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Epidemiology of Tuberculosis During the COVID-19 Pandemic

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Abstract The COVID-19 pandemic profoundly disrupted global tuberculosis (TB) control, reversing decades of progress. This review synthesizes evidence on the epidemiological dynamics of pulmonary TB during 2020–2023, revealing an 18% global decline in TB notifications in 2020, with regional variations ranging from minimal impact in Africa to >35% reductions in Southeast Asia. TB/COVID-19 co-infection was reported in 38 countries, with a pooled prevalence of 0.02–0.06% in general populations but rising to 24.3% among active TB patients in high-endemic settings. Co-infected patients faced a pooled fatality rate of 7.1% (increasing to 11.4% among hospitalized cases), alongside elevated risks of hospitalization and prolonged recovery. Health system disruptions included diversion of diagnostics and staff, while socioeconomic determinants exacerbated TB transmission. Recovery strategies centered on telehealth and integrated diagnostics offer pathways for rebuilding resilient TB services.

Keywords Tuberculosis, Epidemiology, COVID-19, Pandemic

1. Introduction

Convergence of Respiratory Pandemics

Pulmonary tuberculosis (TB), caused by Mycobacterium tuberculosis, remains a leading cause of infectious mortality, with 10 million annual cases and 1.5 million deaths pre-pandemic. The emergence of SARS-CoV-2 in 2019 triggered a parallel pandemic, with both pathogens sharing respiratory transmission routes and clinical manifestations. COVID-19's rapid global spread strained health systems, particularly in low/middle-income countries (LMICs) bearing >80% of the global TB burden. This review examines the multifaceted epidemiological interplay between these diseases, encompassing:

- Disruptions to TB detection and treatment programs
- Biological and clinical interactions in co-infected individuals
- Sociodemographic determinants of differential outcomes
- Policy innovations for health system recovery

WHO data reveals an 18% global reduction in TB notifications in 2020 compared to 2019, equivalent to 1.3 million undiagnosed cases 11. Regional variations were stark:

Southeast Asia: 26–37% declines (Philippines, Indonesia)

Africa: Minimal reduction (2.3%) with recovery by 2021

Europe: Steady declines consistent with pre-pandemic trends.

The epidemiology of pulmonary tuberculosis (PTB) has been profoundly affected by the COVID-19 pandemic, posing a significant global health challenge. In 2023, the World Health Organization (WHO) identified tuberculosis (TB) as the most prevalent infectious disease worldwide, which has led to considerable mortality rates, particularly among vulnerable populations. [1] [2]

While COVID-19 temporarily overshadowed TB as the leading cause of death by a single pathogen, it is anticipated that TB regained this unfortunate title by 2021, as healthcare systems struggled under unprecedented pressures brought on by the pandemic. The COVID-19 pandemic disrupted essential health services globally, contributing to a notable decline in TB case notifications and treatment adherence. According to WHO reports, TB case notifications dropped by more than one-third in early 2020 compared to the previous year, with dramatic decreases in several countries, raising concerns over underreporting and delayed diagnoses. [1] [3] [4]

Resource diversion was widespread:

Diagnostic capacity: Sputum-based testing replaced by COVID-19 PCR platforms

Clinical staff: TB specialists redeployed to COVID-19 wards

Supply chains: Interruptions in drug-resistant TB medication delivery

The INER Hospital in Mexico documented reduced TB testing volumes and interrupted follow-ups, contributing to elevated hospitalization mortality in post-pandemic periods.

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This disruption threatens progress toward achieving the TB targets set by the 2030 Sustainable Development Goals, prompting fears of resurgence in TB incidence and mortality rates. Co-infection with COVID-19 has emerged as a critical area of study, with research indicating a mortality rate of approximately 10.8% among patients suffering from both infections. Factors such as advanced age, male sex, and pre-existing comorbidities significantly increase the risk of adverse outcomes. [1]

Additionally, regional disparities in TB epidemiology, particularly in high-incidence areas like Siberia and the Far East of Russia, further complicate public health responses, emphasizing the need for targeted interventions to address multidrug-resistant TB (MDR-TB) and socio-economic factors influencing disease transmission. [5] [6]

The pandemic has not only highlighted the interconnections between TB and COVID-19 but has also underscored the importance of addressing social determinants of health. Vulnerable populations, affected by poverty and inadequate healthcare access, face compounded risks that exacerbate the impacts of both diseases. A comprehensive and integrated approach is essential to enhance disease management and health outcomes in communities grappling with these overlapping health crises. [6] [7]

Epidemiology of Pulmonary Tuberculosis

Pulmonary tuberculosis (PTB) remains a significant global health challenge, especially during the COVID-19 pandemic. The World Health Organization (WHO) reported that tuberculosis (TB) was the most prevalent infectious disease worldwide in 2023, leading to substantial mortality, particularly in vulnerable populations. TB's status as the leading cause of death by a single pathogen was temporarily supplanted by COVID-19 during the pandemic, but it is likely to have regained this unfortunate distinction by 2021 as healthcare systems faced unprecedented pressures. [1] [2]

Impact of COVID-19 on TB Notification and Treatment

The COVID-19 pandemic disrupted essential health services globally, with WHO indicating that nearly half of all health services were affected, and disruptions continued in 90% of countries through the early months of 2021. [1]

This disruption notably impacted TB diagnosis and treatment, as healthcare resources were diverted to manage COVID-19 cases. In Eswatini, for instance, a significant decrease in TB case notifications was observed, with 1,560 patients notified prior to the pandemic compared to 840 during it. [3]

This decline raises concerns about underreporting and delayed diagnosis, which could exacerbate the TB epidemic.

Co-infection with COVID-19

The interplay between TB and COVID-19 has garnered attention, particularly regarding co-infection rates and mortality. A global cohort study indicated a mortality rate of approximately 10.8% for patients with TB/COVID-19 co-infection, with advanced age, male sex, and existing comorbidities as significant risk factors for adverse outcomes. [1]

This highlights the critical need for integrated healthcare strategies to address both diseases simultaneously.

Regional Disparities in TB Epidemiology. Geographical disparities in TB incidence and prevalence have been notable, especially in regions like Siberia and the Far Eastern Federal Districts of Russia, where incidence rates were as high as 58.7 per 100,000 population in 2022. The prevalence of multidrug-resistant TB (MDR-TB) in these areas also raises alarms, with rates significantly exceeding the national average. [5] These regional variations underline the necessity for targeted interventions that address the specific challenges faced by different populations.

Social Determinants of Health. The COVID-19 pandemic has further illuminated the role of social determinants in disease transmission and outcomes. Factors such as poverty, inadequate healthcare access, and poor living conditions disproportionately affect the most vulnerable populations, exacerbating the impact of both TB and COVID-19.[6] Addressing these determinants is essential for effective disease management and improving health outcomes in affected communities.

Effects of COVID-19 on Tuberculosis Epidemiology. The COVID-19 pandemic has significantly impacted the epidemiology of tuberculosis (TB), affecting both case detection and treatment outcomes globally. A systematic review has highlighted these interactions, underscoring the disruption in TB services since the onset of the pandemic, which has led to a marked decline in TB case notifications. For instance, a report from the WHO indicated that TB case notifications decreased by more than one-third in the second quarter of 2020 compared to the same period in 2019 in the European Region alone [4] [8]. This decline threatens the progress made towards achieving the TB targets outlined in the 2030 Sustainable Development Goals.

Changes in Case Detection and Diagnosis. The pandemic has introduced several diagnostic challenges, particularly in patients with co-infections such as TB and HIV, which complicates both diagnosis and treatment [9] [10]. Research found that the average number of TB tests performed per patient decreased by up to 25% during 2020, a reflection of reduced medical attention amidst the pandemic [11]. Consequently, many patients delayed seeking medical care until their conditions became severe, often leading to more complicated clinical presentations. [11] [12].

Impact on Treatment and Patient Outcomes

In patients diagnosed with pulmonary tuberculosis (PTB) during the pandemic, there were instances where symptoms were ignored or misdiagnosed, causing delays in treatment initiation [13] [12]. In a study involving PTB patients who contracted COVID-19, some patients had displayed TB symptoms for as long as six months before being properly diagnosed [11]. Moreover, the use of corticosteroids in COVID-19 treatment raised concerns about potential treatment failure in TB patients [11].

Long-Term Consequences and Future Directions

The long-term implications of these disruptions are

concerning, as they may lead to an increase in TB transmission rates due to a rise in undiagnosed and untreated cases [8] [14]. Modeling studies predict that the declines in TB case notifications could reverse the progress achieved over the past decade if not adequately addressed [15]. As a response, it is essential to sustain and enhance TB detection services, including active case finding, contact tracing, and improved diagnostic capabilities [15] [16].

Comparative studies during the COVID-19 pandemic have highlighted significant changes in the epidemiology and treatment outcomes of pulmonary tuberculosis (TB). With nearly 770 million confirmed cases of COVID-19 and approximately 7 million deaths reported globally by mid-2023 [17], researchers have focused on the pandemic's indirect effects on TB care and outcomes.

Impact on TB Treatment Outcomes. Several studies have observed fluctuations in TB treatment success rates during the pandemic. For instance, a comparison of treatment outcomes from 2017-2018 and 2019-2020 revealed an increase in the treatment success rate from 82.7% to 89.1% during the COVID-19 period, alongside a reduction in loss-to-follow-up from 1.7% to 0.6% [18]. This shift suggests that, in some contexts, TB management may have adapted positively amidst the pandemic challenges. Conversely, other research indicates that the pandemic has adversely affected TB treatment adherence and outcomes. There is evidence of increased treatment failure and death rates among TB patients, particularly in certain countries like Nigeria, which warrants further investigation [16]. The trends observed during the pandemic illustrate the complex relationship between COVID-19 and TB, with varying impacts across different regions.

Regional Variations in TB Incidence. The epidemiological landscape of TB has also shifted regionally due to the pandemic. The European Region experienced the largest estimated reduction in TB incidence rates, with a 27% decrease by 2023 compared to the 2015 baseline [19]. In contrast, the Region of the Americas saw a troubling net increase of 20% in TB incidence during the same period, suggesting that healthcare disruptions have disproportionately impacted certain areas [19]. Furthermore, the WHO reported that while TB incidence rates were maintained in the African Region, there was a noticeable decline in case detection during 2020 and a slower recovery thereafter [14]. The variance in these trends emphasizes the importance of contextual factors, including healthcare access and socioeconomic conditions, which play critical roles in the management of TB during health crises like the COVID-19 pandemic.

Socioeconomic and Demographic Factors. Demographic and socioeconomic factors have emerged as significant predictors of both COVID-19 and TB outcomes. The pandemic has compounded existing inequities, with populations facing inadequate healthcare access, poor sanitation, and insecure employment being more vulnerable to infections and adverse health outcomes [6]. In regions with high TB incidence, the interplay between HIV and TB coinfection has further complicated treatment efforts, particularly in southern Africa, where more than 50% of new TB cases are co-infected with HIV. [14]

Role of Digital Health Technologies

The integration of existing electronic health technologies (eHealth) has the potential to revolutionize tuberculosis (TB) management by facilitating remote support through innovative platforms. These platforms can utilize video-supported therapy and electronic medication monitors, enabling healthcare workers to guide TB patients in their clinical management, monitor co-morbidities, and promote treatment adherence [7]. Mobile health solutions (mHealth) enhance this approach by enabling the delivery of critical health information via SMS and WhatsApp, as well as employing geographic information systems (GIS) for efficient outreach to at-risk communities [7]. The heightened public interest in digital health approaches during the COVID-19 pandemic has provided an opportunity to improve engagement in infectious disease monitoring and information dissemination [7].

Community Engagement and Stakeholder Networks

Building networks of community stakeholders is essential for addressing the public health challenges associated with TB. These groups, composed of diverse individuals with shared goals, can help identify community needs and health system vulnerabilities related to TB prevention and control [7]. By fostering collaboration and sharing lessons learned, stakeholders can drive community engagement initiatives aimed at increasing TB awareness and reducing stigma [7]. Health leaders can also work with these community members to advocate for creative solutions that address social determinants of health, thereby enhancing public welfare programs for TB patients, such as cash transfers or food parcels [7].

Training and Support for Healthcare Workers

Healthcare workers play a critical role in TB management and should receive skills-based training in field epidemiology, outbreak investigation, and operational research [7]. This training will equip them to identify priority health issues, conduct literature reviews, and engage with community stakeholders effectively [7]. Moreover, as the demands on healthcare workers increase—especially in light of concurrent health priorities—it is vital to monitor their mental health and mitigate burnout risk to maintain an effective healthcare workforce [7].

Addressing the Syndemic of TB and COVID-19

The overlapping impacts of TB and COVID-19 have highlighted the need for health systems to recognize and address syndemic effects. Factors such as social determinants of health, environmental conditions, and access to healthcare services must be analyzed to optimize clinical and community management practices [7]. The concept of "One Health," which emphasizes the interconnectedness of human, animal, and environmental health, promotes collaborative approaches to TB and other health threats [7]. Addressing the "knowledge-action" gap in health system infrastructure

and community engagement will further enhance the effectiveness of public health responses to TB [7].

Long-Term Impacts on TB Epidemiology

The COVID-19 pandemic has significantly affected the epidemiology of pulmonary tuberculosis (TB), with both immediate and long-lasting consequences. It is projected that deaths from TB may increase by nearly 13% in the coming years, marking a substantial setback in global TB control efforts. [20]

The pandemic has disrupted healthcare systems, resulting in delays in diagnosis and treatment, particularly for individuals already diagnosed with TB who experienced disruptions in care during lockdowns. [21]

Impact of COVID-19 on TB Diagnosis and Treatment

The restrictions implemented to curb the spread of COVID-19 have severely impacted TB case identification and management. The loss of sputum microscopy and bacterial culture testing capabilities has hindered the follow-up of pulmonary TB patients, potentially leading to worsening health outcomes for those with treatment failures or multi-drug-resistant TB. [20] [22]

Additionally, while social distancing measures have reduced TB transmission rates, they have concurrently increased the risk of untreated TB cases being passed on to household members, further complicating TB control efforts in endemic regions. [8]

Changes in TB Incidence Trends

Research has identified four mechanisms that may contribute to the trends observed in TB incidence during 2020-2023, including immigration patterns, respiratory contact rates, and the accuracy of diagnoses made during this period. [21] [23]

Economic contractions and malnutrition caused by pandemic-related restrictions have disproportionately affected low-income populations, exacerbating the TB epidemic in these vulnerable groups. [8] [22] The direct health impacts of COVID-19 are immense, with an estimated one million deaths attributed to the virus; however, the indirect effects, particularly the disruption of essential healthcare services, may have even more profound and lasting implications for TB control globally. [24]

Future Challenges in TB Control

As health systems attempt to recover from the pandemic, challenges remain in addressing TB. There is an urgent need for improved public health system leadership and infrastructure to ensure a rapid response to TB outbreaks, especially concerning drug-resistant strains. [7] [15]

2. Conclusions

Strategies such as early diagnosis, isolation, and treatment of active TB cases remain crucial in the fight against the disease. [25] Furthermore, the push for ongoing attention to infectious diseases, including TB, may provide new opportunities for increased identification of cases and reinvigoration of TB control efforts. [26] The goal is to meet the World Health Organization's target for TB elimination by decreasing incidence rates significantly each year, emphasizing the importance of integrated healthcare approaches to overcome these long-term challenges.

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