

IMPACT OF COVID-19 ON TUBERCULOSIS (TB) DIAGNOSIS AND TREATMENT

Mr. Belkone Vishwajeet Dnyaneshwar*, Mr. Mahesh Mukta M. pharm

¹B. Pharm Student, ²Assistant Professor,

Swami Vivekanand College of Pharmacy, Udgir Latur District, Maharashtra, India.

Article Received on 05 Feb. 2026,
Article Revised on 25 Feb. 2026,
Article Published on 01 March 2026,

<https://doi.org/10.5281/zenodo.18884032>

*Corresponding Author

**Mr. Belkone Vishwajeet
Dnyaneshwar**

B. Pharm Student Swami,
Vivekanand College of Pharmacy,
Udgir Latur District, Maharashtra,
India.



How to cite this Article: Mr. Belkone Vishwajeet Dnyaneshwar*, Mr. Mahesh Mukta M. pharm. (2026). Impact Of Covid-19 On Tuberculosis (Tb) Diagnosis And Treatment World Journal of Pharmaceutical Research, 15(5), 1392-1412.

This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

The emergence of COVID-19 caused by SARS-CoV-2 significantly disrupted global healthcare systems and shifted public health priorities. During the pandemic, essential tuberculosis (TB) control programs were adversely affected due to lockdowns, restricted mobility, and fear of infection, leading to reduced access to healthcare services. The similarity in clinical and radiological features of COVID-19 and TB caused delays in diagnosis and under-reporting of TB cases. Several reports showed a substantial decline in TB notifications, with India experiencing nearly a 29% reduction during peak pandemic periods along with increased mortality. Diagnostic services were compromised as laboratory infrastructure and manpower were diverted toward COVID-19 testing, while contact tracing and drug supply chains were also disrupted. Socioeconomic difficulties, stigma, and psychological stress further influenced TB patient outcomes. However, increased

awareness of hygiene and infection control may have contributed to reduced transmission in some settings. This review emphasizes the impact of COVID-19 on TB services and highlights the need for integrated disease surveillance, digital health strategies, and resilient TB programs to manage future public health emergencies.

KEYWORDS: COVID-19, Tuberculosis, SARS-CoV-2, TB Diagnosis, Treatment Outcomes, Public Health Impact.

1. INTRODUCTION

2. 2.1-Tuberculosis (TB)

Tuberculosis (TB) is a chronic infectious disease primarily caused by *Mycobacterium tuberculosis*. It mainly affects the lungs (pulmonary TB) but can also involve other organs (extra-pulmonary TB). TB remains a major global health burden, particularly in developing countries, due to overcrowding, malnutrition, and limited healthcare access.^[1]

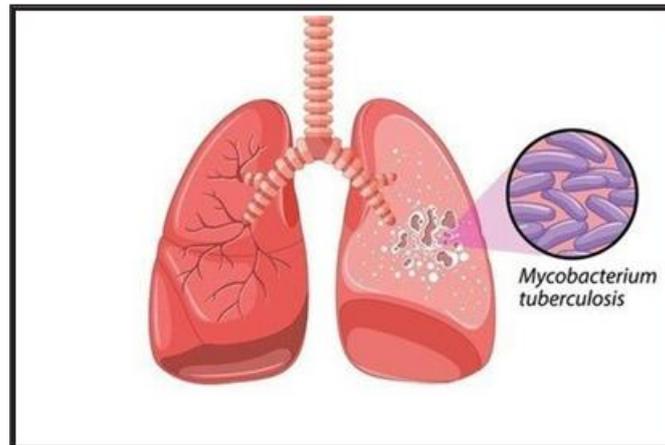


Figure 01: Lungs infected With Tuberculosis(TB).

2.2-Causes and Transmission

TB spreads through airborne droplets released when an infected person coughs, sneezes, or speaks. Factors increasing risk include weakened immunity, HIV infection, poor nutrition, diabetes, alcohol/smoking, and close contact with TB patients.^[2]

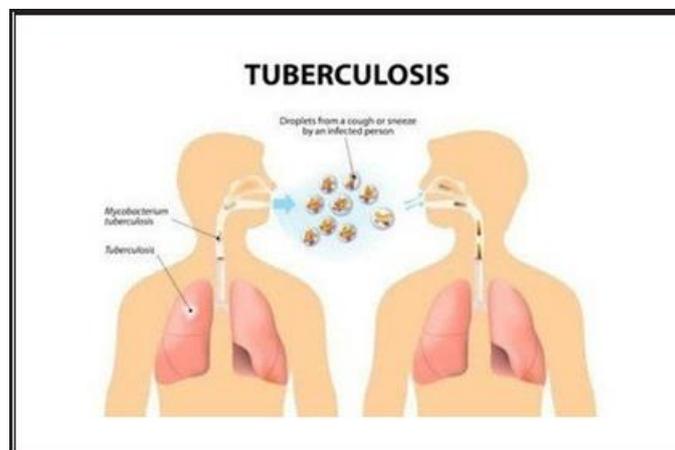


Figure 02: Transmission Of Tuberculosis (TB).

2.3 Diagnosis and Drug Used

Diagnosis is based on sputum microscopy, Gene-Xpert test, chest X-ray, Mantoux test, and culture methods. The treatment regimen includes first-line anti-TB drugs such as Isoniazid, Rifampicin, Pyrazinamide, Ethambutol, and Streptomycin under DOTS strategy. Newer regimens include bedaquiline and delamanid for MDR-TB cases.^[3]

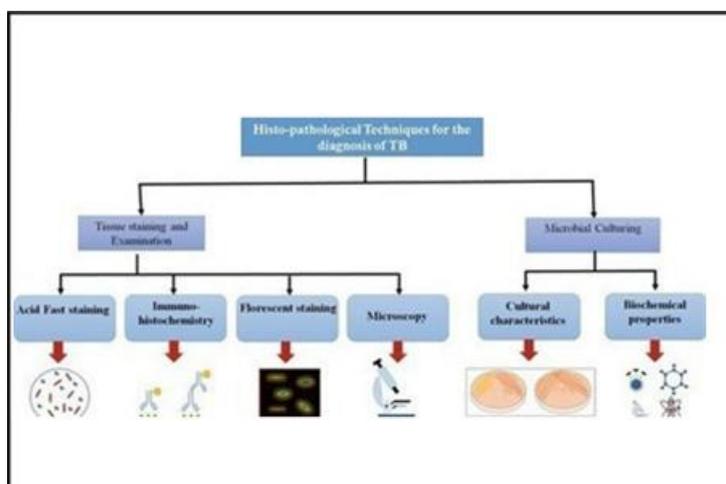


Figure 03: Diagnosis Of Tuberculosis (TB).

2.4 Drugs Used in Tuberculosis

Tabel 01: Drugs Used in Tuberculosis (TB).

WHO GROUPING*	DRUG	
1: First-line drugs	Isoniazid Rifampicin Pyrazinamide	Ethambutol Rifabutin Streptomycin
2: Second-line parenteral drugs	Amikacin Capreomycin	Kanamycin+
3: Fluoroquinolones	Levofloxacin Moxifloxacin	Gatifloxacin+ Ofloxacin
4: Oral bacteriostatic second-line drugs	Ethionamide+ Prothionamide+ Cycloserine	Terizidonet p-Aminosalicylic acid
5: Drugs with unclear efficacy	Clofazimine+ Linezolid Co-amoxiclav	Thioacetazone+ Imipenem/cilastatin ± Clarithromycin
*Drugs grouped by the World Health Organization based on their efficacy, class; Unlicensed in the UK; Not licensed to treat tuberculosis in the UK		

Tabel 02: Drugs Used in Tuberculosis(TB).

Regimen	Drugs Used	Treatment Duration	Key Findings
BPaLM Standard Treatment (Reference)	Bedaquiline, Pretomanid, Linezolid, Moxifloxacin	6 months	Baseline Comparison Regimen for RifampicinResistant, Fluoroquinolone -Susceptible TB
BPaL Standard Treatment (Reference)	Bedaquiline, Pretomanid, Linezolid	6 months	Baseline Comparison Regimen for Rifampicin- and Fluoroquinolone - Resistant TB
8-Week Intensive BedaquilineLinezolid Regimen	Bedaquiline, Linezolid, Isoniazid, Pyrazinamide, Ethambutol	8 weeks (Followed by Continuation Phase)	Non-inferior to standard 24week treatment; Improved Adherence
Shortened Regimen with Levofloxacin or Bedaquiline Regimen	Linezolid, Cycloserine, Clofazimine, Pyrazinamide, Levofloxacin or Bedaquiline	24 weeks	Less hepatotoxicity than injectablebased regimens
Lower Exposure to Linezolid Regimen	600 mg Linezolid for 9-13 weeks + 300 mg Linezolid for remaining treatment (as part of BPaL)	26 weeks	Maintains efficacy of standard treatment

2.5 COVID 19

COVID-19 is an acute respiratory disease caused by the SARS-CoV-2 virus, first identified in December 2019 in Wuhan, China. The disease rapidly spread worldwide, resulting in a global pandemic. COVID-19 primarily affects the respiratory system but can also impact cardiovascular, neurological, and immune systems.

2.6 Causes of Covid 19

COVID-19 is caused by SARS-CoV-2, an enveloped, positive-sense single-stranded RNA virus belonging to the Coronaviridae family. The virus enters the human body and binds to the ACE-2 receptors present on respiratory epithelial cells, facilitating viral replication and disease progression. The primary source of infection is an infected individual, and disease severity is influenced by factors such as age, immune status, comorbid conditions

(diabetes, hypertension, chronic lung disease), and viral mutations.

2.7 Transmission of Covid 19

COVID-19 spreads mainly through respiratory droplets released when an infected person coughs, sneezes, talks, or breathes. Transmission also occurs via aerosols in poorly ventilated indoor environments, and by touching contaminated surfaces followed by contact with the face, nose, or eyes. Close physical contact, crowds, public gatherings, and lack of mask usage significantly increase transmission risk. The virus has an incubation period of approximately 2–14 days, during which infected individuals may remain asymptomatic but still capable of spreading the infection.^[6]

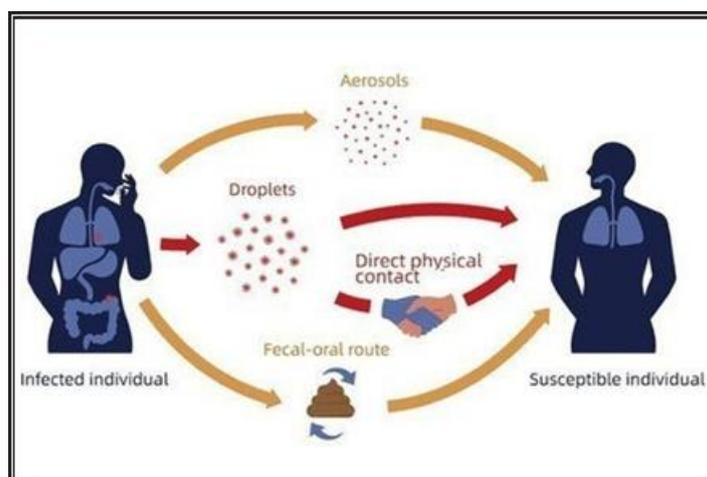


Figure 04: Transmission Of Covid 19.

2.8 Diagnosis and Drug Used

The diagnosis of COVID-19 in this procedure is performed using the RT-PCR (Reverse Transcription Polymerase Chain Reaction) technique, which is considered the gold standard test for detecting SARS-CoV-2 infection. The process begins with the collection of a nasopharyngeal or oropharyngeal swab from the patient to obtain respiratory secretions. The collected sample is then stored and transported under controlled conditions to preserve viral material. Following this, the virus is inactivated and RNA is extracted from the specimen. The extracted viral RNA undergoes reverse transcription to form complementary DNA (cDNA). This cDNA is then amplified through real-time PCR, involving cycles of denaturation, annealing, and elongation, allowing specific viral genetic sequences to multiply. Fluorescent markers are used to detect the presence of viral DNA during

amplification. If the fluorescence signal crosses the set threshold, the result is interpreted as positive for COVID-19; if not, it is considered negative. This method is highly sensitive and specific, enabling accurate early-stage detection of COVID-19 infection.^[7]

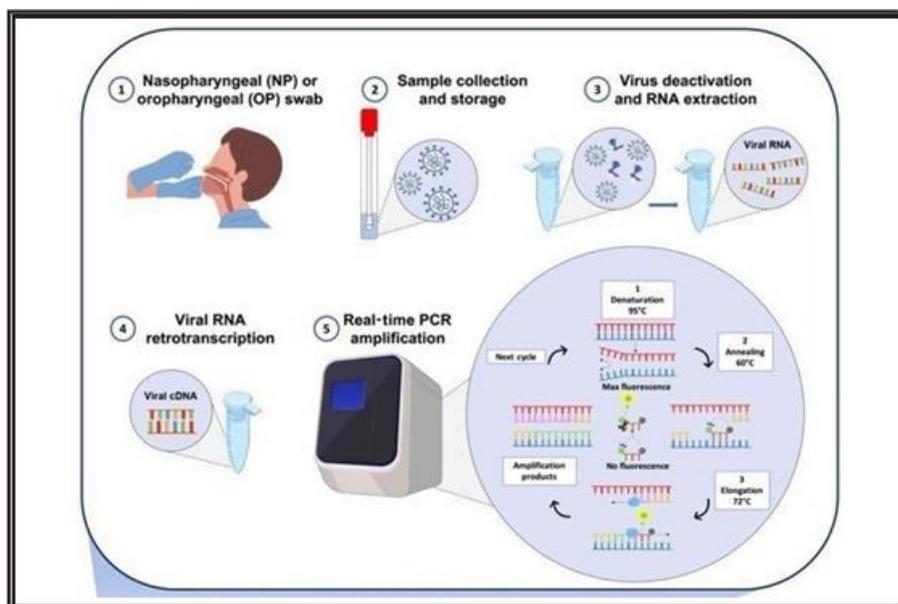


Figure 05: Diagnosis of Covid 19.

2.9 Drug Used In Covid 19

Treatment of COVID-19 includes antiviral drugs, supportive therapy, and immunomodulating agents based on disease severity. Antiviral medications such as Remdesivir are used in hospitalized patients to reduce viral replication.

Corticosteroids (e.g., Dexamethasone) are administered in moderate to severe cases to control severe inflammation and prevent complications like acute respiratory distress syndrome (ARDS). Anticoagulants like Heparin or Enoxaparin are given to prevent blood clots, which are common in advanced stages. Antipyretics such as Paracetamol help relieve fever and body pain, while oxygen therapy and ventilatory support are required in patients with respiratory distress. Monoclonal antibodies and immunomodulators like Tocilizumab may be used in selected cases to reduce severe immune reactions. Adequate hydration, rest, nutrition, and symptomatic care form the basis of supportive treatment. Vaccination is also an essential strategy to prevent severe disease and complications.^[8]

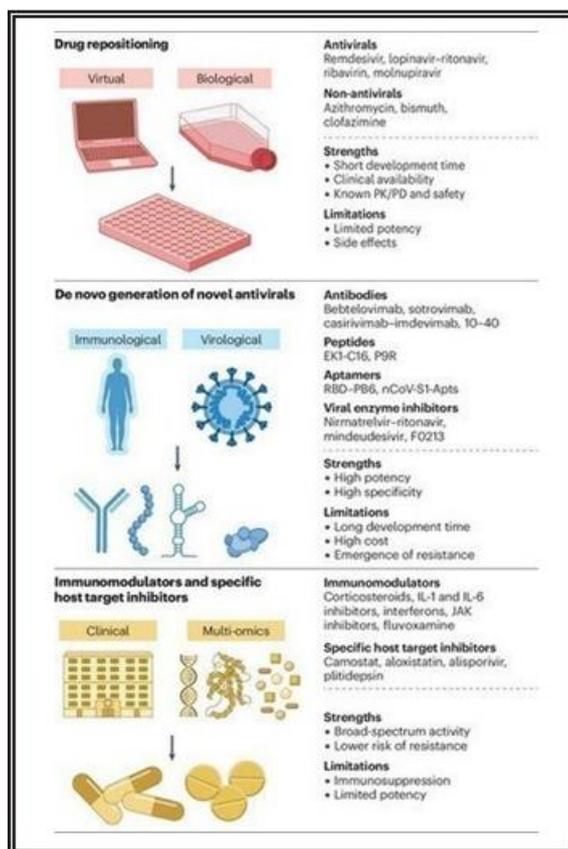


Figure 06: Drug used in Covid 19.

3. LITERATURE REVIEW

3.1 Kant S., Tyagi R et.al

The COVID-19 pandemic caused significant global morbidity and mortality, particularly among individuals with existing health conditions, and exposed critical gaps in healthcare systems. At the same time, it improved public awareness of preventive measures such as mask use, cough etiquette, physical distancing, and hygiene practices. Strengthening peripheral healthcare facilities and adopting digital consultations enhanced healthcare delivery and reduced unnecessary patient movement, including for tuberculosis care. The experiences and resources developed during the pandemic present an important opportunity to improve healthcare preparedness and strengthen future disease control strategies.^[9]

3.2 Maniya M., Patel S., et.al

The COVID-19 pandemic substantially disrupted tuberculosis services and influenced health-seeking behavior, resulting in reduced diagnosis and treatment during 2020. Nevertheless, timely interventions by health authorities led to a recovery of TB notification and

treatment services in 2021. This study highlights the importance of understanding the relationship between TB and COVID-19 for primary care physicians. Improved awareness of overlapping symptoms and risk factors supports more accurate diagnosis and timely management. Overall, the findings aid clinicians in enhancing diagnostic vigilance, patient education, and disease control, thereby improving patient outcomes and public health response.^[10]

3.3 Sahu S., Nagtode N. et.al

This review highlights a notable reduction in tuberculosis case notifications in India during the COVID-19 pandemic compared to expected trends in the absence of the pandemic. The decline reflects disruptions in detection as well as possible changes in transmission dynamics due to widespread mask use, reduced mobility, and physical distancing. Evidence suggests that a large proportion of TB transmission occurs outside households; therefore, mobility restrictions and social behavior changes may have influenced disease spread. The study emphasizes that effective tuberculosis control requires a deeper understanding of community-level transmission dynamics and coordinated strategies that consider both global and regional factors.^[11]

3.4-Togun T., Kampmann B., et.al

The COVID-19 pandemic has significantly diverted global public health attention, placing tuberculosis control at risk, particularly in low- and middle-income countries. Without effective mitigation strategies, existing TB incidence and mortality may rise further. However, the simultaneous occurrence of both pandemics offers an opportunity for collaboration among communities, healthcare professionals, and policymakers. Strengthened recognition of the connection between infectious diseases and socioeconomic factors can promote increased investment and long-term structural improvements in disease control, ultimately benefiting global public health.^[12]

3.5 Kara Lukas, Madeleine T.Dang., et.al

Recent advancements in tuberculosis management indicate progress toward shorter, more effective, and better-tolerated treatment regimens for both drug-sensitive and drug-resistant TB. Novel drug combinations and host-directed therapies show potential in improving treatment outcomes and reducing disease-related complications. However, challenges such as drug toxicity, emerging resistance, limited monitoring facilities, and high implementation

costs persist, particularly in high-burden settings. Emerging diagnostic technologies and vaccine candidates offer promising future directions but require further validation and scalability. Overall, integrated approaches combining improved pharmacotherapy, advanced diagnostics, preventive strategies, and patient-centered care are essential to achieve meaningful and sustainable TB control.^[13]

4. NEED OF STUDY

The present study is needed because TB services were severely affected during the COVID-19 pandemic due to resource diversion and strict lockdowns, which led to reduced TB screening, limited diagnostic testing, and significant under-reporting of cases. These disruptions caused delays in case detection, increased treatment interruptions, and weakened patient follow-up, thereby raising the risk of developing drug-resistant TB. TB mortality also showed a rising trend during the COVID period, and the shared respiratory symptoms between TB and COVID-19 created major diagnostic confusion. Understanding these impacts is essential to strengthen integrated TB-COVID programs, ensure uninterrupted TB care during future health crises, and provide strong evidence support for public health planning and India's TB elimination initiatives.

5. AIM AND OBJECTIVE

5.1 Aim: To evaluate the impact of the COVID-19 pandemic on tuberculosis(TB) diagnosis and treatment services, and to assess changes in TB case notification, diagnostic practices, treatment outcomes, and program-level responses during and after the pandemic period.

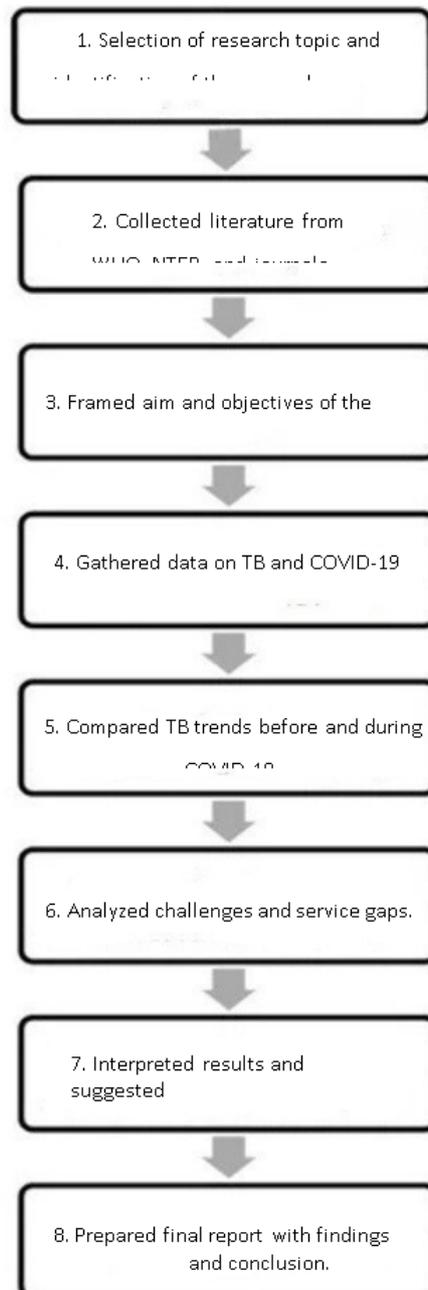
5.2 OBJECTIVES

1. To assess the effect of COVID-19 on TB case detection and notification trends before, during, and after pandemic phases.
2. To analyze changes in TB diagnostic services availability and utilization, including sputum testing, CBNAAT/GeneXpert, and radiological examinations during COVID-19
3. To evaluate the impact of COVID-19 on TB treatment initiation and adherence, including interruptions, regimen modifications, and treatment outcomes.
4. To examine programmatic challenges faced by TB control services such as workforce diversion, logistic constraints, and access barriers during the pandemic.
5. To understand the role of integrated TB-COVID screening and tele-health strategies in

restoring TB services and patient follow-up.

6. To identify gaps and delays in healthcare access among TB patients due to lockdowns, travel restrictions, and fear of infection.
7. To recommend strategic measures for strengthening TB control systems and ensuring continuity of care during future infectious disease emergencies.

6. PLAN OF WORK



7. DIAGNOSTIC AND TREATMENT GUIDELINES

WHO and Government of India (MoHFW) guidelines on TB diagnostics (GeneXpert, CBNAAT, Truenat) and treatment (DOTS and daily regimen) were referenced for contextual data, as reported in Kant Tyagi *et al.* (2021) and Patel *et al.* (2024).^[9,10]

Table 3: Sources of Data and Materials Used in the Study.

Type of Material	Source of Data	Study Period / Year	Supporting Reference
TB Notification Data	Nikshay Portal, District TB Office (Surat Rural)	2019-2021	Patel <i>et al.</i> , 2024 (PMC11668376)
Global TB & COVID-19 Reports	World Health Organization (WHO) and NTEP Annual Reports	2019-2022	Kant Tyagi <i>et al.</i> , 2021 (PMC8193657)
Published Literature and Reviews	PubMed, Cureus Journal, MDPI Tropical Medicine	2020-2023	Cureus Global Review (2023); MDPI Special Issue (2023)
Diagnostic & Treatment Guidelines	WHO and MoHFW Guidelines on TB Diagnosis and Therapy	2020-2021	Kant Tyagi <i>et al.</i> , 2021; Patel <i>et al.</i> , 2024

8. METHODS

After obtaining permission from the District Tuberculosis Officer (DTO), secondary data were collected from the District Tuberculosis Centre, Surat. This study was conducted as a cross-sectional study using programmatic data analysis of secondary data extracted from the NIKSHAY portal.

The study included all tuberculosis cases notified from Surat Rural between 2019 and 2021 and registered at the District TB Office from both public and private healthcare sectors. Records with missing or incomplete data for the selected variables were excluded. Data variables included sociodemographic characteristics (age group, sex, and block-wise distribution), TB case notification, universal drug sensitivity testing (UDST), contact tracing, sector-wise notification, diagnostic methods such as CBNAAT and chest X-ray, microbiologically confirmed cases, and treatment outcomes.

Data analysis was performed using descriptive statistics, expressed as frequencies and percentages. Comparative analysis across the three-year period (2019–2021) was conducted to assess differences in case notification, diagnostic modalities, sector-wise reporting, and patient outcomes using the Paired t-test and Chi-square test. As the study involved secondary data analysis, ethical approval was not required.^[10]

8.1 OBSERVATIONS

In this study, data from three consecutive years (2019–2021) were compared, including one year before and one year after the COVID-19 lockdown. Among the study population, females accounted for 2,488 cases (32.8%), while males constituted 5,104 cases (67.2%). The majority of cases (30%) belonged to the 21–30 years age group, whereas the least affected age group was 81–90 years. A decline in the notification rate was observed across different talukas, with the highest reduction noted in Choryasi taluka and the lowest reduction in Umarpada taluka.

A total of 3,893 TB cases were reported in 2019, which declined to 2,363 cases in 2020 and then increased to 3,637 cases in 2021. A statistically significant decline of 29% in reported cases was observed in 2020 compared to 2019 ($P = 0.0019$), followed by a 32% increase in 2021 compared to 2020. Pairwise comparison showed a significant difference between 2019–2020 (37.8 ± 324.4 , $P = 0.0019$) and 2020–2021 (108.3 ± 196.9 , $P = 0.02$), while the difference between 2019–2021 was not statistically significant (94.2 ± 303.1 , $P = 0.4782$) (Figure 7).^[10]

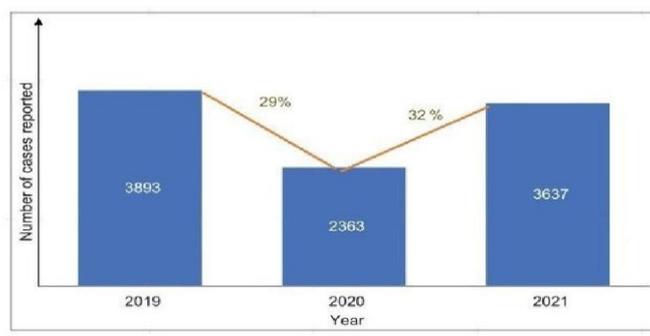


Figure 7: Year wise differences in Number of notified cases reported.

Overall, microbiological methods were the predominant diagnostic modality used for tuberculosis diagnosis. Of all diagnostic methods, 62.1% of cases were confirmed

through microbiological tests, mainly sputum examination, showing a 25% reduction compared to the previous year. Additionally, private healthcare facilities exhibited a declining notification trend, with a 12.51% decrease in reported cases in 2020 compared to the preceding year (Figure 8).^[10]

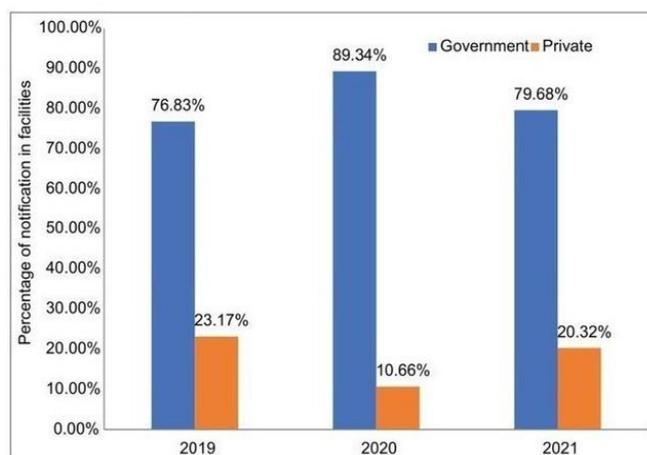


Figure 8: Notification in Government & Private facilities.

9. IMPACT OF COVID-19 ON TUBERCULOSIS(TB)

9.1 The Potential Impact of the COVID-19 Pandemic on Tuberculosis Control

The COVID-19 pandemic has the potential to affect tuberculosis control through multiple pathways. It may increase household transmission of TB, delay diagnosis and initiation of treatment, and negatively influence treatment outcomes, thereby increasing the risk of drug-resistant tuberculosis. In addition, both the direct and indirect economic impacts of the pandemic at national and global levels may have short-term as well as long-term consequences on TB control programs and healthcare service delivery.^[14]

9.2-Impact of COVID-19 on household transmission of TB

Countries implemented stay-at-home orders and lockdowns to reduce the spread of COVID-19. While these measures were effective in limiting community transmission, they inadvertently increased the risk of household transmission of tuberculosis (TB). Prolonged close contact within households is a key risk factor that facilitates TB transmission.^[15,16]

Modelling studies suggest that a 3-month COVID-19 lockdown in India could result in an additional 1.65 million TB cases and 438,000 TB-related deaths over the

next five years. Evidence from Brazil indicates that higher intensity and duration of household exposure significantly increase the risk of TB infection and disease among household members. Children living with sputum-positive adults are particularly vulnerable, as their risk of infection is higher than that of the general population. Prolonged household contact further increases the likelihood of transmission.^[17,18]

Since TB has a long incubation period, the consequences of increased household transmission may only become evident in the coming years. Historical data from the HIV pandemic show that TB epidemics emerged in several countries, including South Africa, emphasizing the need for continuous public health vigilance and strengthened TB control measures during and after pandemics.^[19,20]

9.3 Impact of COVID-19 on TB Treatment and Diagnostic Services

The overwhelming of healthcare systems by COVID-19 has significantly affected TB treatment and diagnostic services. This impact occurs through multiple mechanisms: diversion of human and financial resources from routine TB care to pandemic management, reduced oversight of TB programs due to focus on COVID-19 by health authorities and the media, stress and anxiety among healthcare personnel leading to errors and lower quality of care, unavailability of staff due to illness or quarantine, and stigma or fear of COVID-19 discouraging patients from visiting healthcare facilities.^[21]

9.4 Impact of COVID-19 on the prevention and control of TB

The COVID-19 pandemic has disrupted TB prevention and control strategies worldwide. Many opportunities for sharing TB research and knowledge, such as seminars, workshops, and conferences, were canceled in 2020. Even public awareness events, like World Tuberculosis Day on March 24, which aim to educate communities and raise funds for TB control, were not held in several countries.

Vaccination programs have also been affected, including the BCG vaccine, which protects children from TB. Additionally, preventive therapy for high-risk populations, designed to stop latent TB from progressing to active disease, may have been delayed or interrupted. These disruptions can potentially increase TB incidence in vulnerable groups.

The broader consequences of COVID-19, including resource diversion, stretched national

budgets, and a shift in public, governmental, and media focus toward pandemic management, have further hindered routine TB control programs. As a result, the global goal of ending TB by 2035 faces significant challenges, with reduced prioritization of TB and other endemic diseases compared to pre-pandemic levels.^[22, 23]

9.5 Impact of COVID-19 on Late Reactivation of TB

COVID-19 can affect the health and immune status of individuals, potentially increasing the risk of developing active TB. Severe respiratory complications, such as pneumonia and respiratory failure caused by COVID-19, may cause long-term lung damage, which could make individuals more susceptible to TB. Evidence from previous viral infections, including HIV and influenza, suggests that such infections can either trigger active TB soon after exposure or reactivate latent TB infections.^[24]

In addition to direct health effects, the COVID-19 pandemic has had a severe impact on global and national economies. The crisis disproportionately affects vulnerable populations through job losses, reduced remittances, rising costs of living, and disruptions to essential services such as healthcare and education. These economic disruptions can indirectly increase TB risk, as poverty is a well-established factor that contributes to both TB infection and progression to active disease.^[25]

The World Bank estimates that the global extreme poverty rate could rise by 0.3 to 0.7 percentage points in 2020, pushing an additional 40–60 million people into extreme poverty. This increase in poverty may result in higher long-term TB incidence, highlighting how socioeconomic consequences of the pandemic are closely linked to TB burden and outcomes.^[26]

9.6 Possible Strategies to Mitigate the Impact of COVID-19 on TB Control

To reduce the negative effects of COVID-19 on TB control, several measures can be adopted. Household transmission of TB can be limited by implementing basic infection prevention and control measures, as recommended by the World Health Organization for healthcare facilities and high-risk environments. To prevent delays in TB diagnosis and treatment caused by the pandemic, strategies such as virtual care and digital health technologies can be utilized. Additionally, decentralizing TB treatment to community health workers and strengthening the capacity of private healthcare providers and academic institutions to deliver TB testing and treatment can help

ensure continuity of care and maintain TB control efforts.^[27]

Tabel 4: Possible strategies to mitigate the impact of COVID-19 on tuberculosis (TB) control.

Impact of COVID-19 on TB	Strategies to Mitigate the Impact of COVID-19 on TB Control
Increased household transmission of TB	<ul style="list-style-type: none"> • Apply infection prevention and control measures (e.g., cough etiquette, personal protective equipment); • Consider using upper-room germicidal ultraviolet (GUV) where indicated; • Apply room ventilation (including natural, mixed-mode, mechanical ventilation, and recirculated air through high-efficiency particulate air (HEPA) filters); • Separate or isolate people with presumed or demonstrated infectious TB; • Provide TB preventive treatment for high-risk groups; • Initiate TB treatment early.
Delayed TB diagnosis and treatment services	<ul style="list-style-type: none"> • Maintain supports to essential TB services during and after the COVID-19 pandemic; • Provide information to patients about COVID-19 and TB so they can protect themselves and continue their TB treatment; • Apply patient-centred delivery of TB prevention, diagnosis, treatment, and care services; • Decentralise TB treatment to community health workers and increase access to TB treatment for home-based TB care; • Provide adequate supply of TB medication to patients for safe storage at home; • Design mechanisms to deliver medicines and to collect specimens for follow-up testing at home; • Integrate TB and COVID-19 services for infection control, contact tracing, community-based care, surveillance and monitoring; • Provide short-term training for students and health professionals and recruit additional staff to work on TB programs; • Change policy if required and support private hospitals, and academic or research centres, to provide TB testing and treatment; • Use virtual care and digital health technologies (e.g., video observed therapy) for adherence support, early initiation of treatment, remote monitoring of TB patients, counselling, and follow-up consultations.
Affecting TB prevention and control strategies	<ul style="list-style-type: none"> • Organize virtual conferences, seminars, workshops and fundraising; • Design strategies to deliver BCG and TB preventive therapy at home; • Create community awareness of the importance of TB services.
Reactivation of TB	<ul style="list-style-type: none"> • Plan additional support and resources to reduce the burden of TB; • Conduct research to identify the impact of COVID-19 on reactivation of TB and to design interventions mitigating this problem.

9.7 The Likely Impact of COVID-19 on Children with TB

Children account for a significant proportion of TB mortality, with an estimated 205,000 deaths annually, predominantly in resource-limited settings. Survival depends on timely diagnosis, prompt treatment initiation, continuous availability of child-friendly medications, and prevention of transmission from adults with sputum-positive TB. During the COVID-19 pandemic, these critical elements of TB care are at risk because health resources are redirected to managing COVID-19 patients. Dedicated pediatric TB clinics, general child health clinics, and hospital wards may be closed or overwhelmed, resulting in missed diagnostic opportunities for children. Moreover, general

physicians and nurses who normally provide care for children may be reassigned to adult COVID-19 cases, while specialist expertise in pediatric respiratory medicine is diverted to managing the pandemic.

Laboratory services for TB diagnostics are also likely to be affected, as testing platforms such as GeneXpert machines may be prioritized for COVID-19 testing. Routine review of children for subtle TB presentations, such as TB meningitis or slow-progressing pulmonary TB, may be delayed, increasing the risk of undetected disease progression. Families may hesitate to bring children to healthcare facilities due to fear of COVID-19 exposure, further compromising timely diagnosis and treatment. Additionally, preventive therapies like isoniazid preventive therapy (IPT) require contact tracing, screening, and administration, which are resource-intensive and may not be prioritized during the pandemic, increasing the risk of progression from latent TB infection to active TB in vulnerable children under five years old.

Social distancing measures and prolonged household confinement may inadvertently increase children's exposure to infectious adults with TB. Therefore, contact tracing for COVID-19 should also consider TB exposure to protect children from additional risks. Without adequate mitigation strategies, childhood TB incidence and severity are likely to rise during the COVID-19 pandemic, highlighting the need for integrated TB and COVID-19 healthcare planning.^[12,28]

10. CONCLUSION

The COVID-19 pandemic significantly affected tuberculosis (TB) diagnosis, treatment, and control programs, especially in high-burden countries like India. During the pandemic, diversion of healthcare resources, lockdown restrictions, and fear of COVID-19 infection led to reduced access to TB services. A marked decline in TB case notification clearly indicated underdiagnosis and delayed detection. Diagnostic facilities such as sputum microscopy and CBNAAT/GeneXpert testing were disrupted as laboratories and the workforce were redirected toward COVID-19 management. Treatment initiation and follow-up of TB patients were compromised, resulting in interruptions and poor treatment adherence. These challenges increased the risk of unfavorable treatment outcomes and drug-resistant TB. Prolonged indoor stay during lockdowns likely increased household transmission of TB. Preventive activities like contact tracing, IPT, and BCG vaccination

also suffered setbacks. Children and vulnerable populations were disproportionately affected due to limited access to healthcare services. However, gradual recovery of TB services was observed with the adoption of integrated TB–COVID screening, digital health tools, and tele-consultation. The pandemic exposed major gaps in healthcare preparedness and disease surveillance systems. Strengthening integrated disease management, ensuring uninterrupted TB services, and improving health system resilience are essential. Lessons learned from the COVID-19 pandemic should guide future strategies to protect TB control programs. Sustained efforts are required to achieve national and global TB elimination targets.

11. REFERENCES

1. Advocate Health Care. Tuberculosis (TB): an overview. Advocate Health Care [Internet], [cited 2025 Dec 07]; Available from: <https://www.advocatehealth.com/health-services/lung-respiratory-care/tuberculosis-tb>
2. Team Dr Lal PathLabs. Do you know TB's causes and symptoms to keep your family safe? Dr Lal PathLabs Blog [Internet], 2018 Mar 30 [cited 2025 Nov 28]; <https://www.lalpathlabs.com/blog/do-you-know-enough-about-tbs-causes-and-symptoms-to-keep-your-family-safe/>
3. Tiwari P, Yadav A, Dwivedi R, Chaubey R, Rasaily DR, Tripathi M, Mathur SR, Dada R. Pathology- Based Diagnosis of Tuberculosis. In: Singh A, Sharma D, editors. Diagnosis of Mycobacterium. Cham: Springer, 2023; p. 25–38. Available from: https://link.springer.com/chapter/10.1007/978-981-99-5624-1_3.
4. Gothard A, Millington K, Capstick TGD. Tuberculosis management. Pharm J [Internet]. 2013 Jul 11 [cited 2025 Nov 28]; Available from: <https://pharmaceutical-journal.com/article/ld/tuberculosis-management>.
5. Lukas K, Dang MT, Necas C, Venketaraman V. Anti- TB drugs for drug- sensitive and drug- resistant Mycobacterium tuberculosis: a review. Curr Issues Mol Biol [Internet], 2025 Sep 19 [cited 2025 Nov 28]; 47(9): 776. Available from: <https://pubmed.ncbi.nlm.nih.gov/41020898/>.
6. Zhao Y, Cui C, Zhang K, Liu J, Xu J, Nisenbaum E, Huang Y, Qin G, Chen B, Hoffer M, Blanton S, Telischi F, Hare JM, Daunert S, Shukla B, Pahwa SG, Jayaweera DT, Farmer PE, del Rio C, Liu X, Shu Y. COVID- 19: A Systematic Approach to Early Identification and Healthcare Worker Protection. Frontiers in Public Health [Internet], 2020 May 19 [cited 2025 Nov 28]; 8: 205. Available from: <https://www.frontiersin.org/journals/public->

- health/articles/10.3389/fpubh.2020.00205/full.
7. Falzone L, Gattuso G, Tsatsakis A, Spandidos DA, Libra M. Current and innovative methods. for the diagnosis of COVID-19 infection (Review). *Int J Mol Med* [Internet], 2021 Available from, Jun: 47(6): 100, [publications.com/10.3892/ijmm.2021.4933](https://www.spandidos-publications.com/10.3892/ijmm.2021.4933) <https://www.spandidos->.
 8. Chan JFW, Yuen KY, Cunningham AL. COVID- 19 drug discovery and treatment options. *Nat Rev Microbiol* [Internet], 2024 [cited 2025 Nov 28]; 22(7): 391- 407. doi:10.1038/s41579-024-01036-y. Available from: <https://www.nature.com/articles/s41579-024-01036-y>.
 9. Kant S, Dwivedi S, Dubey S, Mishra A, Chawla V, Singh A. The impact of COVID-19 on tuberculosis: lessons learned and the way forward. *Int J Tuberc Lung Dis* [Internet], 2021 [cited 2025 Nov 30]; 25(7): 569-571. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8193657/>.
 10. Maniya M, Chauhan P, Sharma N, et al. Impact of COVID-19 pandemic on tuberculosis notification and treatment services. [Internet], 2024 [cited 2025 Nov 30]; Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC11668376/>.
 11. Sahu S, Nagtode N. Impact on tuberculosis notification during COVID-19 pandemic in India: a narrative review. Datta Meghe Institute of Higher Education & Research, Wardha, India [Internet], [cited 2025 Nov 30], Available from: <https://share.google/XdQry75BhL8soU5Gi>.
 12. Togun T, Kampmann B, Stoker NG, Lipman M. Anticipating the impact of the COVID-19 pandemic on TB patients and TB control programmes. *Ann Clin Microbiol Antimicrob* [Internet]. 2020 [cited 2025 Nov 30]; 19(1): 21. Available from, <https://pubmed.ncbi.nlm.nih.gov/32446305/>.
 13. Lukas K, Dang MT, Necas C, Venketaraman V. Anti-TB drugs for drug-sensitive and drug-resistant *Mycobacterium tuberculosis*: a review. *Curr Issues Mol Biol* [Internet], 2025; 47(9): 776. Available from: <https://pubmed.ncbi.nlm.nih.gov/41020898/>.
 14. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 pandemic on tuberculosis control: an overview. *Trop Med Infect Dis* [Internet]. 2020 Jul 24 [cited 2025 Dec 02]; 5(3): 123. Available from: <https://www.mdpi.com/2414-6366/5/3/123>.
 15. Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? <https://www.thelancet.com/journals/lancet/article/PIIS0140->.

16. Xiao Y, Torok ME. Taking the right measures to control COVID-19. *Lancet Infect Dis.* 2020; 20: 523-524. [https://www.thelancet.com/journals/laninf/article/PIIS1473-3099\(20\)30152-3/fulltext](https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30152-3/fulltext).
17. Acuña-Villaorduña C, Jones-López EC, Fregona G, Marques-Rodrigues P, Gaeddert M, Geadas C, Hadad DJ, White LF, Molina LPD, Vinhas S, et al. Intensity of exposure to pulmonary tuberculosis determines risk of tuberculosis infection and disease. *Eur Respir J.*, 2018; 51: 1701578. <https://erj.ersjournals.com/content/51/3/1701578>.
18. Cilloni L, Fu H, Vesga JF, Dowdy D, Pretorius C, Ahmedov S, Nair SA, Mosneaga A, Masini EO, Suvanand S, et al. The potential impact of the COVID-19 pandemic on tuberculosis: A modelling analysis. *medRxiv.* 2020. <https://www.medrxiv.org/content/10.1101/2020.04.16.20067056v1>.
19. Ragonnet R, Trauer JM, Geard N, Scott N, McBryde ES. Profiling Mycobacterium tuberculosis transmission and the resulting disease burden in the five highest tuberculosis burden, countries. *BMC Med.*, 2019; 17: 208. <https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-019-1446-0>.
20. McCreesh N, White RG. An explanation for the low proportion of tuberculosis that results from transmission between household and known social contacts. *Sci Rep.*, 2018; 8: 5382. <https://www.nature.com/articles/s41598-018-23749-7>.
21. World Health Organization. *Global Tuberculosis Report 2019*. Geneva: World Health Organization; 2019. <https://www.who.int/publications/i/item/9789241565714>.
22. United Nations. *Policy Brief: The Impact of COVID-19 on Children*. New York: United Nations, 2020; https://www.un.org/sites/un2.un.org/files/impact_of_covid19_on_children.pdf.
23. World Health Organization. *WHO Operational Handbook on Tuberculosis: Module 1: Prevention: Tuberculosis Preventive Treatment*. Geneva: World Health Organization, 2020; <https://www.who.int/publications/i/item/9789240001503>.
24. Ni L, Ye F, Cheng ML, et al. Detection of SARS-CoV-2-specific humoral and cellular immunity in COVID-19 convalescent individuals. *Immunity*, 2020; 52: 971–977.e3. <https://pubmed.ncbi.nlm.nih.gov/32330462/>.
25. United Nations. *COVID-19 and socio-economic impact*. UN Policy Brief, 2020; <https://www.un.org/development/desa/dspd/2020/04/un-policy-brief-covid-19-and-socio-economic-impact/>.
26. World Bank. *COVID-19 to add as many as 100 million people to extreme poverty*.

Washington, DC: World Bank, 2020 [cited 2025 Dec 07]; Available from: <https://www.worldbank.org/en/news/press-release/2020/10/07/covid-19-to-add-as-many-as-100-million-people-to-extreme-poverty>.

27. World Health Organization. WHO Guidelines on Tuberculosis Infection Prevention and Control, 2019 Update. Geneva: WHO, 2019; <https://www.who.int/publications/i/item/9789241550536>.
28. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 pandemic on tuberculosis control: An overview. *Trop. Med. Infect Dis.*, 2020; 5(2): 123. https://www.mdpi.com/journal/tropicalmedicine/special_issues/COVID-19_challenges_perspectives.