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Predictors of mortality among multidrug-resistant tuberculosis patients after decentralization of services in Tanzania from 2017 to 2019: retrospective cohort study

George Mrema^{1,2*} , Ally Hussein², Welema Magoge³, Vida Mmbaga³, Robert Balama⁴, Emmanuel Nkiligi⁴, Isack Lekule⁴, Riziki Kisonga⁴ and Gideon Kwesigabo¹

Abstract

Background Multidrug-resistant tuberculosis (MDR-TB) presents persistent global health challenges, characterized by low treatment success rates among patients enrolled for treatment. The World Health Organization recommends decentralization to improve outcomes. This study aims to assess predictors of mortality among MDR-TB patients after decentralization of services in Tanzania. This was a retrospective cohort study involving all MDR-TB patients enrolled in treatment in all 31 regions in Tanzania from 2017 to 2019. The overall mortality rate among MDR-TB patients was calculated using the incidence rate. Additionally, independent factors of MDR-TB mortality were determined using multivariable cox proportional hazards models.

Results The study followed 985 patients for a total of 12,929 months. During this time, it found that approximately 12 out of every 1000 patients died each month. Specifically, the death rates were about 18 out of 1000 patients at 6 months, 8 out of 1000 at 12 months, and 7 out of 1000 at 24 months. Patients who had both MDR-TB and HIV, as well as those who were malnourished, had a lower chance of surviving at 6, 12, and 24 months. Malnourished patients had almost three times the risk of dying [adjusted hazard ratio (aHR) 2.96, with a 95% confidence interval (CI) of 2.10–4.19], while those with HIV had nearly double the risk [aHR 1.91, with a 95% CI of 1.37–2.65].

Conclusion In summary, our study on MDR-TB patient outcomes in Tanzania between 2017 and 2019 reveals a pattern of high mortality rates within the first 6 months of treatment. Furthermore, malnutrition and HIV co-infection were found to be significant predictors of mortality. To decrease mortality, it is crucial to closely monitor patients during the initial 6 months of treatment, especially those who are malnourished or co-infected with HIV, and ensure they receive appropriate and timely care. Additionally, further investigation is needed to find out what may be contributing to possible rise in mortality rate.

Keywords Mortality, Multidrug-resistant tuberculosis, Tanzania

*Correspondence:

George Mrema
drgeorgemrema@gmail.com

Full list of author information is available at the end of the article



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Background

Multidrug-resistant tuberculosis (MDR-TB), is defined as a form of Tuberculosis (TB) that is resistant to at least isoniazid and rifampicin the two most effective TB drugs. This poses a pressing public health issue, as indicated by the increase in the global number of new TB and MDR-TB cases reported in 2022 compared to the preceding 2 years (WHO) World Health Organization 2023).

In 2022, the World Health Organization (WHO) reported a global total of 176,586 cases of MDR-TB that were detected among bacteriologically confirmed pulmonary TB cases who were tested for resistance. Additionally, only 63% of cohort of patients who began treatment in 2020 had successful outcomes, with a significant portion of unsuccessful outcome contributed by fatalities (WHO) World Health Organization 2023; 2024).

Tanzania remains among the list of 30 countries globally with a high burden of TB and TB/HIV (i.e., condition where a person is infected with both TB and HIV at the same time), yet it has a low burden of MDR-TB (WHO) World Health Organization 2023; 2021). In 2019, the prevalence of MDR-TB among new and retreatment patients in the country was reported to be 0.97% and 13% respectively (Ministry of Health Tanzania 2020). While these statistics suggest a lower prevalence of MDR-TB compared to other high-burden countries, there has been a continuous increase in number of patients from 167 in 2017 to 534 in 2019. Moreover, the most recent data from a group of patients who began treatment in 2019 indicates a decline in the rate of treatment success, dropping from 83% in 2017 to 73% in 2019. This decline has been linked to increase in patient mortality (Tanzania 2023; Nkiligi et al. 2023).

The World Health Organization (WHO) has taken steps to improve MDR-TB patient treatment outcome which includes updating management guidelines and recommending decentralization of services (WHO 2019, 2022, 2011). Experience from studies conducted in sub-Saharan Africa have generally favored decentralization as it shows that decentralizing MDR-TB services has improved access to care, with more patients being tested, diagnosed and enrolled in treatment. Furthermore, it has been observed to be more cost-effective, particularly in settings with limited resources, resulting in higher rates of treatment success and improved patient retention in care (Achayo 2022).

In line with WHO recommendations, Tanzania began the decentralization of MDR-TB services in 2016 while also introducing new treatment guidelines (Ministry of Health Tanzania 2020). This decentralization efforts involved increasing treatment facilities to provide care

to MDR-TB patients across the country, thus increasing accessibility. Moreover, capacitating the regions with molecular test to facilitate detection of drug resistance. Despite these commendable measures, treatment outcome of MDR-TB is still not satisfying hence the need for further investigation to comprehend the factors contributing to the observed trend.

This study therefore aimed at assessing predictors of mortality among MDR-TB patients after decentralization of services in Tanzania. Correct identification of predictors of mortality serves as a cornerstone for formulating strategies to further enhance MDR-TB patient care and prevent premature deaths attributed to drug-resistant tuberculosis.

Specific objectives

1. To determine mortality rates of MDR-TB patients after decentralization of services in Tanzania from 2017 to 2019
2. To identify predictors of mortality of MDR-TB patients after decentralization of services in Tanzania from 2017 to 2019

Methods

Study design

A retrospective cohort study was conducted involving MDR-TB patients who had been enrolled in second-line treatment from January 2017 to December 2019. The follow-up period was between June 2017 and December 2021.

Study area

This study included all 31 regions of Tanzania. As of 2021, 304 out of 8446 total health facilities in the country provide management of MDR-TB patients. Furthermore, there are 1752 TB diagnostic centers throughout the country that comprises microscopes, line probe assay (LPA) and GeneXpert (i.e., advanced diagnostic tool for rapid and accurate diagnosis of TB, including drug-resistant strains).

Study participants

Study participants included patients of any age with confirmed resistance to rifampicin and/or isoniazid on drug susceptibility testing who were initiated on the standard MDR-TB treatment regimen from January 2017 to December 2019.

Inclusion and exclusion criteria

Inclusion

The inclusion criteria were all MDR-TB patients who were enrolled on second line treatment available in the NTLP data from January 2017 to December 2019.

Exclusion

Exclusion criteria were inconsistent treatment dates/missing dates to treatment initiation, extensively drug-resistant TB (XDR-TB) and duplicates.

Variable

Dependent variable

The dependent variable in this study was MDR-TB mortality. This was a binary outcome where we had a group of those patients who died and another group patient who were alive which included patients who were cured, completed treatment, lost to follow up and those failed treatment.

Independent variables

Independent variables included demographic characteristics and clinical factors. Demographic characteristics included sex and age. Clinical factors included previous history of TB, nutritional status, HIV status, resistance pattern, regime, and drug adverse event.

Power of the study

Power of the study was calculated using the formula for estimation of power for cohort studies as shown below (Sahai and Khurshid 1996)

$$\text{Power} = \Phi \left(\frac{\sqrt{(n_1 * \Delta^2)} - z_{1-\alpha/2} \sqrt{(1 + 1/\kappa) * p * q}}{\sqrt{(p_1 * q_1) + (p_2 * q_2/\kappa)}} \right)$$

The notations for the formulae are:

Δ = difference of risk of disease between exposed group and non-exposed group.

κ = ratio of sample size: non-exposed group/exposed group.

p_1 = risk of disease among the exposed group.

p_2 = risk of disease among the non-exposed group.

$p = (p_1 * n_1 + p_2 * n_2) / (n_1 + n_2)$.

$q = 1 - p$.

n_1 = available sample size among the exposed group.

We used the following assumptions;

- A total of estimated 985 MDR-TB cases were enrolled in treatment from 2017 to 2019

- We took comorbidity as a variable for comparisons
- MDR-TB patient without comorbidity was used as unexposed group where there were 583 cases reported
- MDR-TB patient with comorbidity was used as exposed group where there were 402 cases reported
- Calculating K, we obtained 0.7
- $n_1 = 402$, $n_2 = 583$
- So, in this study our outcome of interest was mortality, hence risk in exposed group is 22.9% and risk among unexposed group is 10.5%
- Power was calculated using open epi software version 3.01 which can be assessed at https://www.openepi.com/Menu/OE_Menu.htm.
- Power of the study was 100%

Operational definitions

Centralized setting: Defined as inpatient treatment and care provided solely by centres or teams specialized in drug-resistant TB for the duration of the intensive phase of therapy or until culture or smear conversion.

Cured: Treatment completed as recommended by the national policy without evidence of failure and three or more consecutive cultures taken at least 30 days apart are negative after the intensive phase.

Decentralized setting: Defined as care provided in the local community where the patient lives, by non-specialized or peripheral health centres, by community health workers or nurses, non-specialized doctors, community volunteers or treatment supporters.

Extensive drug resistance Tuberculosis: Resistance to any fluoroquinolone and to at least one of three second-line injectable drugs (capreomycin, kanamycin and amikacin) in addition to multidrug resistance.

Lost to follow up: Treatment interrupted for 2 consecutive months or more.

Malnutrition: Refers to deficiencies or excess in nutrient intake which consist of both undernutrition and overweight/obesity (i.e., Body Mass Index (BMI) below 18.5 or above 24.9).

Multidrug resistance Tuberculosis: Resistance to at least both isoniazid and rifampicin.

Normal nutrition status: Refers to a BMI within a healthy range between 18.5 and 24.9

Polyresistance: Resistance to more than one first-line anti-TB drug, other than both isoniazid and rifampicin.

Rifampicin Resistance: Resistance to rifampicin detected using phenotypic or genotypic methods, with or without resistance to other anti-TB drugs.

TB/HIV: Refers to the co-infection of tuberculosis and HIV.

Treatment completed: Treatment completed as recommended by the national policy without evidence of failure BUT no record that three or more consecutive cultures taken at least 30 days apart are negative after the intensive phase.

Treatment failed: Treatment terminated or need for permanent regimen change of at least two anti-TB drugs because of: lack of conversion by the end of the intensive phase or bacteriological reversion in the continuation phase after conversion to negative or evidence of additional acquired resistance to fluoroquinolones or second-line injectable drugs or adverse drug reactions (ADRs).

Treatment outcome: Refers to the final result of a patient's treatment for tuberculosis infection.

Treatment success: Cured + treatment completed.

Dataset description and data abstraction procedure

Data was obtained from NTLP database, information usually recorded on case-based system through available Electronic Tuberculosis and Leprosy System (ETL). This electronic system acts as surveillance tool for monitoring performance of different NTLP program indicators. The system also monitors progress on treatment of TB, MDR-TB and Leprosy patients from when registered throughout to treatment completion.

Data collection starts at the primary health facilities where patients go for treatment after presenting with symptoms. Normally, clinicians make a diagnosis by matching patient's symptoms and signs to form a preliminary diagnosis. Then, a sputum sample is requested for gene expert testing to confirm the presence of *Mycobacterium tuberculosis* and drug resistance. Patients with confirmed diagnoses are then connected to TB clinics for treatment initiation by trained Directly Observed Treatment (DOT) clinicians and nurses. In TB clinics, MDR-TB patients identified, their information is recorded in the normal TB register (TB 03), as well as the MDR-TB register, both of which are accessible at the facility. Subsequently, the notification is sent to the District TB and Leprosy Coordinator (DTLC). The DTLC or trained facility staffs registers the patient in the electronic TB register

(ETL) and transfers them to the MDR-TB register. As soon as the patient is registered in the system, this information is immediately reflected at all levels (i.e., national and sub-national level). To ensure that patient information is both accurate and complete, the ETL system mandates that all fields be filled out before proceeding to the next stage of registration. Additionally, regional quarterly data review meetings are convened to further compliance accuracy and completeness.

Data was extracted from the ETL system in form of an MS Excel.

Data management and analysis

Data extracted from ETL in form of MS Excel was then cleaned and analysed using Stata 15.0.

The demographic and clinical variables were presented using frequencies/proportions for all categorical data, while measures of central tendency and dispersion were used for continuous variables.

The overall mortality rate among MDR-TB patients was calculated using the incidence rate. Additionally, mortality rates at different follow-up times i.e., 6 months, 12 months, and 24 months were estimated (The 6-month period provides insights into the initial response to treatment, while the 12-month period allows for a more comprehensive evaluation of treatment outcomes. The 24-month follow-up is essential for assessing the long-term outcomes of MDR-TB treatment). The mortality rate was also analysed based on the demographic and clinical characteristics of the MDR-TB patients. To visualize regional-specific mortality rates, the Quantum Geographic Information System (QGIS) software version 3.26.3 was used to create a map.

To examine independent predictors of MDR-TB mortality, multivariable cox proportional hazards models was utilized after verification of proportional hazard assumptions. All eight explanatory variables met the proportional hazard assumption after running a Schoenfeld's test. Bivariate analysis was conducted for all eight variables, which were later included in the multivariable model to adjust for confounding. The likelihood ratio test was used to get the overall p value for each variable. The adjusted hazard ratio and its 95% confidence interval were presented. Factors that exhibited statistical significance (P value ≤ 0.05) was used to predict death in MDR-TB patients.

Results

Study participants included patients of any age with confirmed resistance to rifampicin and/or isoniazid on drug susceptibility testing who were initiated on the standard

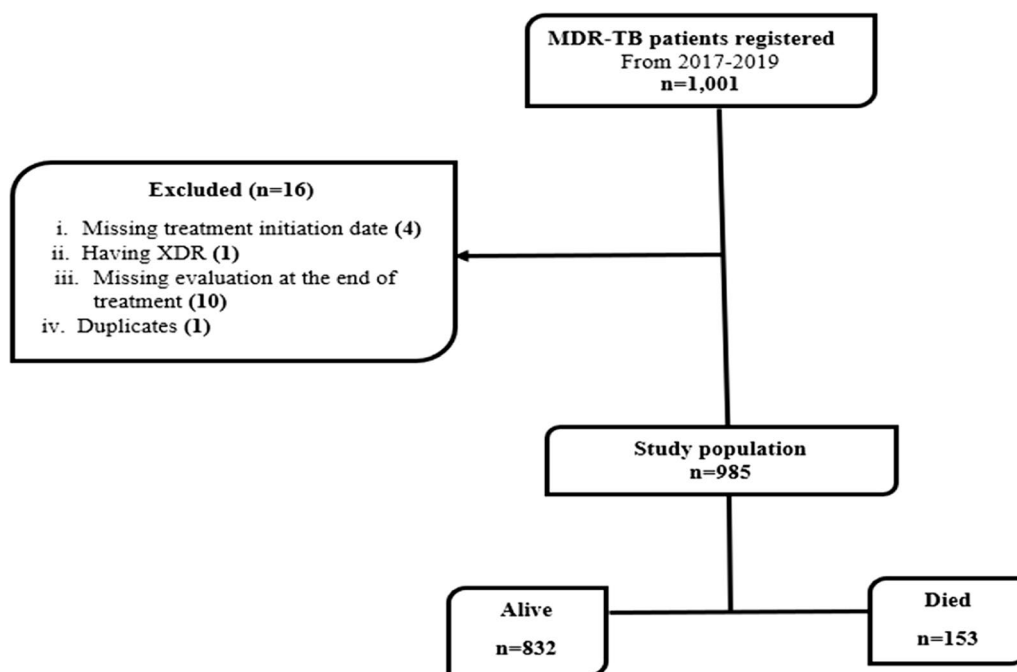


Fig. 1 Chart outlining how research participants were enrolled into the study among MDR TB cases in Tanzania from the year 2017 to 2019

Table 1 Baseline demographic and clinical characteristics of patients with MDR-TB enrolled in treatment in Tanzania from January 2017 to December 2019 (n = 985)

Variables	Frequency (n)	Percentage (%)
Sex		
Female	338	34.3
Male	647	65.7
Age group (years)		
≤ 14	21	2.1
15–49	726	73.7
≥ 50	238	24.2
Mean ± SD (years)	40 ± 15.3	
History of treatment		
New	594	60.3
Previously treated	391	39.7
Nutrition status		
Malnourished	410	41.6
Normal	575	58.4
Resistance pattern		
Polyresistance	206	20.9
RR only	778	79.1
Drug adverse effects		
Yes	27	2.7
No	958	97.3
HIV status		
Positive	342	34.7
Negative	643	65.3

MDR-TB treatment regimen from January 2017 to December 2019.

From January 2017 to December 2019, 1,001 records were found in the NTLP database. Among these, 16 (1.6%) were omitted from the study analysis because they missed the treatment initiation date, were XDR-TB patients, were duplicated or were not evaluated at the end of treatment. The final analysis included 985 (98.4%) patients (Fig. 1). Patients who have been included in the study and those who have been excluded from it share similar demographic and clinical characteristics.

Baseline demographic and clinical characteristics

A total of 985 cases were included in the analysis, with male patients accounting for the majority at 647 (65.7%). The majority of patients, 726 (73.7%), were between the ages of 15–49 years with a mean age of 40 (SD = 15.3) years. Furthermore, 594 (60.3%) of the cases were new patients, and 778 (79.1%) had rifampicin resistance (RR) as their only form of resistance (Table 1).

Mortality rate of MDR TB patients

The study followed 985 patients for 12,929 person-months and found a crude mortality rate of 11.83 per 1000 person-months (95% Confidence Interval (CI), 10.10–13.87). At the 6-month follow-up point, we observed a relatively high mortality rate of 17.74 (95% CI 14.54–21.64) in comparison to the mortality rates at other follow-up times (Table 2).

Table 2 Mortality rate of MDR-TB patients stratified by demographic and clinical characteristics among cases enrolled in treatment from January 2017 to December 2019

Variables	Person months	Deaths	Mortality rate per 1000 person-months (95% confidence interval)
Crude mortality rate	12,929	153	11.83 (10.10–13.87)
Follow up time			
6 months	5469	97	17.74 (14.54–21.64)
12 months	4177	33	7.90 (5.62–11.11)
24 months	3283	23	7.00 (4.66–10.54)
Sex			
Female	4542	49	10.79 (8.15–14.28)
Male	8387	104	12.40 (10.23–15.03)
Age group (years)			
≤ 14	285	3	10.52 (3.39–32.62)
15–49	9625	105	10.91 (9.01–13.21)
≥ 50	3019	45	14.91 (11.13–19.97)
History of treatment			
New	7512	86	11.45 (9.27–14.14)
Previously treated	5417	67	12.37 (9.73–15.71)
Nutrition status			
Malnourished	5119	104	20.32 (16.76–24.62)
Normal	7810	49	6.27 (4.74–8.30)
Resistance pattern			
Polyresistance	2727	34	12.47 (8.91–17.45)
RR only	12,202	119	11.67 (9.75–13.96)
Drug adverse effects			
Yes	392	1	2.55 (0.35–18.11)
No	12,537	152	12.12 (10.34–14.21)
HIV status			
Yes	4225	78	18.46 (14.79–23.05)
No	8704	75	8.62 (6.87–10.81)

The regional specific mortality rate from 2017 to 2019 showed that the Dodoma region was the leading region with a high mortality rate of 28 deaths per 1000 person-months (95% CI 13.68–60.20). Conversely, the lowest mortality rate was observed in the Mbeya region, with only 6 deaths per 1000 person-months (95% CI 1.54–24.65). However, during the period analysed, Pemba Island and three regions i.e. Songwe, Rukwa, and Katavi did not report any deaths of MDR-TB patients (Fig. 2).

Survival probability of MDR TB patients

HIV-positive patients had lower survival probabilities at 6, 12, and 24 months compared to HIV-negative patients. Malnourished MDR-TB patients also had lower survival probabilities compared to those with normal nutrition status at the same time intervals (Figs. 3 and 4).

Predictors of mortality among MDR-TB patients

During the follow-up period, MDR-TB patients who are malnourished had 2.96 hazard of dying from MDR-TB compared to patients with normal nutrition status [aHR 2.96 (95% CI 2.10–4.19)]. Additionally, MDR-TB HIV co-infected patients had 1.91 hazards of dying from MDR-TB compared to MDR-TB patients who are HIV negative [aHR 1.91 (95% CI 1.37–2.65)] (Table 3).

Discussion

The study revealed that, mortality rate was higher during the first 6 months of treatment, then progressively decreased until treatment was completed. Additionally, the study also identified that malnutrition and HIV coinfection were significant predictors of mortality.

In the current study it was observed that during intensive phase of treatment, mortality rate was

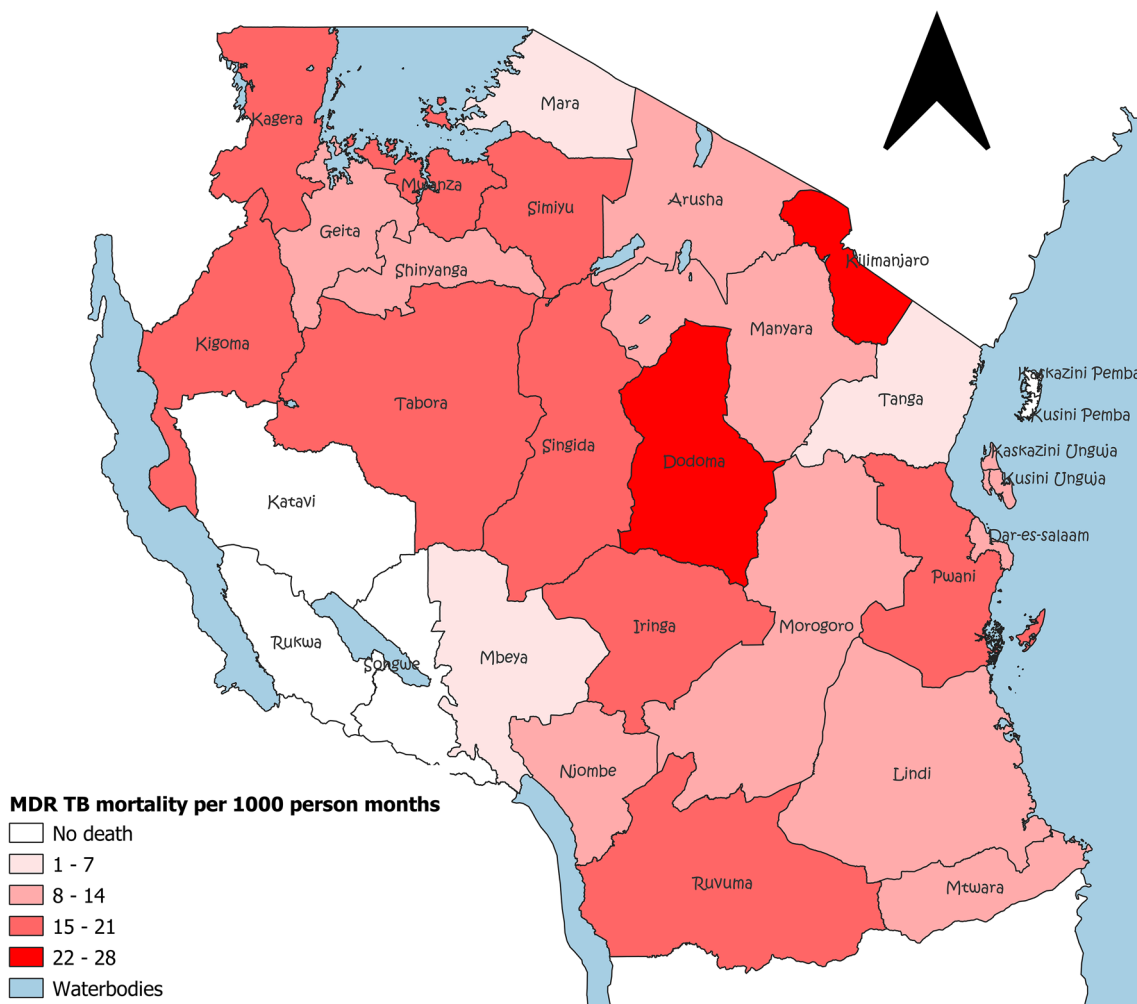


Fig. 2 Distribution of MDR-TB mortality rate by regions in Tanzania from the year 2017 to 2019

considerably greater compared to the evaluation done at 12 and 24 months. Our findings were comparable to other studies done in Africa which also reported high death rate in the first six month of treatment (Matambo et al. 2021; Muluneh et al. 2021; Kassa et al. 2020). In other settings, the death rate is determined by capacity of health care facilities, social economic status and presence of comorbidity by the time of treatment initiation (Kassa et al. 2020). Since most African countries have similar social and economic statuses, these factors may be the same in our situation. However, additional investigation is necessary to ascertain whether this pattern is influenced by patient-related factors or problems within the healthcare system.

Moreover, our study found that among enrolled MDR-TB patients for treatment, mortality rate increases with age with patients aged 50 years and older having the greatest mortality rate. This finding is consistent with previous study conducted in Tanzania that found that

the older the individual, the higher the mortality rate (Myemba et al. 2021). Contrary to our finding, a study conducted in China found that mortality rates were higher in younger age groups and decreased gradually with increasing age (Wang et al. 2020). The conflicting findings in China may be attributed to the study being carried out at a single location, suggesting that the results may only be applicable to that specific site and not generalizable. Moreover, our study revealed a higher rate of mortality in male individuals and those who had previous history of TB treatment, a trend that is consistent with similar studies conducted in Tanzania and China. Additionally, the study showed that HIV positive patients had a mortality rate twice as high as those without HIV, a finding that was also reflected in studies carried out in Tanzania and China, where higher mortality rates were observed in HIV positive patients and those with other underlying health conditions, respectively (Myemba et al. 2021; Wang et al. 2020).

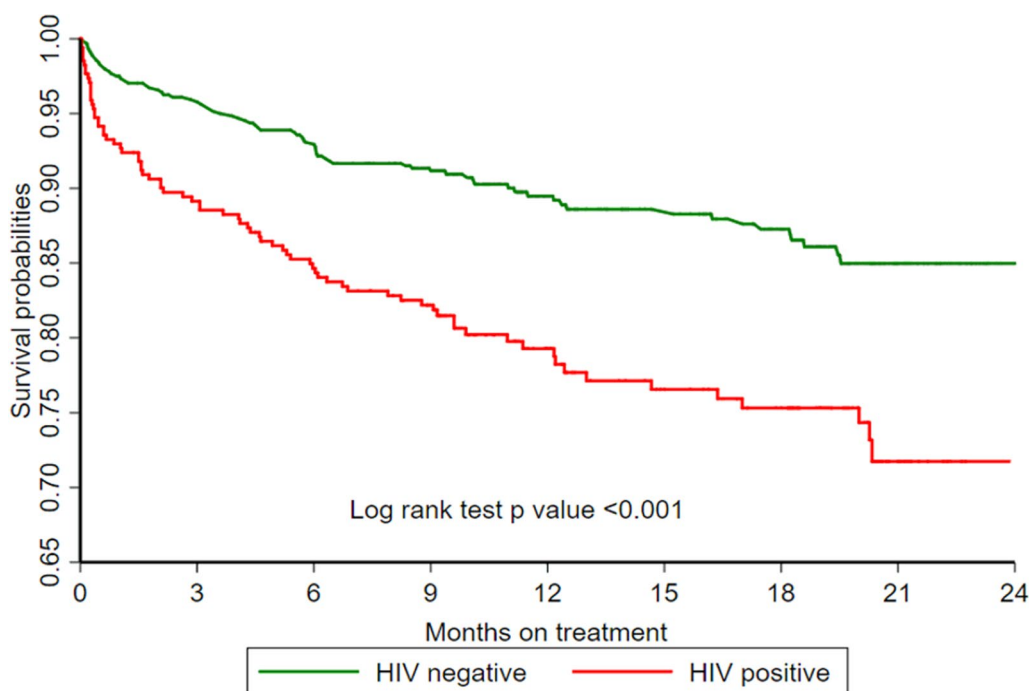


Fig. 3 Kaplan–Meier survival probability curve among MDR-TB patients enrolled to treatment in Tanzania stratified by HIV status from 2017 to 2019

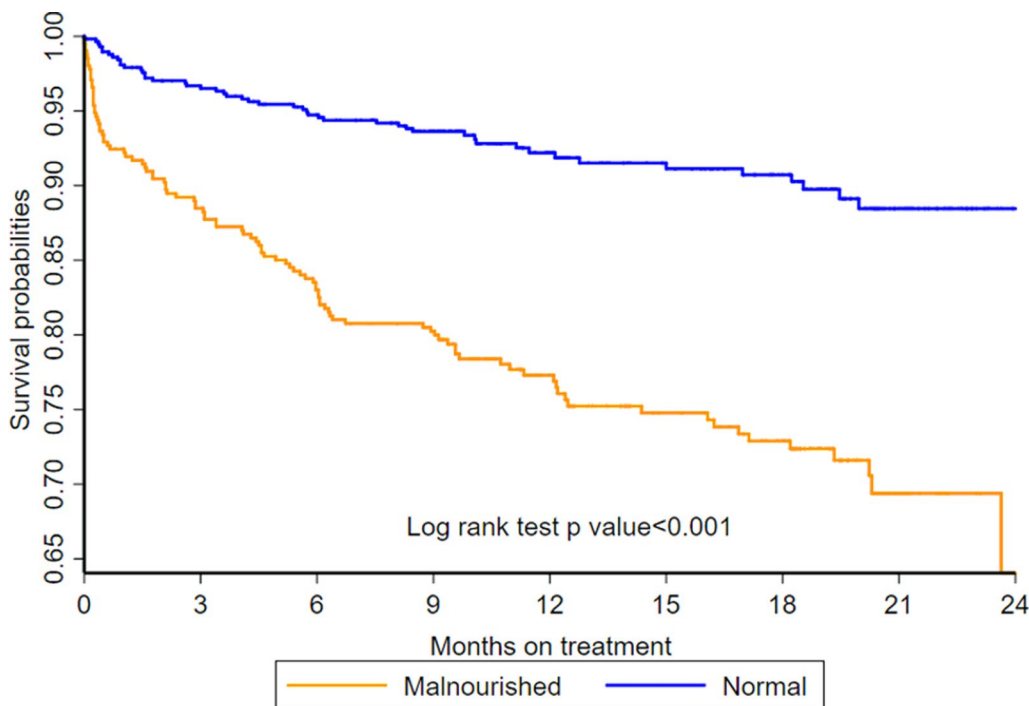


Fig. 4 Kaplan–Meier survival probability curve among MDR-TB patients enrolled to treatment in Tanzania stratified by nutrition status from 2017 to 2019

The results of this study revealed that patient baseline nutrition status of patients is a significant factor in predicting mortality among individuals with MDR-TB. It has

been demonstrated that malnourished MDR-TB patients at the time of diagnosis have higher relapse rates and shorter survival times during treatment (Wagnew et al.

Table 3 Multivariable cox regression on predictors of mortality among MDR-TB patients after decentralization of services in Tanzania from 2017 to 2019

Covariates	Total	Event (death) n (%)	Bivariate analysis		Multivariate analysis	
			Crude hazard ratio (95% CI)	P value	Adjusted hazard ratio (95% CI)	P value
Sex						
Female	338	49 (14.5)	Reference		Reference	
Male	647	104 (16.1)	1.13 (0.81–1.59)	0.48	1.22 (0.86–1.72)	0.26
Age group (years)						
≤ 14	21	3 (14.3)	Reference		Reference	
15–49	726	105 (14.5)	1.02 (0.32–3.22)	0.23	1.31 (0.41–4.18)	0.07
≥ 50	238	45 (18.9)	1.37 (0.43–4.42)		1.96 (0.60–6.41)	
History of Treatment						
New	594	86 (14.5)	Reference		Reference	
Previously treated	391	90 (17.1)	1.11 (0.81–1.54)	0.51	0.94 (0.67–1.31)	0.71
Nutrition status						
Malnourished	410	104 (25.4)	3.20 (2.28–4.49)	< 0.01	2.96 (2.10–4.19)	< 0.01
Normal	575	49 (8.5)	Reference		Reference	
Resistance pattern						
Polyresistance	206	34 (16.5)	1.07 (0.73–1.57)	0.72	1.13 (0.77–1.66)	0.54
RR resistance only	779	119 (15.3)	Reference		Reference	
Regime						
Longer	615	109 (17.7)	1.19 (0.83–1.70)	0.34	1.09 (0.76–1.58)	0.63
Shorter	370	44 (11.9)	Reference		Reference	
Drug adverse effects						
No	958	152 (15.9)	4.62 (0.65–33.02)	0.13	4.97 (0.70–35.61)	0.11
Yes	27	1 (3.7)	Reference		Reference	
HIV status						
No	643	75 (11.7)	Reference		Reference	
Yes	342	78 (22.8)	2.10 (1.53–2.88)	< 0.01	1.91 (1.37–2.65)	< 0.01

[§] Variables included in the model: Sex, age, history of treatment, nutrition status, resistance pattern, regime, drug adverse effects and HIV status

2023; Sayem et al. 2020; Ockenga et al. 2023). The study shows that, individuals with malnutrition had almost thrice-as-high risk of death when compared to those with normal nutrition status. This result was in line with previous studies that also demonstrated a high correlation between mortality and undernutrition among MDR-TB patients (Kassa et al. 2020; Wagnew et al. 2023; Alemu et al. 2021). Our study showed that, MDR-TB patients who are HIV coinfecting to have almost twice the risk of mortality as compared to those who are HIV negative. In previously conducted study, risk of death in MDR-TB HIV coinfecting patients ranged from 1.34 to 5.70 fold in MRD-TB HIV coinfecting (Matambo et al. 2021; Muluneh et al. 2021; Alemu et al. 2021; Ketema et al. 2020; Habimana et al. 2021). One possible reason for the increased risk of mortality in this group of patients could be the immunosuppression caused by both conditions.

This study utilized secondary data, which has its limitations. Several variables, such as Cluster of Differentiation

4 (CD4) counts, history of alcohol use, and cigarette smoking, which were among other predictors of mortality in MDR-TB patients were not present in the database hence potentially introducing confounding biases that were not addressed or quantified in this analysis. Despite this drawback, the study offers fresh perspectives that will help researchers better understand the risk factors that affect patient mortality.

Conclusions

In summary, our study on MDR-TB patient outcomes in Tanzania between 2017 and 2019 reveals a pattern of high mortality rates within the first 6 months of treatment. Furthermore, malnutrition and HIV co-infection were found to be significant predictors of mortality. To decrease mortality, it is crucial to closely monitor patients during the initial 6 months of treatment, especially those who are malnourished or co-infected with HIV, and ensure they receive appropriate and timely care.

Lastly, further investigation is needed to find out what may be contributing to possible rise in mortality rate.

Abbreviations

aHR	Adjusted hazard ratio
ART	Anti-retroviral therapy
CDC	Centers for disease control and prevention
CD4	Cluster of differentiation 4
CI	Confidence interval
DOT	Direct observed treatment
DR	Drug resistance
DTLC	District TB and leprosy coordinator
ETL	Electronic TB and leprosy system
HIV	Human immunodeficiency virus
MDR-TB	Multidrug-resistance tuberculosis
MUHAS	Muhimbili University of Health and Allied Science
NLTP	National tuberculosis and leprosy program
QGIS	Quantum geographic information system
RR	Rifampicin resistance
SD	Standard deviation
TB	Tuberculosis
TB/HIV	Tuberculosis and human immunodeficiency virus
TFELTP	Tanzania field epidemiology and laboratory training program
WHO	World Health Organization
XDR_TB	Extensive drug resistance tuberculosis

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Author contributions

All authors have read and approved the manuscript and take responsibility for the integrity of the data and the accuracy of the data analysis. GM, AH, WM, GK conceptualized and designed the study; GM collected data; GM, AH, WM, GK performed data cleaning and analysis; GM, AH, WM, VM, RB, EN, IL, RK, GK drafted, reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Data generated during and/or analysed during the current study are available from the corresponding authors upon reasonable request.

Declarations

Ethics approval and consent to participate

Muhimbili University of Health and Allied Science (MUHAS) approved the study protocol with approval number MUHAS-REC-12-2022-1468. Permission to use MDR-TB data was obtained from the Program Manager of the National TB and Leprosy Programme (NLTP) in the Ministry of Health. Unique number was used in place of names to maintain confidentiality.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no commercial or other associations that may pose a conflict of interest.

Author details

¹Department of Epidemiology and Biostatistics, Muhimbili University of Health and Allied Sciences, P.O. Box 65001, Dar es Salaam, Tanzania. ²Tanzania Field Epidemiology and Laboratory Training Program, Ministry of Health, P.O. Box 9083, Dar es Salaam, Tanzania. ³Epidemiology and Disease Control Section, Ministry of Health, P.O. Box 743, Dodoma, Tanzania. ⁴National Tuberculosis and Leprosy Program, Ministry of Health, P.O. Box 743, Dodoma, Tanzania.

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