

## Original Article

# Predictors of Adherence to Tuberculosis Treatment Among Adolescents in Kano, Nigeria

Mahmoud M<sup>1</sup>, Tsiga-Ahmed FF<sup>2</sup>, Jalo RF<sup>2\*</sup>, Umar AA<sup>2</sup>, Ayaba AK<sup>3</sup>, Ibrahim UM<sup>3</sup>, Musa A<sup>3</sup>, Haruna MM<sup>4</sup>, Aminu A<sup>5</sup>, Yusuf MA<sup>5</sup>, Abubakar MK<sup>6</sup>

1. Murtala Muhd Specialist Hospital Kano & Ministry for Higher Education, Kano State - Nigeria
2. Department of Community Medicine, Bayero University Kano & Aminu Kano Teaching Hospital, Kano - Nigeria
3. Department of Community Medicine, Abubakar Tafawa Balewa University Teaching Hospital, Bauchi, Nigeria
4. Department of Community Medicine, Bayero University Kano, Nigeria
5. Department of Medical Microbiology and Parasitology, Bayero University Kano & Aminu Kano Teaching Hospital Kano, Nigeria
6. Department of Surgery, Bayero University Kano & Aminu Kano Teaching Hospital, Kano - Nigeria

\*Corresponding author: [rabiubrahimjalo@yahoo.com](mailto:rabiubrahimjalo@yahoo.com)

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### ABSTRACT

**Background:** Poor adherence to tuberculosis (TB) treatment is common among young and vulnerable populations such as children and adolescents, despite various interventions aimed at improving treatment completion. Lack of a comprehensive and holistic understanding of barriers and facilitators of treatment adherence is currently a major obstacle to the elimination of tuberculosis.

**Methods:** The study aimed to determine the level of adherence and factors affecting tuberculosis treatment adherence among adolescents attending Murtala Muhammad Specialist Hospital, Kano. Using a cross-sectional study design, an interviewer-administered questionnaire was used to collect information from 381 adolescents.

**Results:** The majority of the respondents (70.08%, n=267) had low adherence to anti-TB medication, 23.10% (n=88) had medium adherence and few (6.82%, n= 26) had higher adherence to anti-TB medication. Compared to adolescents between 10-13 years, those who were 14-17years (aOR:2.49 95% CI:1.23-7.40) and 18-19 years (aOR:3.02 95% CI:1.77-11.81) had higher odds of low adherence. Residence was associated with level of adherence as respondents from urban areas were 63% less likely to have low adherence (aOR:0.27, 95% CI:0.13-0.80) and 47% less likely to have moderate adherence (aOR:0.53, 95% CI:0.10-0.78). Also, lower odds of having both moderate (aOR:0.17, 95% CI:0.25-0.96) and low adherence (aOR:0.31, 95% CI: 0.18-0.89) were seen among female adolescents. Similarly, having good and excellent relationships with other healthcare workers in the TB treatment centres was seen to reduce the likelihood of having low adherence (aOR:0.98, 95% CI:0.27-1.56).

**Conclusions:** There is need for healthcare workers in TB treatment centres to improve adherence counseling services among adolescents and their families.

**Key words:** Adherence, drugs, adolescents, tuberculosis, treatment, Anti-TB.

## INTRODUCTION

Adherence is crucial to the success of tuberculosis (TB) treatment. Patients with poor adherence are at a very high risk of developing drug-resistant tuberculosis which is associated with increased morbidity and mortality<sup>1</sup>. Medication adherence is a growing concern to clinicians and other stakeholders because of mounting evidence that non-adherence is prevalent and associated with adverse outcomes and higher cost of care<sup>2</sup>. The World Health Organization (WHO) defines adherence as the extent to which a person's behaviour such as taking medication, following a diet, or making healthy lifestyle changes, corresponds with agreed-upon recommendations from a healthcare provider<sup>2,3</sup>. Adherence has also been defined as the active, voluntary, collaborative involvement of the patient in a mutually acceptable course of behaviour to produce a therapeutic result<sup>4</sup>. It is a term used to describe the patient's behaviour concerning taking drugs correctly based on mutual agreement between the patient and healthcare provider<sup>5</sup>. It involves taking the right drugs in the right dose, with the right frequency and at the right time.

Although most research has focused on adherence to medication, adherence also encompasses numerous health-related behaviours that extend beyond taking prescribed pharmaceuticals<sup>6</sup>. Rate of adherence for individual patients are usually reported as a percentage of the prescribed doses of medication actually taken by the patient over a specific period.

The most important unresolved challenge in TB control is treatment completion. Worldwide, patient's adherence to anti-TB therapy remains the principal cause of treatment failure<sup>7</sup>. Treatment will only be effective if the patient completes the regimen. Treatment adherence is crucial for cure, controlling the spread of infection and minimizing the development of drug resistance<sup>8</sup>. Re-treatment requires more expensive drugs producing a greater financial burden on the patient and public health delivery system. Moreover, defaulting patients remain infectious and constitute a danger to their families and the community<sup>9</sup>. Poor adherence contributes to the worsening of the TB situation by increasing the incidence of drug resistance<sup>10,11</sup>. The critical aspect of TB management is ensuring adherence to a full course of chemotherapy.

Adolescence and early adulthood are increasingly recognized as a key risk period for tuberculosis infection, disease and adverse outcomes. In contrast to young children aged 0-4 years, adolescents commonly develop infectious forms of tuberculosis and frequently have a much wider range of social contacts outside of the household<sup>12</sup>. Consequently, adolescents and young adults with tuberculosis contribute more to ongoing tuberculosis transmission. In high tuberculosis transmission settings, the incidence of tuberculosis increases rapidly during adolescence to peak in early adulthood.

Historical data suggest that the risk of infection with *Mycobacterium tuberculosis* is highest during adolescence and young adulthood<sup>12</sup>. Furthermore, much co-morbidity relevant to tuberculosis emerge or are exacerbated during the adolescence period, including infection with human immunodeficiency virus (HIV), diabetes mellitus, risky substance use (including tobacco use) and mental health conditions<sup>12,13</sup>. It was reported that the most serious problem hindering tuberculosis treatment and control is non-adherence of patients to therapy. Non-adherence is believed to delay sputum conversion from smear-positive to smear-negative; it also markedly increases the relapse rate (about 5-6 times) and encourages the emergence of resistant/mutant strains<sup>14</sup>. Multi-drug resistant tuberculosis (MDR-TB) is now thought to afflict between 1 to 2 million patients annually<sup>15</sup>. There were an estimated 4.1% of new cases and 19% of previously treated cases with MDR-TB in 2016<sup>15</sup>. Drug resistance surveillance data show that an estimated 240,000 people died from MDR-TB in 2016<sup>15</sup>. Successful treatment of MDR-TB requires the use of second line drugs, which are very expensive, not widely available and need to be taken for a longer period.

Tuberculosis is a disease of poverty that thrives where social and economic determinants of ill health prevail<sup>16,17</sup>. Nigeria is one of the most populous country in sub-Saharan Africa with a population of about 206 million in 2020<sup>18</sup>. Nigeria is also amongst the countries with the highest burden of TB in the world with a prevalence rate of 616 per 100,000 (compared to a global prevalence of 217 per 100,000) and an incidence rate of 311 per 100,000 annually ranking fourth in the world<sup>19,20</sup>. Poor adherence to anti-TB medications is common despite various interventions aimed at improving treatment completion. Lack of a comprehensive and holistic understanding of barriers and facilitators of treatment adherence is currently a major obstacle to eliminating tuberculosis. Many studies have linked poor adherence to the development of drug-resistant tuberculosis. The implications of multi-drug resistant tuberculosis for individuals and the community are extremely serious, contributing significantly to morbidity and mortality<sup>21</sup>. Despite the increasing magnitude of this problem in our environment, little research has been done to assess the level of adherence to anti-TB medication among adolescents particularly in the northern part of the country where there is a high prevalence of TB. This study is aimed at assessing adherence and predictors of adherence to anti-TB treatment among adolescents attending Directly Observed Therapy Short course (DOTS) clinic of Murtala Mohammed Specialist Hospital Kano (MMSH), Northern Nigeria. The study will provide data relevant for planning an effective intervention strategy to address individual and structural barriers contributing to non-adherence to anti-TB drugs among adolescents. Ultimately, it will help to improve cure and reduce the transmission of tuberculosis to prevent the development of drug-resistant TB.

## METHODOLOGY

### Study area/setting

The study was conducted at the DOTS clinic of Murtala Muhammed Specialist Hospital, Kano - Nigeria. Kano state is located in the Northwest geo-political zone of Nigeria. It shares borders with Kaduna and Katsina states to the west, Katsina and Jigawa states to the north, Jigawa state to the east and Bauchi and Kaduna states to the south. The major tribes are Hausa and Fulani. Other tribes such as Yoruba, Igbo, Nupe, Kanuri and Ebirra also reside in the state. The state has 44 local government areas and a 2020 projected population of 13,065,294 people based on the 2006 National Population Census<sup>22</sup>. It has the third highest number of TB cases notified to the National TB programme<sup>23</sup>.

Rural Area was defined as a sparsely populated area with less than 20,000 inhabitants, usually located outside a city or town and has boundaries specified by the state government authority; people here are mostly engaged in agricultural practices with much lesser social and economic infrastructure<sup>24</sup>. Urban Area was defined as having a population of up to 20,000 people. It has high concentration of schools, businesses and social amenities. All states and LGA headquarters are administratively regarded as urban<sup>24</sup>.

Murtala Muhammad Specialist Hospital (MMSH), Kano is a State Government owned Specialist Hospital. It has the capacity to accommodate about 800 in-patients and more than 4500 outpatients daily. The hospital receives referrals from various hospitals within the state and neighboring states and countries such as Niger and Cameroon. The Directly Observed Therapy Short course (DOTS) clinic is run by Pulmonologists, Public Health Physicians, Family Physicians, Nurses and Community Health Extension Workers who attend to an average of 28 old and 5 new TB patients every working day. Patients who attend the clinic are usually those referred from the general outpatient clinic, other clinical departments of the hospital and also from the neighbouring local government areas. The Federal Ministry of Health through the Kano State Ministry of Health supplies the anti-tuberculosis drugs given to all patients free of charge.

### Study design and population

The study was cross-sectional in design and the study population was made up of adolescent patients aged 10-19 years attending the DOTS clinic of MMSH. Patients who were reactive to HIV were excluded because they had earlier received adherence counseling during recruitment to receive highly active anti-retroviral therapy (HAART). We also excluded MDR-TB patients who are managed in a different hospital in the state (State Infectious Disease Hospital).

### Sample size determination

The target sample size for the survey was determined using Fisher's formula. Using a smear-positive tuberculosis prevalence of 50.3% from a previous study<sup>25</sup>, 95% confidence level, a desired level of precision of 0.05 and an increase of 10% to account for non-response, a sample size of 407 was obtained.

### Sampling technique

Systematic sampling technique was used to recruit 407 participants for the study. About 28 patients attend the DOTS clinic every working day (approximately 140 patients weekly) for their anti-tuberculosis medication. Working with a sample size of 407 and sampling frame of 1260, the sampling interval was determined by dividing the sample frame by the sample size (1260/407) which was 3. The first subject was chosen via simple random sampling technique by balloting. Subsequent participants were recruited by selecting every third patient who met the inclusion criteria.

### Measurement of adherence

Assessment of tuberculosis treatment (Anti-TB medication) adherence was done using the Morisky Medication Adherence Scale (MMAS).<sup>26</sup> This is a validated 8-item scale that measures patients' adherence. Each question has a score of 0 for 'No' and 1 for 'Yes'. Question 5 was reverse scored i.e. 'No' response was scored 1 and 'Yes' response was scored 0. Cumulative scores were used to arrive at the level of adherence; they ranged from 0 - 8. A total score of 0 indicated high adherence, 1-2 indicated medium adherence and 3-8 indicated low adherence<sup>26</sup>.

### Data management and analysis

Data collected were entered into Microsoft Excel spreadsheet and cleaned prior to analysis. Analysis was done using statistical package for the social sciences (SPSS) version 22 statistical software (IBM Corp., Armonk, NY). Absolute numbers and simple percentages were used to describe categorical variables such as educational level, marital status, religion, occupation, residence and ethnicity. Similarly, quantitative variables such as age and income were described using measures of central tendency (mean, median) and measures of dispersion (range, standard deviation) as appropriate.

Chi-square test or Fisher's exact test was used to test association between categorical variables. Variables that showed significant association using bivariate analysis were fitted into the multinomial logistic regression model by stepwise (forward selection) method to test for the association of each variable with the level of adherence at 95% confidence interval (CI). A p-value of < 0.05 was considered statistically significant.

### Ethical consideration

Ethical approval was obtained from the Health Research Ethics Committee of Ministry of Health, Kano. A written informed consent was obtained from all participants and for minors (aged 10 - 17 years) consent of parents / guardians was obtained. Consent was sought for after the respondents had been provided with all the necessary information about the study in simple terms. For respondents who could not read, the consent form was explained in detail to them, and they provided consent by signature or thumb printing in front of a witness. An assent was also obtained for participants less than 18 years of age.

## RESULTS

The age of the respondents ranged from 10 to 19 years with a mean age and standard deviation (SD) of  $14.76 \pm 2.75$  years. Almost half of the respondents (46.98%,  $n=179$ ) were between 14-17 years, and exactly half (50.39%,  $n=192$ ) were males. The majority (73.23%,  $n=279$ ) of the respondents were Muslims and 58.01% ( $n=221$ ) were of the Hausa tribe. Approximately two-thirds (64.57%,  $n=246$ ) of the respondents lived in an urban area, and 41.99% ( $n=160$ ) were under parental care. Almost all the respondents (80.31%,  $n=306$ ) were single and 63.68% ( $n=242$ ) were enrolled in secondary school. Slightly over a third of the respondents (39.37%,  $n=150$ ) had a monthly family income of between 21,000-50,000 Naira. The socio-demographic characteristics of the participants are shown in Table 1.

**Table 1. Socio-demographic characteristics of the respondents**

Variable	Frequency (n=381)	Percentages (%)
<b>Age (years)</b>		
10-13	124	32.55
14-17	179	46.98
18-19	78	20.47
<b>Mean <math>\pm</math> SD</b>	14.76 $\pm$ 2.75	
<b>Sex</b>		
Male	192	50.39
Female	189	49.61
<b>Residence</b>		
Rural	135	35.43
Urban	246	64.57
<b>Marital Status</b>		
Single	306	80.31
Married	69	18.11
Divorced	6	1.57
<b>Religion</b>		
Islam	279	73.23
Christianity	102	26.77
<b>Ethnicity</b>		
Hausa	221	58.1
Fulani	80	21.0
Yoruba	28	7.35
Igbo	9	2.36
Others	43	11.29
<b>Educational status</b>		
None	21	5.53
Primary	86	22.63
Secondary	242	63.68
Tertiary	22	5.79
Qur'anic only	9	2.93
<b>Occupation</b>		
Under care	160	41.99
Teacher assistant	21	5.51
Trader	40	10.50
Artisan	4	1.05
Student/Unemployed	156	40.94
<b>Family Income (Naira)</b>		
$\leq$ ₦20,000	140	36.75
₦21,000- $<$ 50,000	150	39.37
₦51,000-100,000	69	18.11
$>$ ₦ 100,000	22	5.77

The majority of the respondents (70.08%, n=267) had low adherence to anti-TB drugs (Table 2).

**Table 2. Adherence to anti-TB medication among respondents**

Variable	Frequency (n = 381)	Percentage (%)
<b>Adherence</b>		
High	26	6.82
Medium	88	23.10
Low	267	70.08

All the respondents, 381(100%), obtained their anti-TB medication from the DOTS clinic, and over half (56.17%, n=214) were observed by a family member while taking anti-TB drugs. Less than 1 in 10 respondents (6.56%, n=25) were on other medications and 81.98% (n=312) travelled for more than 10km to obtain anti-TB drugs. Almost three-quarters of the respondents (71.92%, n=274) had a very good relationship with their physicians and 49.08% (n=187) had a very good relationship with other healthcare workers (Table 3).

**Table 3. Relationship between medication-related factors and level of adherence**

Variables	High (%) n=26	Medium (%) n=88	Low (%) n=267	P-value
<b>Who observes taking anti-TB</b>				
No observer	15 (57.69)	34 (38.64)	118 (44.19)	0.222
Family member	11 (42.31)	54 (61.36)	149 (55.81)	
<b>On other medication apart from anti-TB</b>				
Yes	4 (15.38)	8 (9.09)	13 (4.87)	0.065
No	22 (84.62)	80 (90.91)	254 (95.13)	
<b>Relationship with physician</b>				
Fair	0 (0)	0 (0)	1 (0.37)	
Good	3 (11.54)	4 (4.55)	31 (11.61)	0.216
Very good	19 (73.08)	61 (69.32)	194 (72.66)	
Excellent	4 (15.38)	23 (26.13)	41 (15.36)	
<b>Relationship with other health workers</b>				
Fair	0 (0)	0 (0)	3 (1.12)	<0.001
Good	6 (23.08)	16 (18.18)	118 (44.19)	
Very good	12 (46.15)	54 (61.36)	121 (45.32)	
Excellent	8 (30.77)	18 (20.54)	25 (9.36)	
<b>Distance from home to medication</b>				
≤10km	3 (11.54)	7 (7.95)	59 (22.10)	0.008
>10km	23 (30.77)	81 (92.05)	208 (77.90)	

At the bivariate level of analysis, anti-TB drugs adherence was found to be significantly associated (p<0.05) with the kind of relationship adolescents had with other healthcare workers as well as the distance from their home to the anti-TB drugs collection centre (Table 3).

Similarly, gender, residence and family income were significantly associated with adherence to anti-TB drugs among the respondents (Table 4).

**Table 4. Relationship between Socio-demographic variables and level of adherence**

Variables	Adherence			P-value	
	High (%) n=26	Medium (%) n=88	Low (%) n=267		
<b>Age (years)</b>					
10-13	14(53.85)	29 (32.95)	81(30.34)	0.193	
14-17	8(30.77)	42(47.73)	129(48.31)		
18-19	4(15.38)	17(19.32)	57(21.35)		
<b>Gender</b>					
Male	5 (19.23)	52 (59.09)	135 (50.56)	0.002	
Female	21 (80.77)				
<b>Residence</b>					
Rural	2 (7.69)	16 (18.18)	117 (43.02)	<0.001	
Urban	24 (92.31)	72 (81.82)	150 (56.18)		
<b>Marital status</b>					
Single	22 (84.62)	77 (87.50)	207 (77.53)	0.110	
Married	3 (11.54)	9 (10.23)	57 (21.35)		
Divorced	1 (3.85)	2 (2.27)	3 (1.12)		
<b>Religion</b>					
Islam	21 (80.77)	63 (71.59)	195 (73.03)	0.644	
Christianity	5 (19.23)	25 (28.41)	72 (26.97)		
<b>Ethnicity</b>					
Hausa	17 (65.38)	55 (62.50)	149 (55.81)	0.272	
Fulani	5 (19.23)	10 (11.36)	65 (24.34)		
Yoruba	1 (3.85)	6 (6.82)	21 (7.87)		
Igbo	1 (3.85)	3 (3.41)	5 (1.87)		
Others	2 (7.69)	14 (15.91)	27 (10.11)		
<b>Educational status</b>					
None	1 (3.85)	6 (6.82)	14 (5.26)	0.129	
Primary	11 (42.31)	19 (21.59)	56 (21.05)		
Secondary	11 (42.31)	60 (68.18)	171 (64.29)		
Tertiary	3 (11.54)	2 (2.27)	17 (6.39)		
Qur'anic only	0 (0)	1 (1.14)	8 (3.01)		
<b>Occupation</b>					
Under care	17 (65.38)	42 (47.73)	101 (37.83)	0.120	
Teacher assistant	0 (0)	2 (2.27)	19 (7.12)		
Trader	2 (7.69)	6 (6.82)	32 (11.99)		
Artisan	2 (7.69)	8 (9.09)	37 (13.86)		
Students/Unemployed	5 (19.23)	33 (34.1)	74 (27.71)		
<b>Family Income</b>					
≤₦ 20,000	9 (34.62)	21 (23.86)	110 (41.20)		0.007
₦21,000-<50,000	9 (34.62)	35 (39.77)	106 (39.70)		
₦51,000-100,000	5 (19.23)	22 (25.00)	42 (15.73)		
>₦100,000	3 (11.54)	10 (11.36)	9 (3.37)		
<b>Cigarette smoking</b>					
Yes	0 (0)	0 (0)	20 (7.49)	0.011	
No	26 (100)	88 (100)	247 (92.51)		

After adjusting for all covariates in the final model, (age, residence, marital status, gender, family income, having an observer while taking the anti-TB drugs, relationship with other workers and distance to medication collection centre); age, residence, gender, family income, having an observer while taking the anti-TB drugs and relationship with other workers were found to be significant predictors of adherence.

Compared to adolescents who were between 10-13 years, those who were 14-17 years (aOR:2.49 95% CI:1.23-7.40) and 18-19 years (aOR:3.02 95% CI:1.77-11.81) had higher odds of having low adherence. Place of residence was associated with level of adherence as respondents from urban areas were 63% less likely to have low adherence (aOR:0.27, 95% CI:0.13-0.80) and 47% less likely to have moderate adherence (aOR:0.53, 95% CI:0.10-0.78). Also, lower odds of having both moderate (aOR:0.17, 95% CI:0.25-0.96) and low adherence (aOR:0.31, 95% CI: 0.18-0.89) were seen among female adolescents.

Similarly, adolescents whose monthly family income was > ₦100,000 and those whose families earned between ₦51,000-100,000 monthly were all significantly less likely to have low adherence [(aOR:0.60, 95% CI:0.11-0.74) and (aOR :0.76, 95% CI:0.19-3.05) respectively]. In addition, individuals who had observers during ingestion of the anti-TB medication had decreased odds of low adherence relative to those who had no observer (aOR:0.74, 95% CI:0.43-0.91).

Having good and excellent relationships with other healthcare workers in the TB treatment centers were seen to reduce the likelihood of having low adherence (aOR:0.98, 95% CI:0.27-1.56) (Table 5).

**Table 5. Multinomial logistic regression showing predictors of low and medium adherence to anti-Tb drugs**

Variable	Medium Adherence	Low Adherence	P-Value	Medium Adherence	Low Adherence	P-Value
	<i>Crude OR (95% Confidence Interval)</i>	<i>Crude OR (95% Confidence Interval)</i>		<i>*Adjusted OR (95% Confidence Interval)</i>	<i>*Adjusted OR (95% Confidence Interval)</i>	
<b>Age group (years)</b>						
10-13	Reference	Reference	0.044	Reference	Reference	0.02
14-17	2.53 (1.04-6.81)	2.78 (1.11-6.93)		2.51(0.79-7.92)	2.49 (1.23-7.40)	
18-19	2.05 (0.58-7.25)	2.46 (1.77-7.87)		2.19 (0.51-9.38)	3.02(1.77-11.81)	
<b>Residence</b>						
Rural	Reference	Reference	<0.001	Reference	Reference	0.001
Urban	0.37 (0.08-0.75)	0.23(0.05-0.63)		0.53 (0.10-0.78)	0.27 (0.13-0.80)	
<b>Marital status</b>						
Single	Reference	Reference	0.10	Reference	Reference	
Married	0.85 (0.21-3.44)	2.01(0.58-6.98)		0.78(0.06-9.53)	1.36 (0.14-12.98)	0.25
Divorced	0.57 (0.04-6.60)	0.31(0.31-3.19)				
<b>Religion</b>						
Christianity	Reference	Reference	0.620			
Islam	1.66 (0.56-4.90)	1.55(0.56-4.26)				
<b>Gender</b>						
Male	Reference	Reference	<0.001	Reference	Reference	0.01
Female	0.16 (0.26-0.87)	0.23(0.15-0.63)		0.17(0.25-0.96)	0.31(0.18-0.89)	
<b>Family Income</b>						
≤N 20,000	Reference	Reference	0.042	Reference	Reference	
N 21,000-<50,000	1.66 (0.57-4.86)	0.96(0.36-2.52)		1.48(0.44-5.00)	0.72(0.23-2.22)	0.03
N 51,000-100,000	1.88 (0.54-6.55)	0.68(0.21-2.16)		1.74(0.40-7.54)	0.76(0.19-3.05)	
>N 100,000	1.42 (0.31-6.45)	0.24(0.05-0.67)		2.17(0.41-11.3)	0.60(0.11-0.74)	
<b>Occupation</b>						
Under care	Reference	Reference	0.482	Reference	Reference	
Teacher assistant	--	1.29 (0.41-3.53)		--	1.09 (0.44-5.13)	
Trader	1.21 (0.22-6.62)	2.69 (0.59-12.2)		0.77 (0.06-9.15)	1.65 (0.15-17.05)	
Artisan	1.61(0.31-8.42)	3.11 (0.68-14.1)		1.80 (0.10-31.5)	0.90 (0.06-12.34)	
Students/ Unemployed	2.10 (0.69-6.39)	2.02 (0.70-5.75)		1.11 (0.31-3.94)	1.00 (0.29-3.34)	
<b>Educational status</b>						
None	Reference	Reference	0.165			
Primary	0.28 (0.30-2.71)	0.36(0.43-3.05)				
Secondary	0.90 (0.99-8.30)	1.11(0.13-9.23)				
Tertiary	0.11 (0.01-1.77)	0.40 (0.37-4.33)				
Qur'anic only	--	2.31 (0.20-6.51)				
<b>Ethnicity</b>						
Hausa	Reference	Reference				
Fulani	0.61 (0.18-2.05)	1.48(0.52-4.19)	0.561			
Yoruba	1.85 (0.20-16.50)	2.39(0.30-18.9)				
Igbo	2.16 (0.90-9.50)	1.54(0.33-7.05)				
*Others	0.92 (0.90-9.50)	0.57(0.62-5.17)				
<b>The person who observes taking anti-TB</b>						
No one	Reference		0.029	Reference	Reference	0.01
Family member	0.16 (0.09-5.26)	0.72(0.26-0.88)		0.45 (0.27-6.66)	0.74 (0.43-0.91)	
<b>Relationship with physician</b>						
Fair	--					
Good	Reference	Reference	0.652	Reference	Reference	0.77
Very good	0.78 (0.10-4.34)	0.34 (0.23-6.21)		0.93 (0.10-5.64)	0.44 (0.22-6.48)	
Excellent	0.67 (0.06- 13.11)	0.97 (0.11-8.93)		0.69 (0.10- 14.31)	0.19 (0.13-9.00)	
Relationship with other workers						
Fair	--	--		--	--	
Good	Reference	Reference	0.03	Reference	Reference	0.02
Very good	2.40(0.49-11.72)	0.98(0.27-1.13)		1.90(0.89-11.72)	0.98(0.27-1.56)	
Excellent	4.31(0.68-27.02)	0.59(0.20-0.75)		3.61(0.68-27.02)	0.69(0.22-0.74)	
On other medication apart from anti-TB						
Yes	Reference	Reference	0.50			
No	1.81 (0.50-6.60)	3.55(1.06-11.8)				
Distance from home to medication						
≤10km	Reference	Reference	0.461	Reference	Reference	0.562
>10km	1.50 (0.36-6.30)	1.49 (0.13- 1.58)		1.65 (0.28-9.54)	1.37 (0.79-1.80)	

**Adjusted for age, residence, marital status, gender, family income, per who observes taking medication, relationship with other workers and distance to medication collection centre.**

## DISCUSSION

This study aimed to determine the level of adherence and factors affecting tuberculosis treatment adherence among adolescents attending the DOTS clinic of Murtala Muhammad Specialist Hospital, Kano. The study found that over two-thirds of the respondents (70.08%) had a low level of adherence to tuberculosis treatment; 2 in 10 had medium adherence, and only a few (6.82%) had high adherence level. The finding from this study was higher than the study conducted in India, where 50 % of the respondents were reported to have lower level of adherence<sup>27</sup>. It also contradicts the study from Uganda among TB /HIV co-infected individuals where 75 % had a good level of adherence to anti-TB drugs<sup>28</sup>. Probably, in part due to exclusion of co-infected patients in this study. Conversely, studies in Nigeria and in Tanzania, reported higher rates of adherence to anti-TB drugs (93% and 95.7% respectively)<sup>6, 29</sup>. The high level of adherence was attributed to the provision of home-based care for all the patients, thereby improving adherence to anti-tuberculosis medication.

The result of this survey found that all of the respondents obtained their anti-TB drugs from the DOTS clinic of the hospital, over half (56.17 %) were observed by family members while taking anti-TB drugs and the majority (81.98%) had to travel for more than 10km to obtain their anti-TB drugs. The finding is similar to results from Indonesia which reported better adherence amongst patients observed by family members while taking anti-TB medication<sup>30</sup> and also similar with findings from Uganda, which reported poor adherence amongst participants who were not observed while taking their drugs<sup>31</sup>. Observation while taking anti-TB drugs is an essential component of the DOTS strategy.

After adjusting for all covariates in the final model: age, residence, gender, family income, having observers while taking the anti-TB drugs and relationship with other health workers were found to remain independent predictors of adherence to anti-TB drugs. Respondents who were between 14-17 years and 18-19 years had higher odds of low adherence when compared to those between 10-13 years.

The finding from this study is similar to a study in Ethiopia, which documented that age was an important determinant of medication adherence<sup>28</sup>. More so, being younger than 24 years of age was associated with non-adherence to anti-TB drugs<sup>28</sup>. A similar finding from South Africa reported patients aged 25 years and above to be more adherent compared to the other age groups<sup>32</sup>. The reason could be that the young age groups were less experienced and may not understand the need for adequate adherence. Another study conducted in South Africa, found that children, young adolescents and older adults had significantly lower odds of loss to follow-up compared to adult patients<sup>12</sup>. On the contrary, some other study documented that age had no significant relationship with drugs adherence<sup>33</sup>.

Place of residence was associated with level of adherence as respondents from urban areas were 63% less likely to have low adherence and 47% less likely to have moderate adherence. Similarly, a study conducted in a Kenyan tertiary hospital reported place of residence to affect anti-TB medication adherence, with those in the urban areas having better adherence than those in the rural area<sup>34</sup>. On the contrary, previous studies conducted in Ethiopia and Nigeria showed no relationship between adherence and place of residence<sup>9,35</sup>. Probably, because the DOTS strategy adopted by the two countries specified that the patient be assigned to a treatment location based on place of residence and proximity to the health care facility. Intensive Directly Observed Therapy (DOT) centers were introduced with many branches as close to the patient's residence as possible in order to improve adherence. DOTS strategy also provides a room for "transfer in or out" of patients to health centers closer to their area of residence (as they relocate) to improve their adherence to anti TB medication. Also, lower odds of having both moderate and low adherence were seen among female adolescents. This finding is similar to a study conducted in Thailand, which reported higher (95%) treatment adherence among female adolescents compared to males 86.1%<sup>6</sup>.

Contrary to this finding study in Sudan and Kenya found no significant association between family income and anti-TB medication adherence<sup>7,34</sup>. From the finding of this study, individuals who had observers during ingestion of the anti-TB medication had decreased odds of low adherence relative to those who had no observer. This finding is similar to findings from Indonesia and Uganda that reported better adherence amongst patients observed by family members while taking anti-TB medication<sup>30,31</sup>. Observation while taking anti-TB drugs is an essential component of the DOTS strategy.

Having good and excellent relationships with other healthcare workers in the TB treatment centers was seen to reduce the likelihood of having low adherence. Similarly, a study from Ethiopia reported that about half (45.83%) of the study participants had very good relationship with their physicians and this significantly improved their adherence<sup>33</sup>. Another study conducted in Peru, also noted that having a good relationship with the healthcare providers positively affected adherence to medication<sup>39</sup>. Better communication between health professionals, particularly dispensers and patients is essential for improving treatment adherence. Conversely, negative attitudes from the health care providers often discourage treatment adherence<sup>6</sup>.

Some of the respondents (28.16%) reported having too many pills as the most common reason for missing doses. Similarly, a study from Addis-Ababa reported pills burden as a major barrier to medication adherence<sup>40</sup>. Another study from India found a strong relationship between multiple drugs and non-adherence<sup>41</sup>. World Health Organization and International Union Against Tuberculosis and Lung Disease (IUATLD), together with their partners, recommend the use of fixed-dose combination (FDC) formulations of the essential anti-tuberculosis drugs. This has reduced the problem of pills burden and subsequently improved medication adherence. However, fixed-dose combinations have some limitations as dose adjustments in some situations like the presence of liver and kidney diseases may not be feasible. The study also found that 5.79% (22) of the respondents had medication side effect as a factor for non-adherence to anti-TB drugs. This is similar to findings from a study in Ethiopia that reported drug side effects as a significant predictor of adherence<sup>28</sup>.

The major limitation of the study was our inability to look into health system-related factors/constraints that may affect patient's adherence. In addition, only adolescent patients attending a single specialist hospital were studied. However, the study explored the level of adherence to tuberculosis treatment, which is a major cause of deaths related to antimicrobial resistance.

**Conclusion:** Adherence specific counseling activities among patients, families and healthcare workers will be needed to further improve the level of anti-tuberculosis medication adherence, so as to help prevent treatment failure and development of multi-drug resistance tuberculosis.

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