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Prevalence of Tuberculosis in Coastal Communities of Port Harcourt City, Rivers State, Nigeria

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Abstract

Tuberculosis (TB) remains a major public health challenge in Nigeria, with an estimated 586,000 incident cases in 2023, and coastal zones such as Port Harcourt present distinct epidemiological risks due to high population density, informal settlements, frequent flooding, and limited access to diagnostic and treatment services. Against the backdrop of scarce TB data specific to coastal communities and an almost complete absence of information on immunopathological mechanisms in this setting, this study examined TB prevalence and treatment compliance among residents of three coastal communities in Port Harcourt City, Rivers State—Eagle Island, Marine Base, and Borikiri Sea Side—and explored how risk factor exposure, preventive practices, attitudes, and knowledge relate to disease patterns. Using a descriptive cross-sectional design, 400 respondents completed a structured questionnaire capturing socio-demographic characteristics, TB-related knowledge, exposure to risk factors, preventive behaviors, attitudes, and treatment history, and the data were analyzed with descriptive statistics (frequencies, percentages, mean scores) and hypothesis testing. The findings show an overall TB prevalence of 11.5%, with community-specific prevalence of 12.0% in Eagle Island, 10.5% in Marine Base, and 12.5% in Borikiri Sea Side. Significant exposure to risk factors such as overcrowding, occupational hazards, and household tobacco smoke was positively correlated with TB prevalence ($r = 0.462$, $p < 0.05$). Moderate adoption of preventive measures (e.g., mouth covering and ensuring proper ventilation) was associated with better treatment compliance ($r = 0.378$, $p < 0.05$), although routine health check-ups were relatively uncommon. Positive attitudes toward TB—recognizing its seriousness and rejecting stigma—were linked to improved adherence ($r = 0.421$, $p < 0.05$), and higher TB knowledge similarly correlated with higher treatment compliance ($r = 0.394$, $p < 0.05$). The study concludes that TB control in these coastal communities requires an integrated strategy that simultaneously reduces exposure to structural and behavioral risk factors, strengthens preventive practices, promotes positive attitudes, and enhances TB-related knowledge. These context-specific insights provide an empirical basis for designing targeted public health interventions to improve treatment compliance and curb TB transmission in coastal Nigerian settings.

Keywords: Tuberculosis; Coastal Communities; Treatment Compliance; Risk Factors; Port Harcourt, Nigeria.

INTRODUCTION

Tuberculosis (TB) is a potentially serious infectious disease that primarily affects the lungs, although it can impact other organs as well. It is caused by the bacterium Mycobacterium tuberculosis and remains a major public health challenge, particularly in developing countries (World Health Organization [WHO], 2020). TB continues to be a leading cause of morbidity and mortality worldwide, despite advances in medical research and public health interventions. One of the critical aspects of TB is the prevalence of latent or idle cases, in which infected individuals do not display clinical symptoms. Research indicates that about one-third of latent TB infections may progress to active disease, especially among individuals with compromised immunity, such as those living with HIV, diabetes, or undergoing immunosuppressive therapy (Getahun et al., 2015; Lönnroth et al., 2010). These latent infections act as a hidden reservoir for TB transmission, thereby complicating efforts aimed at disease eradication (Zumla et al., 2013).

Historically, TB has exerted a significant burden on human health for centuries. For much of human history, the cause of TB remained unknown until Robert Koch identified Mycobacterium tuberculosis in 1882, a landmark discovery commemorated annually as

World TB Day (Daniel, 2006). This discovery marked the beginning of a scientific understanding that allowed for the development of diagnostic and treatment strategies. TB is primarily transmitted through airborne particles expelled when individuals with active pulmonary TB cough, sneeze, or speak, which highlights the importance of early detection, timely treatment, and community-level interventions to curb its spread (WHO, 2020). Consequently, understanding the modes of transmission has been central to designing effective public health strategies.

At the global level, TB remains a pressing health challenge. Nigeria ranks fourth among the six countries with the highest TB prevalence, alongside India, China, Indonesia, South Africa, and Pakistan. Collectively, these countries accounted for 60% of global TB cases in 2015 (WHO, 2015). Within Nigeria, Rivers State has been identified as a high-burden region, ranking fifth among the 36 states and the Federal Capital Territory. Current estimates indicate that over 16,000 TB cases exist in Rivers State, reflecting ongoing challenges in TB control (Federal Ministry of Health [FMOH], 2019). Importantly, TB is the leading cause of death among persons living with HIV, accounting for roughly 40% of HIV-related deaths, which illustrates the compounded impact of immunodeficiency on TB outcomes (Lawn & Zumla, 2011).

Global and national efforts to reduce TB prevalence have been reinforced through strategic health initiatives. The United Nations' Sustainable Development Goals (SDGs) and the WHO End TB Strategy set ambitious targets for 2020–2035, including reducing TB deaths by 35% and TB prevalence by 20% relative to 2015 levels (WHO, 2015; United Nations, 2015). In line with these initiatives, the WHO has consistently produced country-level TB estimates since 2000 to monitor progress and guide evidence-based policy interventions (WHO, 2020). These global strategies underscore the need for integrated approaches that combine prevention, early diagnosis, treatment, and socio-economic interventions to achieve sustainable reductions in TB burden. Such international frameworks provide a reference point for understanding the effectiveness of local TB management programs.

Despite the global prevalence of TB, the disease is curable when diagnosed and treated appropriately. The Directly Observed Treatment Short Course (DOTS) is the primary global strategy, accessible at primary healthcare centers in both rural and urban areas (WHO, 2017). DOTS ensures that patients adhere to supervised treatment regimens, enabling effective diagnosis, timely treatment, and the prevention of drug resistance. Globally, DOTS has been recognized as a major public health breakthrough, curing approximately eight out of ten treated patients (Gandhi et al., 2010). Its adoption across over 110 countries highlights its effectiveness and scalability (WHO, 2017). The widespread implementation of DOTS illustrates how coordinated health programs can significantly reduce the TB burden when patients are supported to complete treatment.

In Africa, where socioeconomic challenges such as poverty, political instability, and corruption are pervasive, TB has emerged as a leading cause of morbidity and mortality. According to the WHO (2022), TB is responsible for more deaths than any other single infectious agent, making it a priority for global health interventions. The bacterium M. tuberculosis is a gram-positive, rod-shaped, acid-fast organism, which enables laboratory detection using staining techniques resistant to acid decolorization. It is a strict aerobe, thriving in oxygen-rich tissues such as the apices of the lungs, renal parenchyma, and growing ends of bones, which explains why pulmonary TB is the most common clinical manifestation. These oxygen-rich tissues are particularly conducive to bacterial growth, allowing the organism to establish persistent infection and generate characteristic granulomatous lesions known as tubercles (Floyd et al., 2018). While M. tuberculosis accounts for the majority of human cases, M. bovis and M. africanum occasionally contribute to disease burden, particularly in regions with zoonotic exposure or localized outbreaks (Zumla et al., 2015). Despite slight variations in epidemiology, the clinical presentation of TB caused by these species remains largely indistinguishable.

Transmission of TB is primarily airborne, occurring through the inhalation of droplets expelled by individuals with active pulmonary infection. These droplets are released during coughing, sneezing, speaking, or spitting, and their infectivity depends on factors such as concentration in the environment, duration of exposure, and the immune status of the exposed individual (Lonnroth et al., 2010). Once inhaled, the bacteria are engulfed by alveolar macrophages. Some are destroyed by host immune defenses, but others survive and replicate intracellularly, forming granulomas that simultaneously contain the infection and permit latent persistence. The latent phase of TB is of particular concern because individuals may harbor the bacteria without symptoms for years, maintaining the potential to progress to active disease if the immune system is compromised. HIV infection has been identified as the most significant factor that triggers progression from latent to active TB, highlighting the intersection of TB with other infectious diseases and the complexity of managing co-infections (Zumla et al., 2015; Floyd et al., 2018).

Socioeconomic and environmental determinants play a crucial role in shaping TB epidemiology. Studies indicate that overcrowding, poor nutrition, substandard housing, and coexisting illnesses significantly increase susceptibility to infection and reinfection, particularly among vulnerable populations (Lonnroth et al., 2010). Individuals living in poverty, incarcerated populations, and workers in environments with poor occupational conditions are disproportionately affected by TB. Conversely, improved living conditions, access to nutrition, environmental sanitation, and healthcare reduce the risk of infection and the likelihood of progression from latent to active disease. Longitudinal studies have shown that, without treatment, approximately 50% of patients with primary TB die within five years, 25% remain chronically ill and infectious, and only 25% achieve spontaneous remission through natural immune defense mechanisms (Zumla et al., 2015). These findings underscore the necessity of timely diagnosis, effective treatment, and interventions targeting underlying social determinants to reduce TB-related morbidity and mortality.

Drug resistance has emerged as a major challenge in TB management, with multidrug-resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB) becoming increasingly prevalent (Zumla et al., 2015). Studies indicate that drug resistance primarily arises from incomplete or inconsistent treatment, microbial genetic adaptations, and inadequate healthcare systems, necessitating the development of new therapeutic strategies and robust monitoring of treatment adherence. The co-occurrence of TB and HIV/AIDS has further intensified the burden of disease in sub-Saharan Africa, complicating treatment regimens and contributing to higher mortality rates. Social interventions, including improved nutrition, reduction of overcrowding, and integration of TB and HIV healthcare services, have been shown to enhance treatment outcomes and reduce TB incidence, emphasizing the need for holistic public health approaches (Lonnroth et al., 2010; Floyd et al., 2018).

The epidemiology of tuberculosis (TB) remains a focal point of global public health research due to the persistent burden of the disease and its complex interplay with socioeconomic, biological, and environmental factors. As one of the oldest known human pathogenic infectious diseases, Mycobacterium tuberculosis (M. tuberculosis) continues to pose a formidable health challenge, prompting ongoing research aimed at understanding its pathogenesis, transmission, and control measures (Zumla et al., 2015). Historically, TB has exerted a significant economic and health impact, affecting millions of individuals annually and placing substantial strain on healthcare systems worldwide. Despite continuous advancements in diagnostic tools, therapeutic interventions, and preventive strategies, TB infections persist as a major global concern, particularly in low- and middle-income countries, where poverty, overcrowding, and limited access to healthcare exacerbate disease transmission and morbidity (World Health Organization [WHO], 2022).

One of the most pressing concerns in TB epidemiology is the emergence of antibiotic-resistant strains, particularly multidrug-resistant (MDR-TB) and extensively drug-resistant (XDR-TB) variants. These resistant strains complicate treatment regimens, prolong infectious periods, and increase mortality rates, presenting significant challenges for public health systems (Zumla et al., 2015). In addition, comorbid conditions such as HIV/AIDS and diabetes significantly elevate susceptibility to TB infection and progression to active disease. Studies indicate that the immunosuppressive effects of HIV infection, particularly depletion of CD4+ T lymphocytes, compromise host immunity, thereby increasing vulnerability to both primary and reactivated TB infections (Lonnroth et al., 2010; Floyd et al., 2018). Similarly, diabetes has been identified as a metabolic condition that impairs immune response and heightens TB risk, with evidence suggesting that diabetic patients are more likely to develop active TB upon exposure (Jeon & Murray, 2008). This intersection of infectious and non-communicable diseases underscores the complex epidemiological landscape of TB and highlights the need for integrated approaches to disease control.

The evolving nature of M. tuberculosis has further contributed to the epidemiological complexity of TB. Beyond the classic pulmonary form, which predominantly affects the lungs, the disease has increasingly manifested as extrapulmonary TB, affecting organs such as lymph nodes, bones, the central nervous system, and other body sites (Floyd et al., 2018). Approximately 15% of TB cases globally are extrapulmonary, and these cases pose unique diagnostic and treatment challenges due to their atypical presentation and the difficulty in obtaining microbiological confirmation. Extrapulmonary TB can also be inadvertently transmitted during procedures such as organ transplantation, highlighting the importance of rigorous screening and infection control measures in clinical settings (Khan et al., 2016). Moreover, the capacity of M. tuberculosis to establish latent infection in asymptomatic individuals contributes to sustained transmission within populations, with an estimated one-quarter of the global population harboring latent TB infection (WHO, 2022). This reservoir of latent infection represents a persistent challenge for TB control and eradication, as reactivation can occur years or decades after initial exposure, particularly when host immunity declines.

Accurate diagnosis of TB is fundamental to epidemiological surveillance and effective clinical management. Immunoreactivity-based tests, including the tuberculin skin test (TST) and the interferon-gamma release assays (IGRAs) such as QuantiFERON-TB Gold In-Tube (QFT-GIT), are widely used to detect TB infection (Cellestis Limited, 2020). The TST demonstrates high sensitivity, ranging from 89% to 95%, while QFT-GIT sensitivity is reported at approximately 83% (Pai et al., 2014). These tests rely on the principle of immune memory, where prior exposure to M. tuberculosis triggers a measurable immunological response. However, limitations exist, particularly in immunocompromised individuals, including those with HIV/AIDS, where diminished CD4+ T-cell populations can result in false-negative results. Additionally, low bacterial loads may further reduce test sensitivity, complicating accurate case detection in early or latent infection (Zumla et al., 2015). Cell-mediated immunity, predominantly orchestrated by CD4+ T lymphocytes, plays a critical role in containing infection and preventing progression to active disease. This immunological understanding explains why HIV-positive individuals are at markedly higher risk for TB infection and reactivation, even though studies indicate that they often have lower sputum bacillary loads and are therefore less infectious than HIV-negative patients (Floyd et al., 2018; Lawn & Zumla, 2011).

The global epidemiology of TB reflects both historical patterns and contemporary public health challenges. Annually, there are approximately 10 million new TB infections worldwide, with mortality exceeding 1.2 million cases among HIV-negative individuals, and an additional 0.2 million deaths among HIV-positive patients (WHO, 2022). While pulmonary TB remains the predominant clinical form, extrapulmonary TB accounts for a significant proportion of cases, particularly in immunocompromised populations. The disease disproportionately affects socially and economically disadvantaged populations, including those living in poverty, individuals in correctional facilities, and people with limited access to healthcare services (Lonnroth et al., 2010). Overcrowding, malnutrition, and inadequate healthcare infrastructure amplify transmission risk, perpetuating cycles of infection and reinfection that are difficult to break without comprehensive interventions.

Research also highlights the dynamic interaction between TB and other infectious diseases. The HIV epidemic, in particular, has synergistically increased TB incidence in sub-Saharan Africa and other high-burden regions. Co-infection with HIV accelerates progression from latent to active TB and complicates clinical management, given the overlapping toxicity profiles of antiretroviral therapy and TB medications (Lawn & Zumla, 2011). Furthermore, emerging MDR and XDR strains compound these challenges, as they require prolonged, expensive, and often less effective treatment regimens. This dual burden underscores the necessity for integrated disease management strategies that combine TB control with HIV prevention and treatment programs, alongside interventions targeting social determinants such as poverty, housing, and nutrition.

The epidemiology of TB is shaped by a multifactorial interplay of microbial evolution, host immunity, socioeconomic determinants, and global health interventions. Despite significant advances in diagnostic tools, therapeutic strategies, and preventive measures, TB remains a persistent public health threat, particularly in resource-limited settings. The emergence of drug-resistant strains, the ongoing HIV epidemic, and the widespread prevalence of latent infections highlight the continuing challenges in controlling the disease. Effective TB control necessitates a comprehensive, multidisciplinary approach encompassing early diagnosis, prompt and effective treatment, integration with HIV care, and strategies aimed at addressing underlying social determinants of health. Continued research into host-pathogen interactions, immunological responses, and innovative therapeutic approaches remains essential to reduce the global burden of TB and achieve sustainable disease control (Zumla et al., 2015; WHO, 2022; Floyd et al., 2018; Lonnroth et al., 2010; Pai et al., 2014; Lawn & Zumla, 2011; Khan et al., 2016).

Tuberculosis (TB) pathogenesis represents a complex interplay between the virulence of Mycobacterium tuberculosis, host immune responses, and environmental and genetic factors that influence susceptibility and disease progression. TB is primarily an airborne infectious disease, transmitted via inhalation of droplet nuclei expelled by individuals with active pulmonary infection (Zumla et al., 2015). Upon inhalation, the tubercle bacilli reach the alveoli, where they are phagocytosed by alveolar macrophages. This initial host-pathogen interaction represents the first line of defense against infection, as the macrophages attempt to contain the bacilli through endocytosis and enzymatic destruction (Floyd et al., 2018). However, M. tuberculosis has evolved mechanisms to evade immune destruction, allowing it to survive and multiply within these host cells. This intracellular survival forms the basis for latent tuberculosis infection (LTBI), a state in which individuals are asymptomatic but carry viable bacteria capable of reactivation under conditions of immune compromise (Lawn & Zumla, 2011). Following alveolar infection, M. tuberculosis may disseminate through lymphatic channels and the bloodstream to distant organs, particularly in cases where host immune defenses are insufficient. The pathogen often localizes in tissues with high oxygen tension, including the apex of the lungs, renal parenchyma, central nervous system, bones, and lymph nodes (Floyd et al., 2018; Zumla et al., 2015). This dissemination underlies the development of both pulmonary and extrapulmonary TB. The formation of granulomas, structured aggregates of immune cells surrounding the bacteria, represents a key host defense mechanism that contains infection while simultaneously permitting bacterial persistence (Khan et al., 2016). Granulomas facilitate immunological priming, enabling systemic immune responses and the establishment of immunological memory, which can be detected using diagnostic tools such as the tuberculin skin test (TST) and interferon-gamma release assays (IGRA) (Pai et al., 2014). These assays, which measure host immunoreactivity to M. tuberculosis antigens, remain critical for surveillance and the identification of latent TB cases, guiding public health interventions aimed at reducing disease progression.

The pathogenicity of M. tuberculosis is further enhanced by its unique ability to form intracellular cords, a characteristic that correlates with increased virulence and persistence within host tissues (Zumla et al., 2015). Genetic mutations, environmental adaptation, and cord-forming capacity have collectively contributed to the emergence of drug-resistant TB strains, including multidrug-resistant (MDR-TB) and extensively drug-resistant TB (XDR-TB) (Lawn & Zumla, 2011). MDR-TB refers to strains resistant to the two most potent first-line anti-TB drugs, isoniazid and rifampicin, whereas XDR-TB exhibits additional resistance to second-line drugs, such as fluoroquinolones or injectable agents like amikacin, kanamycin, or capreomycin (World Health Organization [WHO], 2022). These resistant strains pose significant challenges for treatment, prolong infectious periods, and contribute to higher morbidity and mortality rates, particularly in resource-limited settings. The risk of progression from LTBI to active TB is influenced by multiple host factors. In the general population, the lifetime risk of developing active TB after infection is approximately 10% (Floyd et al., 2018). However, this risk increases substantially among individuals with comorbidities such as diabetes, which raises the lifetime risk by an estimated 30%, and HIV infection, which increases the annual risk by approximately 10% (Zumla et al., 2015; Lawn & Zumla, 2011). Immunocompromised individuals, particularly those with diminished CD4+ T-cell populations, are less capable of containing bacillary replication, making them more susceptible to disease progression. Paradoxically, studies have shown that HIV-positive patients often have lower sputum bacillary loads than HIV-negative individuals, resulting in reduced transmissibility despite heightened vulnerability to disease (Floyd et al., 2018). This complexity underscores the necessity for nuanced epidemiological surveillance and individualized clinical management in high-risk populations.

While pulmonary TB remains the most common form of the disease, extrapulmonary manifestations have been increasingly documented, accounting for 15–25% of all TB cases globally (Khan et al., 2016). Extrapulmonary TB can involve organs such as the lymph nodes, kidneys, bones, brain, and joints, and in rare instances, can be transmitted via organ transplantation or blood transfusion (Zumla et al., 2015). The diagnosis and management of extrapulmonary TB are particularly challenging due to the atypical clinical presentation and limited sensitivity of conventional diagnostic methods. These factors contribute to delayed detection, prolonged infectious periods, and increased morbidity, emphasizing the need for advanced diagnostic tools and vigilant clinical oversight.

The emergence of drug-resistant TB strains has further complicated the pathogenesis and management of the disease. Primary drug resistance occurs when individuals are infected with already resistant M. tuberculosis strains, while secondary resistance develops due to incomplete or inappropriate treatment (WHO, 2022). MDR-TB and XDR-TB are associated with increased treatment duration, reduced therapeutic options, and heightened risk of mortality. The global burden of drug-resistant TB highlights the urgent need for new pharmacological interventions, adherence monitoring, and public health strategies that address both microbial evolution and host vulnerability (Zumla et al., 2015; Floyd et al., 2018).

The pathogenesis of TB reflects a multifaceted interplay between microbial virulence, host immunity, and environmental factors. The inhalation of airborne bacilli initiates infection, followed by either containment within granulomas leading to latent infection or progression to active disease depending on host immune competence. The pathogen's ability to disseminate, form intracellular cords, and develop drug resistance amplifies the complexity of disease management. Moreover, comorbid conditions such as HIV and diabetes, as well as the prevalence of extrapulmonary TB, compound the public health challenge. Effective control of TB pathogenesis requires integrated strategies encompassing early diagnosis, targeted treatment, robust surveillance, and consideration of underlying social and biological determinants. Ongoing research into host-pathogen interactions, immunological defense mechanisms, and novel therapeutic approaches remains critical to reducing the global burden of TB and mitigating the impact of drug-resistant strains (Zumla et al., 2015; Floyd et al., 2018; Lawn & Zumla, 2011; Khan et al., 2016; WHO, 2022).

Nigeria's position in the global TB landscape underscores the urgency of effective intervention. Historically, the country ranked sixth worldwide in terms of TB burden and exhibited an estimated multidrug-resistant (MDR) prevalence of 4.3% in new TB cases. More recent data indicate that Nigeria has moved to seventh position globally while ranking second in Africa among countries with a high TB burden (WHO, 2020). Despite this high burden, Nigeria has historically experienced some of the lowest TB case detection rates worldwide. In 2018, only 24% of incident TB cases were detected, falling significantly short of the WHO Stop TB target of 84% detection. Low detection rates, coupled with delayed diagnosis, result in prolonged periods of infectivity, increased transmission, and higher morbidity and mortality, particularly in socioeconomically disadvantaged communities (Uplekar et al., 2015).

The challenges of TB control in Nigeria are multifaceted. The disease's prolonged treatment duration, which often spans several months, leads to loss of income for patients and potential treatment non-adherence. In addition, the health system's capacity to diagnose TB is constrained by limited infrastructure, shortages of trained personnel, and inadequate laboratory facilities. The emergence of drug-resistant TB strains further complicates management, requiring more complex, costly, and prolonged therapeutic regimens (Zumla et al., 2015). Beyond these systemic challenges, the intersection of TB with other health crises has amplified the public health burden. Co-infection with HIV remains a significant driver of TB morbidity, as immunocompromised individuals are more susceptible to progression from latent infection to active disease. More recently, the COVID-19 pandemic has disrupted TB prevention and treatment services, creating delays in diagnosis, interruptions in treatment adherence, and heightened vulnerability among populations with preexisting TB and HIV co-infections (WHO, 2021).

The TB nomenclature system, while primarily a tool for classification, has critical implications for research, policy, and clinical practice. By categorizing individuals according to infection status, disease activity, and treatment history, healthcare providers and public health authorities can prioritize interventions, monitor treatment outcomes, and allocate resources effectively. Surveillance efforts focused on individuals with active or suspected TB are particularly important in high-burden settings like Nigeria, where delayed diagnosis and incomplete treatment can fuel ongoing transmission and facilitate the development of drug-resistant strains. Furthermore, the classification system provides a framework for evaluating the effectiveness of TB control programs, informing strategies aimed at reducing disease prevalence, improving case detection rates, and mitigating the impact of comorbidities such as HIV and diabetes (Floyd et al., 2018; Lawn & Zumla, 2011).

TB nomenclature system serves as a critical instrument in the global fight against tuberculosis, offering standardized categories that facilitate clinical management, epidemiological surveillance, and research prioritization. The substantial TB burden in Nigeria, compounded by population growth, low detection rates, multidrug resistance, and overlapping health crises such as HIV and COVID-19, underscores the urgent need for robust surveillance and intervention programs. Strengthening case detection, expanding access to treatment, and integrating TB control with broader health and social interventions are essential strategies for reducing the morbidity and mortality associated with TB. By linking classification, surveillance, and intervention efforts, countries like Nigeria can better manage the disease, prevent its spread, and ultimately move closer to achieving global TB control targets (WHO, 2018; Uplekar et al., 2015; Zumla et al., 2015).

The management of TB infection, e.g. its diagnosis and treatment, has been considered core intervention to pursue TB Elimination, specifically being the fourth of the 8 activities according to the WHO Framework for TB Elimination (Lönnroth et al., 2015; Matteelli et al., 2018, WHO 2020). In a recent UNION document reporting the clinical Standards for TB infection management (Migliori et al., 2022), a specific Public Health Standard was proposed, which recommends the following: A TB infection screening and testing registry should be kept to inform the cascade of care. it is necessary that an important proportion of individuals belonging to the groups at risk to progress to disease are screened for TB infection, accept to be treated if positive, undergo and complete the prescribed regimen. This process is called 'TB infection cascade of care', a crucial path towards TB Elimination (Lönnroth et al., 2015). A registry that reports the individuals with TB infection and the variables associated with TB infection is needed to build the "cascade". These variables need to be discussed and implemented by countries, in parallel to what is presently done for TB disease. TB infection registry is nowadays considered as best-practice for patient follow-up, programmatic planning and clinical governance tool to evaluate programmatic effectiveness of the intervention (Alsdurf et al., 2016; Collin et al., 2019, Global Tuberculosis Report 2021: Executive Summary, 2021). The registry has a clinical value, reporting the necessary information to manage the patient (e.g. follow-up visits, notification of adverse events and successful regimen completion): it is also relevant for public health issues to notify the infected individuals, to avoid duplications, to monitor how the patients are managed, and, most importantly, to trace the individuals who started the treatment and completed it. As a general principle in surveillance, the best option is to design an electronic registry based on individual data which is much more precise and flexible than the option based on designing the registry based on aggregated data. The legislation in force (with data-protection requirements) in each country or setting and the resources available will define how the registry will be designed and will operate.

The WHO, in its recent guidelines, recommends three core indicators allowing the global evaluation of TB infection management (WHO. Global Tuberculosis Report 2021):

1 Contact investigation coverage: percentage of contacts of bacteriologically-confirmed TB patients who were evaluated for TB disease and TB infection out of those eligible;

2 TB preventive therapy coverage: percentage of individuals that initiated on TPT out of those eligible;

3 TB preventive therapy coverage completion: percentage of individuals completing TPT out of those initiating treatment.

Important to underline that whenever an individual notified in the TB infection registry progress to TB disease, this event needs to be notified to the TB Registry.

Recently, blood gene expression signatures of the host have been identified in both HIV-uninfected and -infected individuals as associated with a higher risk to develop active TB. (Mendelsohn et al., 2021; Scriba et al., 2021) These signatures can predict short-term progression to active disease and positron emission tomography-computed tomography images confirmed intrathoracic lesions with increased uptake of radiolabelled glucose in the absence of specific symptoms or chest radiography images indicative of TB disease.

(Esmail et al., 2020, 2016) The best therapy for the individuals that are "transcript signature positive" is unknown now, since preventive therapy failed to prevent disease development. (Scriba et al., 2021)

Another approach is to detect *Mtb* DNA based on a bacteriophage-based technology, as shown in 3/18 asymptomatic TB contacts living in a different low-incidence setting (United Kingdom), of whom 2 went on to develop active TB after 7 months. (Verma et al., 2020) This approach proposes to detect the pathogen (Mtb) more than the immune response as a tool to identify those with TB infection more likely to progress to active disease.

Other approaches to detect Mtb DNA in whole blood by a digital PCR have been recently described in a population of HIV-infected and uninfected subjects in Ethiopia. Preventive therapy to HIV-infected participants reduced the prevalence of PCR-detected *Mtb* from 95% at baseline to 54% post-treatment (Belay et al., 2021). Experimental in vitro tests based on the detection of IFN-γ to heparin-binding hemagglutinin antigen (HBHA) have been shown interesting results as associated with *Mtb* containments and as tools to monitor active TB clinical states in children (Sali et al, 2018) confirming results from the adults (Delogu et al., 2011, Hedid et al., 2020; Chiacchio et al, 2017; Tang et al, 2021).

WHO revised (Global Tuberculosis Report 2021: Executive Summary, 2021, WHO 2020) the available evidence and indicated the following population groups as at high risk for progression to TB disease or at high rates of TB infection as: HIV-infected individuals as adults, adolescents, and children; household or close contacts of patients with bacteriologically confirmed pulmonary TB (all ages, but especially young children <5 years of age); candidates to either tumour necrosis factor(TNF)-α inhibitors, or dialysis, or organ or haematological transplant; subjects with silicosis; prisoners, healthcare workers having frequent unprotected contact with TB patients, migrants from countries with high TB burden, homeless people and people who abuse drugs.

Additional groups at risk are those with diabetes, alcohol abusers, tobacco smokers and those underweight; however, systematic TB infection testing and preventive therapy is not recommended unless they also belong to the risk groups described above.

Treatment is an essential component to the programmatic management of TB infection, designed to prevent the progression of TB infection to clinically active TB disease. Currently recommended treatment regimen are selected on the basis of evidence around efficacy, tolerability, acceptability, costs, feasibility under program conditions, and risk of fostering drug resistance during treatment. Safety is obviously pivotal, as all treated patients are healthy, and only a small proportion would develop active TB even in the absence of treatment. For example, pyrazinamide containing regimens were excluded from the WHO recommended options based on the evidence of fatal cases in a survey of state and city TB programs and other health-care settings in the United States. (McElroy et al., 2005)

Isoniazid has been the mainstay of TB infection treatment for a long time, with efficacy ranging from 60 to 90% (Horsburgh and Rubin, 2011) (Table 2.1). More recently, research around preventive therapy developed around two main axes: developing regimens that are less toxic than isoniazid and that are shorter, to increase the probability of completing treatment. A network meta-analysis published in 2017 evaluated the comparative efficacy and harms of TB infection treatment regimens aimed at preventing active TB among adults and children. It included 61 studies and showed evidence for the efficacy and safety of 6-months isoniazid monotherapy, rifampicin monotherapy for 4 months, and combination therapies with 3 months of isoniazid and rifampicin. (Zenner et al., 2017) A comparison of regimens for efficacy and hepatotoxicity showed that rifampicin for 4 months had lower liver-related serious adverse events compared to both 6 months of isoniazid and 3 months of rifampicin and isoniazid. A couple of years later a multicenter, randomized clinical trial run for about a decade, demonstrated the equivalence, in terms of efficacy, of daily rifampin for 4 months compared to a 9-month regimen of isoniazid. (Menzies et al., 2008).

In Rivers State, however, the effectiveness of TB control is influenced by socio-economic and environmental factors. High poverty levels, low literacy, limited awareness about TB, and poor adherence to treatment regimens remain significant barriers to TB management across the state's 23 Local Government Areas (FMOH, 2019). Coastal communities, in particular, face unique challenges. For instance, communities in Port Harcourt City are characterized by overcrowding, poor sanitation, inadequate drainage systems, and frequent flooding, conditions that increase vulnerability to airborne infections such as TB (Okonko et al., 2013). The interaction between environmental risk factors and socio-economic constraints contributes to delayed diagnosis, poor treatment compliance, and sustained disease transmission (Obi et al., 2018). This demonstrates that TB management cannot be limited to medical interventions alone but must incorporate socio-environmental considerations for effective control.

Moreover, TB disproportionately affects women, reflecting the intersection of disease burden, poverty, and gender inequality (Styblo, 1991). Understanding how socio-economic factors, gender, and environmental conditions interact to influence TB prevalence is therefore critical for designing targeted interventions. Coastal communities in Port Harcourt present an opportunity to study these interactions in depth, given their unique living conditions, high population density, informal settlements, and limited access to healthcare services (Obi et al., 2018). The presence of migration, poor housing, and low health literacy further complicates TB control, leading to delayed treatment and poor adherence, which perpetuates transmission cycles.

Given these challenges, localized studies on TB prevalence and treatment adherence are essential. By generating empirical evidence on TB patterns and treatment compliance in coastal communities, public health authorities can develop community-specific strategies for effective disease management. This study, therefore, seeks to examine the prevalence of tuberculosis and compliance with treatment protocols in the coastal communities of Port Harcourt City, Rivers State, Nigeria.

METHODOLOGY

Research Design

A descriptive cross-sectional survey was chosen to capture TB prevalence and related factors at one point in time, without manipulating variables. This design works well for quantifying disease burden and exploring demographic patterns.

Area of the Study

The research focused on three coastal settlements in Port Harcourt City LGA, Rivers State: Eagle Island, Marine Base, and Borikiri Sea Side. These densely populated waterfront areas have overcrowded wooden homes, poor ventilation, limited sanitation, and scant health-care access—conditions that heighten TB risk.

Population of the Study

All residents of the three communities formed the target population. The National Population Commission in 2024 estimate the population at 215 000 live in these coastal zones, making them a high-risk group for TB.

Sample and Sampling Technique

A total sample of 400 respondents was used for the study. The sample size was determined using Taro Yamane's (1967) formula for determining sample size from a finite population. The formula is expressed as

$$n = \frac{N}{1 + N(e^2)}$$

Where:

n = sample size

N = population size

e = margin of error (0.05)

For this study:

Estimated coastal population

N=215,000 persons

Desired margin of error

e=0.05

Substituting into the formula:

$$n = \frac{215,000}{1 + 215,000(0.05^2)}$$

$$n = \frac{215,000}{1 + 215,000(0.0025)}$$

$$n = \frac{215,000}{1 + 537.5}$$

$$n = \frac{215,000}{538.5}$$

$$n = 399.63$$

The calculated sample size was 399.63, which was rounded up to 400 respondents to strengthen data precision and ensure adequate representation of sub groups within the coastal population.

Instrument for Data Collection

The instrument used for data collection was a structured questionnaire developed by the researcher. It consisted of four major sections designed to capture comprehensive and relevant information for the study. The first section obtained demographic details such as age, sex, educational level, and occupation. The second section measured respondents' knowledge of tuberculosis, including causes, symptoms, and modes of transmission. The third section assessed exposure to environmental and behavioral risk factors such as overcrowding, smoking, and proximity to infected persons. The final section focused on self-reported symptoms, previous diagnosis, and treatment history. The questionnaire was written in clear and simple English to accommodate respondents with varying educational backgrounds.

Validation of the Instrument

The instrument underwent face and content validation to ensure accuracy and relevance. The supervisor other experts in Measurement and Evaluation reviewed the questionnaire to determine whether the items adequately covered the objectives of the study. Their corrections addressed issues such as clarity of wording, logical arrangement of questions, and appropriateness of response options. The final version of the questionnaire reflected all expert recommendations, thereby enhancing its validity and ensuring that the instrument measured the variables it was intended to assess.

Reliability of the Instrument

The reliability of the instrument was established through a test-retest procedure. The questionnaire was administered to a group of 20 residents from a coastal community not included in the main study. After a two-week interval, the same instrument was administered to the same group of respondents. The responses from both administrations were analyzed using Cronbach's Alpha. A reliability coefficient of **0.82** was obtained, indicating that the instrument had high internal consistency and was dependable for use in the main study.

Method of Data Collection

Data were collected through direct administration of the questionnaires to respondents in the selected communities. The researcher, together with trained research assistants, visited the coastal areas and distributed the questionnaires to selected households. Respondents were given explanations where necessary to ensure full understanding of each question. Those who were unable to read were assisted by research assistants who interpreted the items without influencing their responses. The face-to-face method increased the response rate and ensured that the data collected were accurate and complete.

Method of Data Analysis

After data collection, the completed questionnaires were retrieved, sorted, and coded for statistical analysis. Descriptive statistics such as frequencies, percentages, and mean scores were used to analyze the data. These statistics provided a clear summary of tuberculosis prevalence, associated risk factors, and demographic characteristics of respondents. The results were presented in tables to enhance clarity and allow for easy interpretation. The findings were discussed in line with the research objectives and linked to relevant literature.

RESULTS

Retrieval of Questionnaires

The study administered 400 questionnaires to respondents in the selected coastal communities of Eagle Island, Marine Base, and Borikiri Sea Side. Out of these, 392 questionnaires were correctly filled and returned, resulting in a response rate of 98 percent, which is considered very high for survey studies. The eight questionnaires that were not retrieved or were incomplete were excluded from analysis. The high retrieval rate reflects the effectiveness of the face-to-face administration and prior engagement with community leaders, which helped respondents understand the purpose of the study and motivated participation This is represented in the table below.

Table 1: The distribution and retrieval of questionnaires

Community	Questionnaires Administered	Questionnaires Retrieved	Not Retrieved	Retrieval Rate (%)
Eagle Island	**133**	**131**	**2**	**98.5**
Marine Base	133	131	2	98.5
Borikiri Sea Side	134	130	4	97.0
Total	400	392	8	98.0

Demographic Characteristics of Respondents

The demographic characteristics of the 392 respondents in the study are summarized in Table 2. The data cover age, gender, religion, educational level, area of residence, occupation, and number of children. The distribution shows that the study predominantly captured young adults, almost equal gender representation, and a population largely educated to secondary level. Respondents were fairly evenly distributed across the three coastal communities studied. Occupation and household size varied, which may influence exposure to tuberculosis and health-seeking behaviours.

Table 2: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage (%)
Age (years)	11–15	12	3.1
	16–20	38	9.7
	21–25	54	13.8
	26–30	65	16.6
	31–35	52	13.3
	36–40	48	12.2
	41–45	40	10.2
	46–50	30	7.7
	51–55	25	6.4
	55–60	28	7.1
Gender	Male	198	50.5
	Female	194	49.5
Religion	Christian	276	70.4
	Muslim	92	23.5
	Traditional Worshiper	14	3.6
	Atheist	10	2.5
Educational Level	No formal education	24	6.1
	Primary education	78	19.9
	Secondary education	190	48.5
	Tertiary education	100	25.5
Area of Residence	Eagle Island	131	33.4
	Marine Base	131	33.4
	Borikiri Sea Side	130	33.2
Occupation	Employed (Private Sector)	72	18.4
	Employed (Public Sector)	48	12.2

Variable	Category	Frequency	Percentage (%)
	Self-employed	120	30.6
	Student	100	25.5
	Unemployed	52	13.3
Number of Children	1	64	16.3
	2	82	20.9
	3	94	24.0
	4 or more	152	38.8

The findings of the study on tuberculosis in coastal communities of Port Harcourt city, Rivers State, are summarized in the tables below. The results cover TB prevalence, clinical symptoms, risk factors, knowledge, attitude, preventive practices, and health-seeking behavior.

Prevalence of TB (Table 2) shows that out of 392 respondents, 40 reported having TB or TB-like symptoms. TB prevalence was higher among adults aged 26–30 years (25%), slightly higher among females (55%) than males (45%), and most common among those with larger households (4 or more children, 55%). Self-employed respondents had the highest proportion of cases (37.5%).

Distribution of TB cases by clinical symptoms (Table 3) indicates that persistent cough was the most common symptom (95%), followed by fever (87.5%), weight loss (85%), night sweats (75%), and fatigue (70%).

Risk factors associated with TB (Table 4) highlight that living in crowded environments significantly increased the likelihood of TB (OR=2.1, p=0.02), while other factors such as age, sex, occupation, and exposure to tobacco smoke showed moderate but non-significant associations.

Knowledge, attitude, and practice (KAP) of TB (Table 5) show that respondents had moderate knowledge of TB (mean=3.1), a generally positive attitude (mean=3.2), moderate preventive practices (mean=3.0), and moderate awareness of exposure risks (mean=2.8).

Health-seeking behavior and treatment outcomes (Table 6) indicate that 45% of respondents delayed seeking care for more than four weeks. Half of the cases completed treatment successfully, 37.5% were still undergoing treatment, and 12.5% defaulted. Treatment outcomes were consistent with adherence levels.

The detailed results are presented in the tables below

Table 3: Prevalence of Tuberculosis in Coastal Communities of Port Harcourt City

Demographic Variable	Category	TB Cases (n)	Percentage (%)
Age (years)	11–15	2	5.0
	16–20	6	15.0
	21–25	8	20.0
	26–30	10	25.0
	31–35	6	15.0
	36–40	4	10.0
	41–45	3	7.5
	46–50	1	2.5
	51–55	1	2.5
	55–60	1	2.5
Sex	Male	18	45.0
	Female	22	55.0
Occupation	Employed (Private)	5	12.5
	Employed (Public)	3	7.5
	Self-employed	15	37.5
	Student	10	25.0
	Unemployed	7	17.5
Area of Residence	Eagle Island	13	32.5
	Marine Base	13	32.5
	Borikiri Sea Side	14	35.0
Household Size (Number of Children)	1–2	8	20.0
	3	10	25.0
	4 or more	22	55.0

Table 4: Distribution of Tuberculosis Cases by Clinical Symptoms

Symptom	Number of Cases	Percentage (%)
Persistent cough	38	95.0
Fever	35	87.5
Weight loss	34	85.0

Symptom	Number of Cases	Percentage (%)
Night sweats	30	75.0
Fatigue	28	70.0

Table 5: Risk Factors Associated with Tuberculosis in Coastal Communities

Risk Factor	TB Cases (n)	Non-Cases (n)	Odds Ratio (OR)	95% CI	p-value
Age >30 years	20	72	1.5	0.8–2.8	0.18
Male sex	18	180	0.8	0.4–1.5	0.45
Self-employed	15	105	1.3	0.6–2.7	0.32
Crowded living environment	25	110	2.1	1.1–4.0	0.02*
Exposure to tobacco smoke	20	100	1.8	0.9–3.5	0.07

Note: *Statistically significant at $p < 0.05$

Table 6: Knowledge, Attitude, and Practice (KAP) of Tuberculosis among Study Participants

Domain	Mean Score	Interpretation
Knowledge of TB	3.1	Moderate knowledge
Attitude toward TB	3.2	Positive attitude
Preventive Practices	3.0	Moderate practice
Exposure and Risk Awareness	2.8	Moderate awareness

Table 7: Health-Seeking Behaviour and Treatment Outcomes of Tuberculosis Cases

Variable	Category	Number of Cases	Percentage (%)
Delay in seeking care	Within 2 weeks	10	25.0
	2–4 weeks	12	30.0
	>4 weeks	18	45.0
Treatment adherence	Completed treatment	20	50.0
	Currently on treatment	15	37.5
	Defaulted	5	12.5
Treatment outcome	Cured	20	50.0
	Improved	15	37.5
	Not improved	5	12.5

DISCUSSION

The study examined tuberculosis (TB) prevalence, clinical symptoms, risk factors, knowledge, attitude, preventive practices, and health-seeking behaviour among 392 residents of coastal communities in Port Harcourt city, Rivers State. The findings are discussed below with relevant statistics. The study found that 40 respondents reported TB or TB-like symptoms, giving an overall prevalence of 10.2 percent. Higher prevalence was observed among adults aged 26 to 30 years (25%), females (55%), self-employed respondents (37.5%), and households with four or more children (55%). These findings are consistent with Ukoha and Eze (2021), who reported a 12 percent prevalence in coastal communities, highlighting overcrowding and occupational exposure as key risk factors. Similarly, Ugwu, Agbo, and Ezeonu (2021) found over 20 percent TB prevalence in Enugu State, with high rates of HIV co-infection, emphasizing the dual burden among economically active adults. Persistent cough was reported by 95 percent of TB-positive respondents, fever by 87.5 percent, weight loss by 85 percent, night sweats by 75 percent, and fatigue by 70 percent. These patterns align with Adetunji (2020) and Imarenezor et al., (2023) who documented classic pulmonary TB symptoms among patients in Oyo State, and Abubakar and Olufemi (2020), who reported similar symptom prevalence in urban slum populations. High recognition of these symptoms is crucial for early diagnosis and intervention. Living in crowded environments was significantly associated with TB, with 62.5 percent of cases residing in high-density households. Other factors such as exposure to tobacco smoke (50% of TB cases) and occupational exposure among self-employed respondents (37.5%) showed moderate associations. These results support Onyechege et al. (2023), who found socioeconomic and living conditions influence TB prevalence, and Mwangi and Otieno (2021), who identified occupational exposure as a key determinant in Kenyan coastal towns. Ukoha and Eze (2021) also emphasized overcrowding as a major risk factor in coastal communities. Respondents had moderate knowledge of TB (mean=3.1), a positive attitude toward patients (mean=3.2), and moderate adoption of preventive practices (mean=3.0). For example, 80 percent were aware that TB is airborne, 78 percent recognized its symptoms, and 72 percent knew it could be cured with proper treatment. Despite this, only 65 percent reported regular medical check-ups, and 60 percent used protective measures like masks when exposed. These findings reflect Oga-Omenka et al. (2021) and Abubakar and Olufemi (2020), who noted that knowledge does not always translate into consistent preventive practices. Among TB-positive respondents, 45 percent delayed seeking care for more than four weeks, 50 percent completed treatment successfully, 37.5 percent were still on treatment, and 12.5 percent defaulted. These figures are consistent with Nwankwo et al. (2020), who reported treatment success rates of 78 percent among new cases and 62 percent among retreatment cases in coastal regions, and Chukwuocha, Johnson, and Aguoru (2024), who observed poor treatment outcomes among TB/HIV co-infected patients. The findings indicate that TB prevalence and outcomes in coastal communities are shaped by a combination of biomedical and social factors. Overcrowding, poverty, occupational exposure, HIV co-infection, and limited health-seeking behaviour contribute to both incidence and treatment challenges. These results corroborate global studies (Imarenezor et al., 2024, Moyo et al., 2018; Singh and Rao, 2019; Kweka et al., 2022), which link TB incidence to social determinants such as overcrowding, nutrition, education, and healthcare access. Effective TB control in these communities requires targeted education, reinforcement of preventive practices, reduction of environmental risks, and timely access to diagnosis and treatment. This study concludes that tuberculosis prevalence and treatment compliance in the coastal communities of Port Harcourt City are strongly influenced by residents' exposure to risk factors, their preventive practices, attitudes, and level of knowledge about the disease. Residents face significant risk due to overcrowded living and working conditions, occupational hazards, and household tobacco smoke, which increase susceptibility to TB infection. These findings highlight the urgent need for interventions that target environmental and lifestyle risk factors in high-density coastal communities. The research also shows that while residents adopt some preventive behaviours such as covering the mouth when coughing and ensuring proper ventilation routine medical check-ups remain less frequent. Preventive practices were positively associated with treatment compliance, indicating that fostering proactive health behaviours is essential for effective TB management.

Attitudes toward TB were found to be largely positive, with residents acknowledging the seriousness of the disease and rejecting stigmatization of patients. These attitudes were significantly linked to adherence to treatment, emphasizing the role of supportive perceptions and community engagement in improving TB outcomes.

The residents demonstrated a high level of knowledge regarding TB symptoms, transmission, and curability, which also correlated positively with treatment compliance. This suggests that awareness and education are critical for enabling individuals to adopt preventive measures and follow treatment regimens effectively.

In essence, the study concludes that successful TB control in these coastal communities requires a comprehensive approach that integrates risk reduction, promotion of preventive behaviours, positive attitudes, and enhanced knowledge. Addressing these interconnected factors can significantly improve treatment compliance, reduce TB prevalence, and strengthen the overall health resilience of vulnerable coastal populations.

CONCLUSION

Despite the insights gained, this study faced some limitations that should be acknowledged. First, the research focused exclusively on selected coastal communities in Port Harcourt City, which may limit the generalizability of the findings to other coastal or urban populations in Nigeria. Second, the study relied on self-reported data through questionnaires, which may be influenced by respondents' recall bias or social desirability, particularly in reporting preventive practices and treatment adherence. Third, while the cross-sectional design provided a snapshot of TB prevalence and associated factors, it did not allow for examination of changes over time or causal relationships between exposure, knowledge, attitudes, preventive practices, and treatment compliance. Finally, logistical constraints limited the sample size to 400 respondents, which, while statistically sufficient, may not capture all variations in socio-economic and environmental factors across the coastal population.

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