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Resistance Pattern of Tuberculosis Before and During COVID-19 Era in Nigeria: A Systematic Review

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Abstract

Background: Tuberculosis (TB), one of the leading infectious diseases of global health concern has drawn the attention of researchers towards investigating the trends of the infection, its resistance and associated risk factors in Nigeria in the pre-COVID-19 era and during the COVID-19 era to understand how the pandemic may have possibly influenced the prevalence trends of TB infection.
Objective: This review was aimed at examining the trend of TB infection, the resistant patterns and associated risk factors before COVID-19 era and then during COVID-19 era in Nigeria
Methodology: Following the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) protocol, a systematic review and meta-analysis was conducted. A total of 4 electronic databases (African journal online library (AJOL), PubMed, ScienceDirect and Semantic scholar) were searched using Boolean functions and search filters to streamline the search results to the research focus. A total of 563 studies were gathered from the databases and imported to EndNote, from where they were exported to Covidence via XML file. The exported studies underwent two levels of screenings; title and abstract screening, and full article screening based on the inclusion criteria. A total of 14 studies passed the screening and were eligible for data extraction, quality assessment and risk of bias using Newcastle Ottawa Scale (NOS) for cross-sectional studies.
Results: The mean prevalence of TB before and during COVID-19 era were 15.8% and 28.8% respectively. The pooled prevalence rifampicin (RIF) resistance was 20.8% in both pre-COVID-19 and COVID-19 eras among TB patients. The pooled prevalence of multi-drug resistant TB (MDR-TB) before the COVID-19 era was 1.01% while in the COVID-19 era it was 10.1%. The prevalent assocated risk factors before COVID-19 era were age and settlement while in COVID-19 era were age and sex.
Conclusion: This review has shown an upward trend in TB and MDR-TB rates during the pandemic in Nigeria with age appearing as the leading risk factors in both eras.

Keywords: *Nigeria, pandemic, patients, rifampicin*

INTRODUCTION

Tuberculosis (TB) is an infection caused by the Mycobacterium tuberculosis bacteria [1][2]. It primarily affects the lungs but can also damage the bone, brain, and spine [1]. TB spreads via infectious droplets sprayed into the air during coughing or sneezing [1]. The disease is divided into two stages: latent TB, in which the infection is dormant, and active TB, which requires rapid treatment [1].

TB is a significant public health issue in Nigeria, accounting for the eighth leading cause of mortality among communicable, maternal, neonatal, and nutritional disorders [3][4][5]. Despite being the ninth highest cause of mortality in the world and the leading cause from a single infectious agent, ranking higher than HIV/AIDS [6], it is estimated that only one in every four TB cases in Nigeria is identified and recorded [7]. In 2020, Nigeria had an expected 440,000 incident cases of tuberculosis, or 212 cases per 100,000 population. Of these, 77,000 (18%) were children [5]. Aside from its ubiquity, a particularly worrying medical issue is co-infection with tuberculosis and HIV, which considerably increases the health risk [3].

Several factors contribute to the spread of tuberculosis in Nigeria. Poverty and urbanization are key socioeconomic issues [8]. In Nigeria, an estimated 152 million people live below the poverty line, frequently in substandard living circumstances where diseases spread quickly [9]. Stigma and discrimination linked with tuberculosis impede efforts to control the disease. Many people avoid seeking treatment for fear of social ostracization [6]. Health-related variables contribute to the spread of tuberculosis. Additionally, alcohol consumption, smoking, and diabetes have been recognized as risk factors for tuberculosis [3][10].

The high prevalence of tuberculosis has a substantial impact on Nigeria's healthcare system [9]. The expense of diagnosing and treating tuberculosis is high, and the disease frequently causes lost productivity owing to illness or premature mortality [11]. Efforts to control tuberculosis in Nigeria have centered on improving detection and treatment. The Nigerian government, in partnership with international partners such as the World Health Organization and the Global Fund[12], has introduced the Directly Observed Treatment Short-course (DOTS) plan, which entails seeing patients as they take their medication to guarantee adherence [13][14]. Despite these efforts, obstacles continue, including inadequate funds, weak health infrastructure, and a lack of awareness of tuberculosis among the community [14].[15][16][17][18][19].

While most TB cases are treatable and curable, drug-resistant TB develops when bacteria grow resistant to medications used to treat TB, such as rifampicin and isoniazid [20]. Drug-resistant tuberculosis is caused by TB germs that are resistant to at least one first-line anti-TB medication [20]. It develops when the suggested treatment regimen is not followed. This can occur when a patient skips doses or does not finish the entire course of treatment [21]. Other factors include being prescribed the incorrect medication, dose, or timing to take the drugs [22]. In some circumstances, effective medications may not be available [22].Furthermore, the rise of drug-resistant TB strains creates considerable hurdles for TB care. In instance, multidrug-resistant tuberculosis (MDR-TB) strains have evolved as a result of insufficient or incomplete therapy. MDR-TB is resistant to at least two of the most effective TB medicines, isoniazid and rifampicin [23], [24], [25]. Patients infected with these strains require long-term treatment regimens that include second- and/or third-line medicines such fluoroquinolones and aminoglycosides. However, these treatments are linked with harmful side effects and low cure rates [26]. According to a recent study, the global incidence of MDR/RR-TB infections increased by 3.1% between 2020 and 2021, from 437,000 to an anticipated 450,000 [27]. This surge is mostly due to an overall increase in tuberculosis incidence during this time period, which is thought to be caused by the COVID-19 pandemic's impact on tuberculosis detection [27]. Despite this tendency, the study found that drug resistance rates in several nations have remained relatively constant and low over the last decade. According to the Public Health Agency of Canada, resistance rates to any first-line anti-TB treatment have been found to range between 8.2% and 10.5% [28].

The COVID-19 pandemic, produced by the SARS-CoV-2 virus, has had a dramatic worldwide impact, resulting in a large loss of life and posing unprecedented difficulties to public health, food systems, and employment [29, 30]. The pandemic's overwhelming

impact on healthcare systems has influenced the detection and management of other diseases, including tuberculosis [31].

Measures such as social distancing and lockdowns have impacted on the diagnosis rates for diseases like seasonal influenza. Furthermore, the pandemic has exposed and exacerbated health inequalities across various demographics, including income, age, race, sex, and geographic location [31]. Disruptions in health service delivery and routine immunizations have led to an increase in deaths from other causes. This is corroborated by a WHO survey, which highlighted that 90% of countries are experiencing persistent disruptions to essential health services [32].

The common symptoms of COVID-19 and tuberculosis [33], such as cough, fever, shortness of breath, fatigue, and loss of appetite, confuse the link between the two respiratory illnesses [34]. Although both mostly affect the lungs [35], their causes differ. Some distinguishing aspects of tuberculosis include a longer incubation time and a slower onset than COVID-19 [35].

Beyond overlapping symptoms, the connection between COVID-19 and tuberculosis epidemiology in Nigeria is also being investigated and discussed [34][36]. The pandemic may have had an impact on TB trends [34][37], drug resistance [33][34][38], and risk factors [33][34][36] in Nigeria. For example, there may have been changes in clinic attendance and TB patient identification, detection, and care since the outbreak of COVID-19 [35][39][40], although these findings are tentative. The economic hardship caused by the epidemic may exacerbate poverty [41][42], a known risk factor for tuberculosis. The pandemic may have had an impact on Nigeria's tuberculosis (TB) epidemic, potentially influencing TB service access, delivery, and quality, as well as TB patients' health and nutrition [33][34][43].

Furthermore, different challenges may have occurred, including decreased diagnosis and treatment, disturbed supply chain and logistics, diverted financing and human resources, increased transmission and poor results, and diminished prevention and control methods [44][45][46]. To address these possible issues, the Nigerian government, its partners, the WHO, and the national tuberculosis programme have established certain solutions [36]. These include incorporating COVID-19 screening into TB surveillance activities, adapting TB service delivery models, strengthening TB infection control measures, utilizing digital platforms and community volunteers to aid in TB case finding and treatment adherence, and ensuring that personal protective equipment and infection prevention and control measures are available to health workers and patients. These techniques are consistent with World Health Organization (WHO) recommendations [47] on maintaining critical health services during the pandemic, which recommends prioritizing tuberculosis (TB) as one of the basic services to be sustained. However, it is crucial to stress that further efforts may be required to ensure that TB services are maintained and reinforced throughout and after the COVID-19 pandemic, and that TB patients are not overlooked in the COVID-19 response. This is a difficult subject that necessitates continual monitoring and research.

As a result, the purpose of this systematic review is to monitor the trend of tuberculosis (TB), drug resistance trends (rifampicin and MDR-TB), and associated risk factors in Nigeria before and during the COVID-19 pandemic, as well as to provide evidence-based recommendations for improving tuberculosis control and care. While there have been systematic evaluations on tuberculosis prevalence in Nigeria [3][48]49], no systematic review has looked at how the pandemic has changed the patterns or TB landscape in Nigeria. This evaluation will synthesis data from various sources and databases, employing explicit and transparent procedures to assure validity and reduce bias. The findings of this research will add to the body of knowledge in the area, highlight gaps and insights into the state of tuberculosis prevalence in Nigeria during both eras, and inform TB stakeholders' policies and practices in Nigeria and beyond.

Methodology

This is a systematic review including meta-analysis. This review followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) procedure, which was documented in 2015 throughout the review process [51].

Eligibility criteria

Because the purpose of this review is not to evaluate the outcome of an intervention for which a randomized clinical trial (RCT) would be appropriate, the study concentrated on tracking the trends in pooled prevalence in the pre-COVID-19 and COVID-19

eras separately. On this point, the publications chosen for consideration were cross-sectional studies aimed at analyzing the epidemiology of tuberculosis in Nigeria, including data on TB prevalence, drug-resistant trends, and related risk factors. The primary studies were evaluated for inclusion if they were published online in peer-reviewed journals to guarantee that the study's data were reliable, as peer-reviewing is an important element of article evaluation in preserving the quality of all journal publications. Studies were investigated between 2017 and 2023 to cover both the pre-COVID-19 and COVID-19 eras. Studies conducted between 2017 and 2019 were classed as pre-COVID-19, whereas studies conducted between 2020 and 2023 were designated as COVID-19 era. While COVID-19 infection has decreased to the point where many limitations have been lifted, we must remember that the effects it has on individuals, particularly in Nigeria, such as employment and company losses, continue to persist. Many people have yet to return to their well-paying occupations following the release of COVID-19 restrictions in order to resume regular human activities. It will be acceptable to record the COVID-19 era from 2020 to 2023 in addition to delving into the related risk factors with TB infection in the pre-COVID-19 and COVID-19 periods. On the other hand, examining 2017 to 2019 is the closest period to the start of the pandemic and will thus accurately depict the pre-pandemic era nature. It is important to note that the year of publication does not always correspond to the year the study was conducted. A study completed in 2019 may be published in 2021; so, publication by 2021 does not qualify it for inclusion in the COVID-19 era.

However, review articles were eliminated. Studies on TB epidemiology conducted outside of Nigeria were also omitted, as were studies on TB that did not meet any of the review study's aims, such as those aimed at assessing TB treatment adherence.

Information sources and search strategy

The studies included in this study were collected from appropriate electronic databases to ensure comprehensiveness, extensive coverage, and a reflection of the African research database. On this note, studies were sourced from the African Journals Online Library (AJOL), a resource of several African journals and articles. Nigeria, being an African nation, will have the majority of its curriculum available in AJOL. Furthermore, Boolean functions were used to customize search results for PubMed, ScienceDirect, and Sematic Scholar to the review study's emphasis or aims [51].

Table 1: Search strategy

Database	Boolen function	Other filters
AJOL	("tuberculosis" OR "TB") AND ("drug-resistant" OR "MDR" OR "DR-TB" OR "XDR") AND "Nigeria" ("prevalence" OR "epidemiology") AND ("original article" OR "research article")	none
PubMed	Prevalence AND drug-resistant TB AND Nigeria	2017-2023
ScienceDirect	Prevalence AND drug-resistant TB AND Nigeria	2017-2023 Original research
Sematic scholar	("prevalence" OR "epidemiology") AND ("tb" OR "tuberculosis") AND ("original article" OR "research article") AND "nigeria" -"reviews"	2020-till date

Data management

Covidence, a highly renowned platform for managing systematic reviews [52], was utilized throughout the review, including study identification, title and abstract screening, full text screening, quality rating, and data extraction. This tool follows the PRISMA protocol for managing the review process and, as a result, generates a PRISMA chart at the end of the review process. In addition to Covidence, the references from the selected papers were managed

using EndNote, a popular reference manager [53]. The extracted data from the selected studies was exported to Microsoft Excel.

Selection process

All identified studies from the specified databases were imported into EndNote software, a reference management tool [54], and then exported as XML files to Covidence, a web-based platform for systematic review administration. Using Covidence, the exported studies were screened at two levels: title and abstract screening, and full article screening. In the title and abstract screening, studies that did not meet the inclusion criteria were excluded, and the remaining studies were subjected to full article screening. The whole papers were studied to identify additional important information that the abstract may not have provided. Following screening, only suitable studies were submitted for quality assessment and data extraction. When the Covidence review process is completed, it provides a PRISMA flowchart that depicts the full review process, from identifying exported studies to filtering the studies to selecting the final studies for quality evaluation and extraction.

Data extraction process, quality assessment and risk of bias

All qualifying studies that were selected were moved on to the next stage of the review process, which included data extraction, quality assessment, and risk of bias. The following data were extracted during the extraction process: study title, lead author, and year of publication, study population, study design, year of study, state where study was conducted, prevalence of TB, prevalence of rifampicin resistance, prevalence of MDR-TB, and associated risk factor for TB infection.

The Newcastle-Ottawa Scale (NOS) for cross-sectional studies was used to assess the quality and risk of bias of all eligible studies for extraction, capturing key selection and outcomes such as sample size adequacy, representativeness of the study population, appropriateness of the sampling method, assessment outcome, and statistical analysis to determine the level of article quality and potential study bias. NOS was employed since all of the papers eligible for extraction were all cross-sectional studies and thus were suitable for this assessment because the NOS tool is suggested for quality assessment of non-randomized studies and risk of bias assessment [55].

Data Synthesis and Analysis

Data synthesis entailed a descriptive examination of the retrieved data from the selected research. The descriptive data looked at the mean prevalence of tuberculosis, rifampicin, and MDR-TB in both the pre-COVID-19 and COVID-19 era groups. The data gathered on relevant risk factors from the selected research were non-numeric and thus simply described.

Ethical Considerations

Systematic review and meta-analysis studies are studies that collect data from other primary research to provide a comprehensive and summary view on a topic of interest. As such, they are not empirical in nature and do not require human or animal participation. This study did not require ethical approval because it solely used secondary data from previously published works. That is, the study did not require human or animal participation, hence no ethical clearance or approval was required. However, all data collected from published works were properly cited as needed in academic and research papers.

Results

PRISMA flowchart

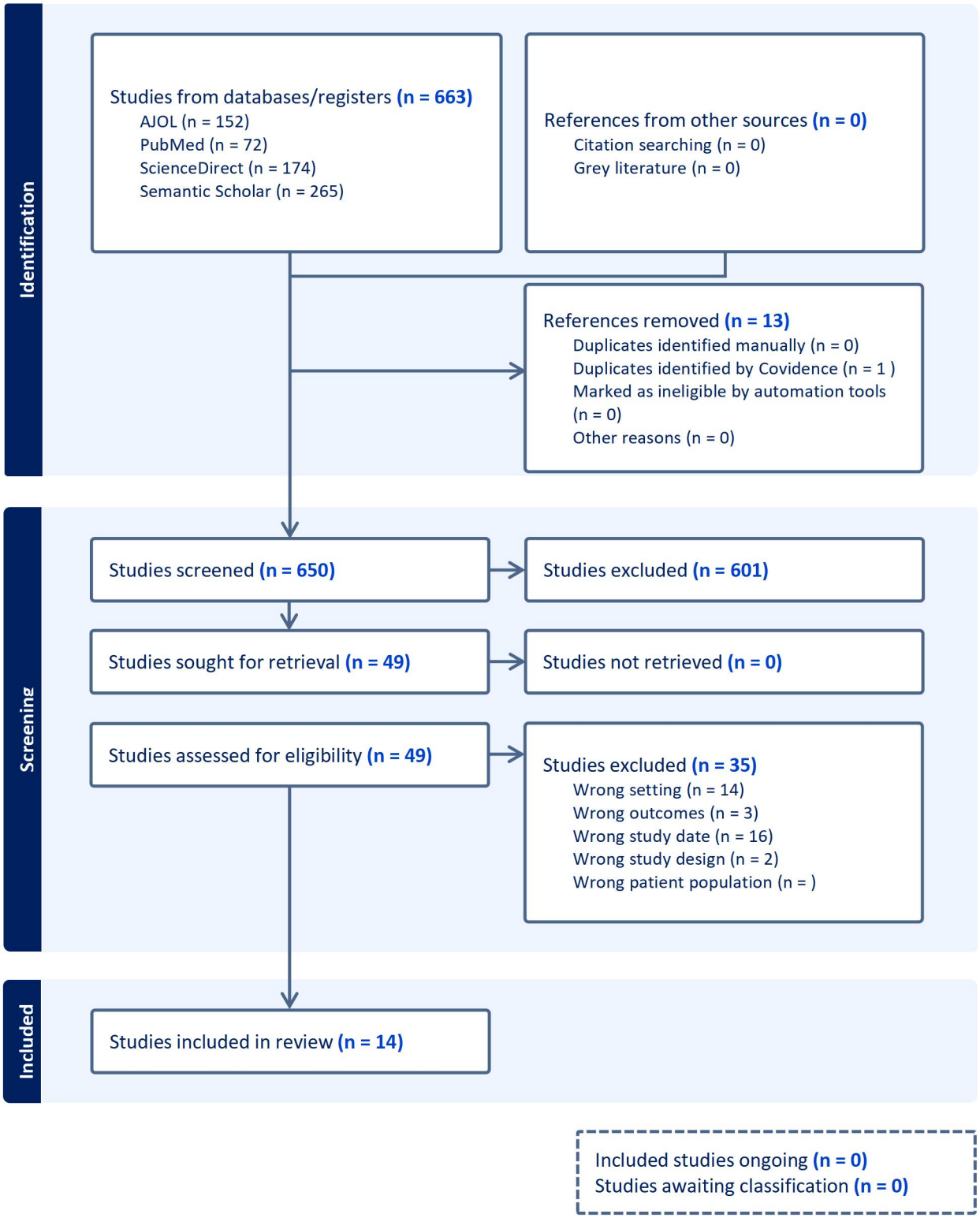

Figure 1: PRISMA Flowchart

Table 2 below showed the characteristics of the included studies. A total of 9 studies were captured before the COVID-19 era while 5 studies were captured during the COVID-19 era. All studies were cross-sectional and dealt with presumptive TB patients population in various states in Nigeria.

Table 2: Study characteristics

Studies	Study design	Population	Sample size	State in Nigeria
Studies conducted before 2020 (Pre-COVID-19 era)				
Olabiyi et al., 2023	Cross-sectional	Presumptive TB patients	1203	Ekiti/Ondo
Ibrahim et al., 2022	Cross-sectional	Presumptive TB patients	2451	Maiduguri
Ibadin et al., 2018	Cross-sectional	Presumptive TB patients	276	Edo
Ejeh et a., 2020	Cross-sectional	Presumptive TB patients	425	Benue
Abdulazeez et al., 2019	Cross-sectional	Presumptive TB patients	1610	Kwara
Ugwu et al., 2020	Cross-sectional	Presumptive TB patients	868	Enugu
Mohammad et al., 2017	Cross-sectional	Presumptive TB patients	384	
Ejeh et a., 2021	Cross-sectional	Presumptive TB patients		Benue
Daniel et al., 2023a	Cross-sectional	Presumptive TB patients	17334	Ogun
Studies conducted from 2020 (COVID-19 era)				
Obiora et al., 2020	Cross-sectional	Presumptive TB patients	200	Abuja
Ologunde et al., 2021	Cross-sectional	Presumptive TB patients	191	Ekiti
Alex-Wele et al., 2021	Cross-sectional	Presumptive TB patients	260	Rivers
Daniel et al., 2023b	Cross-sectional	Presumptive TB patients	24516	Ogun
Maori et al., 2021	Cross-sectional	Presumptive TB patients	130	Gombe

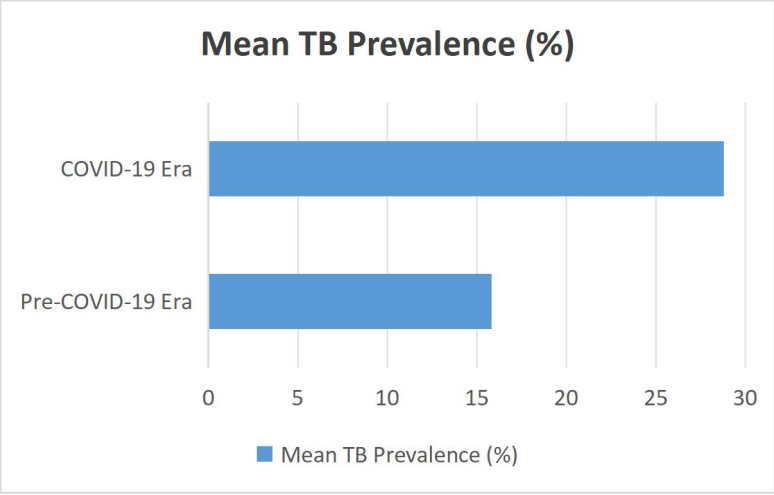

Figure 2: The Mean Prevalence of TB Before COVID-19 Era and COVID-19 Era

Figure 2 above reveals a marked increase in TB prevalence during the COVID-19 era, with a mean prevalence of approximately 29%, compared to 15% in the pre-COVID-19 era. This suggests a nearly two-fold rise in TB cases during the pandemic period.

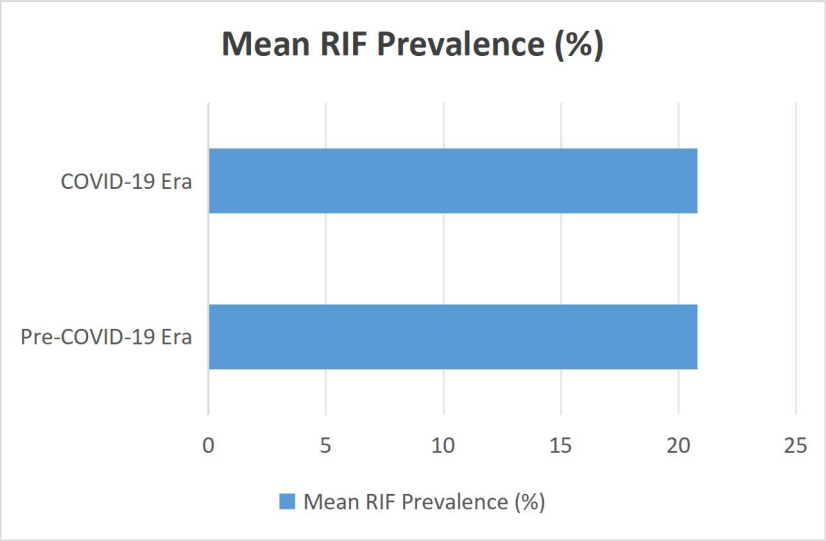

Figure 3: The Mean Prevalence of RIF Before COVID-19 Era and COVID-19 Era

Figure 3 above shows that the mean RIF prevalence remained relatively unchanged, with both periods recording a similar prevalence of approximately 21%.

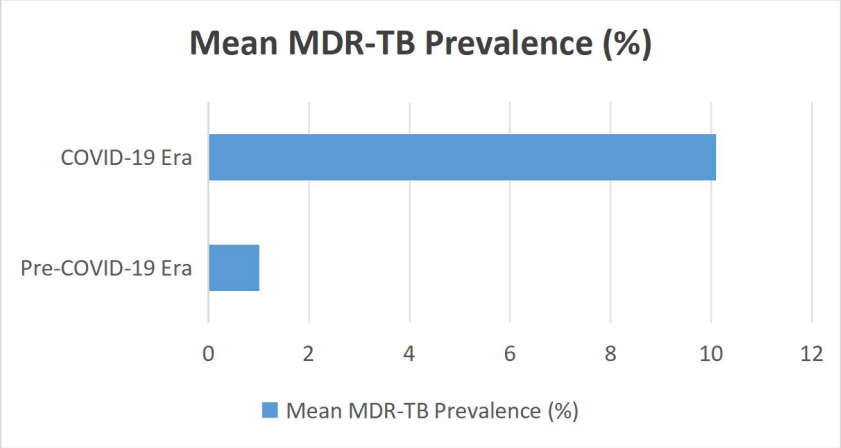

Figure 4: The Mean Prevalence of MDR-TB Before COVID-19 Era and COVID-19 Era

Figure 4 above shows that the mean prevalence of MDR-TB pre-COVID-19 was 1% while during COVID-19 it rose to 10%.

Table 5: Associated Risk factors of TB infection before the COVID-19 era and COVID-19 era

Studies	Associated risk factor of TB
Before COVID-19 era	
Olabiyi et al., 2023	Gender (male), overcrowding, room size, smoking, dry and dry season
Ibrahim et al., 2022	-
Ibadin et al., 2018	-
Ejeh et al., 2020	Age (15-34), settlement (rural)
Abdulazeez et al., 2019	-
Ugwu et al., 2020	Combination therapy, multiple therapy and compliance to treatment
Mohammad et al., 2017	-
Ejeh et al., 2021	Age (15-45), ethnic group, settlement (urban)
Daniel et al., 2023a	-
COVID-19 era	
Obiora et al., 2020	Age (36-45), sex (male)
Ologunde et al., 2021	Age (26-30), sex (female)
Alex-Wele et al., 2021	
Daniel et al., 2023b	
Maori et al., 2021	Age (>60), sex (male) and marital status (married)

According to the findings in Table 5, age and settlement were the most identified risk factors contributing to the spread of tuberculosis, with patients aged 15 to 45 being the most at risk of infection, while rural and urban areas were both considered risk factors in the pre-COVID-19 era. In the COVID-19 era, age and sex were the most often associated risk factors, with young people (26-45 years) being more at risk of tuberculosis infection than any other age group, and males being the most likely gender to contract tuberculosis.

DISCUSSION

This study aimed to investigate the influence of COVID-19 on the epidemiological landscape of tuberculosis in Nigeria, with a focus on TB prevalence, resistance patterns, and associated risk factors. Before the pandemic, this study found that the mean prevalence of tuberculosis was 15.8%, which was lower than the pooled prevalence during the COVID-19 era. The COVID-19 era saw a TB prevalence of 28.8%. This finding suggests that tuberculosis infection increased in Nigeria during the COVID-19 timeframe. In general, global reports show that TB rates have been dropping since 2000, but according to a World Health Organization report in 2023, there has been a rapid surge or upward trend in TB after 2019 [56]. This increase could be attributed to the influence of the pandemic over the world. The results of this study are consistent with the WHO report for Nigeria. Beyond Nigeria, several African countries observed an increase in tuberculosis incidence. Countries such as the Central African Republic, Democratic Republic of the Congo, United Republic of Tanzania, and Zambia have all reported rising TB rates, which are thought to be related to the epidemic [56]. In general, both the Africa and the global TB report charts showed a slowing of the TB rate in 2020 and a minor increase in the rate. According to the worldwide report, the rate of tuberculosis in 2020 exceeded the rate in 2015, causing the WHO End TB strategy objective of 2025 to be reconsidered [56]. The disruption in crucial TB health services during the pandemic may have had an impact on TB's downward trend. Another study found that 0.25% of COVID-19 patients recovered after receiving TB treatment. The prevalence exceeded the global average of 0.15%. It was thus implied that the pandemic may have had an impact on the geography of tuberculosis [57]. In contrast, a Ghanaian study found a substantial decrease in tuberculosis infections during the epidemic [58]. Transitioning into the pandemic era, in which medical attention was focused on treating the rapidly invading virus, may have resulted in a neglect of other infectious diseases such as tuberculosis, resulting in an increase in TB cases documented in this study. It is important to note that TB had been on a downward trend prior to the COVID-19 era [59], implying that there had been progressive improvement in TB management; thus,

the sudden rise in TB during the pandemic era can only be explained by the fact that COVID-19 may have impacted on the general management of the disease, which may include patient-related factors, health-system-related factors, socioeconomic factors, and others [59]. This is reinforced by Brown and colleagues' research, which found that COVID-19 had an impact on individuals' health systems, income, and job security [59].

Rifampin resistance (RIF) is particularly troubling because it is frequently associated with multidrug-resistant tuberculosis (MDR-TB) [59]. In fact, Fadeyi classified rifampicin as a serrugate for MDR-TB because isonaziad resistance accounts for 90% of rifampicin resistance [60]. In this study, the pooled prevalence of rifampicin resistance in the pre-pandemic period was 20.8%. Other writers' investigations, on the other hand, found differing prevalences reflecting other aspects of the problem, such as geographic variances. Fadeyi found a prevalence of 4.2% [60], but Adejumo reported a more alarming rate of 23.4% [61]. In contrast, Onyedeji's 2020 study found no evidence of RIF resistance [62]. However, Audu's study in 2017 revealed a prevalence of 12.1% [63], which is consistent with the findings of this review. This variance in the prevalence of rifampicin resistance highlights the variability of rifampicin resistance across Nigeria, as discovered in this review. During the pandemic, the prevalence was 20.8%, according to one study by Alex-Wele in 2021 [64]. When studying the rifampicin resistance rate, efforts were made to determine whether the pandemic caused a shift in the trend of rifampicin resistance among TB patients in Nigeria. This study found that there was no change in rifampicin resistance rate as it moved from the pre-COVID-19 to the COVID-19 era.

Prior to the COVID-19 pandemic, the prevalence of MDR-TB was 1.01%. This estimate differs from Lawson's 2010 observation of a rate of 13% [65]. Again, it contrasted substantially from Rasaki's 2014 data, which claimed a prevalence of 31.4% [66]. This difference could be attributed to peculiarities connected with individual studies, such as geography. However, a systematic review conducted by Molla in East Africa between 2007 and 2019 found a low MDR-TB case rate of 4% in TB [67], which is consistent with the findings of our study. Musa's systematic assessment of six African countries from 2007 to 2017 indicated a low rate of 2.1% in tuberculosis cases [68]. The results of this review analysis revealed that the prevalence of MDR-TB was known from only one study, which was conducted during the COVID-19 era by Alex-Wele [64], who reported a prevalence of 10.1%. Although it is simple to conclude that MDR-TB increased from 1.01% to 10.1% between the pre-COVID-19 and COVID-19 eras, caution must be exercised in interpreting the results because the outcome of one study may not be sufficient to warrant this conclusion.

The research included in this analysis indicated a pattern in which the prevalence of tuberculosis is impacted by a variety of factors such as age, gender, settlement status, and many others. The included studies revealed age and settlement as risk factors for tuberculosis infection. This shows that age and settlement were seen as the primary risk factors for tuberculosis infections. Before the epidemic, teenagers and adults were more likely to contract tuberculosis than children and the elderly in Nigeria. This finding contradicted a study conducted in Uganda, which found that elderly persons were more susceptible to tuberculosis infection than younger people with strong immunity [69]. The pandemic may not have affected the trend in the risk factors for tuberculosis. Settlement was not included, possibly because of the limited studies available during the COVID-19 era. Age and gender were the primary risk variables contributing to the spread of tuberculosis in Nigeria. The capture of the younger age group before and during the COVID-19 era demonstrated that this age group was more vulnerable than youngsters and the elderly. This could be because this age group is more active, engaged, mobile, and sociable than others, putting them at risk of meeting infected patients and visiting TB-endemic areas. Males were regarded to have the highest risk of tuberculosis infection. This trend has long existed and is consistent with global reports [70].

Conclusion

This review examined the trends in tuberculosis, RIF, and MDR-TB before and after COVID-19. In addition, it identified the most common risk factors connected with infection rates. This review indicated that the TB infection rate in Nigeria increased somewhat during the pre-COVID-19 and COVID-19 eras. Similarly, RIF resistance remained unchanged during the COVID-19 era. However, there was an arguably higher trend of

MDR-TB from the pre-COVID-19 era to the COVID-19 era. The observed increased trends may have resulted from a shift in health-care delivery priorities from other diseases to COVID-19. Age (teens and young adults) and settlement were the most common risk factors in the pre-COVID-19 era, whereas age (young adults) and gender (male) were the most vulnerable groups to tuberculosis in Nigeria.

Recommendation

While combating pandemics like COVID-19, it is critical that other health services are not overlooked in order to avoid an upward trend in the already declining disease rate. Targeted TB intervention activities should be strongly encouraged, particularly among teenagers and young adults who are more vulnerable to infection. Targeted TB intervention strategies are also suggested for males, who have been demonstrated to be the gender most at risk of TB infection. Further research is needed to determine the male factor or characteristics that make them more vulnerable to tuberculosis infection.

Limitation

There were few research on TB resistance patterns, especially during the COVID-19 era, which influenced how resistance trends were interpreted. Most research in Nigeria focused on RIF and MDR-TB, with inadequate data on solely resistant TB (XDR-TB), hence this study did not capture that aspect of TB drug resistance.

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