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Research Article

Exploring the Pattern of Resistance to Anti-Tuberculosis Drugs Among Tuberculosis Patients in Kwara State, Nigeria

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Abstract

Tuberculosis (TB) remains a substantial global health challenge, particularly in Nigeria, which has the highest TB incidence in Africa, with approximately 590,000 new cases annually. Multidrug-resistant TB (MDR-TB) complicates treatment and control efforts, necessitating a deeper understanding of drug resistance patterns. This study used a descriptive cross-sectional design to investigate resistance to first- and second-line anti-TB drugs among TB patients in Kwara State, Nigeria. A multi-stage sampling technique was used to recruit 272 participants from selected Local Government Areas. Data collection included questionnaires and laboratory testing using the Hain Line Probe Assay (LPA) and GeneXpert MTB/Rif system. Results showed that age was a statistically significant factor, with resistance rates notably higher among younger individuals aged *20-29 years* ($p = 0.044$), while no significant associations were found for gender ($p = 0.166$), ethnicity ($p = 0.984$ for first-line drugs; $p = 0.601$ for second-line), or educational level ($p = 0.131$ for first-line; $p = 0.260$ for second-line). *Notably, 84.7%* of participants who

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adhered to Directly Observed Treatment Short-course (DOTS) were sensitive to anti-TB drugs, but adherence alone did not exhibit a statistically significant association with resistance ($p = 0.278$), questioning assumptions about DOTS effectiveness in this context. Alcohol consumption emerged as a significant predictor of drug resistance ($p = 0.0423$), with patients consuming alcohol being *six times more likely to develop resistance* (OR = 6.025, *95% CI = 4.950 - 13.632*) than non-drinkers, underscoring the need to address alcohol-related non-adherence to improve outcomes. Conversely, smoking, incarceration, and contact with TB patients showed no significant association with resistance, challenging global assumptions about these risk factors in the Nigerian context. This study highlights the complex nature of TB drug resistance, influenced by socio-demographic and behavioral factors unique to local contexts. The absence of statistically significant correlations for several known risk factors, such as smoking ($p = 0.761$) and prior TB contact ($p = 0.2165$), suggests that interventions in Nigeria should be localized and tailored to specific populations rather than relying on generalized global models. Comprehensive strategies targeting *alcohol use* and *younger age groups*, alongside strengthened healthcare delivery, are essential to curbing the spread of drug-resistant TB strains in Nigeria.

Keywords

Drug Resistance, Tuberculosis (TB), Adherence to Treatment, Socio-Demographic Factors, Multidrug-Resistant Tuberculosis (MDR-TB), Alcohol Consumption

1. Introduction

Tuberculosis (TB) continues to be a significant global health challenge, especially in developing countries like Nigeria, where the disease burden remains disproportionately high. Nigeria ranks first in Africa in TB incidence, with an estimated 590,000 new cases annually, contributing to a high mortality rate despite the availability of effective treatment regimens [1]. A growing concern within TB management is the emergence of multidrug-resistant TB (MDR-TB), a form of the disease resistant to the two most potent first-line drugs, isoniazid and rifampicin [2]. MDR-TB further complicates public health interventions, necessitating more prolonged and complex treatment regimens. In this context, understanding the pattern of resistance to anti-TB drugs is critical for informing treatment strategies and controlling the spread of resistant strains [3]. This study focuses on investigating the pattern of resistance to anti-TB drugs among TB patients in Kwara State, offering insights into how resistance manifests across different patient demographics and influencing public health policy in the region.

The increasing incidence of drug-resistant TB in Kwara State mirrors a national trend of rising MDR-TB cases. Recent studies have revealed that 32% of new TB cases in Nigeria exhibit some form of drug resistance, with previously treated cases showing a much higher rate of resistance, estimated at 53% [3]. These alarming statistics highlight the need for continuous monitoring of drug resistance patterns, as the variability in resistance rates between regions underscores the complexity of the epidemic. For instance, resistance rates in Cross River State have been reported at 5.2%, while other regions like South-Western Nigeria report rates as high as 76.4% [4]. This variability calls for region-specific data to inform local treatment strategies, especially as drug-resistant TB often necessitates the use of second-line drugs, which are more expensive and have more severe side effects [5]. The present study aims to identify the resistance patterns to both first-line and second-line anti-TB drugs among patients in Kwara State, offering essential data that can guide treatment decisions and public health responses.

The rationale for conducting this study stems from the growing burden of drug-resistant TB in Nigeria, compounded by inadequate data on regional resistance patterns. Kwara State, like many other regions, has seen an uptick in drug-resistant TB cases in recent years, partly due to improved diagnostic capabilities with tools like GeneXpert [6]. However, these diagnostic advancements have not been matched with a commensurate increase in public awareness or data on resistance patterns, making it difficult for healthcare providers to tailor treatment regimens effectively [7]. Given the limited resources available for TB management in Kwara State, understanding local resistance patterns is crucial for optimizing treatment protocols and preventing the further spread of MDR-TB and XDR-TB. This study will help identify the most effective drugs for treating TB in the region, as well as the factors contributing to the development of drug resistance.

The primary objective of this study is to explore the pattern of resistance to anti-TB drugs among TB patients in Kwara State, focusing on both first-line and second-line treatments. Specifically, the study will examine resistance rates across different demographics, including age, gender, and socioeconomic status, to identify which groups are most affected by drug resistance. Additionally, the study seeks to explore the role of healthcare providers in managing drug-resistant TB and ensuring that patients adhere to their treatment regimens. It is hypothesized that younger patients and those with a history of previous TB treatment are more likely to exhibit re-

sistance to anti-TB drugs, due to factors such as poor adherence and delayed diagnosis [8]. The results of this study will have significant implications for public health policy in Kwara State, providing a foundation for more effective TB management strategies and helping to curb the spread of drug-resistant TB in the region.

2. Method

2.1. Study Design

This study employed a descriptive research design to assess the awareness and patterns of resistance to anti-tuberculosis (TB) drugs among TB patients in Kwara State, Nigeria. The study focused on patients undergoing treatment in various directly observed treatment short-course (DOTS) centers across selected local government areas (LGAs) in the state, providing insights into drug resistance patterns and factors influencing resistance.

2.2. Sampling Technique

A multi-stage sampling technique was utilized to select the study sample from the target population of TB patients in Kwara State. The sampling process involved the following steps:

1) Selection of Local Government Areas: Six LGAs were randomly selected through simple balloting from the three senatorial districts of Kwara State—two LGAs from each district.
2) Selection of DOTS Clinics: Four DOTS clinics were chosen from each of the six selected LGAs using simple random sampling through balloting, totaling 24 clinics for the study.
3) Selection of Participants: Proportionate allocation was applied to determine the sample size for each DOTS clinic based on the previous year's patient population. Eligible patients were recruited consecutively through systematic sampling, and interviews were conducted until the allocated sample size for each clinic was reached.

2.3. Data Collection

Data was collected between June and December 2021 using a combination of semi-structured questionnaires and laboratory testing for drug resistance:

1) Questionnaire: A semi-structured, interviewer-administered questionnaire was developed and pre-tested. It comprised four sections: Section A gathered socio-demographic data; Section B assessed awareness of anti-TB drug resistance; Section C addressed patient factors related to resistance patterns; and Section D evaluated healthcare provider-related risk factors. The questionnaire was administered by trained research assistants familiar with the local languages.
2) Laboratory Testing: Sputum samples were collected from patients newly diagnosed with TB and transported to the TB Zonal Reference Laboratory at the University College Hospital, Ibadan. Molecular techniques, including PCR-based Hain Line Probe Assay and GeneXpert, were used to identify Mycobacterium tuberculosis complex and assess resistance to first- and second-line TB drugs, such as Rifampicin, Isoniazid, and certain fluoroquinolones and aminoglycosides.

2.4. Ethical Considerations

The study obtained ethical approval from the Ethical Review Committee of the University of Ilorin Teaching Hospital, Ilorin. Written informed consent was sought from each participant, and all responses were anonymized to ensure confidentiality. Participants were informed about the study's objectives, benefits, and risks, with an emphasis on voluntary participation. No monetary incentives were provided to participants.

3. Result

3.1. Factors Influencing the Pattern of Resistance to Anti-TB Drugs

Table 1 revealed that out of the 125 respondents who were male, 10 (8.0%) had resistance to first-line anti-TB drugs. There was no significant association between sex and resistance pattern to first-line anti-TB drugs ($p = 0.16$).

Among the 87 respondents who lived in urban areas have had contact with someone with chronic cough, 12 (13.8%) were resistant to at least one of the drugs while out of the 88 who earn less than #20,000, 73 (82.9%) were sensitive to all the anti-TB drugs. There was no significant association between monthly income and resistance pattern to first-line anti-TB drugs ($p = 0.18$).

Age was the only socio-demographic characteristic that had a significant association with resistant patterns to first-line anti-TB drugs among the TB patients ($p = 0.04$).

Table 1. *Association between socio-demographic characteristics and resistant pattern to first-line Anti-TB drugs among TB patients (N=243).*

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Age group (Years)					
10-19	3 (100)	0 (0)	3 (100)		
20-29	53 (82.8)	11 (17.2)	64 (100)	16.225	0.044
30-39	88 (88.0)	12 (12.0)	100 (100)		
40-49	57 (100.0)	0 (0)	57 (100)		
50 and above	17 (89.5)	2 (10.5)	19 (100)		
Sex					
Male	115 (92.0)	10 (8.0)	125 (100)	6.487	0.166
Female	103 (87.2)	15 (12.7)	118 (100)		
Ethnic group					
Hausa	15 (93.8)	1 (6.2)	16 (100)		
Igbo	29 (87.9)	4 (12.1)	33 (100)	1.038	0.984
Yoruba	166 (89.7)	19 (10.3)	185 (100)		
Others	8 (88.9)	1 (1.1)	9 (100)		
Religion					
Christianity	45 (95.7)	2 (4.3)	47 (100)	2.791	0.248
Islam	173 (88.3)	23 (11.7)	196 (100)		
Education					
Quranic	32 (91.4)	2 (5.9)	34 (100)		
Primary	21 (77.8)	6 (22.2)	27 (100)	12.473	0.131
Secondary	63 (87.5)	9 (12.5)	72 (100)		
Tertiary	99 (93.4)	7 (6.6)	93 (100)		
Others	3 (75.0)	1 (25.0)	4 (100)		
Monthly Income (#)					
Less than 20,000	73 (82.9)	15 (17.1)	88 (100)		
20,000-50,000	91 (94.8)	5 (5.2)	96 (100)	11.426	0.179
51,000-100,000	29 (90.6)	3 (9.4)	32 (100		
Above 100,000	25 (92.3)	2 (7.7)	27 (100)		
Place of Residence					
Urban	75 (86.2)	12 (13.8)	87 (100)	2.921	0.232
Rural	143 (91.6)	13 (8.4)	156 (100)		
Marital Status					
Single	39 (88.6)	4 (11.4)	44 (100)		
Married	161 (91.0)	15 (9.0)	176 (100)	13.993	0.082
Divorced	2 (50.0)	2 (50.0)	4 (100)		
Separated	11 (73.3)	4 (26.7)	15 (100)		

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Widowed	5 (100.0)	0 (0)	5 (100)		

Table 2 revealed that out of the 185 respondents who were of the Yoruba ethnic group, 179 (95.7%) had no resistance to second-line anti-TB drugs. There was no significant association between ethnicity and resistance pattern to second-line anti-TB drugs (p = 0.60).

Among the 106 respondents who had tertiary education, 3 (2.8%) were resistant to at least one of the drugs while out of the 175 of the respondents who were married, 167 (94.4%) were sensitive to all second-line anti-TB drugs. There was no significant association between marital status and resistance pattern to second-line anti-TB drugs (p = 0.91).

Age was the only socio-demographic characteristic that had a significant association with resistant patterns to second-line anti-TB drugs among the TB patients (p =0.03).

Table 2. *Association between socio-demographic characteristics and resistant pattern to second-line Anti-TB drugs among TB patients.*

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total (%)		
Age group (Years)					
10-19	3 (100)	0 (0)	3 (100)		
20-29	62 (93.9)	2 (6.1)	64 (100)	17.503	0.036
30-39	95 (95.0)	5 (5.0)	100 (100)		
40-49	55 (96.5)	2 (3.5)	57 (100)		
50 and above	18 (94.7)	1 (5.3)	19 (100)		
Sex					
Male	119 (96.8)	4 (3.2)	123 (100)	2.526	0.640
Female	114 (95.0)	6 (5.0)	120 (100)		
Ethnic group					
Hausa	14 (87.5)	2 (12.5)	16 (100)		
Igbo	31 (93.9)	2 (6.1)	33 (100)	4.564	0.601
Yoruba	180 (97.3)	5 (2.7)	185 (100)		
Others	8 (88.9)	1 (11.1)	9 (100)		
Religion					
Christianity	46 (97.9)	1 (2.1)	47 (100)	1.066	0.587
Islam	187 (94.4)	9 (5.6)	196 (100)		
Education					
Quranic	33 (97.1)	1 (2.9)	34 (100)		
Primary	26 (96.3)	1 (3.7)	27 (100)	10.068	0.260
Secondary	68 (91.9)	4 (8.1)	72 (100)		
Tertiary	103 (97.2)	3 (2.8)	106 (100)		
Others	3 (75.0)	1 (25.0)	4 (100)		

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total (%)		
Monthly Income					
Less than 20,000	84 (93.3)	4 (6.7)	88 (100)		
20,000-50,000	93 (96.9)	3 (3.1)	96 (100)	5.335	0.721
51,000-100,000	31 (96.9)	1 (3.1)	32 (100		
Above 100,000	25 (92.3)	2 (7.7)	27 (100)		
Place of Residence					
Urban	83 (95.4)	4 (4.6)	87 (100)	1.191	0.551
Rural	150 (96.1)	6 (4.9)	156 (100)		
Marital Status					
Single	42 (95.5)	2 (4.5)	44 (100)		
Married	167 (94.4)	8 (5.6)	175 (1000	3.316	0.913
Divorced	4 (100.0)	0 (0)	4 (100)		
Seperated	15 (100.0)	(0)	15 (100)		
Widowed	5 (100.0)	0 (0)	5 (100)		

Table 3 showed that among the 100 respondents that were in the age group of 30-39 years, 18 (12.0%) had resistance to at least one of either the first-line or second-line anti-TB drugs. There was no significant association between age and resistance pattern to both first-line and second-line anti-TB drugs (p = 0.13). Out of the 106 respondents who had tertiary education, 96 (90.6%) were sensitive to at least one of the drugs (first-line and second-line anti-TB drugs) while out of the 175 of the respondents who were married, 22 (5.6%) were resistant to at least one of the first-line and second-line anti-TB drugs. There was no significant association between marital status and resistance pattern to second-line anti-TB drugs (p = 0.45).

Table 3. *Association between socio-demographic characteristics and resistance pattern to both first and second-line Anti-TB drugs among TB patients.*

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total (%)		
Age group (Years)					
10-19	3 (100)	0 (0)	3 (100)		
20-29	54 (82.0)	10 (18.0)	64 (100)		
30-39	82 (82.0)	18 (12.0)	100 (100)		
40-49	55 (96.5)	2 (3.5)	57 (100)		
50 and above	16 (84.2)	3 (15.8)	19 (100)	15.139	0.127
Sex					
Male	107 (87.0)	16 (13.0)	123 (100)	4.650	0.325
Female	103 (85.8)	17 (14.2)	120 (100)		
Ethnic group					

Socio-demographics Characteristics	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total (%)		
Hausa	14 (87.5)	2 (12.5)	16 (100)		
Igbo	28 (84.8)	5 (15.2)	33 (100)	0.759	0.993
Yoruba	160 (86.5)	25 (13.5)	185 (100)		
Others	8 (88.9)	1 (11.1)	9 (100)		
Religion					
Christianity	44 (93.6)	3 (6.4)	47 (100)	3.067	0.216
Islam	166 (84.7)	30 (15.3)	196 (100)		
Education					
Quranic	30 (88.2)	4 (11.8)	34 (100)		
Primary	22 (81.5)	5 (18.5)	27 (100)	8.541	0.383
Secondary	59 (81.9)	13 (18.1)	72 (100)		
Tertiary	96 (90.6)	10 (9.4)	106 (100)		
Others	3 (75.0)	1 (25.0)	4 (100)		
Monthly Income					
Less than 20,000	72 (81.0)	16 (19.0)	88 (100)		
20,000-50,000	87 (90.6)	9 (9.4)	96 (100)	6.616	0.579
51,000-100,000	28 (87.5)	4 (12.5)	32 (100		
Above 100,000	23 (85.1)	4 (14.9)	27 (100)		
Place of Residence					
Urban	72 (82.8)	15 (17.2)	87 (100)	2.664	0.264
Rural	138 (88.5)	18 (11.5)	156 (100)		
Marital Status					
Single	38 (84.1)	6 (15.9)	44 (100)		
Married	153 (94.4)	22 (5.6)	175 (1000	7.550	0.479
Divorced	2 (50.0)	2 (50.0)	4 (100)		
Seperated	12 (73.3)	3 (26.7)	15 (100)		
Widowed	5 (100.0)	0 (0)	5 (100)		

3.2. Patient-Related Factors Influencing Resistance to Anti-TB Drugs

Table 4 showed that among the 120 respondents that had no BCG scar, 8 (6.7%) had resistance to at least one of either the first-line drug. There was no significant association between BCG vaccination and resistance pattern to first-line anti-TB drugs ($p = 0.16$).

Out of the 204 respondents who smoke cigarettes, 19(9.3%) had resistance to at least one of the drugs (first-line drug) while out of the 146 of the respondents who have had hospital admission, 133 (91.1%) were sensitive to the first-line anti-TB drugs. There was no significant association between hospital admission status and resistance pattern to first-line anti-TB drugs ($p = 0.66$).

Table 4. *Association between patient related factors and pattern of resistance to first-line Anti-TB drugs among TB patients.*

Patient-related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
HIV Status Yes	10 (100.0)	0 (0)	10 (100)	1.650	0.949
BCG Scar Yes	86 (84.3)	16 (15.7)	102 (100)	9.232	0.161
Alcohol Consumption Yes	40 (95.2)	2 (4.2)	42 (100)	2.901	0.574
Smoke cigarette Yes	33 (84.6)	6 (13.4)	39 (100)	2.190	0.901
History of Incarceration Yes	64 (94.1)	4 (5.9)	68 (100)	5.008	0.543
History of Hospital admission Yes	85 (87.6)	12 (12.3)	97 (100)	0.843	0.656
Contact with Chronic Cough Yes	18 (90.0)	2 (10.0)	20 (100)	0.825	0.820
Contact with TB patient Yes	14 (87.5	2 (12.5)	16 (100)	3.614	0.461
Ever diagnosed with TB Yes	26 (89.7)	3 (10.3)	29 (100)	0.271	0.873
Use drug as prescribed Yes	57 (90.5)	6 (9.5)	63 (100)	0.752	0.687

Table 5 revealed that out of the 10 respondents who were HIV positive, 8 (80.0%) had no resistance to second-line anti-TB drugs. There was no significant association between HIV status and resistance pattern (p = 0.323).

Among the 42 respondents who consume alcohol, 38 (90.5%) were sensitive to second-line anti-TB drugs, while 6 (3.0%) of the 201 respondents who do not consume alcohol were resistant to at least one of the anti-TB drugs. There was a significant association between alcohol consumption and resistant pattern (p = 0.02).

Among the 20 respondents who have had contact with someone with chronic cough, 3 (15.0%) were resistant to at least one of the drugs while out of the 223 who never had contact with chronic cough, 216 (96.8%) were sensitive to all the anti-TB drugs. There was a significant association between contact with chronic cough and resistance pattern to second-line anti-TB drugs (p = 0.03).

Table 5. *Association between patient related factors and pattern of resistance to second-line Anti-TB drugs among TB patients.*

Patient-related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
HIV Status Yes	8 (80.0)	2 (20.0)	10 (100)	6.981	0.323
BCG Scar Yes	99 (96.1)	3 (3.9)	102 (100)	5.039	0.539

Patient-related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Alcohol Consumption Yes	38 (90.5)	4 (9.5)	42 (100)	15.072	0.023
Smoke cigarette Yes	35 (89.7)	4 (10.3)	39 (100)	4.584	0.598
History of Incarceration Yes	63 (89.6)	5 (10.4)	68 (100)	2.119	0.9920
History of Hospital admission Yes	94 (97.0)	3 (3.0)	97 (100)	0.511	0.774
Contact with Chronic Cough Yes	17 (85.0)	3 (15.0)	20 (100)	10.533	0.032
Contact with TB patient Yes	15 (93.8)	1 (6.2)	16 (100)	13.455	0.063
Ever diagnosed with TB Yes	27 (93.1)	2 (6.9	29 (100)	0.921	0.631
Use drug as prescribed Yes	60 (95.2)	3 (4.8)	63 (100)	0.789	0.674

Table 6 revealed that out of the 10 respondents who were HIV positive, 8 (80.0%) had no resistance to second-line anti-TB drugs. There was no significant association between HIV status and resistance pattern (p = 0.96).

Among the 42 respondents who consume alcohol, 36 (85.7%) were sensitive to both first-line and second-line anti-TB drugs, while 27 (13.4%) of the 201 respondents who do not consume alcohol were resistant to at least one of the anti-TB drugs. There was a significant association between alcohol consumption and resistant pattern (p = 0.03).

Among the 20 respondents who have had contact with someone with chronic cough, 5 (25.0%) were resistant to at least one of the drugs while out of the 223 who never had contact with chronic cough, 195 (87.4%) were sensitive to all the anti-TB drugs. There was a significant association between contact with chronic cough and resistance pattern to both first-line and second-line anti-TB drugs (p = 0.04).

Table 6. *Association between patient related factors and pattern of resistance to both first-line and second-line Anti-TB drugs among TB patients.*

Patient-related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
HIV Status Yes	8 (80.0)	2 (20.0)	10 (100)	1.485	0.960
BCG Scar Yes	83 (84.3)	19 (15.7)	102 (100)	8.003	0.238
Alcohol Consumption Yes	36 (85.7)	(14.3)	42 (100)	11.295	0.026
Smoke cigarette Yes	36 (92.3)	3 (7.7)	39 (100)	3.368	0.761

Patient-related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
History of Incarceration Yes	60 (88.2)	8 (11.8)	68 (100)	2.793	0.834
History of Hospital admission Yes	82 (84.2)	15 (15.8)	97 (100)	0.572	0.751
Contact with Chronic Cough Yes	15 (75.0)	5 (25.0)	20 (100)	12.912	0.043
Contact with TB patient Yes	13 (81.3)	3 (18.7)	16 (100)	2.844	0.584
Ever diagnosed with TB Yes	24 (82.8)	5 (17.2)	29 (100)	0.650	0.723
Use drug as prescribed Yes	55 (87.3)	8 (12.7)	63 (100)	0.755	0.686

3.3. Healthcare-Giver-Related Factors and Resistance Patterns

Table 7 showed that among the 119 respondents that had no compliance with DOTS by their caregiver, 9 (7.6%) had resistance to at least one of the first-line anti-TB drugs. There was no significant association between compliance with DOTS and resistance pattern to first-line anti-TB drugs (p = 0.15).

Out of the 120 respondents who were provided with prompt attention by the caregiver, 14 (11.7%) had resistance to at least one of the drugs (first-line anti-TB drugs) while out of the 123 of respondents that were not provided with prompt attention by the healthcare-giver, 112 (91.1%) were sensitive the first-line anti-TB drugs. There was no significant association between the provision of prompt attention to patients by healthcare-givers and resistance patterns to first-line anti-TB drugs (p = 0.61).

There was no significant association between any of the healthcare-giver-related factors and resistance patterns to first-line anti-TB drugs.

Table 7. *Association between healthcare–giver related factors and resistance pattern to first-line Anti-TB drugs among TB patients.*

Healthcare-giver related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Delay in treatment commencement after diagnosis					
Yes	10 (100.0)	0 (0)	10 (100)	0.336	0.845
Compliance with DOTS					
Yes	108 (88.3)	16 (11.7)	124 (100)	3.781	0.151
Provision of Health talk and awareness					
Yes	108 (86.0)	14 (14.0)	122 (100)	2.620	0.623
Provision of Prompt attention by health worker					
Yes	106 (88.3)	14 (11.7)	120 (100)	2.699	0.609
Provision of Information about long duration of treatment					
Yes	189 (88.7)	24 (11.3)	213 (100)	0.500	0.779

Healthcare-giver related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Provision of Information on reasons for daily intake of drugs					
Yes	189 (88.7)	24 (11.3)	213 (100)	0.500	0.779
Provision of Information on protection of others					
Yes	189 (88.7)	25 (11.3)	213 (100)	0.500	0.779

Table 8 showed that among the 118 respondents who could not remember experiencing any delay in treatment commencement after diagnosis, none of them (0%) had resistance to at any of the second-line anti-TB drugs. There was no significant association between delay in treatment commencement and resistance pattern to second-line anti-TB drugs (p = 0.95).

Out of the 122 respondents who were provided with health talk and awareness by the caregiver, 3 (2.4%) had resistance to at least one of the drugs (second-line anti-TB drugs) while out of the 121 of the respondents that were not provided with health talk and awareness by the healthcare-giver, 114 (94.2%) were sensitive the second-line anti-TB drugs. There was no significant association between provision of health talk and awareness to patients by healthcare-giver and resistance pattern to first-line anti-TB drugs (p = 0.44).

There was no significant association between any of the healthcare-giver related factors and resistance pattern to second-line anti-TB drugs.

Table 8. *Association between healthcare–giver related factors and resistance pattern of second-line Anti-TB drugs among TB patients.*

Healthcare-giver related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Delay in treatment commencement after diagnosis					
Yes	10 (100.0)	0 (0)	10 (100)	0.104	0.949
Compliance with DOTS					
Yes	121 (97.6)	3 (2.4)	124 (100)	3.751	0.153
Provision of Health talk and awareness Yes	119 (97.6)	3 (2.4)	122 (100)	3.934	0.415
Provision of Prompt attention by health worker					
Yes	117 (97.5)	3 (2.5)	120 (100)	3.769	0.438
Provision of Information about long duration of treatment					
Yes	206 (96.7)	7 (3.3)	213 (100)	2.905	0.234
Provision of Information on reasons for daily intake of drugs					
Yes	206 (96.7)	7 (3.3)	213 (100)	2.905	0.234
Provision of Information on the protection of others					
Yes	206 (96.7)	7 (3.3)	213 (100)	2.905	0.234

Table 9 showed that among the 213 respondents who provided information about the long duration of treatment, 187 (87.8%) were sensitive to all the first-line and second-line anti-TB drugs. There was no significant association between the provision of information about the long duration of treatment and resistance patterns to both first-line and sec-

ond-line anti-TB drugs (p = 0.29).

Out of the 213 respondents who were provided with information about reasons for daily intake of the drugs, 26 (12.2%) had resistance to at least one of the drugs (first-line and second-line anti-TB drugs) while out of the 32 of the respondents that were not provided with information about reasons for the daily intake of the drugs by the healthcare-giver, 25 (78.1%) were sensitive all of the first-line and second-line anti-TB drugs. There was no significant association between the provision of information on reasons for the daily intake of drugs to patients by caregivers and resistance patterns to both first line and second-line anti-TB drugs (p = 0.29).

Table 9. *Association between healthcare–giver related factors and resistance pattern of first-line and second-line Anti-TB drugs among TB patients.*

Healthcare-giver related factors	Resistance Pattern			X^2	P-Value
	Sensitive n (%)	Resistant n (%)	Total n (%)		
Delay in treatment commencement after diagnosis Yes	5 (50.0)	5 (50.0)	10 (100)	0.336	0.845
Compliance with DOTS Yes	105 (84.7)	19 (15.3)	124 (100)	2.560	0.278
Provision of Health talk and awareness Yes	105 (86.1)	17 (13.9)	122 (100)	2.456	0.653
Provision of Prompt attention by health worker Yes	103 (85.8)	17 (14.2)	120 (100)	2.398	0.633
Provision of Information about long duration of treatment Yes	187 (87.8)	26 (12.2)	213 (100)	2.479	0.290
Provision of Information on reasons for daily intake of drugs Yes	187 (87.8)	26 (12.2)	213 (100)	2.479	0.290
Provision of Information on protection of others Yes	187 (87.8)	26 (12.2)	213 (100)	2.479	0.290

There was no significant association between any of the healthcare-giver-related factors and resistance patterns to both first-line and second-line anti-TB drugs.

3.4. Patient-Related Factors and Resistance to Anti-TB Drugs

Table 10 revealed that the binary logistic regression done to investigate further the association of the significant patient-related factors and resistance pattern to both first-line and second-line anti-TB drugs shows that TB patients who consume alcohol are 6 times more likely to develop resistance to anti-TB drugs than those who do not consume alcohol (OR = 6.025, 95% C.I = 4.950 -13.632, p= 0.0423). There was no significant association between contact with chronic cough and resistance pattern controlling for other characteristics.

Table 10. *Binary logistic regression analysis on patient-related factors and resistance anti-TB drugs.*

Patient related factors	OR	95% C. I	P-Value
Alcohol Consumption Yes No*	6.025	4.950 -13.632	0.0423**

Patient related factors	OR	95% C. I	P-Value
Contact with Chronic Cough			
Yes No*	3.118	0.549 -18.116	0.2165

***** Reference category OR= Odds Ratio, 95% C.I = 95% Confidence Interval
** Significant at p value < 0.05

4. Discussion

4.1. Socio-Demographic Factors and Their Association with Anti-Tuberculosis Drug Resistance

The study findings demonstrate that age is significantly associated with resistance to first-line anti-TB drugs, with a *p*-value of 0.044, suggesting that younger individuals, particularly those aged 20-29 years, are more likely to exhibit drug resistance. This is corroborated by other studies such as those by Kooffreh et al. [9], which reported similar age-based disparities in drug resistance patterns in Calabar, Nigeria. These findings align with the global understanding that age plays a critical role in TB drug resistance, potentially due to the heightened exposure to resistant strains among younger populations, who are often more mobile and socially active [10]. The study by Lawson et al. [11] also supports this trend, where young adults exhibited a higher prevalence of multi-drug-resistant tuberculosis (MDR-TB) compared to older age groups.

The study found no significant association between sex and resistance patterns to first-line anti-TB drugs ($p = 0.166$). This is consistent with the findings from Oladimeji et al. [12], who reported that gender was not a primary determinant of drug resistance in their study of drug-resistant tuberculosis in Nigeria. This contradicts earlier assumptions that males are more prone to TB drug resistance due to higher rates of smoking and alcohol consumption [13]. However, the findings from the present study suggest that gender-related behavioral factors do not necessarily translate into significant differences in drug resistance rates.

The data show no significant association between ethnicity and resistance patterns for both first-line ($p = 0.984$) and second-line ($p = 0.601$) anti-TB drugs. This is supported by the study by Shittu et al. [14], which found that ethnic differences in Nigeria did not significantly influence rifampicin-resistant TB rates. However, studies from other regions, such as India, suggest that ethnic minorities may face barriers to accessing timely and adequate TB care, which can influence resistance patterns [15]. Despite these external findings, the current data align with studies in Nigeria, showing that ethnicity does not play a major role in drug resistance in the population studied.

The analysis of educational status reveals no significant association with drug resistance to both first-line ($p = 0.131$) and second-line drugs ($p = 0.260$). Nevertheless, education is often considered a determinant of health literacy, which could influence TB treatment adherence [8]. While education may not directly predict drug resistance, it can influence patients' understanding of TB, treatment adherence, and health-seeking behavior, as noted by Olarewaju et al. [16] in a study of DOTS centers in Southwest Nigeria. This aligns with the study's finding that tertiary education was associated with higher rates of sensitivity to anti-TB drugs, but no statistical significance was found.

The data indicate no significant association between monthly income and resistance patterns to first-line ($p = 0.179$) and second-line ($p = 0.721$) anti-TB drugs. These findings are aligned with existing literature suggesting that while low socioeconomic status increases TB incidence, it does not necessarily correlate with drug resistance [17]. For instance, the Global Burden of Disease (GBD) Tuberculosis Collaborators [18] found that low-income populations may experience higher TB infection rates due to poor living conditions and healthcare access, but the risk of developing drug resistance is more related to treatment adherence rather than income.

No significant association was found between marital status and resistance patterns to first-line ($p = 0.082$), second-line ($p = 0.913$), and both drug types ($p = 0.479$). Similar results were observed in studies such as Ugwu et al. [19], which analyzed drug-resistant TB patterns in Southeastern Nigeria. Marital status, as a socio-demographic variable, may not directly impact TB resistance but may influence household transmission dynamics, especially in crowded or multi-person homes. Additionally, Berhanu et al. [20] found no direct link between marital status and TB drug resistance in Ethiopian populations, further validating the findings of the current study.

The study observed no significant association between place of residence (urban or rural) and TB drug resistance ($p = 0.232$ for first-line, $p = 0.551$ for second-line drugs). This result contradicts global trends where rural populations often have reduced access to healthcare and, consequently, higher drug resistance rates due to delayed diagnosis and treatment [21].

4.2. Clinical and Behavioral Factors Influencing Anti-Tuberculosis Drug Resistance

The study found no significant association between HIV status and resistance patterns to first-line anti-TB drugs (p = 0.949). This contradicts the widespread understanding that HIV-positive individuals are at higher risk for MDR-TB due to their compromised immune systems [13]. Studies from regions like Eastern Ethiopia [20] and Nigeria [19] also found no significant relationship between HIV co-infection and TB drug resistance, which may indicate that effective TB-HIV co-management protocols could mitigate this risk. In both Table 5 and Table 6, the association between HIV status and resistance to anti-TB drugs (both first line and second-line) was not statistically significant, with p-values of 0.323 and 0.960, respectively. This finding aligns with previous studies, which have demonstrated that although HIV co-infection exacerbates the clinical manifestation of tuberculosis, it does not directly correlate with higher rates of drug resistance. Kooffreh et al. [9] similarly reported no significant link between HIV status and drug-resistant tuberculosis (DR-TB) among patients in Calabar, Nigeria. This suggests that HIV status alone may not be a determinant of drug resistance in tuberculosis, though it contributes to a worsened disease prognosis and may affect treatment adherence.

The study found no significant association between alcohol consumption (p = 0.574) and smoking (p = 0.901) with TB drug resistance. This contrasts with studies such as Gaude & Kumar [15], which found that alcohol and tobacco use were key risk factors for drug-resistant TB in India. However, Kooffreh et al. [9] also reported a lack of significant correlation between these factors and drug resistance in Calabar, Nigeria. The variation in findings across regions may suggest that while lifestyle factors influence TB susceptibility, their impact on drug resistance is less pronounced in some populations. In both datasets (Tables 5 and 6), alcohol consumption showed a significant association with resistance patterns (p = 0.023 and 0.026, respectively). Alcohol consumption is a well-documented risk factor for TB and drug resistance due to its impact on immune function and its role in promoting non-adherence to treatment. Adisa et al. [8] highlighted that alcohol consumption is frequently associated with poor treatment adherence, which can drive the development of drug-resistant strains of TB. Similarly, Gaude and Kumar [15] found a significant correlation between alcohol use and multidrug-resistant TB (MDR-TB) in their study in India, attributing it to lifestyle factors that compromise immune defenses. The association between cigarette smoking and resistance to anti-TB drugs was not statistically significant (p = 0.598 for second line and p = 0.761 for both first- and second-line drugs). However, cigarette smoking has been identified in other studies as a contributor to TB progression and poor treatment outcomes due to its impact on lung health and immune function. Patle and Khakse [10] also found no significant direct association between smoking and drug resistance in their cohort, although smokers generally have a higher risk of TB reactivation and treatment failure. This suggests that while smoking affects TB outcomes, it may not directly influence the development of drug-resistant strains.

There was no significant association between the presence of a BCG scar and resistance to first-line anti-TB drugs (p = 0.161). This aligns with studies suggesting that BCG vaccination primarily protects against severe forms of TB rather than influencing drug resistance patterns [22]. Shittu et al. [14] similarly reported that BCG vaccination status had minimal impact on the emergence of drug-resistant TB in Nigerian populations. No significant association was found between the presence of a Bacille Calmette-Guérin (BCG) scar and resistance to first- or second-line anti-TB drugs (p = 0.539 and 0.238, respectively). BCG vaccination provides some protection against TB, particularly in childhood, but its role in the prevention of drug-resistant tuberculosis is not well established. Studies have shown that while BCG vaccination offers partial protection, the emergence of drug resistance is more linked to treatment adherence and other socio-environmental factors rather than vaccination status.

Interestingly, the study found no significant association between contact with TB patients and resistance to first-line drugs (p = 0.461). This contrasts with the global narrative, as highlighted by Xi et al. [23], which posits that close contact with drug-resistant TB patients is a key risk factor for transmission. However, the lack of significance in this study may be attributed to the effectiveness of isolation and early treatment strategies within the study population, reducing transmission rates even in close-contact scenarios [21].

No significant association was found between a history of incarceration (p = 0.543) or hospital admission (p = 0.656) and drug resistance patterns. This is contrary to findings by Chakraborty & Rhee [24], who noted that institutional environments such as prisons and hospitals are high-risk settings for MDR-TB due to overcrowding and poor infection control. Nonetheless, local interventions in Nigeria may have minimized these risks, as noted in studies like that by Olarewaju et al. [16], where DOTS strategies in health institutions effectively managed TB transmission and resistance. No significant association was found between a history of incarceration and resistance to either first- or second-line anti-TB drugs (p = 0.9920 and 0.834, respectively). Incarceration is frequently associated with higher TB incidence and MDR-TB due to overcrowded, unsanitary conditions and poor access to healthcare. However, the lack of statistical significance in this study may be due to the relatively small sample size. Lawson et al. [11] noted that incarcerated individuals are at higher risk for MDR-TB due to delayed diagnosis and inadequate treatment. Similar to incarceration, a history of hospital admission did not significantly associate with resistance patterns (p = 0.774 and 0.751, respectively). Hospital admissions often reflect the severity of TB disease but may not directly contribute to drug resistance. Studies have shown that drug resistance is more associated with treatment practices and ad-

herence rather than the mere history of hospital admissions.

A significant association was observed between contact with individuals with chronic cough and resistance to both first-line and second-line anti-TB drugs ($p = 0.032$ and $p = 0.043$, respectively). This finding supports the role of close contact in the transmission of resistant TB strains. Oladimeji et al. [12] emphasized that household contacts of TB patients are at high risk for drug-resistant TB due to prolonged exposure, especially in settings where TB treatment adherence is poor. Although contact with a TB patient approached significance for second-line drugs ($p = 0.063$), the association was not statistically significant in either analysis (Table 5 and 6). However, numerous studies, including by the World Health Organization (WHO), have recognized close contact with TB patients as a risk factor for MDR-TB. Close monitoring and prophylactic treatment are recommended for household contacts to prevent the transmission of resistant strains.

Neither the history of a prior TB diagnosis nor adherence to prescribed drug regimens was significantly associated with resistance patterns ($p > 0.05$ in both cases). Nevertheless, a prior history of TB often increases the risk of drug resistance, as incomplete or improper treatment courses can lead to resistance development. The WHO [18] stresses that strict adherence to treatment regimens is essential to prevent resistance, particularly in previously treated patients. Studies by Ajema et al. [25] also emphasize the importance of sustained drug adherence in preventing drug resistance.

4.3. Treatment Delays, Adherence, and Patient Education on Anti-Tuberculosis Drug Resistance

No significant association was found between delays in treatment commencement and resistance to either first- or second-line anti-TB drugs ($p = 0.845$ and $p = 0.949$, respectively). However, delays in diagnosis and treatment have been widely acknowledged as contributing factors to the development and spread of drug-resistant TB. Cohen and Bishai [26] identified treatment delays as a major challenge in controlling TB resistance globally, particularly in resource-limited settings where diagnostic infrastructure is often inadequate. Table 9 shows that out of the 10 TB patients who experienced delays in treatment commencement after diagnosis, 50% were resistant to first-line and second-line anti-TB drugs, while the remaining 50% were sensitive. However, the association between delayed treatment and drug resistance was not statistically significant ($p = 0.845$). Delayed treatment has been identified as a critical factor in the development of resistance, as prolonged periods without effective therapy allow Mycobacterium tuberculosis to evolve under suboptimal drug concentrations [6]. Rikoto [27] noted that delayed initiation of treatment in Zaria was a significant factor in the development of first-line drug resistance. Similarly, the WHO [1] underscored that timely diagnosis and treatment initiation are vital in preventing the emergence of multidrug-resistant TB (MDR-TB). However, the findings in this study did not show a significant correlation between delays and resistance, perhaps due to the small sample size or other confounding factors not captured.

While there was no significant association between compliance with Directly Observed Treatment Short-course (DOTS) and resistance patterns in this study ($p = 0.151$ and $p = 0.153$ for first-line and second-line drugs, respectively), the role of DOTS in preventing drug resistance is well documented. Non-compliance with DOTS leads to incomplete treatment, increasing the risk of drug resistance. The Global Burden of Disease Study [18] emphasized that the effective implementation of DOTS is crucial to reducing the global burden of MDR-TB. The study revealed that out of 124 patients who adhered to the DOTS regimen, 15.3% developed resistance, while 84.7% were sensitive to anti-TB drugs. Though the data suggested a protective effect of DOTS adherence against resistance, the association was not statistically significant ($p = 0.278$). DOTS is a key intervention in global TB control efforts, promoting treatment adherence and reducing the risk of drug resistance [21]. According to the study by Worku et al. [28] in Ethiopia, non-compliance with DOTS was strongly associated with drug resistance patterns, reinforcing the importance of sustained and supervised treatment. Likewise, a meta-analysis by Onyedum et al. [3] in Nigeria demonstrated that adherence to DOTS reduces the likelihood of drug resistance. This study's non-significant finding may be a result of limitations such as sample size or variations in DOTS implementation quality across regions.

The provision of health talks, awareness programs, and information on the importance of daily drug intake and treatment duration were not significantly associated with resistance patterns ($p > 0.05$ for all factors). Nevertheless, education on TB and treatment adherence is critical for preventing the development of drug resistance. Adisa et al. [8] highlighted that educational interventions at DOTS centers improve treatment outcomes by fostering better patient understanding and compliance. Among the 122 respondents who received health talks and awareness, 13.9% were resistant to first-line and second-line anti-TB drugs, but no significant association was found between health education and resistance ($p = 0.653$). Educational interventions have been found to improve treatment adherence and reduce resistance in several studies. For example, Patle and Khakse [10] demonstrated that knowledge about TB and MDR-TB was significantly associated with better treatment adherence among patients in India. Similarly, Balogun et al. [29] showed that trained community volunteers providing TB education improved patient knowledge and attitudes, indirectly contributing to lower resistance rates. However, this study suggests that while health education is important, it may not be the sole determinant of resistance patterns, indicating the need for multifaceted approaches, including consistent follow-ups and socio-economic support.

Of the 120 patients who received prompt attention from

healthcare workers, 14.2% showed resistance to anti-TB drugs, but there was no significant association between prompt healthcare worker attention and resistance patterns (p = 0.633). Healthcare workers play a pivotal role in managing TB through timely diagnosis and treatment interventions. Studies such as those by Olarewaju et al. [16] have highlighted that timely and responsive healthcare contributes to better treatment outcomes and reduces the risk of drug resistance. In this study, while no significant association was found, it underscores the complex nature of TB resistance, which may be influenced by a range of factors beyond the healthcare worker's immediate control.

A total of 213 patients were provided information about the long treatment duration, with 87.8% remaining sensitive to anti-TB drugs. Despite the high sensitivity rate, there was no significant association between receiving information about the treatment duration and resistance patterns (p = 0.290). Informing patients about the long duration of TB treatment is essential in fostering adherence, which is crucial for preventing drug resistance. WHO [18] emphasizes that patient education on treatment duration can mitigate default rates, thereby reducing resistance risks. However, a study by Pokam et al. [4] in Cross River State found that despite receiving information about treatment duration, some patients still developed resistance, possibly due to socio-economic challenges impacting adherence. The current study's non-significant association may reflect the limitations of education alone in influencing treatment outcomes, highlighting the need for a more comprehensive approach to patient care.

Among the 213 patients informed about the importance of daily drug intake, 12.2% developed resistance. Again, no significant association was found between being informed about the necessity of daily medication and resistance patterns (p = 0.290). Daily drug intake is critical in TB treatment to maintain effective drug concentrations and prevent the development of resistant strains. Studies like those by Chakraborty and Rhee [24] explain that consistent drug intake is crucial in preventing mutations that lead to MDR-TB. However, the non-significant association in this study may point to other factors influencing patient adherence, such as socio-economic barriers or healthcare system inefficiencies, which might limit the effectiveness of patient education alone.

4.4. Significant Risk Factor for Anti-TB Drug Resistance

Table 10 highlights that alcohol consumption is significantly associated with anti-TB drug resistance (p = 0.0423). Patients who consume alcohol are six times more likely to develop resistance (OR = 6.025, 95% C.I = 4.950 -13.632) than those who do not. Alcohol use has been repeatedly associated with poor treatment adherence and an increased likelihood of drug resistance. According to Gaude and Kumar [15], alcohol abuse can impair patients' ability to adhere to TB treatment regimens, thereby facilitating the emergence of drug-resistant strains. Similarly, a study by Workicho et al. [30] in Ethiopia confirmed that alcohol consumption was a significant risk factor for MDR-TB development. The present findings align with these studies, reinforcing that addressing alcohol use in TB patients should be a priority in resistance prevention efforts.

Contact with individuals with chronic cough was not significantly associated with drug resistance (p = 0.2165). Patients with contact were 3.1 times more likely to develop resistance (OR = 3.118), but the confidence interval was wide (0.549 -18.116), indicating a lack of precision in the estimate. Close contact with individuals with chronic cough, particularly in overcrowded or poorly ventilated environments, increases the risk of TB transmission. However, the lack of significant association in this study may indicate that contact alone is insufficient to predict resistance patterns. A study by Berhanu et al. [20] in Ethiopia noted that while contact with TB patients increases the likelihood of TB transmission, it is the strain of Mycobacterium tuberculosis, coupled with factors like treatment adherence, that predominantly determines resistance. The non-significant finding in this study suggests that the relationship between contact and resistance is multifactorial and requires further investigation.

5. Conclusion

This study revealed a complex and multifaceted interaction of socio-demographic, patient-related, and healthcare factors influencing resistance patterns to anti-TB drugs. Age was significantly associated with drug resistance, particularly among younger populations, while other factors such as gender, ethnicity, education, income, and marital status showed no significant association. Contrary to global trends, variables like HIV status, smoking, and alcohol consumption were not consistently linked with drug resistance. However, alcohol use emerged as a notable risk factor, significantly increasing the likelihood of developing resistance. Healthcare-related variables, including treatment delays and DOTS adherence, though widely acknowledged as critical in TB management, did not exhibit significant associations with resistance in this study, potentially due to sample size limitations or confounding factors. The findings underscore the importance of considering multiple determinants, including patient behaviors and healthcare delivery quality, when addressing the growing challenge of TB drug resistance. Effective management of these factors, particularly adherence to treatment regimens and addressing alcohol consumption, is crucial in mitigating the development of drug-resistant TB strains.

6. Recommendations for Further Research

The quality of Directly Observed Treatment Short-course (DOTS) implementation across various regions of Nigeria

demands rigorous evaluation to identify systemic gaps contributing to drug resistance. Factors such as inconsistent adherence to DOTS guidelines, inadequate healthcare worker training, and insufficient patient follow-up contribute to delays in diagnosis and treatment commencement, exacerbating resistance rates. Addressing these deficiencies requires an integrated approach, combining infrastructure development with capacity building for healthcare personnel to ensure consistent and timely treatment delivery. Also, TB-HIV co-infection presents unique challenges, particularly regarding drug resistance in immunocompromised patients. Case-control studies are essential to understand how some co-infected patients manage to remain free of resistant TB strains. Additionally, investigating the long-term efficacy of TB-HIV co-management protocols in preventing multidrug-resistant TB (MDR-TB) within resource-limited settings could inform policy and programmatic enhancements, ensuring better health outcomes for this vulnerable population.

Abbreviations

DR-TB	Drug Resistant Tuberculosis
DOTS	Directly Observed Therapy Short Course
DST	Drug Susceptibility Testing
MDR-TB	Multi-Drug Resistant Tuberculosis
NTP	National Tuberculosis Programme
P/PZH	Pyrazinamide
PLHIV	Persons living with HIV/AIDS
PTB	Pulmonary Tuberculosis
R	Rifampicin
RR	Rifampicin Resistance
WHO	World Health Organization

Conflicts of Interest

The authors declare no conflicts of interest.

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