0.7. The forest plots [Figure 3a and b] display the result of current meta-analysis. The detail result is penned in Table 3.

Spatial pattern in public hospitals during COVID-19 vs post-COVID-19 period

The maximum concentration of TB patients could be seen in western and eastern part of U.P. and the concentration of dots spatially fluctuate slightly depicting the increase in the notification in post-COVID-19 period [Figure 4]. Districts in western border and patches around the capital city Lucknow have high dot density, during lockdown. In eastern region, moderate-to-high-density population thrive where high concentration also be found in Sant Ravidas Nagar and Varanasi. While Mahoba, Shrawasti, Chitrakoot, Lalitpur, Auraiya having the lowest cases (during lockdown) count. While in post-COVID-19 Lucknow, Agra, Ghaziabad, Aligarh, Kanpur Nagar with highest number and Mahoba, Lalitpur, Shrawasti, Sant Ravidas Nagar, Chitrakoot, Baghpat having the lower notification.

Spatial pattern in private hospitals during COVID-19 vs post-COVID-19 period

The number of cases is comparatively low in private hospitals. The concentration of cases in private hospitals shows more disperse dots density [Figure 5]. Concentration in patches could be seen all over U.P. which include district like Kanpur, Mathura, Lucknow, Bareilly, Agra, Moradabad, Prayagaraj, Varanasi during COVID-19 with higher dot density and Shrawasti, Kannauj, Mahoba, Chandauli, Hamirpur lowest number of cases observed (during lockdown) and similar concentration with slight change could

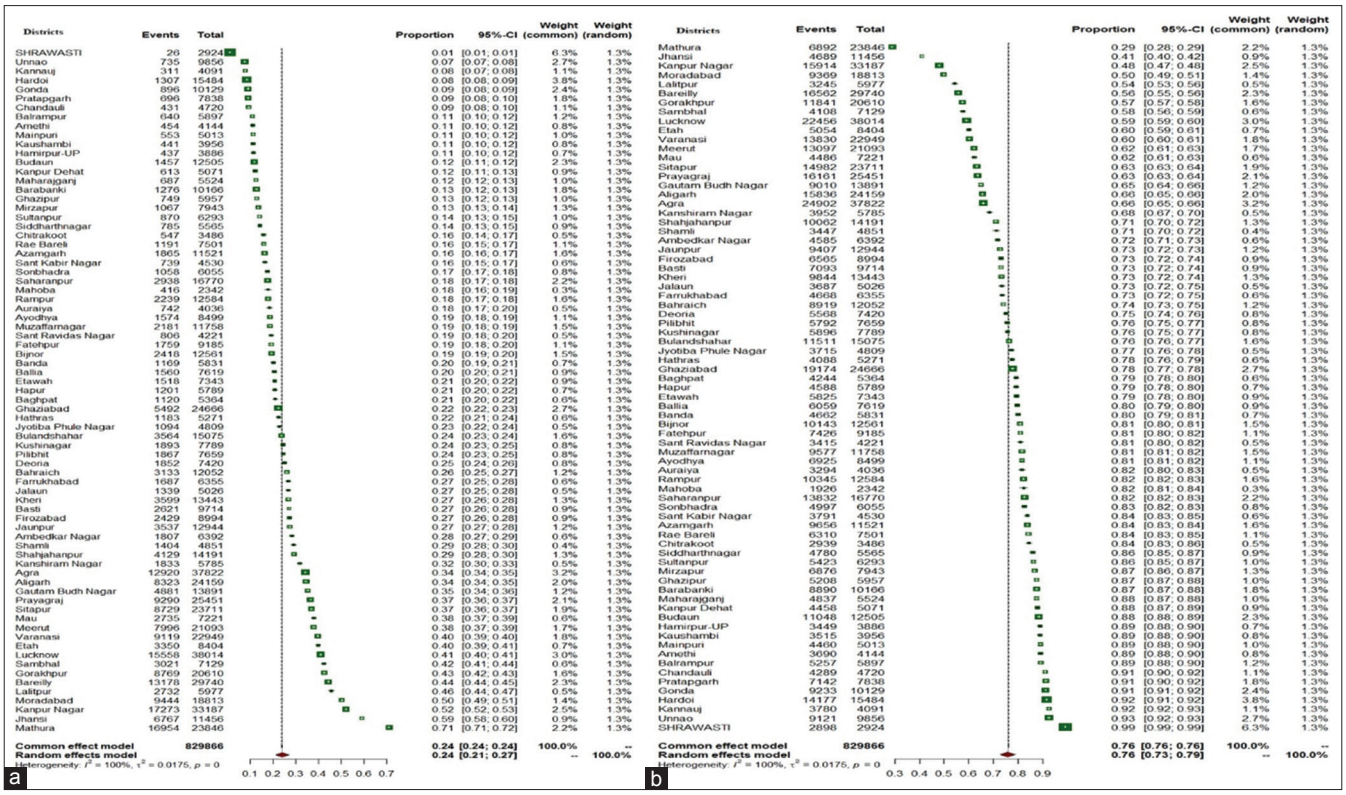

Figure 2: Forest plot for proportion (with 95% CI) of TB patients during COVID-19 in (a) private notified and (b) public notified

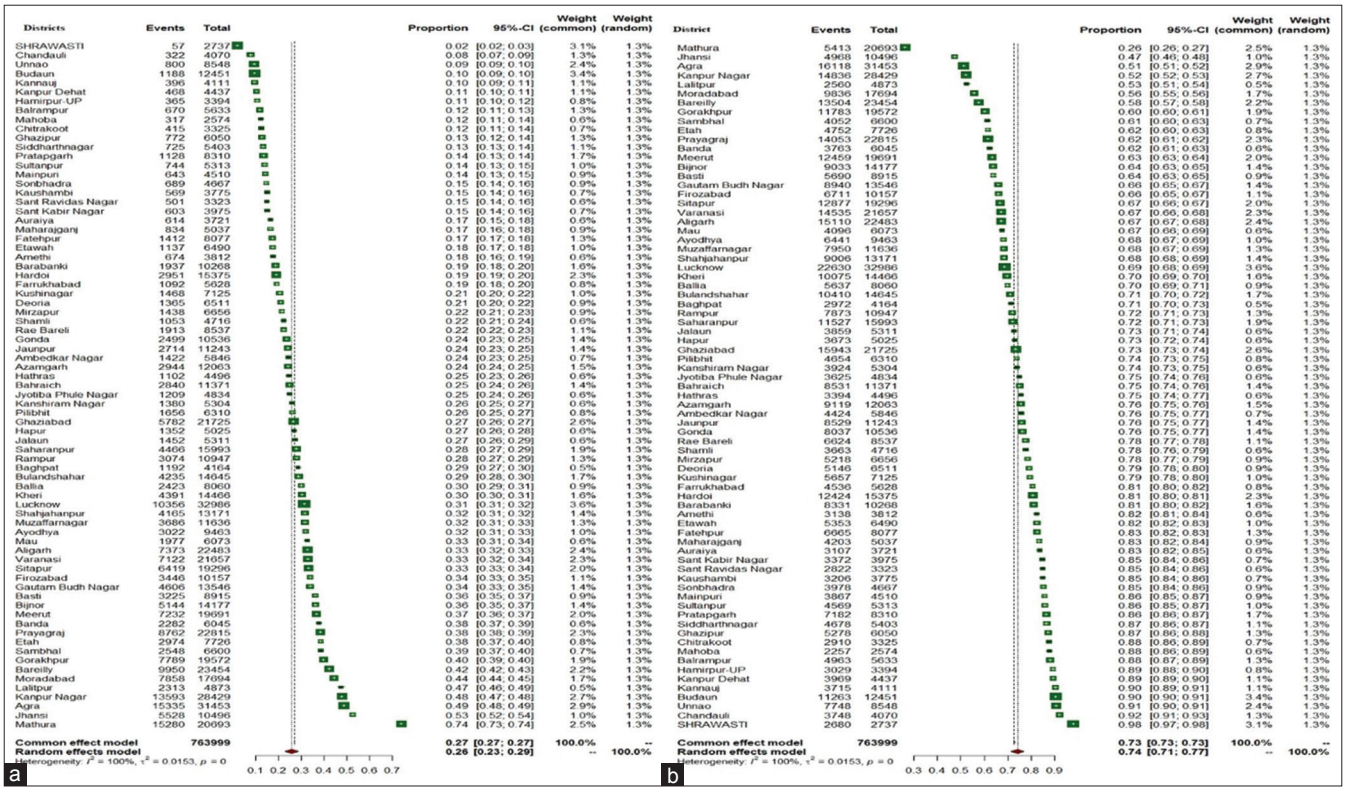

Figure 3: Forest plot for proportion (with 95% CI) of TB patients post-COVID-19 in (a) private notified and (b) public notified

be seen in Agra, Mathura, Lucknow, Kanpur, Bareilly, Prayagraj, Moradabad with a greater number of cases. Whereas in Shrawasti, Mahoba, Chandauli, Hamirpur, Kannauj and Chitrakoot, lowest notification is observed (post-COVID-19 period).

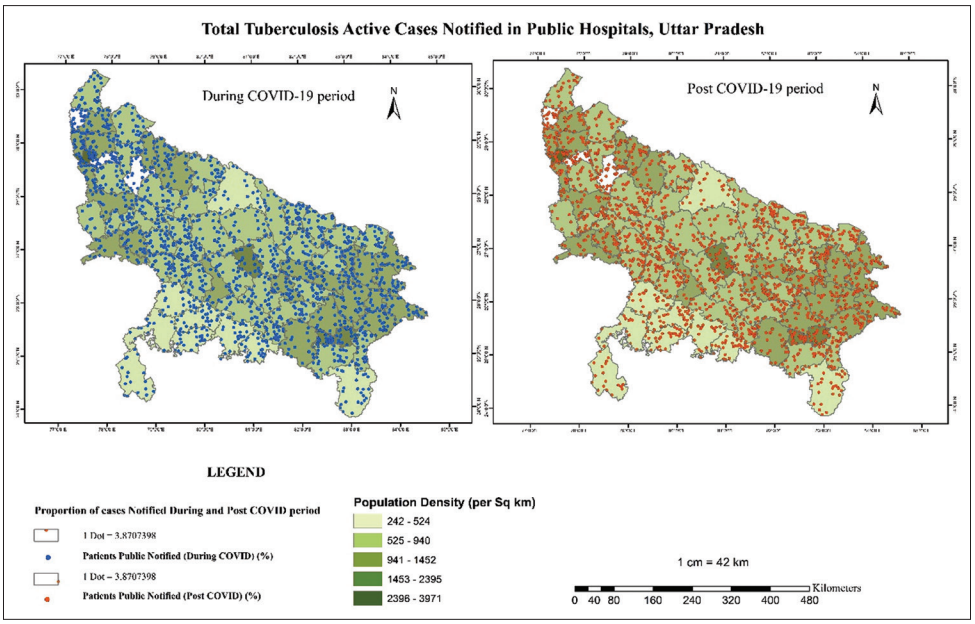

Figure 4: Spatial distribution of proportion of TB cases notified in public hospitals

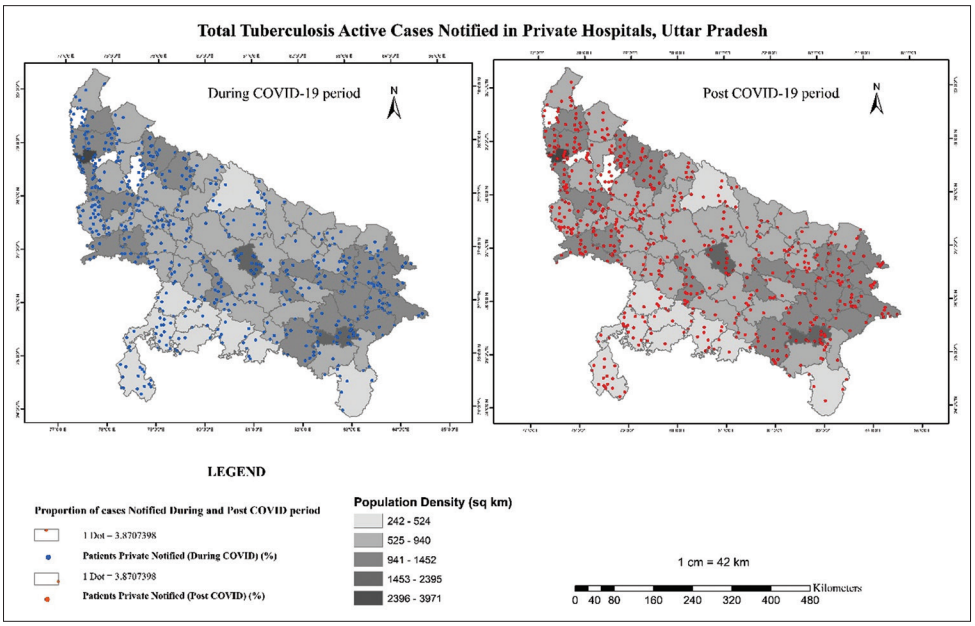

Figure 5: Spatial distribution of proportion of TB cases notified in private hospitals

Discussion

The trend of TB cases reported during both the period are more in public hospitals as compared to private hospitals. The 65 districts have shown significant difference between proportion of TB cases during COVID-19 and post-COVID-19 period in public hospitals. Similarly, the districts which have shown significant difference between proportion of TB cases during COVID-19 vs post-COVID-19 from private hospitals were 69. The pooled proportion of TB cases during COVID-19 from public hospitals were 0.76 (0.73 to 0.79) and private hospitals were 0.24 (0.21, 0.77). Similarly, the pooled proportion TB cases post-COVID-19 from public hospitals were 0.74 (0.71, 0.77), and private hospitals were 0.26 (0.23, 0.29).

The conjectures to understand the effect of COVID-19 on TB cases are: first, TB is bacterial disease, whereas COVID-19 is viral disease. Both the respective diseases effects lungs (primarily) disturbing the respiratory system of body. The cough, fever and difficulty in breathing are common symptoms in both conditions.[17] Second, the transmission occurs through close contacts with infected persons in both conditions.[18,19] Only symptomatic patients with fertile cough are the main source of TB infection, on other hand symptomatic or asymptomatic

Table 1: Comparison of proportion of TB patient's public notified during COVID and post-COVID in the districts of Uttar Pradesh

Districts	Patients Public Notified (During COVID) (%)	Patients Public Notified (Post-COVID) (%)	*P*
Agra	24902 (65.8)	16118 (51.2)	<0.05
Aligarh	15836 (65.5)	15110 (67.2)	<0.05
Ambedkar Nagar	4585 (71.1)	4424 (75.6)	<0.05
Amethi	3690 (89.1)	3138 (82.3)	<0.05
Auraiya	3294 (81.6)	3107 (83.4)	0.03
Ayodhya	6925 (81.4)	6441 (68.1)	<0.05
Azamgarh	9656 (83.8)	9119 (75.5)	<0.05
Baghpat	4244 (79.1)	2972 (71.3)	<0.05
Bahraich	8919 (74.1)	8531 (75.1)	0.07
Ballia	6059 (79.5)	5637 (69.9)	<0.05
Balrampur	5257 (89.1)	4963 (88.1)	0.08
Banda	4662 (79.9)	3763 (62.2)	<0.05
Barabanki	8890 (87.4)	8331 (81.1)	<0.05
Bareilly	16562 (55.6)	13504 (57.5)	<0.05
Basti	7093 (73.1)	5690 (63.8)	<0.05
Bijnor	10143 (80.7)	9033 (63.7)	<0.05
Budaun	11048 (88.3)	11263 (90.4)	<0.05
Bulandshahar	11511 (76.3)	10410 (71.1)	<0.05
Chandauli	4289 (90.8)	3748 (92.1)	0.04
Chitrakoot	2939 (84.3)	2910 (87.5)	<0.05
Deoria	5568 (75.1)	5146 (79.1)	<0.05
Etah	5054 (60.1)	4752 (61.5)	0.07
Etawah	5825 (79.3)	5353 (82.4)	<0.05
Farrukhabad	4668 (73.4)	4536 (80.5)	<0.05
Fatehpur	7426 (80.8)	6665 (82.5)	<0.05
Firozabad	6565 (72.9)	6711 (66.1)	<0.05
Gautam Budh Nagar	9010 (72.9)	8940 (66.1)	<0.05
Ghaziabad	19174 (77.7)	15943 (73.3)	<0.05
Ghazipur	5208 (87.4)	5278 (87.2)	0.77
Gonda	9233 (91.1)	8037 (76.2)	<0.05
Gorakhpur	11841 (57.4)	11783 (60.2)	<0.05
Hamirpur	3449 (88.7)	3029 (89.2)	0.52
Hapur	4588 (79.2)	3673 (73.1)	<0.05
Hardoi	14177 (91.5)	12424 (80.8)	<0.05
Hathras	4088 (77.5)	3394 (75.4)	0.01
Jalaun	3687 (73.3)	3859 (72.6)	0.43
Jaunpur	9407 (72.6)	8529 (75.8)	<0.05
Jhansi	4689 (40.9)	4968 (47.3)	<0.05
Jyotiba Phule Nagar	3715 (77.2)	3625 (74.9)	<0.05
Kannauj	3780 (92.3)	3715 (90.3)	<0.05
Kanpur Dehat	4458 (87.9)	3969 (89.4)	0.01
Kanpur Nagar	15914 (47.9)	14836 (52.1)	<0.05
Kanshiram Nagar	3952 (68.3)	3924 (73.9)	<0.05
Kaushambi	3515 (88.8)	3206 (84.9)	<0.05
Kheri	9844 (73.2)	10075 (69.6)	<0.05
Kushinagar	5896 (75.6)	5657 (79.3)	<0.05
Lalitpur	3245 (54.2)	2560 (52.5)	0.07
Lucknow	22456 (59.1)	22630 (68.6)	<0.05
Maharajganj	4837 (87.5)	4203 (83.4)	<0.05
Mahoba	1926 (82.2)	2257 (87.6)	<0.05
Mainpuri	4460 (88.9)	3867 (85.7)	<0.05
Mathura	6892 (28.9)	5413 (26.1)	<0.05
Mau	4486 (62.1)	4096 (67.5)	<0.05
Meerut	13097 (62.1)	12459 (63.2)	0.01
Mirzapur	6876 (86.5)	5218 (78.3)	<0.05
Moradabad	9369 (49.8)	9836 (55.5)	<0.05
Muzaffarnagar	9577 (81.4)	7950 (68.3)	<0.05
Pilibhit	5792 (75.6)	4654 (73.7)	0.01
Pratapgarh	7142 (91.1)	7182 (86.4)	<0.05
Prayagraj	16161 (63.4)	14053 (61.5)	<0.05
Rae Bareli	6310 (84.1)	6624 (77.5)	<0.05
Rampur	10345 (82.2)	7873 (71.9)	<0.05
Saharanpur	13832 (82.4)	11527 (72.1)	<0.05
Sambhal	4108 (57.6)	4052 (61.3)	<0.05
Sant Kabir Nagar	3791 (83.6)	3372 (84.8)	0.15
Sant Ravidas Nagar	3415 (80.9)	2822 (84.9)	<0.05
Shahjahanpur	10062 (70.9)	9006 (68.3)	<0.05
Shamli	3447 (71.1)	3663 (77.6)	<0.05
SHRAWASTI	2898 (99.1)	2680 (97.9)	<0.05
Siddharthnagar	4780 (85.8)	4678 (86.5)	0.31
Sitapur	14982 (63.1)	12877 (66.7)	<0.05
Sonbhadra	4997 (82.5)	3978 (85.2)	<0.05
Sultanpur	5423 (86.1)	4569 (85.9)	0.81
Unnao	9121 (92.5)	7748 (90.6)	<0.05
Varanasi	13830 (60.2)	14535 (67.1)	<0.05

patients both can be source of COVID-19.[18,19] Third, incubation period is of 05 days for COVID-19,[20] whereas for TB it is for several month to two years.[21]

Fourth, the lockdown resulting due to COVID-19, to stop community wide spread of COVID-19 may open the door for household transmission for TB. One of the major risk factors for TB is prolong contact at household level.[22] Cillioni *et al.* 2020[23] predicted for 5 years that 3 months of lockdown has increases 1.65 million TB cases and 438.000 mortality due to TB in India. Fifth, children living with adults infected with TB has shown higher prevalence of TB.[24,25] Household transmission of TB have been increased.[24,25] Sixth, the distribution of routine services to TB patients has increase drastically due to all focus towards COVID-19. The negligence towards TB is due to over coverage or importance to COVID-19 from policymakers. The stress and anxiety have increased drastically in healthcare workers, leading to poor quality care of TB patients. Seventh, the discouragement to people to visit TB centres due to fear created by COVID-19, leading to delay in health services. Late diagnosis and treatment of TB will lead to increase in its transmission and TB programmes will continue facing major problems from late diagnosis and inappropriate treatments. Eight, the seminars, workshops, and annual conferences for exchange of TB research and information were not conducted due to lockdown. The negative effect on BCG vaccination program (for prevention of

Table 2: Comparison of proportion of TB patients private notified during COVID and post-COVID in the districts of Uttar Pradesh

Districts	Patients Private Notified (During COVID) (%)	Patients Private Notified (Post-COVID) (%)	*P*
Agra	12920 (34.1)	15335 (48.7)	<0.05
Aligarh	8323 (34.4)	7373 (32.7)	<0.05
Ambedkar Nagar	1807 (28.2)	1422 (24.3)	<0.05
Amethi	454 (10.9)	674 (17.6)	<0.05
Auraiya	742 (18.3)	614 (16.5)	0.03
Ayodhya	1574 (18.5)	3022 (31.9)	<0.05
Azamgarh	1865 (16.1)	2944 (24.4)	<0.05
Baghpat	1120 (20.8)	1192 (28.6)	<0.05
Bahraich	3133 (25.9)	2840 (24.9)	0.07
Ballia	1560 (20.4)	2423 (30.1)	<0.05
Balrampur	640 (10.8)	670 (11.8)	0.08
Banda	1169 (20.1)	2282 (37.7)	<0.05
Barabanki	1276 (12.5)	1937 (18.8)	<0.05
Bareilly	13178 (44.3)	9950 (42.4)	<0.05
Basti	2621 (26.9)	3225 (36.1)	<0.05
Bijnor	2418 (19.2)	5144 (36.2)	<0.05
Budaun	1457 (11.6)	1188 (9.5)	<0.05
Bulandshahar	3564 (23.6)	4235 (28.9)	<0.05
Chandauli	431 (9.1)	322 (7.9)	0.04
Chitrakoot	547 (15.6)	415 (12.4)	<0.05
Deoria	1852 (24.9)	1365 (20.9)	<0.05
Etah	3350 (39.8)	2974 (38.4)	0.07
Etawah	1518 (20.6)	1137 (17.5)	<0.05
Farrukhabad	1687 (26.5)	1092 (19.4)	<0.05
Fatehpur	1759 (19.1)	1412 (17.4)	<0.05
Firozabad	2429 (27)	3446 (33.9)	<0.05
Gautam Budh Nagar	4881 (35.1)	4606 (34)	0.5
Ghaziabad	5492 (22.2)	5782 (26.6)	<0.05
Ghazipur	749 (12.5)	772 (12.7)	0.77
Gonda	896 (8.8)	2499 (23.7)	<0.05
Gorakhpur	8769 (42.5)	7789 (39.7)	<0.05
Hamirpur	437 (11.2)	365 (10.7)	0.52
Hapur	1201 (20.7)	1352 (26.9)	<0.05
Hardoi	1307 (8.4)	2951 (19.1)	<0.05
Hathras	1183 (22.4)	1102 (24.5)	0.01
Jalaun	1339 (26.6)	1452 (27.3)	0.43
Jaunpur	3537 (27.3)	2714 (24.1)	<0.05
Jhansi	6767 (59.1)	5528 (52.6)	<0.05
Jyotiba Phule Nagar	1094 (22.7)	1209 (25.1)	<0.05
Kannauj	311 (7.6)	396 (9.6)	<0.05
Kanpur Dehat	613 (12.1)	468 (10.5)	0.01
Kanpur Nagar	17273 (52.1)	13593 (47.8)	<0.05
Kanshiram Nagar	1833 (31.6)	1380 (26.1)	<0.05
Kaushambi	441 (11.1)	569 (15.1)	<0.05
Kheri	3599 (26.7)	4391 (30.3)	<0.05
Kushinagar	1893 (24.3)	1468 (20.6)	<0.05
Lalitpur	2732 (45.7)	2313 (47.4)	0.07
Lucknow	15558 (40.9)	10356 (31.3)	<0.05
Maharajganj	687 (12.4)	834 (16.5)	<0.05
Mahoba	416 (17.7)	317 (12.3)	<0.05
Mainpuri	553 (11.1)	643 (14.2)	<0.05
Mathura	16954 (71.1)	15280 (73.8)	<0.05
Mau	2735 (37.8)	1977 (32.5)	<0.05
Meerut	7996 (37.9)	7232 (36.7)	0.01
Mirzapur	1067 (13.4)	1438 (21.6)	<0.05
Moradabad	9444 (50.1)	7858 (44.4)	<0.05
Muzaffarnagar	2181 (18.5)	3686 (31.6)	<0.05
Pilibhit	1867 (24.3)	1656 (26.2)	0.01
Pratapgarh	696 (8.8)	1128 (13.5)	<0.05
Prayagraj	9290 (36.5)	8762 (38.4)	<0.05
Rae Bareli	1191 (15.8)	1913 (22.4)	<0.05
Rampur	2239 (17.7)	3074 (28.1)	<0.05
Saharanpur	2938 (17.5)	4466 (27.9)	<0.05
Sambhal	3021 (42.3)	2548 (38.6)	<0.05
Sant Kabir Nagar	739 (16.3)	603 (15.1)	0.15
Sant Ravidas Nagar	806 (19.1)	501 (15.1)	<0.05
Shahjahanpur	4129 (29.1)	4165 (31.6)	<0.05
Shamli	1404 (28.9)	1053 (22.3)	<0.05
SHRAWASTI	26 (0.8)	57 (2.1)	<0.05
Siddharthnagar	785 (14.1)	725 (13.4)	0.31
Sitapur	8729 (36.8)	6419 (33.2)	<0.05
Sonbhadra	1058 (17.4)	689 (14.7)	<0.05
Sultanpur	870 (13.8)	744 (14.1)	0.81
Unnao	735 (7.4)	800 (9.3)	<0.05
Varanasi	9119 (39.7)	7122 (32.8)	<0.05

Table 3: Pooled proportion of TB cases during and post-COVID-19 by technique of meta-analysis

Hospitals	During COVID-19 period	Post-COVID-19 period
Public Hospitals	0.76 (0.73, 0.79)	0.74 (0.71, 0.77)
Private Hospitals	0.24 (0.21, 0.77)	0.26 (0.23, 029)

childhood TB) was observed due to COVID-19.[12] The testing, diagnostic, shortages of resources, etc. for TB programmes and cases of TB are affected negatively due to diversion of forces (like government, public, health professionals, etc.) due to COVID-19. Finally, The COVID-19 causing pneumonia and respiratory failure increases the risk of TB[26] as the respiratory system is damaged for long period. As HIV and influenza (virus-related issues) play important role in spread of TB; hence, it may be inferred COVID-19 may also plays similar role in development of TB.

Managing tuberculosis (TB) while dealing with COVID-19 can be difficult due to the similarities in signs and symptoms between the two diseases. Since SARS-CoV-2 affects the respiratory system, and there is no specific therapy for it, drugs are used to reduce viral load and alleviate inflammation. Corticosteroid therapy (CST) is also used for COVID-19, but it poses a risk of reactivation of latent tuberculosis and secondary infection.[27,28]

Both the diseases present with respiratory symptoms like shortness of breath, cough, and chest pain, highlighting the significance of diagnostic testing as COVID patients experience dry cough and TB patients have a productive cough with sputum production, as COVID-19 have a relatively higher proportion of concurrent active pulmonary tuberculosis.[28,29] Kim *et al.* 2008[30] stated in their paper that COVID causes pneumonia and respiratory failure, and the mortality rate reported in patients with acute respiratory failure.[30]

The major limitations of the current investigation are it has only focused on the single state of India (UP). Hence, further investigation should be performed by including more states of India to get a clear picture on proportion of TB cases during COVID-19 vs post-COVID-19. Also, the current investigation has used descriptive statistics, i.e., it is a descriptive phenomenon. Hence, further investigation must be conducted using statistics like odds ratio (OR) to check the risk of COVID-19 in TB cases. The meta-regression technique was not applied, which can identify a significant predictor effecting the proportion of TB cases during mentioned periods. Hence, the predictors like sex ratio, co-morbidity, etc. should be considered and meta-regression technique should be applied. The subgroup meta-analysis should also be performed by dividing the districts into high and low population density areas, etc. to get a clearer scenario.

Conclusion

The study found significant difference for public notified cases of TB during COVID-19 and post-COVID-19 in various districts of Uttar Pradesh. The pooled proportion of TB cases in private notified during COVID-19 was 0.24 with 95% CI 0.21 to 0.27, while the pooled proportion of TB cases in public notified during COVID-19 was 0.76 with 95% CI 0.73 to 0.79.

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Conflicts of interest

There are no conflicts of interest.

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