Global Epidemiology 9 (2025) 100189

Contents lists available at ScienceDirect

Global Epidemiology

journal homepage: www.sciencedirect.com/journal/global-epidemiology

Trends, prevalence, and determinants of unfavorable tuberculosis treatment outcomes among adult patients in Northeast Ethiopia: The race to achieve a 90 % treatment success rate by 2025

Tegene Atamenta Kitaw [a,*], Amsalu Baylie [a], Addisu Getie [b], Ribka Nigatu Haile [a]

[a] Department of Nursing, College of Health Science, Woldia University, Woldia, Ethiopia
[b] Department of Nursing, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia

ARTICLE INFO

Keywords:
Tuberculosis
Treatment outcome,determinants
NorthEast Ethiopia

ABSTRACT

Background: Tuberculosis (TB) continues to be a significant public health issue, especially in developing nations like Ethiopia. The country aims to reach a 90 % treatment success rate for TB by 2025. However, there is a considerable lack of recent data on treatment outcomes in the region. Current data on treatment outcomes and their determinants are crucial for guiding early interventions and aligning efforts with national goals and the End TB Strategy. Understanding the current state of TB treatment outcomes and influencing factors is vital for implementing effective interventions and measuring progress toward the target.
Methods: A four-year retrospective study (2019–2022) was conducted. From 323 patient files, 312 were eligible to be included in the final analysis, resulting in a response rate of 96.6 %. Data collection utilized a structured checklist, and analysis was performed with STATA version 18. The Mann-Kendall trend test was used to detect trends in TB incidence. Multicollinearity was checked using variance inflation factors (VIFs). A logistic regression model identified determinants of treatment outcomes.
Results: The study revealed that 84.94 % of participants achieved favorable treatment outcomes, while 15.06 % had unfavorable outcomes. A decreasing trend in unfavorable outcomes was noted, from 18.84 % in 2019 to 10.71 % in 2022 (Kendall's tau (τ) = −0.0686). Determinants of unfavorable outcomes included older age (AOR: 3.59, 95 % CI: 1.23–10.56), HIV positivity (AOR: 5.43, 95 % CI: 1.65–10.83), and smear-negative pulmonary TB (AOR: 3.82, 95 % CI: 1.39–10.45).
Conclusion: The overall treatment success rate of 84.94 % is below the global target of >90 % for 2025. Tailored treatment strategies for older patients and those co-infected with HIV are recommended. Additionally, improving TB diagnostic capabilities is essential for early intervention and achieving better outcomes.

Introduction

Despite global efforts, tuberculosis (TB) remains a significant cause of mortality and morbidity worldwide. In 2021, an estimated 106 million people experienced active TB, and 106 million fatalities were caused by TB [1]. According to the World Health Organization (WHO) study, TB is one of the top 10 main causes of mortality globally. Along with better service delivery, improved disease prevention and treatment prevented an estimated 54 million TB deaths between 2000 and 2017 alone [2]. However, close to 10 million individuals continued to get sick with TB in the same year. In 2016 alone, 1.5 million TB fatalities were documented worldwide, of which approximately three-fourths were in Africa [3]. According to the WHO TB report, 20 countries account for 85 % of all estimated TB cases worldwide, and Ethiopia falls into this category, implying a significant TB burden in the nation [4]. According to the WHO 2014 and 2015 reports, the prevalence and incidence of all types of TB were 211 and 224 per 100,000 people, respectively [5].

According to WHO reports, the African region ranks second in terms of TB cases, accounting for 23 % of the global total [6]. In sub-Saharan Africa, 2.5 million people were infected with TB, representing a quarter of the new TB cases worldwide [7]. In Ethiopia, the distribution of TB varies, with rates such as 25.8 % in the Gambella Region [8], 39.9 % in Ethiopia University Hospital [9], 26 % in Felege Hiwot Referral Hospital [10], 10.8 % in the Tigray Region [11], 10.7 % in southern Ethiopia

* Corresponding author.
E-mail address: tegene2013@gmail.com (T.A. Kitaw).

https://doi.org/10.1016/j.gloepi.2025.100189
Received 27 August 2024; Received in revised form 12 February 2025; Accepted 13 February 2025
Available online 15 February 2025

[12], and 9.9 % in Debre Tabor General Hospital [13].

In Ethiopia, TB killed more than 19,000 people in 2022, which amounts to more than two deaths every hour. The WHO estimates that approximately 30 % of TB cases are undetected by the healthcare system in Ethiopia, resulting in unnecessary deaths. Last year, approximately 145,000 Ethiopians contracted TB [14], and while the treatment success rate exceeded 90 %, 30 % of infections remain undiscovered [15]. In Ethiopia, the total pooled percentages of patients with poor treatment outcomes and deaths were 17.86 % and 15.13 %, respectively. The current knowledge of TB treatment outcomes and its determinants will play an enormous role in achieving the National End TB strategy.

Precise documentation and reporting of TB treatment outcomes and related factors are essential for achieving the goals set by the End TB Strategy, particularly the goal of a 90 % TB treatment success rate by 2025 [16]. This information is crucial for healthcare professionals, program managers, and policymakers to effectively plan, prioritize, and allocate resources. In addition, recent evidence is critical for understanding progress toward ending TB and taking appropriate action. Hence, this study sought to evaluate TB treatment outcomes and their determinants among TB patients.

Methods

Study setting and study period

The study was conducted at Woldia Comprehensive Specialized Hospital. The largest hospital in North Wollo, which is living on three million people, has better facilities and health services than other hospitals. It is located 521 km away from Addis Ababa, the capital city of Ethiopia. Hospitals provide many health care services, including TB diagnosis and treatment. It also serves as a referral center for neighboring primary hospitals and health centers.

Study design and study participants

Retrospectively, TB treatment registration books were reviewed to collect data on study participants who were receiving anti-TB treatment from January 1, 2019, to December 30, 2022. The source population included all adults (≥18 years) with TB who were receiving anti-TB treatment at Woldia Comprehensive Specialized Hospital. Multiple records were extracted for each patient, capturing all instances of treatment from the initiation of anti-TB therapy to the completion of treatment. Both hospitalized and outpatient treatment episodes were included in the analysis. The study population specifically comprised adults (≥18 years) with TB who were receiving anti-TB treatment at Woldia Comprehensive Specialized Hospital during the defined follow-up period from January 1, 2019, to December 30, 2022.

Eligibility, sample size determination, and sampling technique

All medical records of adults (≥18 years) with TB admitted to the TB treatment unit in the hospital during the defined follow-up period were eligible for inclusion in the study. The sample size was calculated using a prevalence of 25.8 % prevalnce of unfavorable TB treatment from a previous study in Ethiopia [8].

Using the single population proportion formula and considering a confidence level of 95 % (Z = 1.96) and a margin of error (d) of 5 % (d = 0.05) the initial sample size was 284.

$$n = \frac{Z^2 \cdot P \cdot (1-P)}{d^2} = n = \frac{(1.96)^2 \cdot 0.742 \cdot (1-0.742)}{(0.05)^2} = 294$$

After accounting for a 10 % non-response rate, the final sample size was adjusted to 323.

After obtaining a four-year number of adult patients with TB, the final sample was selected by a random sampling technique. A total of 589 patients were available for inclusion, and 323 patients were selected using simple random sampling to ensure a representative sample while maintaining feasibility for data collection and analysis. We selected a random subset of patients to minimize selection bias, and the sampling rate was approximately 53 %.

Variables and definitions

The dependent variable was unfavorable TB treatment outcome. This study considered different explanatory variables, including sociodemographic factors, clinical characteristics, comorbidities and behavioral factors, to identify determinants of unfavorable treatment outcomes. A bacteriologically confirmed TB case is a person from whom a biological specimen has tested positive by smear microscopy, culture or WHO-approved rapid diagnostics, such as the Xpert MTB/RIF assay. Favorable TB treatment was defined as the sum of cured TB treatment and treatment completed. An unfavorable TB treatment outcome was considered when the treatment of a patient ended in treatment failure, death or default. The patient is deemed “cured” if he or she completes treatment with a negative bacteriological result at the end of the treatment. Treatment was considered “complete” if the patient completed treatment but did not receive a bacteriological result. Treatment failure was defined as follows: a patient who remained smear-positive during treatment or relapsed five months later or a patient who was PTB negative at the start but became smear-positive at the end of the intensive phase. A defaulter was defined as a patient who had been on treatment for at least four weeks and had two or more weeks of therapy interrupted in a row. The patients were considered to “died” if they died as a result of any cause during the course of treatment [17].

Data collection tools

A structured checklist was used to collect the data. The checklist contains four main sections: Part I aimed at collecting information on basic sociodemographic variables; Part II consisted of questions required to gather information related to clinical characteristics; Part III included questions to assess comorbidity; and Part IV dealt with patient behavior-related factors. The records of all study participants were selected according to the eligibility criteria. The final outcomes of TB treatment were obtained from the medical records.

Data processing and analysis

The data were coded, cleaned, and edited. The data were entered into Epi- data version 4.2 and exported to STATA version 16 for analysis. Categorical data were computed in terms of frequency distribution. We performed a thorough check for missing values in the dataset. Any missing values were handled using multiple imputation techniques to ensure the robustness of the results and avoid biases associated with incomplete data. Continuous data were presented through basic descriptive analyses by computing central tendency and dispersion. The outcomes of the participants were dichotomized into unfavorable and favorable TB treatment outcomes. A Mann–Kendall trend test was also conducted to evaluate trends (decreasing, increasing, or constant) in unfavorable TB treatment outcomes over time. A logistic regression model was used to identify the determinants of dependent variables. The linearity of the logit assumption was assessed using the Box-Tidwell test and found that the relationship between the predictors and the log-odds of the outcome is linear. Therefore, the linearity assumption for the logistic regression model is fulfilled. A systematic backward elimination approach to build the model. However, variables were retained if their exclusion caused a ≥ 10 % change in the odds ratio of other key variables, suggesting potential confounding effects. We also considered domain knowledge to ensure the relevance of the predictors. Model fit was assessed using the Hosmer-Lemeshow test and found that the model fit the data well. Multicollinearity was checked using Variance Inflation

Factors (VIF), and cross-validation was performed to ensure the model's generalizability. A VIF above 4 or a tolerance below 0.25 indicated that multicollinearity might exist [18–22]. Least Absolute Shrinkage and Selection Operator (LASSO) technique were also used for variable selection. This method helps in identifying the most relevant predictors by shrinking the coefficients of less important variables to zero. Variables with non-zero coefficients are considered important and were included in the multivariable model, while those with zero coefficients were excluded. Crude odds ratio (COR) and adjusted odds ratio (AOR) with 95 % confidence intervals (95 % CIs). Finally, the findings are presented in the text, tables, and graphs.

Results

From 323 patient files, 312 were eligible to be included in the final analysis, resulting in a response rate of 96.6 %. The remaining charts were excluded due to missing outcome status information. Out of the total variables in the dataset, the following variables had missing data: BMI (8 %) and TB treatment outcomes (3.4 %). The rate of missingness for these variables ranged from 3.4 % to 8 %, with BMI showing the highest percentage of missing values. For the variables with missing data, we used the Multiple Imputation by Chained Equations (MICE) method to impute missing values, ensuring the dataset remained robust and minimizing potential biases. However, for patients with missing TB treatment outcomes, those records were excluded from the study, as this outcome variable is central to our analysis.

Sociodemographic and clinical characteristics of the participants

A total of 312 confirmed TB patients were included. The mean (SD) age of the participants was 40.38 years (SD = 17.61). The mean (SD) body mass index was 27.5 kg/m^2 (SD = 4.2). The majority of the participants (62.5 %) were male. Of the 312 TB patients, 15.4 % were HIV positive. The majority of the patients (84.3 %) had pulmonary TB. Of them, 75.9 % had smear-positive results. A total of 5.1 % of the TB cases were presumptive multidrug-resistant TB *Table 1).*

Outcome and trends of TB treatment outcome

During the follow-up period, 84.94 % of the 312 patients had a favorable treatment outcome, while 15.06 % had an unfavorable treatment outcome. Among them, 30 patients (9.62 %) were cured, 17 (5.45 %) died, 5 (1.60 %) were lost to follow-up, 235 (75.32 %) completed their treatment regimen, and 25 (8.01 %) experienced treatment failure. The prevalence of unfavorable treatment outcome declined from 18.84 % in 2019 to 10.71 % in 2022. In addition, The Mann–Kendall trend test revealed Kendall's tau (τ) = −0.0686 (95 % CI, −0.1262 to −0.0110), indicating decreasing trend in unfavorable TB treatment outcomes over time. *(Fig. 1).* (See Tables 1–4.)

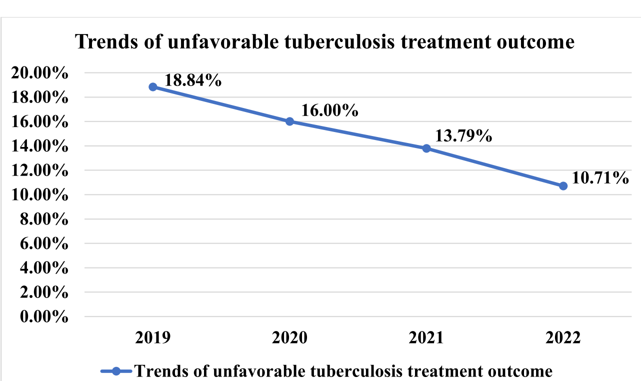

Fig. 1. Trends of unfavorable TB treatment outcomes from 2019 to 2022.

Table 1
Sociodemographic and clinical characteristics of TB patients in northeastern Ethiopia, 2023.

Variables	Categories	Favorable outcome (%)	Unfavorable outcome (%)	(Total) %
Sex	Female	102 (32.7 %)	15 (4.8 %)	117 (37.5 %)
	Male	163 (52.2 %)	32 (10.3 %)	195 (62.5 %)
Marital status	Divorced	11 (3.5 %)	3 (1.0 %)	14 (4.5 %)
	Married	167 (53.5 %)	32 (10.3 %)	199 (63.8 %)
	Single	81 (26.0 %)	5 (1.6 %)	86 (27.6 %)
	Windowed	6 (1.9 %)	7 (2.2 %)	13 (4.2 %)
Residence	Urban	119 (38.1 %)	18 (5.8 %)	137 (43.9 %)
	Rural	146 (46.8 %)	29 (9.3 %)	175 (56.1 %)
Cigarate smoking history	No	234 (75.0 %)	41(13.1 %)	275 (88.1 %)
	Yes	31 (9.9 %)	6 (1.9 %)	37 (11.9 %)
Initial Patient category	New	232 (74.4 %)	26 (8.3 %)	258 (82.7 %)
	Failure	3 (1.0 %)	4 (1.3 %)	7 (2.2 %)
	New Transfer in	17 (5.4 %)	6 (1.9 %)	23 (7.4 %)
	Relapse	13 (4.2 %)	11 (3.5 %)	24 (7.7 %)
Year of treatment	≤2020	140 (44.9 %)	29 (9.3 %)	214 (68.6 %)
	>2020	125 (40.1 %)	18 (5.8 %)	98 (31.4 %)
HIV status	Negative	236 (75.6 %)	28 (9.0 %)	264 (84.6 %)
	Positive	29 (9.3 %)	19 (6.1 %)	48 (15.4 %)
Any comorbidity (other than HIV)	No	212 (67.9 %)	23 (7.4 %)	235 (75.3 %)
	Yes	53 (17.0 %)	24 (7.7 %)	77 (24.7 %)
Type of TB	Pulmonary	230 (73.7 %)	33 (10.6 %)	263 (84.3 %)
	Extra pulmonary	35(11.2 %)	14 (4.5 %)	49 (15.7 %)
Smear result	Positive	176 (67.4 %))	22 (8.4 %)	198 (75.9 %)
	Negative	43(16.5 %	20 (7.7 %)	63 (24.1 %)
Presumptive MDR TB	No	257 (82.4 %)	39 (12.5 %)	296 (94.9 %)
	Yes	8 (2.6 %)	8 (2.6 %)	16 (5.1 %)

Determinants of unfavorable TB treatment outcomes

Multicollinearity test

The variance inflation factor (VIF) and tolerance values were used to check for the presence of multicollinearity between variables. In this study, the maximum VIF was 1.51, with a mean VIF of 1.22, and the minimum tolerance value was 0.66. Thus, there was no multicollinearity between covariates.*(Table 2).*

Box-Tidwell test

The Box-Tidwell test was used to assess the linearity assumption for continuous variables, specifically age and BMI, in relation to the outcome. This test examines the interaction between each continuous variable and its log-transformed counterpart. Below is a summary of the test results for age and BMI. *(Table 3).*

According to multivariable logistic regression analysis, age, HIV

Table 2
Multicollinearity test to examine the relationship between explanatory variables.

Variables	VIF	1/VIF
Age in year	1.51	0.663918
HIV status	1.46	0.684012
Any comorbidity (other than HIV	1.30	0.770878
Presumptive MDR TB	1.24	0.803418
Body mass index (mean) initial	1.22	0.817252
Marital status	1.22	0.819258
Sex	1.18	0.846833
Patient category	1.16	0.864950
Smear result	1.15	0.868758
Type of TB	1.14	0.874416
Cigarette smoking history	1.11	0.901514
Residence	1.08	0.922493
Year of treatment	1.08	0.923584
Mean VIF	1.22	

Table 3
Box-Tidwell Test for Linearity Assumption.

Continuous Variable	Interaction Term	Test Statistic	Linearity Assumption	Interpretation
Age	Age * log (Age)	1.57	Assumption not violated	No departure from linearity ($p = 0.078$), confirming age is linearly related to the outcome.
BMI	BMI * log (BMI)	2.13	Assumption not violated	no departure from linearity ($p = 0.112$), confirming BMI is linearly related to the outcome.

status, and smear results were found to be determinants of unfavorable TB treatment outcomes. Each additional year of age increases the odds of a unfavorable TB treatment outcome by 1.33 times (AOR = 1.33, 95 % CI: 1.11 to 2.03).Compared with HIV-negative patients, HIV-positive patients had a 5.43-fold greater chance of experiencing an unfavorable treatment outcome (AOR: 5.43, 95 % CI: 1.65, 10.83). Smear-negative pulmonary TB was also associated with a 3.82-fold greater chance of experiencing an unfavorable treatment outcome than was smear-positive pulmonary TB (AOR: 3.82, 95 % CI: 1.39, 10.45).*(Table 4)*.

Independent interaction testing of determinants

To evaluate interactions between determinants, we used logistic regression models with interaction terms. The significance of the interaction terms was assessed using the Wald test.

Logit(P(Unfavorable Outcome)) = $\beta_0 + \beta_1$(Age) + β_2(HIV status) + β_3(Smear status) + β_4(Age × HIV status) + β_5(Age × Smear status) + β_6(HIV status × Smear status) + ε.

Interaction	Interaction Term	Conclusion
Age and HIV Status	Age * HIV Status	No interaction. The effect of age on unfavorable outcome does not differ by HIV status.
Age and Smear Status	Age * Smear Status	No interaction. Age does not modify the effect of smear status on unfavorable outcome.
HIV Status and Smear Status	HIV Status * Smear Status	No interaction. HIV status does not modify the effect of smear status on unfavorable outcome.

Discussion

This study was conducted among TB patients receiving care at Woldia Comprehensive Specialized Hospital in Northeast Ethiopia. Among the patients included, 15.06 % presented with unfavorable TB treatment outcomes. Older age, HIV positivity, and smear-negative pulmonary TB were identified as determinants of these unfavorable outcomes.

Table 4
Binary and multivariable logistic regression analyses of determinants of unfavorable TB treatment outcomes among adult patients in northeastern Ethiopia, 2023.

Variables	Categories	COR (95 %CI)	AOR (95 %CI)
Age in year		1.45 (1.21–2.61)	1.33 (1.11–2.03)
Sex	Female	1	1
	Male	1.33(0.69, 2.87)	1.45(0.59, 3.56)
Marital status	Married	1	1
	Not married	0.79(0.41, 1.55)	0.65(0.24, 1.76)
Residence	Urban	1	1
	Rural	1.31(0.69, 2.48)	2.18(0.88, 5.41)
Cigarate smoking history	No	1	1
	Yes	1.10(0.43, 2.81)	2.72(0.86, 8.59)
Body mass index		1.61 (0.51–3.89)	1.51 (0.43–3.45)
Initial Patient category	New	1	1
	Transfer in	3.15(1.14, 8.69)	2.91(0.82, 10.24)
	Retreated	8.36(3.71, 18.85)	3.81(0.98, 11.73)
Year of treatment	≤2020	1	1
	>2020	0.69(0.37, 1.31)	0.75(0.52, 1.62)
HIV status	Negative	1	1
	Positive	5.52(2.75, 11.11)	5.43 (1.65,10.83)
Any comorbidity (other than HIV)	No	1	1
	Yes	4.17(2.18, 7.97)	2.48(0.98, 5.94)
Type of TB	Pulmonary	1	1
	Extra pulmonary	2.79(1.36, 5.72)	2.62(0.29, 8.89)
Smear result	Positive	1	1
	Negative	3.72(1.86, 7.42)	3.82(1.39, 10.45)
Presumptive MDR TB	No	1	1
	Yes	6.59(2.34, 18.57)	2.14(0.46, 9.98

NB: COR: Crude odds ratio, AOR: Adjusted odds ratio.

The rates of unfavorable outcomes among TB patients in this study were lower than those found in a study conducted five years ago in this area, which reported that 20.0 % of TB patients had unsuccessful treatment outcomes [23]. This disparity can be attributed to several factors. First, improvements in TB diagnosis and treatment protocols over the past five years might have contributed to better patient management and outcomes. Enhanced access to healthcare services, increased awareness, and education about TB among the population could also play a significant role in reducing the incidence of unfavorable outcomes. Additionally, the implementation of more effective TB control programs and adherence to treatment regimens may have contributed to this positive trend.

These findings are also lower than those reported in studies conducted in Brazil (20 %) [24], Pakistan (28.4 %) [25], Colombia (26.6 %) [26], Africa (21 %) [27], and Malaysia (19.3 %) [28]. Other studies conducted in Ethiopia have reported higher rates of unfavorable TB treatment outcomes than did the findings of this study, for example, 25.8 % in the Gambella Region [8], 39.9 % in the Ethiopian University Hospital [9], and 26 % in the Felege Hiwot Referral Hospital [10]. In contrast, these findings are greater than those reported in studies conducted in China (1.4 %) [29], the Tigray Region (10.8 %) [11], southern Ethiopia (10.7 %) [12], and Debre Tabor General Hospital (9.9 %) [13]. The findings highlight significant regional disparities in TB treatment outcomes, indicating varying levels of healthcare effectiveness and infrastructure across different countries and regions. Higher rates of unfavorable outcomes in certain areas of Ethiopia and other countries underscore the need for targeted interventions to improve TB management, including strengthening healthcare systems and enhancing patient support programs. Conversely, regions with lower rates of unfavorable outcomes offer valuable lessons into successful TB management strategies that can inform efforts elsewhere. Contextual factors such as socioeconomic status and healthcare infrastructure play a crucial role in this process, emphasizing the importance of tailored interventions. Continuous monitoring and evaluation are essential for tracking progress, identifying areas for improvement, and optimizing TB control efforts globally.

The unfavorable treatment outcomes showed a decline from 18.84 % in 2019 to 10.71 % in 2022. Similarly, previous studies in other parts of Ethiopia have found that unsuccessful TB treatment outcomes have shown a decreasing trend [30]. The significant reduction in unfavorable TB treatment outcomes from 18.84 % in 2019 to 10.71 % in 2022 reflects improvements in TB management in Northeast Ethiopia. Enhanced diagnostic capabilities, timely treatment interventions, better patient follow-up, and expanded healthcare access likely contributed to this positive trend. This decline is consistent with trends observed in other parts of Ethiopia, indicating the effectiveness of nationwide TB control programs and interventions. Successful public health strategies, such as Directly Observed Treatment, Short-course (DOTS) strategies, and integrated TB and HIV care, are key to these improvements. These findings underscore the importance of continuing investment in TB control programs, scaling up diagnostic and treatment infrastructure, and strengthening healthcare systems. Such efforts are crucial for maintaining progress and achieving global TB control targets, such as the End TB Strategy's goal of a 90 % treatment success rate by 2025.

The influence of age on TB treatment outcomes is significant. This finding is also supported by previous studies [31–35]. As individuals grow older, they often encounter a multitude of health challenges that can exacerbate the complexities of TB treatment. Older age is frequently accompanied by the presence of comorbidities, such as diabetes, cardiovascular disease, or respiratory conditions [36], which can complicate TB management and increase the risk of treatment complications. Additionally, the immune system naturally weakens with age, making older individuals more susceptible to infections like TB and less capable of mounting an effective immune response against the bacteria [37]. This diminished immune function can prolong the course of TB treatment and increase the likelihood of adverse outcomes. Older patients may also face challenges in adhering to rigorous TB treatment regimens due to factors such as cognitive decline, mobility issues, or polypharmacy [38–40]. This nonadherence can lead to treatment failure or the development of drug-resistant TB strains. Consequently, it is imperative to implement tailored healthcare interventions for older TB patients. These interventions should include close monitoring of treatment progress, comprehensive care strategies that address both TB and any coexisting conditions, and robust support systems to assist older individuals in adhering to their treatment plan. By addressing the unique needs and challenges faced by older TB patients, healthcare providers can effectively mitigate the impact of age-related factors and improve treatment success rates in this vulnerable population.

This study revealed that smear-negative pulmonary TB is linked to unfavorable outcomes. Likewise, other studies have reported similar findings [33,41,42]. This could be because smear-negative TB poses a diagnostic challenge due to the limitations of conventional smear microscopy in detecting bacteria. As a result, delayed diagnosis and treatment initiation can occur, leading to more advanced disease states and poor prognoses. In addition, sputum smear-negative and culture-positive pulmonary TB twice more common in HIV-infected patients [43]. This results from their compromised immune response, which causes less cavity formation, leading to poor outcome [44]. From a public health perspective, addressing the challenges posed by smear-negative TB is imperative for TB control programs. Strategies aimed at improving diagnostic infrastructure, enhancing healthcare provider awareness, and expanding access to advanced diagnostic technologies can help reduce diagnostic delays and improve case detection rates. Additionally, targeted efforts to increase awareness among at-risk populations and promote early healthcare-seeking behavior are essential for timely diagnosis and treatment initiation.

TB patients who were HIV-positive had a greater chance of experiencing an unfavorable treatment outcome. This finding is consistent with findings from other studies [28,45–48]. HIV-positive individuals face a higher risk of unfavorable treatment outcomes in TB due to their compromised immune systems, which can result in more severe disease and delayed treatment initiation. Managing both HIV and TB simultaneously adds complexity to treatment regimens, leading to increased risks of medication nonadherence and drug interactions. Additionally, HIV infection is associated with higher rates of drug-resistant TB [49], further complicating treatment. Socioeconomic factors, such as limited access to healthcare and social support, exacerbate these challenges. These findings underscore the need for early detection and integrated care services for TB and HIV. Routine screening for infections among at-risk populations, coupled with accessible diagnostic and treatment services, is essential for timely intervention and improved outcomes. Strengthening linkage and retention in care programs is vital to ensure that coinfected individuals receive continuous and coordinated management throughout the course of their illnesses. One of the limitations of this study is the potential for unmeasured confounding. While we have controlled for a range of known confounders, there may be other factors that we were unable to account for, which could still influence the results. Additionally, the cross-sectional nature of the study limits our ability to draw causal conclusions. Future research with longitudinal designs and more comprehensive data collection would help mitigate these limitations and provide a clearer understanding of the relationships explored in this study. Furthermore, the study's significant limitation lies in its retrospective nature, which restricts the ability to comprehensively explore further determinants of unsuccessful treatment outcomes. The small sample size and single-site data collection may also limit the generalizability of the findings to broader populations.

Conclusion and recommendations

The study revealed that 84.94 % of participants achieved a favorable treatment outcome, while 15.06 % experienced an unfavorable outcome. These findings indicate that more efforts are necessary to enhance the overall success rates of treatment. This percentage falls below the 90 % target set by the End TB strategy, indicating a gap in achieving optimal outcomes. Older age, HIV positivity, and smear-negative pulmonary tTB emerged as determinants of unfavorable outcomes, highlighting the need for tailored approaches. It is crucial to implement targeted interventions focused on subgroups facing unfavorable outcomes. Additionally, screening protocols should be strengthened, particularly considering age and HIV status, which emerged as determinants of unfavorable outcomes. Tailored treatment plans should be developed for older patients and those coinfected with HIV, taking into account their increased risk. Furthermore, enhancing diagnostic capabilities to promptly identify smear-negative pulmonary TB, which is identified as a determinant of unfavorable outcomes, is essential. Integrating TB and HIV care services can ensure comprehensive management of coinfected individuals, ultimately improving treatment outcomes and helping individuals move closer to achieving the goals outlined by the End TB strategy.

Ethical consideration and consent

The study was reviewed and approved by the Woldia University Institutional Review Board. The project proposal was also reviewed by

Woldia Comprehensive Specialized Hospital. After review, the hospital's ethical review board approved the project and waived the requirement for written informed consent from participants. Therefore, individual written informed consent was not required in accordance with national legislation and institutional requirements. Information that could identify individuals was not collected. Information obtained from the records was kept anonymous and confidential.

Funding statement

There is no funding to report.

CRediT authorship contribution statement

Tegene Atamenta Kitaw: Writing – review & editing, Writing – original draft, Supervision, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Amsalu Baylie:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation. **Addisu Getie:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Investigation, Formal analysis. **Ribka Nigatu Haile:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

All authors have no any conflicts of interest.

Data availability

Data are available upon reasonable requests.

References

[1] World Health Organization. Global tuberculosis report 2020. Geneva. Available from, https://www.who.int/publications/i/item/9789240013131; 2020.
[2] World Health Organization. EXECUTIVE SUMMARY. Global Tuberculosis Report 2021. URL, https://wwwwhoint/teams/global-tuberculosis-programme/tbreports/global-tuberculosis-report-2021; 2021.
[3] World Health Organization. WHO guidelines on tuberculosis infection prevention and control: 2019 update. World Health Organization; 2019.
[4] World Health Organization. National tuberculosis prevalence surveys. 2021 [Available from, https://www.who.int/publications/i/item/9789240022430; 2007-2016.
[5] World Health Organization. Global tuberculosis report. 2013 [Available from, https://www.who.int/publications/i/item/9789241564656; 2013.
[6] World Health Organization. Global tuberculosis report. 2023 [Available from, https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2023; 2023.
[7] Heaton B. Prevalence of tuberculosis in sub-Saharan Africa. Ballard Brief 2022; 2022(1):3.
[8] Ejeta E, Beyene G, Balay G, Bonsa Z, Abebe G. Factors associated with unsuccessful treatment outcome in tuberculosis patients among refugees and their surrounding communities in Gambella Regional State, Ethiopia. PloS One 2018;13(10):e0205468.
[9] Biruk M, Yimam B, Abrha H, Biruk S, Amdie FZ. Treatment outcomes of tuberculosis and associated factors in an Ethiopian University Hospital. Adv Public Health 2016;2016.
[10] Biadglegne F, Anagaw B, Debebe T, Anagaw B, Tesfaye W, Tessema B, et al. A retrospective study on the outcomes of tuberculosis treatment in Felege Hiwot Referral Hospital, Northwest Ethiopia. Int J Med Med Sci 2013;5(2):85–91.
[11] Berhe G, Enquselassie F, Aseffa A. Treatment outcome of smear-positive pulmonary tuberculosis patients in Tigray Region. Northern Ethiopia BMC public health 2012;12:1–9.
[12] Datiko DG, Lindtjørn B. Health extension workers improve tuberculosis case detection and treatment success in southern Ethiopia: a community randomized trial. PloS One 2009;4(5):e5443.
[13] Worku S, Derbie A, Mekonnen D, Biadglegne F. Treatment outcomes of tuberculosis patients under directly observed treatment short-course at Debre Tabor general Hospital, northwest Ethiopia: nine-years retrospective study. Infect Dis Poverty 2018;7:1–7.
[14] Deribew A, Dememew Z, Alemu K, Tefera G, Negash S, Molla Y, et al. TB-related catastrophic costs in Ethiopia. Public Health Action 2024;14(2):71–5.
[15] Reves R, Angelo S. As Ethiopia moves toward tuberculosis elimination, success requires higher investment. JSTOR; 2016.
[16] Federal Democratic Republic of Ethiopia MoH. Guidelines for management of TB, DR-TB and leprosy in Ethiopia. Artistic printing Enterprise Addis Ababa. 2017.
[17] Linh NN, Viney K, Gegia M, Falzon D, Glaziou P, Floyd K, et al. World Health Organization treatment outcome definitions for tuberculosis: 2021 update. Eur Respiratory Soc 2021;58:2–5.
[18] Kitaw TA, Abate BB, Tilahun BD, Haile RN. Geospatial pattern of HIV seropositivity and its predictors among women in Ethiopia. A spatial and multiscale geographically weighted regression analysis. PloS One 2024;19(7):e0306645.
[19] Kitaw TA, Abate BB, Derese Tilahun B, Haile RN. Geospatial pattern of level of minimum acceptable diet and its determinants among children aged 6–23 months in Ethiopia. Spatial and multiscale geographically weighted regression analysis. Frontiers. Public Health 2024;12:1348755.
[20] Haile RN, Abate BB, Kitaw TA. Predictors of late initiation of breastfeeding practice in Ethiopia: a multilevel mixed-effects analysis of recent evidence from EDHS 2019. BMJ Open 2024;14(4):e081069.
[21] Kitaw TA, Tilahun BD, Abate BB, Haile RN. Minimum acceptable diet and its predictors among children aged 6-23 months in Ethiopia. A multilevel cloglog regression analysis. Matern Child Nutr 2024;20:3–7. e13647.
[22] Haile RN, Abate BB, Kitaw TA. Spatial variation and determinants of delayed breastfeeding initiation in Ethiopia: spatial and multilevel analysis of recent evidence from EDHS 2019. Int Breastfeed J 2024;19(1):10.
[23] Getie A, Alemnew B. Tuberculosis treatment outcomes and associated factors among patients treated at Woldia general Hospital in Northeast Ethiopia: an institution-based cross-sectional study. Infect Drug Resist 2020:3423–9.
[24] Peetluk LS, Rebeiro PF, Ridolfi FM, Andrade BB, Cordeiro-Santos M, Kritski A, et al. A clinical prediction model for unsuccessful pulmonary tuberculosis treatment outcomes. Clin Infect Dis 2022;74(6):973–82.
[25] Khan I, Ahmad N, Khan S, Muhammad S, Khan SA, Ahmad I, et al. Evaluation of treatment outcomes and factors associated with unsuccessful outcomes in multidrug resistant tuberculosis patients in Baluchistan province of Pakistan. J Infect Public Health 2019;12(6):809–15.
[26] Paniagua-Saldarriaga LA, Pelissari DM, Rueda ZV. Factors associated with unsuccessful outcomes of tuberculosis treatment in 125 municipalities in Colombia 2014 to 2016. Am J Trop Med Hyg 2021;105(5):1326.
[27] Teferi MY, El-Khatib Z, Boltena MT, Andualem AT, Asamoah BO, Biru M, et al. Tuberculosis treatment outcome and predictors in Africa: a systematic review and Meta-analysis. Int J Environ Res Public Health 2021;18(20). https://doi.org/10.3390/ijerph182010678.
[28] Tok PSK, Liew SM, Wong LP, Razali A, Loganathan T, Chinna K, et al. Determinants of unsuccessful treatment outcomes and mortality among tuberculosis patients in Malaysia: a registry-based cohort study. PloS One 2020;15(4):e0231986.
[29] Gilmour B, Xu Z, Bai L, Alene KA, Clements AC. Risk factors associated with unsuccessful tuberculosis treatment outcomes in Hunan Province. China Trop Med Int Health 2022;27(3):290–9.
[30] Zenbaba D, Bonsa M, Sahiledengle B. Trends of unsuccessful treatment outcomes and associated factors among tuberculosis patients in public hospitals of Bale Zone, Southeast Ethiopia: a 5-year retrospective study. Heliyon 2021;7(9):e07982. https://doi.org/10.1016/j.heliyon.2021.e07982.
[31] Sengul A, Akturk UA, Aydemir Y, Kaya N, Kocak ND, Tasolar FT. Factors affecting successful treatment outcomes in pulmonary tuberculosis: a single-center experience in Turkey, 2005–2011. J Infect Dev Countries 2015;9(08):821–8.
[32] NM NNR, NS M, NH NR. Factors associated with unsuccessful treatment outcome of pulmonary tuberculosis in Kota Bharu, Kelantan. Malaysian. J Public Health Med 2011:6–15.
[33] Amante TD, Ahemed TA. Risk factors for unsuccessful tuberculosis treatment outcome (failure, default and death) in public health institutions, Eastern Ethiopia. Pan Afr Med J 2015:20.
[34] Albuquerque MdFPMd, Ximenes RadA, Lucena-Silva N, Souza Wvd, Dantas AT, Dantas OMS, et al. Factors associated with treatment failure, dropout, and death in a cohort of tuberculosis patients in Recife, Pernambuco State, Brazil. Cad Saude Publica 2007;23:1573–82.
[35] Wen Y, Zhang Z, Li X, Xia D, Ma J, Dong Y, et al. Treatment outcomes and factors affecting unsuccessful outcome among new pulmonary smear positive and negative tuberculosis patients in Anqing, China: a retrospective study. BMC Infect Dis 2018;18:1–12.
[36] Taylor CA, Bouldin ED, Greenlund KJ, McGuire LC. Comorbid chronic conditions among older adults with subjective cognitive decline, United States, 2015–2017. Innovation. Aging 2020;4(1):igz045.
[37] Pawelec G, Bronikowski A, Cunnane SC, Ferrucci L, Franceschi C, Fülöp T, et al. The conundrum of human immune system "senescence". Mech Ageing Dev 2020;192:111357.
[38] Collado-Mateo D, Lavín-Pérez AM, Peñacoba C, Del Coso J, Leyton-Román M, Luque-Casado A, et al. Key factors associated with adherence to physical exercise in patients with chronic diseases and older adults: an umbrella review. Int J Environ Res Public Health 2021;18(4):2023.
[39] Bea S, Lee H, Kim JH, Jang SH, Son H, Kwon J-W, et al. Adherence and associated factors of treatment regimen in drug-susceptible tuberculosis patients. Front Pharmacol 2021;12:625078.
[40] Caraux-Paz P, Diamantis S, de Wazières B, Gallien S. Tuberculosis in the elderly. J Clin Med 2021;10(24):5888.
[41] Gebrezgabiher G, Romha G, Ejeta E, Asebe G, Zemene E, Ameni G. Treatment outcome of tuberculosis patients under directly observed treatment short course and factors affecting outcome in southern Ethiopia: a five-year retrospective study. PloS One 2016;11(2):e0150560.

[42] Tesfahuneygn G, Medhin G, Legesse M. Adherence to anti-tuberculosis treatment and treatment outcomes among tuberculosis patients in Alamata District, Northeast Ethiopia. BMC Res Notes 2015;8:1–11.

[43] Tessema B, Muche A, Bekele A, Reissig D, Emmrich F, Sack U. Treatment outcome of tuberculosis patients at Gondar University Teaching Hospital, Northwest Ethiopia. A five–year retrospective study. BMC Public Health 2009;9:371. https://doi.org/10.1186/1471-2458-9-371.

[44] Siddiqi K, Lambert ML, Walley J. Clinical diagnosis of smear-negative pulmonary tuberculosis in low-income countries: the current evidence. Lancet Infect Dis 2003; 3(5):288–96. https://doi.org/10.1016/s1473-3099(03)00609-1.

[45] Teferi MY, Didana LD, Hailu T, Woldesenbet SG, Bekele S, Mihret A. Tuberculosis treatment outcome and associated factors among tuberculosis patients at Wolayta Sodo Teaching and Referral Hospital, Southern Ethiopia: a retrospective study. J Public Health Res 2021;10(3). jphr. 2021.46.

[46] Sariem CN, Odumosu P, Dapar MP, Musa J, Ibrahim L, Aguiyi J. Tuberculosis treatment outcomes: a fifteen-year retrospective study in Jos-North and Mangu, Plateau State. North-Central Nigeria BMC Public Health 2020;20:1–11.

[47] Fentie AM, Jorgi T, Assefa T. Tuberculosis treatment outcome among patients treated in public primary healthcare facility, Addis Ababa, Ethiopia: a retrospective study. Arch Public Health 2020;78:1–9.

[48] Gevorgyan L, Grigoryan R, Dumchev K, Akopyan K, Khachatryan A, Kabasakalyan E, et al. Factors associated with unfavourable treatment outcomes in people with HIV-associated tuberculosis in Armenia, 2015 to 2019. Monaldi Arch Chest Dis 2021;91(1).

[49] Singh A, Prasad R, Balasubramanian V, Gupta N. Drug-resistant tuberculosis and HIV infection: current perspectives. HIV/AIDS-Research and Palliative Care 2020: 9–31.