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ASSESSING THE EFFECT OF COVID-19 ON TUBERCULOSIS TREATMENT OUTCOME IN ADAMAWA AND TARABA STATES, NORTH EASTERN NIGERIA

***Danjuma Jibasen, I. J. Dike, Barma Modu and B. Z. Reuben**

Department of Statistics and Operations Research, Modibbo Adama University, Yola.

*Corresponding authors' email: djibasen@mau.edu.ng

ABSTRACT

Tuberculosis is a common, and in many cases lethal, infectious disease caused by various strains of mycobacteria. Successes in treatment of tuberculosis lead to reduction in transmission, complications, and mortality among patients. The outbreak of COVID-19 drew the attention of governments and healthcare practitioners. This study considers the effect of COVID-19 on Tuberculosis treatment. Data were sourced from Taraba and Adamawa States in North-east Nigeria. A total of 8820 patients', records were used, with 3001 from Adamawa State and 5819 from Taraba State which involved TB patients' records. At the bivariate level, the Pearson Chi-square test was employed to measure the association between the treatment outcome and the independent variables (local government area, treatment facility ownership, treatment regimen, patients' supported, disease site, gender, HIV status and year of treatment). Thereafter multinomial Poisson regression analysis was performed on all statistically significant variables identified at the bivariate analysis. Decisions were taken based on p-value and odds ratios. The results of this study shows that the overall treatment success and cure rate across the States was on the average, 92.7% and 49.8% respectively. The highest treatment success rate of 94.5% was achieved in year 2021, while the year 2020 witnessed the highest cure rate of 53.5%. The overall cure rate of 49.8% is below the WHO recommendation. This study recommends that the non-pharmaceutical protocols to curtail the spread of COVID-19 should be strengthened in order to curtail TB spread, and that all TB patients should be tested for HIV.

Keywords: Tuberculosis, COVID-19, HIV, treatment outcome, North eastern Nigeria

INTRODUCTION

Tuberculosis (TB) is present in all countries and age group, it is a global public health problem especially in low and middle-income countries (Amiri et al., 2021; WHO, 2021a). Recent World Health Organization (WHO,2021b) report has it that: a total of 1.5 million people died from TB in 2020 (including 214 000 people with HIV), 10 million people are estimated to be infected with tuberculosis (TB) worldwide. Furthermore, 5.6 million men, 3.3 million women, and 1.1 million children. One of the United Nations Sustainable Development Goals (SDGs) health targets, is ending the TB epidemic by 2030 (WHO, 2017). The control of tuberculosis is dependent on early identification of cases and timely notification to public health facilities to ensure appropriate treatment of cases and control. Surveillance is an important public health function in the prevention and control of tuberculosis. Accurate and complete timely information improves the quality of surveillance data and supports public health decision-making.

In Nigeria, the national TB control activities are coordinated by the National Tuberculosis and Leprosy Control Programme (NTBLCP), NTBLCP is structured along the three tiers of Nigerian government thus: The Federal, State, and Local government areas (LGAs). Each level provides technical and management support to the one directly below it. The NTBLCP is saddled with the responsibility of policy development, tertiary patient care, mobilization and development to human and material resources. The States' TB programmes are responsible for coordinating TB control activities within the States, and provision of secondary patients' care. The operational level of the national TB control programme is the LGAs and it is based on the principles of Primary health-care (PHC) (NTBLCP. (n. d.))

Governments, the world over is facing a torturous path, navigating between the imminent disaster of COVID-19 and the long-running plague of TB. Also, COVID-19 pandemic has disruptive tendencies on routine health services and progress towards Sustainable Development Goals (SDGs). An analysis of survey responses conducted by Global Partnership for Zero Leprosy (GPZL, 2020) indicates that COVID-19 was having a direct impact on the majority of countries. Seventy-six percent of respondents (26 countries) said the outbreak was impacting their program. Their responses varied from clinics and offices being completely closed, to open clinics with limited case finding and community-based activities. This research is aimed at evaluating the effect of COVID-19 on tuberculosis treatment outcomes in Adamawa and Taraba States, Northeast Nigeria.

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, continues to be the leading source of mortality and morbidity across the world (Ahmed &Hussain, 2011). TB is a preventable and curable disease, and its control is a highly cost-effective health intervention. However, diagnostic delay and inadequate treatment contribute to the severity and mortality of the disease as well as the risk of transmission and development of drug resistance (Alagna et al., 2020). The World Health Organization (WHO, 2021a) estimates that there are nearly 2 million deaths worldwide from tuberculosis annually, with the disease ranking second only to human immunodeficiency virus (HIV) as an infectious cause of death. Nearly one third of the world's population is infected with *Mycobacterium tuberculosis*, and the rate continues to increase.

Oshi et al. (2017) conducted a retrospective evaluation of an active case-finding intervention utilizing community-based approaches and targeted systematic TB screening in Ebonyi State, Nigeria. John et al. (2015) carried out an active case finding for TB among nomadic populations over a 2-year period in Adamawa State and they found that Nomads in Nigeria have high TB rates, and active case-finding approaches may be useful in identifying and successfully treating them. Large-scale interventions in vulnerable

populations can improve TB case detection. In their work, Ukwaja et al. (2013) discovered that patient and household costs for TB care were potentially catastrophic even where services are provided free-of-charge and suggested a change in strategy.

In their work, Tadolini et al. (2020) raised two important issues, namely the possible association between tuberculosis (TB) and coronavirus disease 2019 (COVID-19); whether infection by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can re-activate TB, and the effects of TB on early mortality in co-infected patients. Boffan et al. (2020) noted that regardless of HIV status, people with undiagnosed pulmonary TB (PTB), those with drug-resistant TB or complex presentations such as disseminated forms, and those who have only just begun PTB treatment may be at increased risk for severe responses if they become infected with COVID-19. With same symptoms, aside HIV/AIDS, the emergence of COVID-19 added another probable coinfection with TB, (Visca et al., 2021).

Izudi et al. (2020) constructed a retrospective cohort of persons with BC-PTB from a routine tuberculosis clinic database in eastern Uganda and performed bivariate and multivariate analysis at the 5% level of significance. The results revealed that, out of the 1123 records retrieved, 81.1% of the 987 persons with BC-PTB that had treatment outcome, were successfully treated. Successful treatment of tuberculosis was less likely to occur among those with HIV infection. They concluded that, treatment success rate among adult persons with BC-PTB in rural eastern Uganda is suboptimal and mortality rate is high. HIV infection and older age reduce chances of treatment success, and increase mortality rate. Older and HIV infected persons with BC-PTB will require special consideration to optimize treatment success rate and reduce mortality rate.

Jain et al. (2020) assessed the challenges due to COVID- 19 pandemic on management of Tuberculosis and current strategies adopted to mitigate them. The study revealed the disruption in Tuberculosis service provisions both in the primary care and hospital settings. That the COVID-19 protocols; lockdown, social distancing, and isolation strategies impacted the delivery of all aspects of Tuberculosis care. Also, Udwadia et al. (2020) and Cilloni et al. (2020) posited that the consequences of the COVID-19 pandemic, and the global response to it with lockdowns, are likely to leave a profound and long-lasting impact on TB diagnosis and control. Others too, held the same position, that as resources are diverted and the public has been asked to shelter-in-place, the surveillance for and diagnosis of other communicable diseases of public health importance could become more challenging. For tuberculosis (TB), with an untreated case fatality rate of approximately 10%, there could be potential consequences of delayed or missed diagnoses which can lead to increase in TB related hospitalizations and death (Louie et al., 2020; Liu et al., 2021; Togun et al., 2020)

Nath et al. (2021) examined the effect of COVID-19 pandemic on tuberculosis notification in India. To understand the potential effect of the COVID-19 response on TB epidemiology, they indicated that modelling studies published by Stop TB Partnership showed that for every month of Lockdown, 232,665 excess Cases and 71,290 Deaths were added in India. They submitted that the first decline in TB notification was in 2020 during the lockdown across the country due to COVID-19.

Due to certain similarities in the behavior of TB and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) generally called COVID-19, There have been inevitable consequences. On one hand, administrative measures to contain SARS-CoV-2 have simultaneously led to a breaking in the chain of tuberculosis (TB) management (Nath et al., 2021; Soko et al., 2021; Madhukar et al., 2022; CDC March, 2022).

Kant and Tyagi (2021) opined that, in order to contain severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2), lockdowns were imposed by countries worldwide, people were forced to stay indoors, resulting in a number of effects. Furthermore, that the symptom similarity between TB and COVID-19 probably resulted in a delay in suspecting TB, as most people could have attributed similar symptoms to COVID-19 and preferred to wait it out. Also, pre-existing stigma around TB and the added stigma of COVID-19 might have discouraged people from getting tested, even after experiencing symptoms common to both diseases. They stated that, already diagnosed patients might have also suffered during COVID-19 lockdown; outpatient departments have not been functional, while laboratories have mostly been dedicated to the processing of samples of COVID-19 patients; the follow-up and response evaluation of pulmonary TB patients is chiefly done by sputum microscopy and culture growth, this assessment was lost during lockdown. Those who had treatment failure, relapse, or who had developed drug resistance could not be timely identified and may have continued to deteriorate. Furthermore, extensive counseling and motivation is needed for patients to deal with this disease, its side effects, the stigma associated with it, and the long duration of treatment. The entire process came to a standstill with the implementation of lockdown.

Aggarwal et al. (2022) reported that India contributes about a quarter of world tuberculosis burden. However, COVID-19 outshined it leading to several gaps which have caused significant setback in the National Tuberculosis Elimination Program (NTEP). The consequences include reduced and delayed notification of newly detected cases. They applied Winters additive time series model on data obtained for 2018 and 2019 to forecast for 2020 and 2021. They concluded that the decline in recognition of new cases can lead to long-term upsurge in tuberculosis incidence and mortality.

Definition of basic terms

The following terms were defined and used based on WHO (2003) criteria;

Treatment success rate: Is the percentage of cured TB cases and treatment completed. Mortality rate: Is the percentage of persons with TB who died from any cause during tuberculosis treatment.

Cured: Bacteriological positive patient who was sputum negative in the last month of the treatment and on at least one previous occasion.

Treatment completed: Patients who have completed treatment but who do not meet criteria to be classified as cured or failed treatment.

Successful Treatment: Cured plus Treatment completed cases.

Unsuccessful Treatment: Patients whose treatment failed and those who were lost to follow up.

MATERIALS AND METHODS

We retrieved and reviewed records for patients PTB and EPTB, persons with a biological specimen that is positive for Mycobacterium tuberculosis (MTB) on smear microscopy, culture, or molecular test like GeneXpert. We selected 3 LGAs each from Adamawa and Taraba States, North-east Nigeria, between 2017 and 2021. The records are routinely collected by the DOTs centres under the supervision of the LGA TB programme supervisors. The records capture

include; DOTS centre, health facility ownership type (private or public health facilities) and LGA where the patients received treatment, gender, age category, site of disease (pulmonary or extrapulmonary), type of drug regimen, HIV status, and availability of a treatment supporter with clinical outcomes as the dependent variable.

Methods of Data Analysis

The data collected was analysed at the univariate, bivariate and multivariate levels. In the univariate analysis, frequencies and percentages were employed to elucidate information on the categorical variables. At the bivariate level, the Pearson Chi-square test was employed to measure the association between the dependent variables and the independent variables using *P*-value < 0.05 as the criterion for significance. At the multivariate level, multinomial Poisson regression analysis was performed on all statistically significant variables identified at the bivariate level and reported the results as odds ratios. Variables and their levels were deemed significant if the *P*-value associated with the odds ratio is < 0.05.

In constructing the multinomial Poisson regression model, dependent variable is the treatment outcome, this was categorised as; cured, treatment completed, died, lost to follow up, not evaluated, transferred. These were again classified as, successful and unsuccessful for the multinomial Poisson regression. The explanatory variables are; local government area, treatment facility ownership, treatment regimen, patients' supported, disease site, gender, age group, HIV status and year of treatment.

Let π_j denote the probability of an observation falling in the multinomial probability of an observation falling in the j[th] category, to find the relationship between this probability and the p explanatory variables, $X_1, X_2, \ldots, X_p$. The multinomial Poisson regression model used is:

$$log\left(\frac{\pi_j(x_i)}{\pi_k(x_i)}\right) = \alpha_{0i} + \beta_{1j}x_{1i} + \beta_{2j}x_{2i} + \cdots + \beta_{pj}x_{pi}$$

Where, β refers to the effect of the independent variables x_i on the log odds of the occurrence of the dependent variable (treatment outcome).

All statistical analyses were performed using IBM SPSS 23. All patients' record with no treatment outcome evaluation namely; those who were transferred out to other health facilities and those whom treatment outcome was not reported as at the time of data extraction, were excluded.

RESULTS AND DISCUSSION

A total of 8820patients record were used, with 3,001 from Adamawa State and 5,819 from Taraba State. Tables 1 and 2 show the results of the bivariate analysis of treatment outcomes versus other patients' variables. Tables 3 and 4 show the cure rate versus treatment success by year and local government.

Table 1: Chi-square analysis of treatment outcome variables Adamawa State patients

		Treatment outcome				
Variables	**Level**	**Successful**	**Unsuccessful**	**Died**	**Total**	**P-value**
	All cases	2811	70	120	3001	
		93.7%	2.3%	4.0%	100.0%	
LGA	Mubi South	1080	0	14	1094	
		98.7%	0.0%	1.3%	100.0%	0.000
	Yola North	1376	68	92	1536	
		89.6%	4.4%	6.0%	100.0%	
	Numan	355	2	14	371	
		95.7%	.5%	3.8%	100.0%	
Treatment facility ownership	Public	2483	46	102	2631	
		94.4%	1.7%	3.9%	100.0%	0.000
	Private	328	24	18	370	
		88.6%	6.5%	4.9%	100.0%	
Treatment regimen	6 months	2758	69	109	2936	
		93.9%	2.4%	3.7%	100.0%	0.000
	12 months	53	1	11	65	
		81.5%	1.5%	16.9%	100.0%	
Patient supported	Yes	1214	57	84	1355	
		89.6%	4.2%	6.2%	100.0%	0.000
	No	1597	13	36	1646	
		97.0%	.8%	2.2%	100.0%	
Disease site	Pulmonary	2704	66	107	2877	0.001
		94.0%	2.3%	3.7%	100.0%	
	Extra Pulmonary	107	4	13	124	
		86.3%	3.2%	10.5%	100.0%	
HIV status	Positive	313	10	35	358	
		87.4%	2.8%	9.8%	100.0%	0.000
	Negative	2161	43	66	2270	
		95.2%	1.9%	2.9%	100.0%	
	Not Tested	337	17	19	373	
		90.3%	4.6%	5.1%	100.0%	
Gender	Male	1942	59	78	2079	
		93.4%	2.8%	3.8%	100.0%	0.0014

	Female	869	11	42	922	
		94.3%	1.2%	4.6%	100.0%	
Age group	0-4	29	0	0	29	
		100.0%	0.0%	0.0%	100.0%	0.002
	5-14	98	0	3	101	
		97.0%	0.0%	3.0%	100.0%	
	15-24	485	11	12	508	
		95.5%	2.2%	2.4%	100.0%	
	25-34	1334	42	48	1424	
		93.7%	2.9%	3.4%	100.0%	
	35-54	400	7	18	425	
		94.1%	1.6%	4.2%	100.0%	
	55-64	230	6	20	256	
		89.8%	2.3%	7.8%	100.0%	
	>64	235	4	19	258	
		91.1%	1.6%	7.4%	100.0%	
Year	2017	582	2	48	632	
		92.1%	.3%	7.6%	100.0%	0.000
	2018	453	21	21	495	
		91.5%	4.2%	4.2%	100.0%	
	2019	549	17	20	586	
		93.7%	2.9%	3.4%	100.0%	
	2020	601	21	23	645	
		93.2%	3.3%	3.6%	100.0%	
	2021	626	9	8	643	
		97.4%	1.4%	1.2%	100.0%	

Table 1 shows that treatment success across the three LGAs in Adamawa State was at least 90%, the overall State treatment success is 93.70%. Treatment success in public health facilities are higher compared to private health facilities. 12 months treatment regimen has lower treatment success of 81.50%, while 6 months regimen is 93.90%. EPTB patients have treatment success of 86.30%, also patients with HIV coinfection have lower treatment success (87.4%) compared to patients without HIV complication (95.20%). Across the Age group and Gender, there was treatment success of over 90% with 100% success for ages 0-4. All the variables are significant with P-values < 0.05, which implies that these variables are associated with treatment outcome.

Table 2: Chi-square analysis of treatment outcome variables for Taraba State patients

		Treatment outcome				
Variables	**Level**	**Successful**	**Unsuccessful**	**Died**	**Total**	**p-value**
	All casas	5365	218	236	5819	
		92.2%	3.7%	4.1%	100.0%	
LGA	Jalingo	3634	105	160	3899	
		93.2%	2.7%	4.1%	100.0%	0.000
	Gassol	1379	80	34	1493	
		92.4%	5.4%	2.3%	100.0%	
	Wukari	352	33	42	427	
		82.4%	7.7%	9.8%	100.0%	
Treatment facility ownership	Public	4941	160	210	5311	
		93.0%	3.0%	4.0%	100.0%	0.000
	Private	424	58	26	508	
		83.5%	11.4%	5.1%	100.0%	
Treatment regimen	6 months	5343	217	234	5794	
		92.2%	3.7%	4.0%	100.0%	0.672*
	12 months	22	1	2	25	
		88.0%	4.0%	8.0%	100.0%	
Patient supported	Yes	5283	215	229	5727	
		92.2%	3.8%	4.0%	100.0%	0.216*
	No	82	3	7	92	
		89.1%	3.3%	7.6%	100.0%	
Disease site	Pulmonary	5319	217	234	5770	
		92.2%	3.8%	4.1%	100.0%	0.819*
		46	1	2	49	

	Extra Pulmonary	93.9%	2.0%	4.1%	100.0%	
HIV status	Positive	677	35	63	775	
		87.4%	4.5%	8.1%	100.0%	0.000
	Negative	4035	160	160	4355	
		92.7%	3.7%	3.7%	100.0%	
	Not tested	653	23	13	689	
		94.8%	3.3%	1.9%	100.0%	
Gender	Male	3250	125	147	3522	
		92.3%	3.5%	4.2%	100.0%	0.538*
	Female	2115	93	89	2297	
		92.1%	4.0%	3.9%	100.0%	
Age group	0-4	68	2	6	76	
		89.5%	2.6%	7.9%	100.0%	0.073*
	5-14	277	7	15	299	
		92.6%	2.3%	5.0%	100.0%	
	15-24	787	27	19	833	
		94.5%	3.2%	2.3%	100.0%	
	25-34	2536	104	103	2743	
		92.5%	3.8%	3.8%	100.0%	
	35-54	762	37	45	844	
		90.3%	4.4%	5.3%	100.0%	
	55-64	445	21	22	488	
		91.2%	4.3%	4.5%	100.0%	
	>64	490	20	26	536	
		91.4%	3.7%	4.9%	100.0%	
Year	2017	763	15	67	845	
		90.3%	1.8%	7.9%	100.0%	0.000
	2018	923	24	23	970	
		95.2%	2.5%	2.4%	100.0%	
	2019	1044	85	41	1170	
		89.2%	7.3%	3.5%	100.0%	
	2020	1081	41	57	1179	
		91.7%	3.5%	4.8%	100.0%	
	2021	1554	53	48	1655	
		93.9%	3.2%	2.9%	100.0%	

*no significant association

In Taraba State (Table 2), the overall treatment success in the State was 92.20% with Wukari LGA having the lowest at 82.4%, the 12 months treatment regimen has treatment success less than 90% so also patients treated at private facilities. Both PTB and EPTB patients had treatment success greater than 90%, and patients with HIV coinfection had 87.40% treatment success. There was no significant difference in treatment success rate with respect to treatment regimen, site of the disease, patient supporter, age group and gender. Tables 1 and 2 show that treatment success and mortality rates for TB patients with HIV complications were 87.4% and 9.8% respectively in Adamawa State, while in Taraba State, there were 87.4% and 8.1% treatment success and mortality rate respectively. There was also a decrease in treatment success rate in 2019 and an increase in mortality rate in 2020.

Table 3: Overall Chi-square analysis of the variables with respect to treatment success rate

Variables	***p*-value**
States	0.002
LGA	0.000
Treatment facility ownership	0.000
Treatment regimen	0.000
Patient supported	0.000
Disease site	0.007
HIV status	0.000
Age group	0.001
Gender	0.984*
Year	0.000

*Not significant

Table 3 shows that there was significant difference in the treatment outcome across the two States and for all variables except for Gender. That is, the variable, Gender is not significantly associated with treatment success when the data was combined.

Table 4: Chi-square analysis of treatment outcome by year of notification

		Year					
Treatment outcome		**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
	Cured	749	871	915	1020	1364	4919
		47.0%	53.1%	47.9%	53.5%	48.2%	49.8%
	Treatment completed	596	505	677	662	817	3257
		37.4%	30.8%	35.4%	34.7%	28.9%	33.0%
	Treatment failed	3	4	8	2	5	22
		.2%	.2%	.4%	.1%	.2%	.2%
	Died	115	44	61	80	56	356
		7.2%	2.7%	3.2%	4.2%	2.0%	3.6%
	Lost to follow up	14	41	94	60	57	266
		.9%	2.5%	4.9%	3.1%	2.0%	2.7%
	Not evaluated	116	174	153	80	518	1041
		7.3%	10.6%	8.0%	4.2%	18.3%	10.5%
	Transferred	1	0	2	3	10	16
		.1%	0.0%	.1%	.2%	.4%	.2%
Total		**1594**	**1639**	**1910**	**1907**	**2827**	**9877**
	Successful	1345	1376	1593	1682	2180	8176
		91.1%	93.9%	90.7%	92.2%	94.9%	92.7%
	Unsuccessful	132	89	163	142	118	644
		8.9%	6.1%	9.3%	7.8%	5.1%	7.3%
Total		**1477**	**1465**	**1756**	**1824**	**2298**	**8820**

In computing treatment success and mortality rate, patients with incomplete record ($n = 1057$) and those transfered out were excluded.

Treatment success rate ranges between 90% and 95% over the 5 years period, while the cure rate ranges between 47% and 54%, with mortality rate as high as 7.2% in 2017 and 4.2% in 2020 as shown in Table 4. On the LGA basis, treatment success rate ranges between 98.7% in Mubi South and 82.4% in Wukari, while cure rate ranges between 23.1% in Yola North to 84.7% in Gassol. Mortality rate ranges between 1.0% in Mubi South to 7.3% in Wukari (see Table 5).

Table 5: Chi-square analysis of treatment outcome by LGA

		LGA						
Treatment outcome		**Mubi South**	**Yola North**	**Numan**	**Jalingo**	**Gassol**	**Wukari**	**Total**
	Cured	539	368	129	2320	1299	264	4919
		40.0%	23.1%	15.6%	57.9%	84.7%	45.9%	49.8%
	Treatment completed	542	1008	226	1313	80	88	3257
		40.2%	63.4%	27.3%	32.8%	5.2%	15.3%	33.0%
	Treatment failed	0	12	0	8	1	1	22
		0.0%	.8%	0.0%	.2%	.1%	.2%	.2%
	Died	14	92	14	160	34	42	356
		1.0%	5.8%	1.7%	4.0%	2.2%	7.3%	3.6%
	Lost to follow up	0	56	2	97	79	32	266
		0.0%	3.5%	.2%	2.4%	5.1%	5.6%	2.7%
	Not evaluated	252	54	456	92	39	148	1041
		18.7%	3.4%	55.1%	2.3%	2.5%	25.7%	10.5%
	Transferred	0	0	0	14	2	0	16
		0.0%	0.0%	0.0%	.3%	.1%	0.0%	.2%
Total		**1347**	**1590**	**827**	**4004**	**1534**	**575**	**9877**
	Successful	1080	1376	355	3634	1379	352	8176
		98.7%	89.6%	95.7%	93.2%	92.4%	82.4%	92.7%
	Unsuccessful	14	160	16	265	114	75	644
		1.3%	10.4%	4.3%	6.8%	9.6%	17.6%	7.3%
Total		**1094**	**1536**	**371**	**3899**	**1493**	**427**	**8820**

In computing treatment success and mortality rate, patients with incomplete record ($n = 1057$) and those transferred out were excluded.

Multinomial Poisson regression analysis of the significant variables

In this section, variables that were judged significant at the bivariate levels were further analysed for significance based on their levels and their contributions to the levels of the dependent variable (treatment successful and unsuccessful while Died is the reference category), the results are reported as odds ratio (OR). The multinomial regression results are presented in Tables 6a-6c.

Table 6a: Model fitting information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	**-2 Log Likelihood**	**Chi-Square**	**df**	***P*-value**
Intercept	811.958	0.000	0	
LGA	860.481	48.523	4	.000
Age group	844.101	32.143	12	.001
Health facility ownership	817.950	5.992	2	.050
Treatment regimen	816.918	4.960	2	.084
Patient supported	822.285	10.327	2	.006
Disease site	813.165	1.207	2	.547
HIV status	840.353	28.395	4	.000
Gender	821.947	9.989	2	.007
Year	888.831	76.873	8	.000

Table 6a shows that there was no significant difference in treatment success rate with respect to health facility ownership, treatment regimen, and disease site (though these variables were significant at the bivariate level).

Table 6b: Pseudo R-square

Pseudo R-Square	**Value**
Cox and Snell	.096
Nagelkerke	.225
McFadden	.181

The sensitivity analysis presented in Table 6b showed that exclusion of the statistically non-significant variables; health facility ownership, treatment regimen, and disease site resulted in Pseudo R-square (measured by the Nagelkerke statistic) decreasing from 22.5% to 15.6%, which means that these variables contributed in a little way to the variation of the outcome, hence these variables were retained.

Table 6c: Parameters estimates and odds ratio of factors associated with treatment outcome in Adamawa State

Variables/Level	**Successful**		**Unsuccessful**	
	p-value	**OR**	**p-value**	**OR**
Intercept	.000		.012	
LGA				
Mubi South	.007	2.894	.994	7.92E-08
Yola North	.518	0.804	.119	3.698
Numan	Reference			
Health facility ownership				
Public	.964	0.987	.066	0.483
Private	Reference			
Treatment regimen				
6 months	0.097	2.861	0.06	11.978
12 months	Reference			
Patient supported				
Yes	0.009	0.511	0.957	0.977
No	Reference			
Disease site				
Pulmonary	0.994	1.004	0.366	0.472
Extra pulmonary	Reference			
HIV status				
Positive	.001	0.340	.159	0.477
Negative	.414	1.263	.858	1.076
Not tested	Reference			
Age group				
0-4	.998	264722719	.998	6.834
5-14	.040	3.882	.048	5.39E-08
15-24	.004	3.07	.022	4.102
25-34	.001	2.725	.520	4.068
35-54	.020	2.304	.819	1.6
55-64	.947	1.024	0.171	1.186
>64	Reference			
Gender				
Male	.732	1.074	0.007	2.89

Female	Reference			
Year of notification				
2017	.000	0.125	-2.735	.002
2018	.000	0.213	0.276	.643
2019	.001	0.247	0.223	.715
2020	.001	0.238	0.07	.904
2021	Reference			

Table 6c show that success rate is higher in Mubi South (OR=2.894) than Numan LGA, but likely lower in Yola North LGA compared to Numan LGA, that is, patients treated in facilities in Yola North are likely to die compared to those treated in Numan, but more likely to have unsuccessful treatment rate (OR=1.308). The result further revealed that patients treated in public health facilities are likely to die compared to those treated at private health facilities with treatment success rate (OR=0.987) and unsuccessful treatment rate (OR=0.483), also, patients under 6 months regimen are most likely to survive than those on the 12 months regimen, treatment successful rate (OR=2.861), unsuccessful treatment rate (OR=11.978). On disease site, the result shows that, the PTB patients (OR=1.004) are likely to survive compared to the EPTB patients, while on HIV complications, TB patients with HIV complications are more likely to die with treatment success rate (OR=0.340) and unsuccessful treatment rate (OR=0.477), whereas, those without HIV issues are more likely to survive with treatment success rate (OR=1.263), and unsuccessful treatment rate (OR=1.076). Furthermore, the result shows that the male patients are more likely to survive with high treatment success rate (OR=1.074) and high unsuccessful rate (OR=2.890), also the younger patients generally have more chances of survival than the other patients, the survivals of age 0-4 is superb, further, cases notified between 2017-2020 witnessed lower treatment success rate compared to those treated in 2021. Also, mortality was higher in 2020 compare to other years.

The results of the multinomial regression results for data retrieved from Taraba State is presented in Tables 7a and 7b.

Table 7a: Model fitting information

	Model Fitting Criteria			**Likelihood Ratio Tests**		
Model	**AIC**	**BIC**	**-2 Log Likelihood**	**Chi-Square**	**df**	***P*-value**
Intercept	532.398	665.776	492.398[a]	0.000	0	
LGA	587.253	693.955	555.253	62.854	4	.000
Health facility ownership	616.208	736.248	580.208	87.809	2	.000
HIV Status	547.795	654.498	515.795	23.397	4	.000
Year	607.715	687.741	583.715	91.316	8	.000

This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom. Table 7a revealed further that the most significant variables are health facility ownership, HIV status and Year of treatment.

Table 7b: Parameters estimates and odds ratio of factors associated with treatment outcome in Taraba State

Variables / Levels	**Successful**		**Unsuccessful**	
	p-value	**OR**	**p-value**	**OR**
Intercept	.000		0.006	
LGA				
Jalingo	.000	2.198	0.08	0.618
Gassol	.000	3.354	0.043	1.933
Wukari	Reference			
Health facility ownership				
Public	0.017	1.702	.000	0.282
Private	Reference			
HIV status				
Positive	.000	0.300	0.065	0.458
Negative	0.063	0.576	0.218	0.631
Not tested	Reference			
Year of notification				
2017	0.001	0.495	0.01	0.387
2018	0.306	1.309	0.239	1.541
2019	0.275	0.784	.000	3.093
2020	0.025	0.632	0.901	0.964
2021	Reference			

The result presented in Table 7b shows that patients treated in Jalingo and Gassol are more likely to survive with odds ratio (OR=2.198) and (OR=3.354), with unsuccessful treatment rates of (OR=0.618) and (OR=1.933) respectively, all levels of this variable LGA contributed significantly. Patients treated at public health facilities are more likely to survive

with treatment success rate (OR=1.702). On the other hand, patients with HIV complications are more likely to die with treatment success rate (OR=0.300), than those without HIV complications treatment success rate is (OR=0.576), the results show that the case of patients with unsuccessful treatment is worst, the survival rate is (OR=0.065) and (OR=0.218) respectively for HIV positive and HIV negative patients. On the year of disease notification, treatment success rate is poor across the years compared to the year 2021 except for the year 2018.

Findings

The results of this study show that the overall treatment success and cure rate across the six LGAs were on the average of 92.7% (82.4%-98.7%) and 49.8% (15.6%-84.7%) respectively. The highest treatment success rate of 94.5% was achieved in year 2021, while the year 2020 witnessed the highest cure rate of 53.5%. The overall cure rate of 49.8% is below the WHO recommendation, WHO recommends that a good performing tuberculosis program should achieve at least 90% treatment success rate and 85% cure rate (WHO, 2003). This study also revealed that HIV infected persons with TB had a treatment success rate of 87.40% and mortality rate 8.6%. Thus, HIV in TB leads to high mortality, as attested by the multivariate analysis. These findings are in line with established relationship between HIV and tuberculosis, that, HIV is a known strong risk factor for tuberculosis disease (Ungvarski&Flaskerud, 1999; Izudi, et al., 2020). Furthermore, the study revealed that the TB program in the two States performed far below the global milestones and targets for reductions in the number of people who develop TB each year and reductions in the case fatality ratio (CFR) (WHO, 2021b). Thus, we recommend strengthening the collaboration between tuberculosis and HIV control programs to improve the management of HIV infected persons with tuberculosis. A situation where some TB patients have no known HIV status is counterproductive. The results further revealed that the year 2021 witnessed a higher survival rate, this could imply strict patients adherence to pharmaceutical measures of TB and non-pharmaceutical protocols of COVID-19.

CONCLUSION

The results of this work revealed COVID-19 affect TB treatment, hence there is every need to tackle COVID-19 pandemic quickly to pave way for the rebuilding of tuberculosis services in addition to other essential health services. Since both TB and COVID-19 are infectious diseases that primarily attack the lungs, both spread through droplets, and promoted via overcrowding, the non-pharmaceutical protocols to curtail the spread of COVID-19 should be strengthened among TB patients, relatives and health providers to also curtail TB spread.

The results further revealed that TB cure rate is far below the WHO expectations, thus, this posits a lot of danger for all of us, hence, the worsening tuberculosis epidemic needs to be highlighted. Tuberculosis programs should make available real-time TB dashboard, such that, governments can respond with the needed immediacy. Investments in digital data systems, connected diagnostics, and digital treatment-support tools could make tuberculosis data more visible and accessible, particularly for TB burden regions. Finally, there is need to ensure that all TB patients are tested for HIV, since there is an established relationship between HIV and TB. Also, all stakeholders should take the caution given by LoBue of CDC (March, 2022) with all seriousness, that, "Delayed or missed tuberculosis disease diagnoses are threatening the health of people with TB disease and the communities where they live. A delayed or missed TB diagnosis leads to TB disease progression and can result in hospitalization or death – and the risk of transmitting TB to others"

Human subjects' issues and ethics approval

This study was reviewed and approved by the Modibbo Adama University, Yola, Research Ethics Committee. The need for patient consent was waived by the ethics committee because data collection involved retrieval of records from large numbers of TB patients, for whom it would have been logistically impractical to reach and seek individual consent. Data were handled confidentially since names of patients were excluded.

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