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What is the impact of COVID-19 era on annual tuberculosis notifications in India? A comparative study (2017-2022)

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Abstract

Globally Tuberculosis (TB) is 13th leading cause of mortality and the 2nd leading infectious killer after COVID-19, 1.6 million people died in 2021 from TB (including 187 000 people with HIV). The emergence of COVID-19 pandemic situations on the already overburdened health care system of India may have affected new TB cases notification as well as treatment, setting back the previous achievements made to eliminate TB by 2025. Lockdown-induced under-reporting (80% reduction in TB notification rates) of active TB will affect TB epidemiology as well as NTEP (National Tuberculosis Elimination Program) elimination goal by 2025. There are significant studies which found that COVID-19 is promoting the growth of active tuberculosis in a patient with dormant/latent tuberculosis infection. In the COVID-19 epidemic, diagnosis and treatment of tuberculosis, or tuberculosis and the co-infection with COVID-19, may be compromised as TB and COVID-19 both present with respiratory symptoms that are similar to each other. According to the 2019 India TB Report, 2, 24,000 incident cases per year of paediatric TB are estimated accounting for 22% of global burden. In spite of many similarities and differences, there is still a lack of clarity about the exact epidemiological relationship between COVID-19 and TB. This was a cross-sectional, retrospective, quantitative; research study aimed to know the impact of COVID-19 era on TB (tuberculosis) notifications in India (includes all 36 states and UTs of India). All the 36 participants' states and UTs newly detected tuberculosis cases notifications were followed from 1st January 2017 to 31st December 2022. The total number of newly detected tuberculosis cases notifications from 1st January 2017 to 31st December 2022 was 12290180 (n) including all 36 participants. The (period prevalence) total number of newly detected tuberculosis cases notifications during pre-COVID-19 era (2017-2019) was 5914621 and during the COVID-19 era (2020-2022) were 637559. The total annual newly detected tuberculosis cases notifications (including public and private healthcare facilities) in India including all 36 participants from beginning of year 1st January till 31st December during a year were 1525045, 1997873, 2391703, 1810834, 2145678, 2419047, for years 2017, 2018, 2019, 2020, 2021, and 2022 respectively. The mean of newly detected tuberculosis cases notifications from all public and private healthcare facilities during Pre-COVID-19 era (2017-2019) was 164295 (Std. Err. - 37404.92; [95% Conf. Interval] - 88359.01- 240231; Std. Dev. - 224429.5). The mean of newly detected tuberculosis cases notifications from all public and private healthcare facilities during COVID-19 era (2020-2022) was 177098.9 (Std. Err. - 43081.17; [95% Conf. Interval] - 89639.43 -264558.3; Std. Dev. - 258487). The incidence rate of newly detected tuberculosis cases notifications per lakh population was 112.62; 145.94; 172.92; 129.68; 152.44; and 169.63 respectively for years 2017, 2018, 2019, 2020, 2021, 2022. This research study revealed that the incidence rate of newly detected tuberculosis cases notifications per lakh population kept on increasing during the pre-COVID-19 era and it decreased abruptly during the first COVID-19 year 2020 by 25.00 percent (%) compared to previous year of pre-COVID-19 era 2019.

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Impact of COVID-19 era on annual tuberculosis notifications in India

Public Health / Original Research

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Introduction

Background/rationale

Globally Tuberculosis (TB) is **13th leading cause of mortality** and the **2nd leading infectious killer after COVID**-19, 1.6 million people died in 2021 from TB (including 187 000 people with HIV) [1]. The emergence of COVID-19 pandemic situations on the already overburdened health care system of India may have affected new TB cases notification as well as treatment, setting back the previous achievements made to eliminate TB by 2025 [2]. The **COVID-19 have affected several routine healthcare services deliveries** even in well to do countries with advanced technologies and ample human resource [3]. **Worldwide, TB incidence is reducing at the rate of 2%** per year and **between 2015 and 2020** the total decrease was **11% only**

which was only **half way** to achieve the goal to eliminate TB Strategy milestone by achieving 20% reduction between 2015 and 2020 [1].The most obvious impact of COVID-19 was a **large global reduction in the reported number of newly diagnosed TB** which fell from **7.1 million in 2019, to 5.8 million in 2020 (–18%)** and **India is among the three countries** which **accounted for most of the reduction** in 2020 besides Indonesia and the Philippines (67% of the global total) [4].**India have remarkably high annual TB incidence** at 210/100,000 in 2021 as per data of World Bank [5].

An essential element of the global effort to eradicate tuberculosis (TB) is curbing TB in India. Approximately **25 per cent of the world's TB cases are estimated to have occurred in India** [6]. By 2025, five years before the **global deadline in 2030**, India has committed to meeting the Sustainable Development Goal targets of 80% TB incidence reduction and 90% TB death reduction [7].The key author previous research work (is available at **WHO COVID-19 research database)** has found that with phase-wise unlocking beginning on 1 June 2020, a nationwide lockdown was implemented in India in response to the **COVID-19** pandemic for 68 days (from 25 March to 31 May 2020) which **disrupted several routine essential healthcare services delivery in India** as [8]. It is anticipated that **lockdown-induced poverty and under nutrition** will **worsen the TB cases situation** by downgrading poor population health status, pushing those living in vulnerable economic circumstances below poverty line, and that **lockdown-induced under-reporting (80% reduction in TB notification rates)** of active TB will affect TB epidemiology as well as **NTEP (National Tuberculosis Elimination Program)** elimination goal by 2025 [9, 10]. There are significant studies which found that **COVID-19 is promoting the growth of active tuberculosis in a patient with dormant/latent tuberculosis infection** [11]. One study found that **high mortality (11%) is associated with COVID-19/TB co-infection**, additionally, M. tuberculosis co-infection also resulted in the more severe COVID-19 and a faster progression of the disease [12]. The World Bank determined that $3.2 a day is a poverty line for lower-middle-income countries, and the economic downturn due to COVID-19 may push 104 million additional Indians into poverty [13].

In the COVID-19 epidemic, diagnosis and treatment of tuberculosis, or tuberculosis and the co-infection with COVID-19, may be compromised as TB and COVID-19 both present with respiratory symptoms that are similar to each other [14]. COVID-19 often affects children less severely, whereas **1.2 million children fell ill with TB in 2021, globally** and **TB is at present the leading cause of death for children of all ages globally dying from infectious diseases** [15, 16]. According to the 2019 India TB Report, 2, 24,000 incident cases per year of paediatric TB are estimated accounting for **22% of global burden** [17]. As India rank fourth in COVID-19 cases and mortality, there is a possibility that the number of TB cases and deaths might increase in the future [18]. In spite of many similarities and differences, there is still a lack of clarity about the exact epidemiological relationship between COVID-19 and TB [19].

Hence to know the real situation this study was carried out in order to alert policy maker for needful action.

Methods

This was a **cross-sectional, retrospective, quantitative; research** study aimed **to know the impact of COVID-19 era on TB (tuberculosis) notifications in India** (includes all 36 states and UTs of India). **This version** of study is having objective to assess the new TB cases (tuberculosis) notifications of India at country level and the **next version of this study will discuss performance of different states and UTs on individual levels**. As the first case of COVID-19 was notified in January 2020 hence for this study **period before 1st January 2020** (1st January 2017 to 31st December 2019) is considered as **pre COVID-19 era** and from **1st January 2020 till end of this study was considered as COVID-19 era** (1st January 2020 to 31st December 2022), **see table-1 and 2** [20].

Table 1. Annual pre COVID-19 era TB case notifications across 36 states and UTs of India from 1st January 2017 onward till 31st December 2019

State Wise Total Notified From 01/01/2017 To : 31/12/2019	2017	2017	2018	2018	2019	2019	PRE-COVID ERA
State	2017-Total Public Notified	2017-Total Private Notified	2018-Total Public Notified	2018-Total Private Notified	2019-Total Public Notified	2019-Total Private Notified	Total Public & Private Notified
Andaman & Nicobar Islands	615	13	544	18	573	7	1770
Andhra Pradesh	62731	5787	65645	19142	76239	22222	251766
Arunachal Pradesh	3297	2	3045	4	2908	36	9292
Assam	36066	618	36929	4115	40612	7982	126322
Bihar	55906	9298	66337	32282	77922	44240	285985
CHANDIGARH	4225	85	5124	176	6457	496	16563
Chhattisgarh	31280	3764	29901	8736	31536	11679	116896
Dadra and Nagar Haveli and Daman and Diu	1282	59	1244	83	1357	130	4155
Delhi	57255	1667	69911	9731	79743	27852	246159
Goa	1409	116	1833	431	1921	463	6173
Gujarat	97002	17115	106001	36750	104921	53865	415654
Haryana	35060	3350	47836	11727	50895	21835	170703
Himachal Pradesh	13477	542	15181	1244	15785	1560	47789
Jammu & Kashmir	8218	571	10499	764	10493	904	31449
Jharkhand	36155	1991	38487	6884	43677	12544	139738
Karnataka	63636	5705	67316	11942	71861	19619	240079
Kerala	17160	3671	20926	3227	20659	4884	70527
Ladakh	274	2	355	57	360	29	1077
Lakshadweep	49	0	19	0	15	0	83
Madhya Pradesh	116574	6067	120681	29650	139013	47445	459430
Maharashtra	123919	18877	139098	52196	143187	82282	559559
Manipur	1626	304	2165	413	2004	551	7063
Meghalaya	3171	222	4025	573	4709	724	13424
Mizoram	2457	41	2561	36	2939	40	8074
Nagaland	2439	275	3678	471	4149	696	11708
Odisha	48319	1933	45807	2683	48889	4479	152110
Puducherry	1890	5	3485	30	4564	72	10046
Punjab	36252	3251	42232	8211	43891	13940	147777
Rajasthan	85440	8161	111042	37519	121574	51374	415110
Sikkim	1199	2	1507	11	1427	24	4170
Tamil Nadu	77815	8708	75392	19359	82290	27229	290793
Telangana	37009	1713	42087	8922	50554	20551	160836
Tripura	2036	0	2624	19	2719	46	7444
Uttar Pradesh	235505	18069	303728	82555	326306	159771	1125934
Uttarakhand	13393	3496	16951	3872	19744	6157	63613
West Bengal	82118	3306	86951	12893	84897	25185	295350
Total	1396259	128786	1591147	406726	1720790	670913	5914621

In India, all the TB (tuberculosis) new case notifications from 36 states and UTs of India are electronically transmitted / reported / communicated through the Government of India established web based **NIKSHAY** platform [21]. We collected data from the NIKSHAY platform for annual case notifications across 36 states and UTs of India from **1st January 2017 onward till 31st December 2022**, to **compare three equal pre-pandemic years with three years of COVID-19 era** to ascertain the positive / negative impact of COVID-19 on the TB notification rates **see table-1 and 2.**

Table 2. Annual COVID-19 era TB case notifications across 36 states and UTs of India from 1st January 2020 onward till 31st December 2022

State Wise Total Notified From 01/01/2020 To : 31/12/2022	2020	2020	2021	2021	2022	2022	COVID-19 ERA
State	Total Public Notified	Total Private Notified	Total Public Notified	Total Private Notified	Total Public Notified	Total Private Notified	Total Public & Private Notified
Andaman & Nicobar Islands	481	0	506	6	510	24	1527
Andhra Pradesh	46868	17235	62124	24765	62010	30106	243108
Arunachal Pradesh	2522	1	2750	16	2715	141	8145
Assam	29271	6202	29729	8385	36662	10972	121221
Bihar	52317	47521	62365	70260	78619	82052	393134
CHANDIGARH	3767	537	4245	506	5653	399	15107
Chhattisgarh	20981	8400	23695	8882	26739	11684	100381
Dadra and Nagar Haveli and Daman and Diu	869	81	947	65	1293	105	3360
Delhi	59631	27086	68274	35256	76790	29757	296794
Goa	1340	326	1631	381	1612	455	5745
Gujarat	77184	43305	92852	51853	100903	50911	417008
Haryana	41472	21482	45620	23546	51152	24493	207765
Himachal Pradesh	12194	1273	13062	1515	14439	1630	44113
Jammu & Kashmir	7943	881	9503	1395	9995	1783	31500
Jharkhand	30516	15349	35455	17155	43573	13612	155660
Karnataka	48716	17262	52972	19745	59446	20840	218981
Kerala	15076	5822	15437	6628	16725	6590	66278
Ladakh	231	6	282	10	311	9	849
Lakshadweep	18	0	12	0	11	0	41
Madhya Pradesh	104682	33284	111154	55870	130140	55364	490494
Maharashtra	95748	64693	110116	90320	133590	102293	596760
Manipur	1151	433	1256	544	1627	917	5928
Meghalaya	3455	689	3278	892	4054	920	13288
Mizoram	1991	131	1486	273	1696	388	5965
Nagaland	2906	689	2971	741	3341	750	11398
Odisha	40435	5264	45156	7369	50331	9967	158522
Puducherry	2684	88	3407	49	3731	102	10061
Punjab	34694	11720	36737	14482	43218	11684	152535
Rajasthan	95855	41374	102979	46507	126480	42712	455907
Sikkim	1158	180	1305	102	1282	108	4135
Tamil Nadu	54008	16522	64534	18611	71842	21909	247426
Telangana	40540	22703	41488	19311	52264	20556	196862
Tripura	1995	73	2448	111	2860	156	7643
Uttar Pradesh	242722	125317	315422	140843	372651	149230	1346185
Uttarakhand	14292	5798	17356	5610	21157	6328	70541
West Bengal	61905	17489	69644	21476	76751	23927	271192
Total	1251618	559216	1452198	693480	1686173	732874	6375559

We then performed a **linear regression of existing data of pre pandemic years for counterfactual analysis** to find out the TB cases which may be notified if the natural intervention COVID-19 had not occurred. The data were collected and analysed with Microsoft office and stata 15.1software.

Data sources/measurement

The data is available at link given below:

https://reports.nikshay.in/Reports/TBNotification

Bias

To reduce the bias three equal years before and during pandemic were included in this study.

Results

This six year retrospective novel cross-sectional research study included all 36 numbers of different states and union territories (UTs) of India to assess the overall country status regarding the title mentioned research question. All the states and UTs were potentially eligible due to the fact that they (36 states and UTs) continuously and regularly register/communicate/transmit all the of newly detected tuberculosis cases notifications electronically through the NIKSHAY platform of Government of India. NI-KSHAY-(Ni=End, Kshay=TB) is the online **web based patient management system in India exclusively for TB (Tuberculosis) control under the NTEP-2020 (National Tuberculosis Elimination Programme, previously RNTCP) with the key aim to eliminate TB by 2025**. All the **36 participants'** states and UTs newly detected tuberculosis cases notifications were followed from 1st January 2017 to 31st December 2022 and analyzed to get an answer to the title mentioned research question. All participants participated from beginning to end of this study.

There are wide variations in demographic, clinical, social characteristics of above mentioned 36 participants evident from NITI AAYOG annual reports [22]. Information on exposures and potential confounders of different participants is not taken into account as this is a quantitative research study based on secondary data. There were no missing data.

The total number of newly detected tuberculosis cases notifications from**1st January 2017 to 31st December 2022** was 12290180 (n) including all 36 participants. The**(period prevalence)** total number of newly detected tuberculosis cases notifications during **pre-COVID-19 era (2017-2019)** was **5914621** and during the **COVID-19 era (2020-2022)** were **637559**. The total **annual** newly detected tuberculosis cases notifications (including public and private healthcare facilities) in India including all 36 participants from beginning of year**1st January till 31st December during a year** were **1525045, 1997873, 2391703, 1810834, 2145678, 2419047, for years 2017, 2018, 2019, 2020, 2021, and 2022 respectively, see table-1 and 2**

During the base year 2017 of this research study the total newly detected tuberculosis cases notifications from public and private healthcare facilities were 1396259 and 128786 respectively while for consecutive years 2018, 2019, 2020, 2021, 2022 of study it was (1591147, 406726), (1720790, 670913), (1251618, 559216,) (1452198,693480,) and (1686173,732874) respectively, **see table-1 and 2**.

2017

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2017 was 38784.97 (Std. Err.-8202.51; [95% Conf. Interval]-22132.99 -55436.95; Std. Dev.-49215.05) whereas for private healthcare facilities during 2017 it was 3577.39 (Std. Err.-860.98; [95% Conf. Interval] - 1829.51- 5325.26; Std. Dev. - 5165.85). Among public healthcare facilities Lakshadweep reported minimum 49 newly detected tuberculosis cases notifications whereas maximum 235505 was reported from UP (Uttar Pradesh) during 2017. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 18877 was reported from Maharashtra during 2017, **see table-3.**

2018

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2018 was 44198.53 (Std. Err.-9905.34; [95% Conf. Interval]- 24089.62-64307.44; Std. Dev.- 59432.04) whereas for private healthcare facilities during 2018 it was 11297.94 (Std. Err.- 2985.37; [95% Conf. Interval] - 5237.322- 17358.57; Std. Dev. - 17912.22). Among public healthcare facilities Lakshadweep reported minimum 19 newly detected tuberculosis cases notifications whereas maximum 303728 was reported from UP (Uttar Pradesh) during 2018. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 82555 was reported from UP during 2018, **see table-3**.

2019

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2019 was 47799.72 (Std. Err. - 10636.6; [95% Conf. Interval] - 26206.28 -69393.16; Std. Dev. - 63819.58) whereas for private healthcare facilities during 2019 it was 18636.47 (Std. Err. - 5203.06; [95% Conf. Interval] - 8073.698- 29199.25; Std. Dev. - 31218.36). Among public healthcare facilities Lakshadweep reported minimum 15 newly detected tuberculosis cases notifications whereas maximum 326306 was reported from UP (Uttar Pradesh) during 2019. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 159771 was reported from UP during 2019, see table-3.

The mean of newly detected tuberculosis cases notifications from all public and private healthcare facilities during Pre-COVID-19 era (2017-2019) was 164295 (Std. Err. - 37404.92; [95% Conf. Interval] - 88359.01- 240231; Std. Dev. - 224429.5). Among all public and private healthcare facilities Lakshadweep reported minimum 83 newly detected tuberculosis cases notifications whereas maximum 1125934 was reported from UP (Uttar Pradesh) during Pre COVID-19 era (2017-2019), see table-3.

Table 3. Statistical Analysis of tuberculosis cases notifications of Pre-COVID era.

Variable	Obs	Mean	Std. Err.	Confidence Interval-Mean [95% Conf. Interval]	Std. Dev.	Min	Max
2017-Total Public Notified	36	38784.97	8202.51	22132.99 -55436.95	49215.05	49	235505
2017-Total Private Notified	36	3577.39	860.98	1829.51- 5325.26	5165.85	0	18877
2018-Total Public Notified	36	44198.53	9905.34	24089.62-64307.44	59432.04	19	303728
2018-Total Private Notified	36	11297.94	2985.37	5237.322- 17358.57	17912.22	0	82555
2019-Total Public Notified	36	47799.72	10636.6	26206.28 -69393.16	63819.58	15	326306
2019-Total Private Notified	36	18636.47	5203.06	8073.698- 29199.25	31218.36	0	159771
Pre-COVID-19 Total Public & Private Notified	36	164295	37404.92	88359.01- 240231	224429.5	83	1125934

2020

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2020 was 34767.17 (Std. Err. - 7838.52; [95% Conf. Interval] - 18854.13- 50680.21; Std. Dev. - 47031.11) whereas for private healthcare facilities during 2020 it was 15533.78 (Std. Err. - 4142.46; [95% Conf. Interval] - 7124.13 -23943.43; Std. Dev. - 24854.78). Among public healthcare facilities Lakshadweep reported minimum 18 newly detected tuberculosis cases notifications whereas maximum 242722 was reported from UP (Uttar Pradesh) during 2020. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 125317 was reported from UP during 2020, **see table-4**.

2021

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2021 was 40338.83 (Std. Err. - 9743.34; [95% Conf. Interval]- 20558.81 -60118.86; Std. Dev.- 58460.02) whereas for private healthcare facilities during 2021 it was 19263.33 (Std. Err.- 5064.32; [95% Conf. Interval] - 8982.22-29544.45; Std. Dev. - 30385.93). Among public healthcare facilities Lakshadweep reported minimum 12 newly detected tuberculosis cases notifications whereas maximum 315422 was reported from UP (Uttar Pradesh) during 2021. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 140843 was reported from UP during 2021, **see table-4**.

2022

The mean of newly detected tuberculosis cases notifications from public healthcare facilities during 2022 was 46838.14 (Std. Err. - 11485.15; [95% Conf. Interval] - 23522.05- 70154.23; Std. Dev. - 68910.89) whereas for private healthcare facilities during 2022 it was 20357.61 (Std. Err. - 5426.21; [95% Conf. Interval] - 9341.82 -31373.41; Std. Dev. - 32557.27). Among public healthcare facilities Lakshadweep reported minimum 11 newly detected tuberculosis cases notifications whereas maximum 372651 was reported from UP (Uttar Pradesh) during 2022. Among private healthcare facilities Lakshadweep reported minimum 0 newly detected tuberculosis cases notifications whereas maximum 149230 was reported from UP during 2022, **see table-4**.

Table 4. Statistical Analysis of tuberculosis cases notifications of COVID-19 era

Variable	Obs	Mean	Std. Err.	Confidence Interval-Mean [95% Conf. Interval]	Std. Dev.	Min	Max
2020-Total Public Notified	36	34767.17	7838.52	18854.13- 50680.21	47031.11	18	242722
2020-Total Private Notified	36	15533.78	4142.46	7124.13 -23943.43	24854.78	0	125317
2021-Total Public Notified	36	40338.83	9743.34	20558.81 -60118.86	58460.02	12	315422
2021-Total Private Notified	36	19263.33	5064.32	8982.22-29544.45	30385.93	0	140843
2022-Total Public Notified	36	46838.14	11485.15	23522.05- 70154.23	68910.89	11	372651
2022-Total Private Notified	36	20357.61	5426.21	9341.82 -31373.41	32557.27	0	149230
COVID-19-Total Public & Private Notified	36	177098.9	43081.17	89639.43 -264558.3	258487	41	1346185

The mean of newly detected tuberculosis cases notifications from all public and private healthcare facilities during COVID-19 era (2020-2022) was 177098.9 (Std. Err. - 43081.17; [95% Conf. Interval] - 89639.43 -264558.3; Std. Dev. - 258487). Among all public and private healthcare facilities Lakshadweep reported minimum 41 newly detected tuberculosis cases notifications whereas maximum 1346185 was reported from UP (Uttar Pradesh) during COVID-19 era (2020-2022).

Other analyses

$$\text{Incidence Rate (newly detected tuberculosis cases notifications) per lakh population} = = \frac{\text{Total newly detected tuberculosis cases notifications in a specified year x 100000}}{\text{Population (forecasted value as real census is not done) at risk (we considered whole population at risk}}$$

Table 5. Incidence Rate of newly detected tuberculosis cases notifications in a specified year per lakh population

Year	Population	Newly detected tuberculosis cases notifications from all public and private	Incidence Rate/lakh
2017	1354195680	1525045	112.62
2018	1369003306	1997873	145.94
2019	1383112050	2391703	172.92
2020	1396387127	1810834	129.68
2021	1407563842	2145678	152.44
2022	1426099353	2419047	169.63

Population Data Source- The World Bank available at -https://data.worldbank.org/indicator/SP.POP.TOTL?locations=IN

The populations for year 2022 was forecasted with the help of Microsoft excel by utilizing the previous all year available data.

The incidence rate of newly detected tuberculosis cases notifications per lakh population was 112.62; 145.94; 172.92; 129.68; 152.44; and 169.63 respectively for years 2017, 2018, 2019, 2020, 2021, 2022, see figure-1.

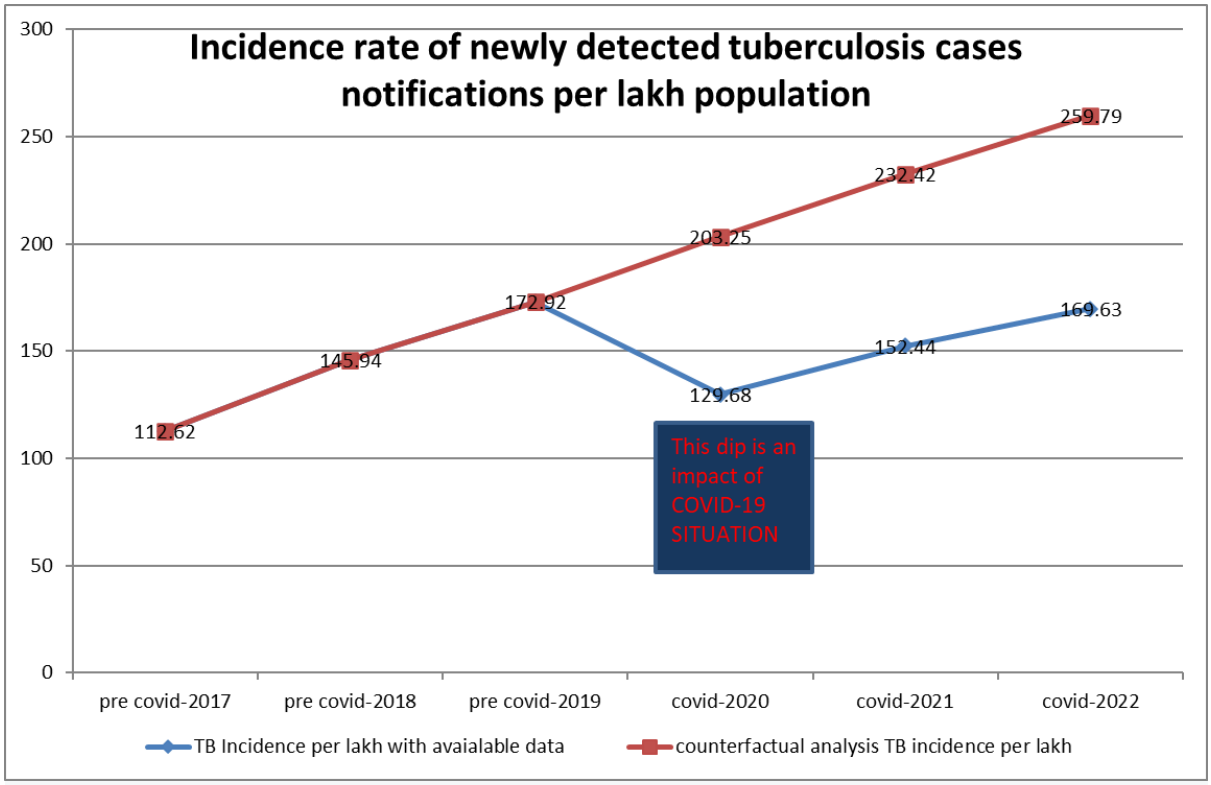

Figure 1. Comparison of newly detected tuberculosis cases notifications per lakh population with counterfactual analysis

Discussion

This research study revealed that the **incidence rate** of newly detected tuberculosis cases notifications per lakh population**kept on increasing during the pre-COVID-19 era** and it **decreased abruptly during the first COVID-19 year 2020 by 25.00 percent (%) compared to previous year of pre-COVID-19 era 2019**and 11.84 percent,1.90 percent for subsequent years 2021, 2022. The incidence rate during pre-COVID-19 era increased by 29.59 and 18.49 percent compared to previous year data considering 2017 as base year.

The incidence rate during COVID-19 era also increased by 17.55 and 11.28 percent compared to previous year data considering 2020 as base year. The trend shows that before COVID-19 era as well as in COVID-19 era the incidence rate is increasing. In coming years it is expected to cross the pre-COVID-19 era 2019 highest incidence rate as well as there are more chances of abrupt increase in incidence of tuberculosis due to missed cases during COVID-19 era. **We all know that the disease cannot be eradicated in one night and the big drop in incidence rate of newly detected tuberculosis cases notifications is most probably a negative impact of prevailing COVID-19 situations/restrictions.** As compared to pre- COVID-19 era**India made partial recoveries in 2021, 2022 but still reduction is seen compared with 2019.**

The statement of PIB (press information bureau), Government of Indiabased on Global TB Report 2022 released by WHO (World Health Organization) Posted On: 28 OCT 2022 6:22PM by PIB Delhi **is questionable in the light of findings of this novel research study**[23].Without considering and analysing COVID-19 impact on the incidence rate of newly detected tuberculosis cases by **visualizing pre- COVID-19 trends** it seems that this above statement was made. This novel research study is intended to**ALERT the policy makers that – THE incidence rate/lakh population of newly detected tuberculosis cases WILL KEEP INCREASING FOR FEW YEARS as it seems that a large number of TB new cases have been missed due to COVID-19 situations. (NTEP BY 2025 SEEMS TO BE IMPOSSIBLE IN LIGHT OF THIS RESEARCH STUDY- AVAILABLE SOON)**

Counterfactual analysis

Considering COVID-19 as a natural intervention in routine healthcare activities we have analyzed the situation in the absence of the COVID-19 intervention, by comparing counterfactual outcomes to data observed under the intervention. Through simple **linear regression** we have forecasted the incidence rate of newly detected tuberculosis through the previous year's data of this study.

Table 6. Counterfactual analysis results

Public forecast without COVID-19 newly detected tuberculosis cases	new tuberculosis cases	Private forecast without COVID-19 newly detected tuberculosis cases	new tuberculosis cases	Counterfactual analysis incidence rate/lakh population-COVID-19 ERA
2020	1893930	**2020**	944268.7	203.25
2021	2056195	**2021**	1215332	232.42
2022	2218461	**2022**	1486396	259.79

This counterfactual analysis suggest that 1027364, 1125849 and 1285810 new tuberculosis cases were missed during 2020, 2021, 2022 respectively as a probable negative impact of COVID-19 in India, see figure-1 and Table-6.

Strength and Limitations

There are several studies done on this research question but this is the first study which also considered year 2022. We know that the first two years of pandemic was quite harsh and it has shattered several routine healthcare services. The COVID-19 is not over and it is quite important to assess the situation of year 2022 in which the cases and mortality from COVID-19 decreased as well as to know that are the healthcare facilities are returning to normal functions? This research study revealed that the notification rates for TB has improved a lot during 2022 which may be a sign to say that healthcare facilities are returning to normal functions. This is the only study which has taken into account 6 years with equal distribution among pre-COVID-19 and COVID-19 period. Lack of more details about data on reported cases, including socio-demographic, **old non-notified cases missed during COVID-19 years,** residence wise data (rural vs. urban, etc.) is one major limitation.

Conclusion and Recommendation

The finding of this research study suggests that about over 3439023 new TB cases were not notified in India that would have been expected in the absence of the COVID-19 pandemic. Where are these cases? Factors which may have affected TB cases notifications may be:

- Decreased mobility and increased COVID-19 related hospital admissions per 100,000 population
- Disruption in TB diagnostic services, the impact of mask use
- Further research is needed to clarify this association
- Identification of other key contributors to the observed gap in TB case notification in India during the pandemic.

Other information

Abbreviations

Tuberculosis (TB); COVID-19- Coronavirus Disease 2019; HIV- Human Immunodeficiency Virus; NTEP (National Tuberculosis Elimination Program).

Declarations

- This version of paper has not been previously published in any peer reviewed journal and is not currently under consideration by any journal. The document is Microsoft word with English language & 2500 words excluding reference and declaration etc. (5292 words Total including all).
- **Ethics approval and consent to participate:** Not applicable. This study has not involved any human or animals in real or for experiments. The submitted work does not contain any identifiable patient/participant information.
- **Consent for publication:** The author provides consent for publication.
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  - The author declares that no funds are taken from any individual or agency-institution for this study.
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