Selected Factors that Influence Nonadherence to Antituberculosis Drug Regimen among Tuberculosis Patients at Two (2) Rural Clinics in Guyana, South America

Bhuwandai Gharbaran [a], Falana Daly [a], Viannie Ferreira [a], Jewel Edmondson-Carter [a], Cecil Boston [b*] and Andrew Hutson [c*]

[a] *College of Medical Sciences, School of Pharmacy, University of Guyana, Turkeyen Campus, Georgetown, Guyana.*
[b] *College of Medical Science, School of Allied Health, University of Guyana, Turkeyen Campus, Georgetown, Guyana.*
[c] *College of Medical Sciences, School of Medicine, University of Guyana, Turkeyen, Georgetown, Guyana.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

_____

*Corresponding author: E-mail: cecil.boston@uog.edu.gy, andrew.hutson@uog.edu.gy;

ABSTRACT

Objectives: This study aimed to identify and compare the factors influencing non-adherence to antituberculosis drug regimens at two rural clinics in Guyana.

Methods: A quantitative, cross-sectional design was employed to examine adherence barriers among tuberculosis (TB) patients at two rural clinics in Guyana. Data were collected using structured questionnaires administered to 46 non-adherent TB patients (15 from Clinic 1 and 31 from Clinic 2). Inclusion criteria and informed consent were adhered to, and a translator facilitated interviews in the Indigenous community served by Clinic 1. Descriptive and comparative statistical analyses were performed to interpret the data.

Results: A total of 46 participants were identified as non-adherent to tuberculosis (TB) treatment protocols were included in the study, with a mean age of 43.7 years for Clinic 1 and 46.3 years for Clinic 2. Among the participants, 32% originated from Clinic 1 and 68% from Clinic 2.

Statistical Analysis: Statistical analysis revealed significant factors influencing non-adherence to treatment. This included knowledge of TB transmission and the quality of patient-provider relationships ($p = 0.049$), frequency of chest clinic visits ($p = 0.015$), adherence to prescribed medication regimens ($p = 0.001$), depression among patients ($p = 0.005$), clinic attendance patterns, and instances of missed medication doses ($p = 0.013$). These findings underscore the multifactorial nature of non-adherence in the study population, highlighting both psychosocial and systemic influences.

Conclusion: The findings highlight the interplay of psychological distress, clinic attendance, and patient-provider relationships in influencing TB treatment adherence. Despite high knowledge levels about TB transmission, adherence was limited. Integrated strategies, including mental health interventions, improved patient-provider communication, and logistical support, are essential to enhance adherence and treatment outcomes in rural populations.

1. INTRODUCTION

Mycobacterium tuberculosis, the causative agent of tuberculosis (TB), is an airborne pathogen that predominantly affects the lungs (World Health Organization, 2020). It is a rod-shaped bacterium within the *Mycobacterium* genus, characterised by slow growth and a thick, waxy cell wall. This structure makes it highly resistant to many disinfectants and antibiotics (Batt et al., 2020). When inhaled, *Mycobacterium tuberculosis* enters the lungs and infects alveolar macrophages, a type of immune cell. Within these cells, the bacterium can proliferate and spread through the bloodstream or lymphatic system, leading to systemic infection (Delogu et al., 2013).

The transmission of *Mycobacterium tuberculosis* typically occurs when an infected individual coughs or sneezes, releasing droplet nuclei into the air. These droplets can then spread the infection if inhaled by others. However, not everyone exposed to *Mycobacterium tuberculosis* develops active TB (Centers for Disease Control and Prevention (CDC, 2019). According to the CDC (2019), TB exists in two forms: latent TB infection and TB disease. Latent TB infection does not cause symptoms, and individuals may not feel ill although they are still infected with *Mycobacterium tuberculosis* (Carranza et al., 2020).

Globally, Tuberculosis (TB) is a major public health concern, with over ten million new cases recorded each year (World Health Organization, 2020). Drug resistance and the disease's ongoing transmission resulted from non-adherence to medication regimens (CDC, 2023). Non-adherence is defined as any positively diagnosed TB patient who does not take their medications or as prescribed by the doctor (Asriwati et al., 2021). In Guyana, free treatment for TB was available in all ten administrative regions at hospitals and treatment centres that offered free diagnostic testing and care; however, there was still a rise in TB. With an estimated TB incidence of 185/100,000 people, Guyana was one of the high-incidence countries in the Western Hemisphere (Alladin et al., 2011). Guyana had fifty-one new cases of TB for every 100,000 people in 2021. Age-adjusted and per 100,000 people, the overall TB death rate in 2019 was 18.8 (8.9 in women and 29.3 in males) (PAHO, 2022).

In 2022, the World Health Organization (WHO) reported 10.6 million cases of TB worldwide, with 6.4 million cases in males, 3.4 million in females, and 12 million in children across all age groups. Among these, 167,000 people living with Human Immunodeficiency Virus (HIV) died from TB. WHO ranked TB as the second most lethal infectious disease globally, after COVID-19, and the 13th leading cause of death (WHO, 2023). When the immune system's defences are compromised, *Mycobacterium tuberculosis* can grow unchecked, transforming latent TB infection into active TB disease (CDC, 2022). Some individuals develop TB soon after infection, while others may develop it later due to weakened immunity (CDC TB, 2020). Diagnosis of TB typically involves the TB skin test or TB blood tests, which identify the presence of TB bacteria in the body (CDC, 2016). A positive result from either test indicates the presence of *Mycobacterium tuberculosis*, but further tests, such as sputum analysis and chest X-rays, are necessary to confirm the presence of active TB (CDC, 2020).

Within the Americas, Brazil and Peru have been identified by WHO as having high TB rates. A study by Ranzani et al. (2021) involving 12 Latin American countries—Argentina, Brazil, Chile, Colombia, Ecuador, El Salvador, Mexico, Panama, Paraguay, Peru, Uruguay, and Venezuela—showed that these countries accounted for over 80% of the region's total estimated TB cases. From 2014 to 2019, the region's estimated number of TB cases rose from 202,290 to 230,100, marking a 13.8% relative increase. The TB incidence rate also grew from 38.4 to 41.7 per 100,000 people (an 8.6% relative increase) (CDC, 2019).

Non-adherence to TB treatment remained a key challenge that could lead to poor treatment outcomes, drug resistance, and increased morbidity and mortality rates (World Health Organization, 2021). This represented a significant public health burden that could be treated and prevented (World Health Organization, 2021). To address the TB epidemic, the United Nations (UN) held a meeting in 2018 and determined that thirteen (13) billion USD would be required yearly for screening, treatment, prevention, and care (WHO, 2021). Several factors contributed to non-adherence, including a lack of knowledge about the disease, side effects from medication, social stigma, and poverty (Ramesh et al., 2015). Interventions such as patient education and counselling, active follow-up, and directly observed therapy (DOT) were identified as effective (Zhang et al., 2016). Nevertheless, implementing these interventions in a contextually appropriate and culturally sensitive way was difficult, especially in Indigenous populations (Rowan et al., 2014).

Indigenous communities encountered several barriers in obtaining healthcare services, such as cultural and geographical isolation. The Pan American Health Organization (2021), in its report, indicated that cultural and sociocultural phenomena impede TB treatment, and understanding these factors is very important when seeking to formulate interventions that will enhance TB treatment adherence.

Antituberculosis medication non-adherence could result in relapse, drug-resistant TB, treatment failure, disease progression that could cause complications and mortality, and continued infection transmission (CDCTB, 2021). Therefore, the effectiveness of TB treatment depends on patient adherence to TB therapy (Salari et al., 2023). The frequency of non-adherence to antituberculosis therapy varied due to several factors. Ahmed & Prins (2016) showed that 2,727 tuberculosis patients visited Tuberculosis treatment clinics in a study they conducted, and 328 patients (14%) had stopped their medication, while 2,399 patients (86%) had continued it. In another study, Tesfahuneygn et al. (2015) showed that 314 participants achieved a response rate of 97.5 percent. Non-adherence to anti-TB therapy was found in 21.2% (95% CI 17.2, 26.1) of all cases (Mekonnen & Azagew, 2018). The records of 227 patients with MDR TB matched the inclusion criteria; 39.4% of the patients were female, 32.6% were in the 25–34 age range, and 54.6% had HIV/AIDS. About 11.9% of the patient population was non-adherent. Other issues included the high prevalence of chronic non-communicable diseases like diabetes, the high rate of substance abuse among TB patients, and the difficulty in accessing care in isolated rural locations.

According to Salari et al. (2023), the global prevalence of drug-resistant TB was found to be extremely high. There were three types of TB drug resistance: Multidrug-resistant Tuberculosis (MDR), pre-extensively drug-resistant Tuberculosis (Pre-XDR), and extensively drug-resistant Tuberculosis (XDR). At the very least, MDR Tuberculosis is caused by an organism resistant to rifampin and isoniazid. Pre-XDR

tuberculosis was produced by an organism resistant to fluoroquinolones, rifampin, and/or isoniazid. XDR Tuberculosis is caused by an organism resistant to bedaquiline or linezolid, isoniazid, and rifampin. It could also be caused by a fluoroquinolone and a second-line injectable (amikacin, capreomycin, and kanamycin) or by an organism resistant to all the above (CDC, 2022). Based on the current study's findings, the worldwide rate of multidrug-resistant, mono-drug-resistant, isoniazid-resistant, and rifampicin-resistant Tuberculosis was 11.6%, 11.8%, 15.7%, and 9.4%, respectively (Salari et al., 2023).

With a rise in TB cases in Guyana, there were several negative impacts on the country. TB, being a highly infectious disease, has led to a rapid increase in the number of people infected with the disease, putting a strain on the country's healthcare system (Ravimohan et al., 2018). Furthermore, TB is a debilitating disease that affects a person's ability to work and earn a living. This led to decreased productivity and economic growth in the country as more people could not participate in the workforce (Przybylski et al., 2014). In addition, TB has serious long-term health consequences if left untreated, such as lung damage and even death. Therefore, an increase in TB cases in Guyana was a significant public health concern, requiring urgent action to prevent further spread of the disease and ensure that affected individuals received appropriate treatment and care (Baker et al., 2017).

Furthermore, the Pan American Health Organization (PAHO) (2022) noted that the HIV epidemic in Guyana was a major barrier to effective TB control. Despite progress in reducing TB/HIV co-infection rates through improved coordination between TB and HIV programs, HIV remained a leading cause of TB morbidity and mortality. Over the years, the TB epidemic in Guyana has undergone an epidemiological shift, notably affecting the country's young working-age population in both urban and rural areas. In response, in collaboration with the Ministries of Human Services and Social Security, the Ministry of Health worked to enhance social protection for low-status TB patients as part of the End TB Strategy (PAHO, 2022).

In Guyana, the Georgetown Public Hospital Corporation Chest Clinic serves as the primary treatment centre for TB. However, treatment initiation occurs in rural areas at local health facilities, provided the patient's vital signs are within the normal range. Therefore, it is crucial to understand the factors influencing non-adherence to anti-tuberculosis treatment in these communities to improve treatment outcomes, reduce TB transmission, optimise resource use, and enhance the quality of care for TB patients in these regions.

2. METHODOLOGY

2.1 Research Design

This investigation focused on two rural villages in Guyana, each representing distinct communities with unique socio-economic characteristics. The first community, an Indigenous settlement located in the Barima-Waini region of northern Guyana (Region I), is accessible by plane, road, and river, connecting more remote villages (see Fig. 1). The primary economic activities in this community are gold mining and subsistence farming. Inhabitants are predominantly Kalina (Carib) people who speak the Carib language fluently. This language barrier, however, presented a challenge in communication, particularly within the healthcare sector, where the transmission of medical information was often hindered.

The second study site was situated in the Essequibo Islands-West Demerara region (Region III), which is more accessible by road and river (see Fig. 1). The community is mainly composed of Indo-Guyanese and Afro-Guyanese populations, with rice farming being the predominant economic activity. Healthcare services in this area are free; however, patients requiring more specialized care are referred to the Georgetown Public Hospital, the national referral hospital.

This study employed a quantitative, cross-sectional design to examine the factors influencing non-adherence to tuberculosis (TB) treatment at the two health clinics. Data was collected using a structured questionnaire developed based on a review of relevant literature. The use of this tool allowed for a comprehensive analysis of the factors affecting treatment adherence within these rural communities.

2.2 Population

Clinic 1, located in Region One (1), catered to a population of 3,500, whereas Clinic 2, located in

Region Three (3), catered to 105,919. These rural clinics were the sites for data collection. From January 2020 to June 2024, Clinic 1 saw a total of forty-two positively diagnosed patients, whereas Clinic 2 saw a total of 225 positively diagnosed patients.
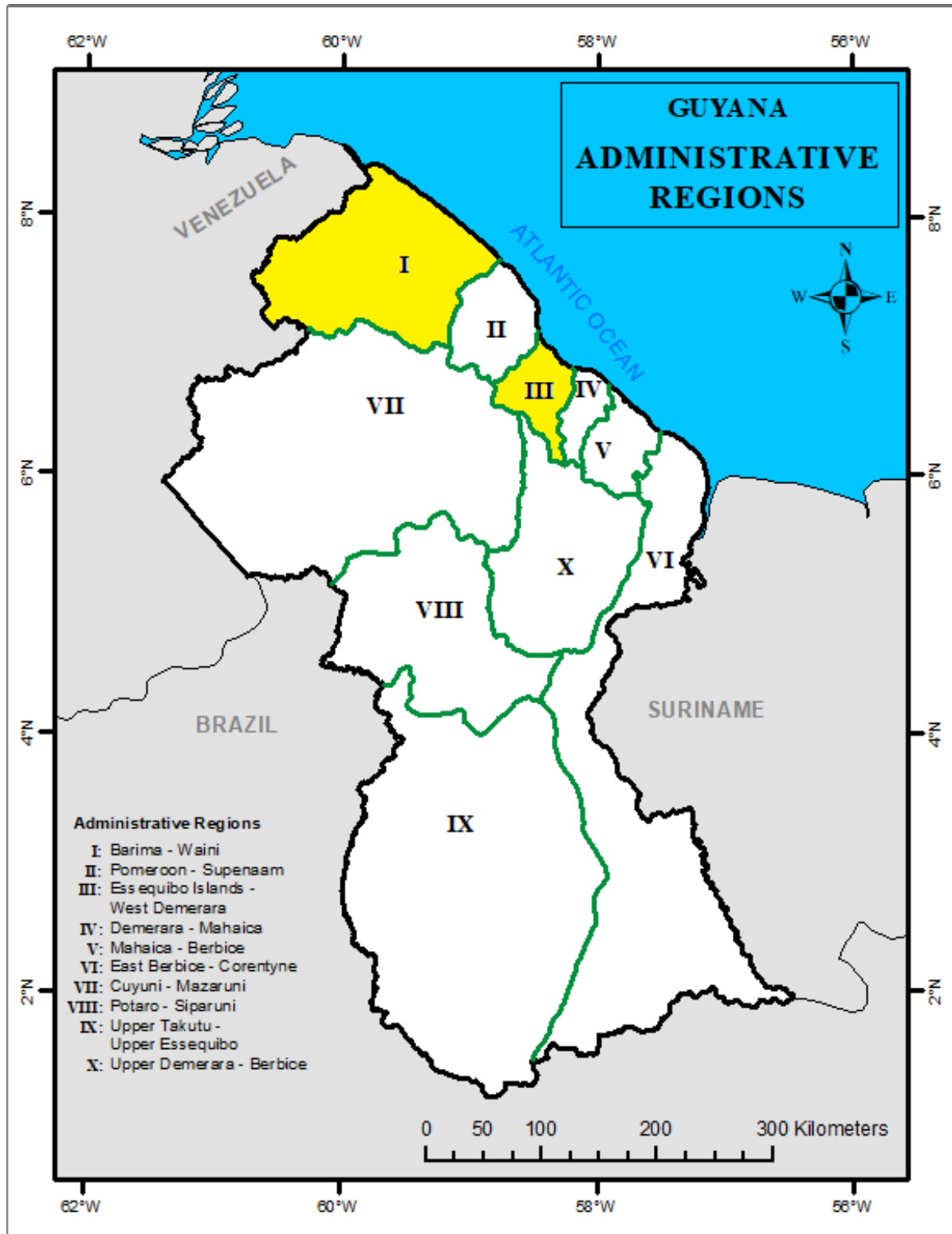

Fig. 1. Map of Guyana Showing the Two Study Locations (highlighted in yellow)

2.3 Sample

The sample size included all patients diagnosed with TB and identified as non-adherent by the respective clinics from January 2020 to June 2024. The total number of subjects identified as non-adherent was 46, of which 15 were from Clinic 1 and 31 were from Clinic 2, which represents 35.7% and 13.8%, respectively.

The participants' medical histories note depression as diagnosed by their attending physicians and surrendered as such without delving into diagnostic particulars, which was made to be believed as secondary to the purpose of primary investigations. However, to enhance understanding of the study, the criteria set for diagnosing Major Depressive Disorder in DSM-5 is provided below. To be diagnosed with MDD in DSM-5 there are such characteristics such as:

a) **There is a depressive episode.** For this diagnosis, the patient must have at least five symptoms within two weeks. One of these symptoms must be either A: The individual must be very sad for the majority of the day or B: The individual lost interest or pleasure in nearly all of their daily activities. The below symptoms must be present as well: Depressed mood; loss of interest in someone or something that used to be loved or liked; weight loss that is not intentional; sleeping too much or too little; slow movement and thought, extreme fatigue or loss of energy; feeling worthless or excessively guilty; settling or difficulty with thinking and making decisions; repetitive thoughts of death or harming oneself.
b) **Denotes a functional disorder**: Clinically recognized level of distress and impairment in areas such as social or work and any other functional areas important to the affected individual.
c) Notably, the episode must last at least two weeks and must not develop due to substance use or any other medical condition.
d) **Exclusion of Other Disorders:** The depressive episode is not better explained by another mental disorder (for example: bipolar disorder).
e) **Absence of Mania:** There is no past manic or hypomanic episode.

2.4 Instrument for Data Collection

Data was collected using a researcher-assisted structured interviewing questionnaire compiled from published literature of a similar nature. The questionnaire was piloted before being used in the study to assess readability and usability. Informed consent was sought from each potential participant prior to being enrolled in the study. A signature or thumbprint was affixed to the consent form, which was detached from the interviewing form to maintain confidentiality. Additionally, a translator (Village Toshao) who was fluent in both the national language and village dialect accompanied the researcher to provide further clarification on the questions asked while conducting the face-to-face interview in Clinic 1 Village and the patients at Clinic 2, whose Graphs had telephone numbers, were contacted via video calls. The original language of the questionnaire was English, and the interviewer was the Toshao of the village who worked along with one of the researchers. The Toshao is the head leader of the town, so therefore is very well experienced in the language. The Toshao was used as the translator/interviewer for the questionnaires. Those doing telephone interviews provided verbal consent, which was recorded with their permission.

The questionnaire comprised three (3) sections - Part A comprised five (5) questions (1-5) that referred to the interviewee's demographic information. Part B comprised eight (8) questions (6-13) about the interviewees' socioeconomic status. Part C comprised twenty-two (22) questions (14-35) about the prospective factors that influenced non-adherence, such as side effects of medication, knowledge, and attitude towards the disease.

To ensure internal consistency, this study sought to employ multiple measures during the structured interview process. Following the work of Wicks et al. (2023), the aim of pilot testing was to enhance the clarity and relevance of the questionnaire improving the consistency of responses. Rios et al. (2020) recommended the use of standardized data extraction forms to cut down on the interpretation of data and enhance homogeneity in the recording of information. In a similar vein, Lencioni (2014) supported regular team meetings and quality control checks to quickly attend to emerging problems while ensuring compliance with the data collection protocols. Furthermore, blinding data collectors,

as advocated by McCambridge et al. (2010), were instrumental in reducing bias while improving the reliability of the responses, especially for sensitive issues such as healthcare adherence. Taking together all these methods served the purpose of making the results of the questionnaire regarding the determinants of tuberculosis treatment adherence maximally reliable and valid.

2.5 Data Analysis

In this study, factors such as understanding TB transmission, the bond between providers and patients, clinic attendance, adherence to treatment, depression and side effects were assessed using the chi-square tests and Fisher's exact test using a p-value of 0.05. All the associations were tested with Fisher's exact tests as there was a small sample size. Fisher's exact test established statistically significant relationships ($p \leq 0.05$) among these variables despite the small sample size. These findings reflect the specific areas through which the provision of TB care can be improved. It was shown that each statistically significant association indicated some interrelationship of the variables, which enabled the outlining of specific target areas for improving TB care delivery.

3. RESULTS AND DISCUSSION

3.1 Demographic Overview

The mean age of respondents from Clinic 1 was 43.7 years (SD = 18.7), aged 18 to 75 years. The majority of participants were male, accounting for 46.7% of the total study population at this site. A notable finding was the low level of educational attainment among Clinic 1 participants; 73.3% of respondents reported having no formal education. This limited educational background could have implications for health literacy, understanding of treatment protocols, and overall adherence to tuberculosis (TB) management regimens. The demographic and educational profile of this clinic is consistent with the socioeconomic challenges typically observed in Indigenous and remote rural communities, where access to formal education and healthcare infrastructure remains limited.

In contrast, respondents from Clinic 2 displayed a different demographic and educational profile. The mean age was slightly higher at 46.3 years (SD = 15.6), aged 19 to 68 years. The overwhelming majority (83.9%) of participants were male, indicating a potential gender disparity in TB treatment-seeking behavior or prevalence in this community. Educational attainment at Clinic 2 was significantly higher compared to Clinic 1, with 83.9% of respondents having completed secondary education. This suggests a relatively higher level of health literacy and awareness, which could influence treatment adherence positively. The higher educational attainment at Clinic 2 may reflect the more developed socio-economic infrastructure of the region, where accessibility to education and healthcare services is greater.

The differences in age, gender distribution, and educational levels between the two clinics underscore the need for tailored public health interventions. At Clinic 1, efforts may need to focus on bridging educational gaps and developing culturally and linguistically appropriate communication strategies to enhance patient understanding of TB treatment. For Clinic 2, the relatively higher educational attainment may allow for the use of more advanced health promotion techniques, including written materials and digital tools, to reinforce adherence to treatment protocols.

3.2 Clinic Attendance and Visit Patterns

Most patients at Clinic 2 (68%) reported visiting the clinic once per month, which is less frequent compared to Clinic 1 (40%). This discrepancy highlights the need for strategies aimed at improving patient engagement, such as individualized follow-up reminders, community outreach programs, or incentives for adherence to treatment schedules. The relatively high attendance may reflect fewer logistical barriers or more robust patient-provider relationships in this clinic. While monthly visits may suffice for stable patients or those in later stages of treatment, they could be inadequate for those requiring closer monitoring, potentially affecting treatment efficacy. Alarmingly, 26% of patients at Clinic 2 reported no clinic visits at all, indicating a critical gap in care delivery. This lack of attendance underscores systemic issues such as accessibility, awareness, or perceived importance of follow-up care. Addressing these gaps may require innovative solutions, such as home-based care programs, transportation subsidies, or intensified health education initiatives.

To address these disparities, interventions should be tailored to the unique needs and barriers of each clinic. For Clinic 1, strategies to sustain and improve existing attendance levels might include patient education campaigns or peer-led adherence programs. For Clinic 2, overcoming systemic barriers through logistical support, such as transportation assistance, community health worker involvement, or digital health tools for appointment reminders, could significantly enhance attendance rates.

Frequent and consistent clinic visits are critical to ensuring the effective management of TB treatment, preventing drug resistance, and reducing the risk of community transmission. Improving attendance and follow-up in these clinics can serve as a model for other healthcare settings facing similar challenges.

As corroborated by previous studies, the literature indicates a relationship between clinic attendance and medication adherence in tuberculosis (TB) treatment (Davies, 2003; Gashu et al., 2021; Oyugu et al., 2017). Compliance rates differed significantly between the two clinics, with Clinic 1 achieving a 60% attendance rate compared to 23% at Clinic 2. However, despite relatively higher attendance at Clinic 1, adherence to the TB medication regimen remained at 40%, suggesting that attendance alone does not ensure adherence. This aligns with existing research, which emphasizes the need for comprehensive interventions beyond mere follow-up appointments to address non-compliance (Davies, 2003; Gashu et al., 2021, Oyugu et al., 2017).

The particularly low attendance rate at Clinic 2, with 77% of patients missing appointments, highlights significant barriers to access which may include logistical challenges such as long travel distances, financial constraints, or competing economic and domestic responsibilities. Furthermore, a lack of patient motivation or inadequate support systems within the community may exacerbate irregular attendance. Interventions such as mobile health services, community-based treatment support, or the integration of peer education could be explored to mitigate these barriers. This pattern is consistent with studies that identify several factors that increase the chances of adherence, including frequent visits regardless of the length of treatment (Davies, 2003).

3.3 Comparative Analysis of Patient Knowledge, Adherence, and Psychosocial Factors in Tuberculosis Treatment

Knowledge of TB Transmission:

Clinic 1: A significant proportion of participants (73%) in Clinic 1 lacked knowledge about TB transmission via airborne droplets. This limited understanding appears to contribute to missed doses and irregular clinic attendance, highlighting substantial gaps in health education efforts. The association between knowledge deficits and non-adherence underscores the need for tailored educational interventions to enhance awareness and promote treatment adherence.

Clinic 2: Conversely, 84% of participants in Clinic 2 demonstrated awareness of TB transmission. However, despite their higher knowledge levels, adherence to treatment remained low, suggesting that awareness alone is insufficient to drive adherence. This disparity indicates the necessity of complementing health education with robust support systems to address practical, emotional, and systemic barriers to compliance.

This indicates gaps on the theory as knowledge alone is inadequate for adherence enhancement as the latter must be combined with other efforts (Asriwati et al., 2021).

3.4 Adherence to TB Medication

Adherence challenges were more pronounced in Clinic 2, where 77.4% of participants reported missing "most" of their doses as compared to Clinic 1 where only 40% of participants admitted to missing "most" doses. This alarming rate of non-compliance highlights critical barriers to effective treatment, including potential logistical, psychological, or systemic challenges. Addressing these issues requires an integrated approach, combining patient education, logistical support, and community engagement to promote consistent medication adherence.

3.5 Side Effects and Non-Adherence

Clinic 1: Most participants (93.3%) reported no severe side effects, with only one individual attributing missed doses to adverse reactions. This suggests that drug tolerability is unlikely to

be a major factor influencing non-adherence in Clinic 1.

Clinic 2: Similarly, 96.8% of participants in Clinic 2 did not experience severe side effects, with only one patient linking side effects to non-compliance. These findings indicate that factors beyond medication tolerability, such as psychological or social barriers, are likely more significant contributors to non-adherence.

The medication side effects did not affect non-adherence to health information in this study. This goes against the studies that emphasize the effects on the body as being more prominent (Oyugu et al., 2017; Salari et al., 2023).

3.6 Psychological Impact of TB Diagnosis

Clinic 1: A smaller proportion of patients (40%) in Clinic 1 reported depression related to their TB diagnosis. This suggests better psychological resilience or access to mental health support within this group. It may also indicate that patients at Clinic 1 face fewer social or emotional challenges, such as stigma or isolation.

Clinic 2: In contrast, 84% of participants in Clinic 2 reported feelings of depression due to their diagnosis, reflecting a significant psychological burden. Factors such as greater stigma, inadequate mental health resources, or more severe socioeconomic challenges could contribute to this disparity. Addressing these issues requires targeted mental health interventions, including counselling, peer support, and community sensitization campaigns.

This is consistent with findings that show the psychological distress associated with TB disease affects adherence (Adane et al., 2013; Ramesh et al., 2015; Oyugu et al., 2017).

3.7 Patient-Provider Relationships

Clinic 1: The majority of participants (73%) in Clinic 1 described their relationship with healthcare providers as "neutral," while only 27% rated it as "good." This indicates a potential area for improvement in fostering stronger, more supportive patient-provider interactions. Building trust and enhancing communication could positively influence adherence and satisfaction with care.

Clinic 2: In Clinic 2, a higher proportion of participants (58%) rated their relationship with healthcare providers as "good," with 36% describing it as "very good." This suggests that healthcare providers at Clinic 2 are more effective in building trust and engaging patients. However, despite these stronger relationships, the high rates of non-adherence indicate that other systemic or individual barriers may outweigh the benefits of positive provider interactions.

The comparative analysis reveals distinct challenges and opportunities in both clinics. While Clinic 1 struggles with knowledge gaps and moderate adherence issues, Clinic 2 faces more severe psychological and systemic barriers despite better patient-provider relationships.

3.8 Analysis of Chi-Square Results: Associations Between Key Variables in TB Treatment

The chi-square analysis reveals statistically significant relationships between several key variables, providing valuable insights into the factors influencing tuberculosis (TB) treatment adherence and patient outcomes. These findings highlight critical areas for intervention to enhance the effectiveness of TB care delivery.

The analysis shows a statistically significant relationship between knowledge of TB transmission and the quality of patient-provider relationships ($p = 0.049$). This suggests that patients with a greater understanding of how TB is transmitted may experience better interactions with healthcare providers. Enhanced knowledge could foster trust and communication, leading to more supportive and productive relationships. Conversely, patients with limited understanding may face barriers to effective engagement, underscoring the importance of integrating health education into care delivery to strengthen these relationships.

A significant association was observed between knowledge of TB transmission and the frequency of chest clinic visits ($p = 0.015$). Patients with higher levels of awareness about TB transmission appear more likely to attend clinics regularly, which is critical for monitoring and adherence. This finding emphasizes the role of education in encouraging consistent healthcare-seeking behaviour. It also suggests that targeted educational campaigns can serve as a tool to

improve clinic attendance rates, particularly in populations where non-adherence is prevalent.

The strongest association identified was between knowledge of TB transmission and adherence to medication regimens (p = 0.001). Patients who understand the airborne nature of TB and its potential consequences are more likely to adhere to prescribed treatments. This underscores the importance of patient education in mitigating non-adherence. Educational interventions should focus not only on how TB is transmitted but also on the risks associated with incomplete treatment, such as disease progression, drug resistance, and community transmission.

A statistically significant relationship was found between knowledge of TB transmission and the prevalence of depression among patients (p = 0.005). While it might be expected that greater knowledge reduces anxiety, the findings could indicate that awareness of the disease's transmission pathways and risks contributes to psychological stress. This highlights the need for holistic education strategies that address not only the factual aspects of TB but also the emotional and mental health challenges patients face. Incorporating mental health support into educational programs could help alleviate the psychological burden associated with TB.

Depression was also significantly associated with missed medication doses (p = 0.005). This finding aligns with existing research that links mental health challenges to poor treatment adherence. Depression may reduce motivation, impair memory, or create a sense of hopelessness, leading to missed doses. Addressing this issue requires integrating mental health services, such as counselling and peer support, into TB treatment programs. Identifying and supporting patients with depressive symptoms early could significantly improve adherence and overall outcomes.

The analysis revealed a significant association between clinic attendance and missed medication doses (p = 0.013). Patients who irregularly attend clinics are more likely to miss doses, potentially due to lapses in monitoring and support. This finding underscores the importance of improving clinic attendance through logistical support, such as transportation assistance, appointment reminders, and patient outreach programs. It also highlights the role of healthcare providers in emphasizing the critical link between consistent clinic visits and adherence.

4. CONCLUSION AND RECOMMENDATIONS

This research highlights the multifaceted challenges of tuberculosis (TB) treatment adherence in rural clinics in Guyana, underscoring the necessity for comprehensive, patient-centred strategies to optimize care. The findings reveal that while clinic attendance and positive patient-provider relationships are foundational, additional measures are required to address knowledge gaps, manage psychological challenges, and enhance adherence, particularly in Clinic 2. The limited sample size and low expected cell counts in chi-square analyses underscore the need for larger, more robust studies to validate these observations. Future research should also explore the impact of health insurance coverage, behavioural factors, and socio-ecological influences unique to rural Caribbean populations.

4.1 Key Challenges

1. **Health Education:** Clinic 1 exhibits significant gaps in patient knowledge regarding TB transmission and treatment, while Clinic 2, despite higher awareness levels, still struggles with adherence. Culturally tailored, context-specific educational programs are essential to improve patient understanding of TB transmission, treatment adherence, and non-compliance risks. Leveraging community engagement and local languages can ensure more effective communication and outreach.
2. **Mental Health Services:** Depression emerged as a significant barrier to adherence, particularly in Clinic 2, where 84% of patients reported psychological distress. This finding highlights the need to integrate mental health services into TB care. Strategies should include regular depression screenings, access to counselling, and the establishment of peer support groups to mitigate the emotional burden associated with TB.
3. **Patient-Provider Relationships:** The neutral patient-provider relationships in Clinic 1 contrast with the positive

interactions observed in Clinic 2. Building trust and empathy between healthcare providers and patients is critical. Targeted training programs for healthcare providers focusing on communication skills, cultural competence, and patient-centred care can strengthen these relationships and foster greater adherence.

4. **Logistical and Structural Support:** Attendance at Clinic 2 is significantly hindered by logistical challenges, with 77% of patients missing appointments. Addressing these barriers requires innovative solutions such as mobile health services, transportation assistance, flexible appointment scheduling, and home-based care options. These measures can facilitate consistent clinic attendance and, in turn, improve adherence rates.

5. **Adherence Monitoring and Support:** Non-adherence remains pervasive across both clinics, requiring active follow-up systems. Employing community health workers, peer advocates, or digital tools (e.g., SMS reminders) to monitor and support patients can bridge gaps in adherence and ensure continuity of care, especially for high-risk populations.

4.2 Recommendations

An integrated, patient-centred approach is vital for improving adherence, enhancing treatment outcomes, and reducing TB transmission. The following recommendations aim to address the interconnected factors influencing adherence:

- **Education:** Design community-based campaigns and materials that align with local languages and cultural norms to educate patients about TB risks and treatment requirements.
- **Mental Health Integration:** Include psychological support as a routine component of TB care to address the high rates of depression.
- **Logistical Support:** Provide transportation subsidies or mobile clinics to overcome geographical and infrastructural challenges.
- **Provider Engagement:** Invest in provider training to improve interpersonal skills, trust-building, and patient engagement.
- **Monitoring Systems:** Use technology and community networks to track adherence

and provide timely interventions for patients at risk of non-compliance.

This study underscores the importance of addressing the socio-demographic, educational, and psychological factors affecting TB treatment adherence in rural Guyana. By adopting a holistic, evidence-based approach, healthcare systems can bridge existing gaps, optimize patient outcomes, and reduce the public health burden of TB. Future studies should expand on these findings with larger sample sizes and a broader focus on systemic and behavioural determinants to inform more comprehensive TB control strategies.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This study received Institutional Review Board approval for commencement and all ethical and administrative bodies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Adane, A. A., Alene, K. A., Koye, D. N., & Zeleke, B. M. (2013). Non-adherence to anti-tuberculosis treatment and determinant factors among patients with tuberculosis in northwest Ethiopia. *PloS one,8*(11),e78791. https://doi.org/10.1371/journal.pone.00787 91

Alladin, B., Mack, S., Singh, A., Singh, C., Smith, B., Cummings, E., Hershfield, E., Mohanlall, J., Ramotar, K., & La Fleur, C. (2011). Tuberculosis and diabetes in Guyana. *International Journal of Infectious Diseases*, 15(12), e818–e821.

https://doi.org/10.1016/j.ijid.2011.07.006

Asekun-Olarinmoye, I., Asekun-Olarinmoye, T., & Oyerinde, O. (2019). Factors influencing adherence among male clients attending DOTS clinic in Abeokuta, Ogun State, Nigeria 121. AU Journal of Health Sciences and Biomedical Research 1(1). *Researchgate.* https://www.researchgate.net/publication/337702503_Factors_influencing_adherence_to_tuberculosis_treatment_among_male_clients_attending_DOTS_clinics_in_Abeokuta_Ogun_State_Nigeria_1_2_1

Asriwati, Yeti, E., Niakurniawati, & Usman, A. N. (2021). Risk factors analysis of non-compliance of Tuberculosis (TB) patients taking medicine in Puskesmas Polonia, Medan, 2021. *Gaceta Sanitaria*, 35, S227–S230. https://doi.org/10.1016/j.gaceta.2021.10.027

Baker, B. J., Peterson, B., Mohanlall, J., Singh, S., Hicks, C., Jacobs, R., Ramos, R., Allen, B., & Pevzner, E. (2017). Scale-up of collaborative TB/HIV activities in Guyana. *Revista Panamericana de Salud Pública*, 41. https://doi.org/10.26633/RPSP.2017.6

Batt, S. M., Minnikin, D. E., & Besra, G. S. (2020). The thick waxy coat of mycobacteria, a protective layer against antibiotics and the host's immune system. *Biochemical Journal*, 477(10), 1983–2006. https://doi.org/10.1042/BCJ20200194

Carranza, C., Pedraza-Sanchez, S., de Oyarzabal-Mendez, E., & Torres, M. (2020). Diagnosis for Latent Tuberculosis Infection: New Alternatives. Frontiers in Immunology, 11. https://doi.org/10.3389/fimmu.2020.02006

CDC. (2019). Fact Sheets. Centers for Disease Control and Prevention. https://www.cdc.gov/tb/publications/factsheets/general/ltbiandactivetb.htm

CDC. (2019). Treatment for TB Disease. CDC. https://www.cdc.gov/tb/topic/treatment/tbdisease.htm

CDC. (2019). Treatment for TB Disease. CDC. https://www.cdc.gov/tb/topic/treatment/tbdisease.htm

CDC. (2020, March 27). Testing & diagnosis | TB | CDC. Www.cdc.gov. https://www.cdc.gov/tb/topic/testing/default.htm#:~:text=There%20are%20two%20kinds%20of

CDC, (2023, February 24). Pharmacy-Based Interventions for Medication Adherence | cdc.gov. Centers for Disease Control and Prevention. https://www.cdc.gov/dhdsp/pubs/medication-adherence.htm#:~:text=Medication%20nonadherence%20is%20when%20a

CDCTB, (2021, April 14). Tuberculosis (TB) - Drug-Resistant TB. Centers for Disease Control and Prevention. https://www.cdc.gov/tb/topic/drtb/default.htm#:~:text=rifampin%20(RIF).-

CDCTB, (2022, February 2). Dear Colleague Letter. Centers for Disease Control and Prevention. https://www.cdc.gov/tb/publications/letters/2022/surv-def-xdr.html#:~:text=Pre%2DXDR%20TB%3A%20caused%20by

CDC (Centers for Disease Control and Prevention), (2016, March 20). Basic TB facts. Centers for Disease Control and Prevention; CDC. https://www.cdc.gov/tb/topic/basics/default.htm

CDC (Centers for Disease Control and Prevention), (2019). Fact Sheets. CDC. https://www.cdc.gov/tb/publications/factsheets/testing/skintesting.htm

CDC (Centers for Disease Control and Prevention), (2020, March 27). Basic TB Facts | TB | CDC. Www.cdc.gov. https://www.cdc.gov/tb/topic/basics/default.htm#:~:text=Tuberculosis%20(TB)%20is%20caused%20by

Davies, P. D. O. (2003). The role of DOTS in tuberculosis treatment and control. *American Journal of Respiratory Medicine: Drugs, Devices, and Other Interventions*, 2(3), 203–209. https://doi.org/10.1007/BF03256649

Davies, P. D. O. (2003). The role of DOTS in tuberculosis treatment and control. American *Journal of Respiratory Medicine: Drugs, Devices, and Other Interventions*, 2(3), 203–209. https://doi.org/10.1007/BF03256649

Delogu, G., Sali, M., & Fadda, G. (2013). The Biology of Mycobacterium Tuberculosis Infection. *Mediterranean Journal of Hematology and Infectious Diseases*, 5(1). https://doi.org/10.4084/mjhid.2013.070

Gashu, K. D., Gelaye, K. A., & Tilahun, B. (2021). Adherence to TB treatment

remains low during continuation phase among adult patients in Northwest Ethiopia. *BMC Infectious Diseases*, 21(1). https://doi.org/10.1186/s12879-021-06428-6

Mekonnen, H. S., & Azagew, A. W. (2018). Non-adherence to anti-tuberculosis treatment, reasons and associated factors among TB patients attending at Gondar town health centers, Northwest Ethiopia. *BMC Research Notes*, 11(1). https://doi.org/10.1186/s13104-018-3789-4

PAHO (2022, March 24). Guyana observes World Tuberculosis Day 2022 - PAHO/WHO | *Pan American Health Organization*. Www.paho.org. https://www.paho.org/en/news/24-3-2022-guyana-observes-world-tuberculosis-day-2022#:~:text=Over%20the%20past%20years%2C%20TB

PAHO. (2022, September 17). Guyana - Country Profile. Health in the Americas. https://hia.paho.org/en/countries-22/guyana-country-profile#:~:text=Communicable%20diseases,100%20000%20population%20in%20Guyana.

Pan American Health Organization. (2021). Guidance for Tuberculosis Prevention and Control in Indigenous Populations in the Region of the Americas [Review of Guidance for Tuberculosis Prevention and Control in Indigenous Populations in the Region of the Americas]. P O. https://iris.paho.org/bitstream/handle/10665.2/54973/9789275122778_eng.pdf

Przybylski, G., Dąbrowska, A., Pilaczyńska-Cemel, M., & Krawiecka, D. (2014). Unemployment in TB Patients – Ten-Year Observation at Regional Center of Pulmonology in Bydgoszcz, Poland. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, 20, 2125–2131. https://doi.org/10.12659/MSM.890709

Ranzani, O. T., Pescarini, J. M., Martinez, L., & Garcia-Basteiro, A. L. (2021). Increasing tuberculosis burden in Latin America: an alarming trend for global control efforts. *B.M.J. Global Health*, 6(3), e005639. https://doi.org/10.1136/bmjgh-2021-005639

Ravimohan, S., Kornfeld, H., Weissman, D., & Bisson, G. P. (2018). Tuberculosis and lung damage: from epidemiology to pathophysiology. *European Respiratory Review*, 27(147), 170077. https://doi.org/10.1183/16000617.0077-2017

Rowan, M., Poole, N., Shea, B., Gone, J. P., Mykota, D., Farag, M., Hopkins, C., Hall, L., Mushquash, C., & Dell, C. (2014). Cultural interventions to treat addictions in Indigenous populations: findings from a scoping study. *Substance Abuse Treatment, Prevention, and Policy*, 9(1), 34. https://doi.org/10.1186/1747-597x-9-34

Salari, N., Amir Hossein Kanjoori, Amin Hosseinian-Far, Razie Hasheminezhad, Mansouri, K., & Mohammadi, M. (2023). Global prevalence of drug-resistant Tuberculosis: asystematic review and meta-analysis. *BMC*, 12(1). https://doi.org/10.1186/s40249-023-01107-x

WHO (World Health Organisation), (2021). Global Tuberculosis Report. Www.who.int. https://www.who.int/teams/global-tuberculosis-programme/tb-reports

World Health Organization. (2020). Tuberculosis. Www.who.int; World Health Organization. https://www.who.int/health-topics/tuberculosis#tab=tab_1

World Health Organization. (2023, April 21). Tuberculosis. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/tuberculosis

Zhang, H., Ehiri, J., Yang, H., Tang, S., & Li, Y. (2016). Impact of Community-Based D.O.T. on Tuberculosis Treatment Outcomes: A Systematic Review and Meta-Analysis. *PLOS ONE*, 11(2), e0147744. https://doi.org/10.1371/journal.pone.0147744

WHO, (2023). Global Tuberculosis Report 2023. https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2023

Tesfahuneygn, G., Medhin, G., & Legesse, M. (2015). Adherence to Anti-tuberculosis treatment and treatment outcomes among tuberculosis patients in Alamata District, northeast Ethiopia. *BMC research notes*, 8, 1-11.

Ramesh, V., Sen, M. K., Sethuraman, G., & D'Souza, P. (2015). Cutaneous tuberculosis due to multidrug- resistant tubercle bacilli and difficulties in clinical

diagnosis. *Indian Journal of Dermatology, Venereology and Leprology*, *81*, 380.

Oyugi, S. O., Garama, C. M., Kweri, J. K., Malik, N. A., Bett, S. K., & Biego, S. C. (2017). Patient Factors Influencing Adherence to Anti-Tuberculosis Medication in Njoro Sub County Hospital, Nakuru County, Kenya. *Int. J. Sci. Res. Publ*, *7*(5), 766.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/128523