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Survival Analysis and Factors Associated with Pulmonary Tuberculosis

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ABSTRACT

Introduction: Analysed the survival rates of patients and factors associated with pulmonary tuberculosis at the Limboto Public Health Center, with particular attention to the role of hypertension as a predictor of treatment failure and its potential integration into TB treatment guidelines.
Methods: The study represents retrospective cohort research conducted by collecting medical records of individual pulmonary tuberculosis patients at the Limboto Public Health Center. The research sample comprised 144 patients and was analysed using survival analysis methods, including the Kaplan-Meier and Cox Regression models.
Result: Among a cohort of 144 pulmonary tuberculosis cases, 21 individuals (14.6%) encountered treatment failure, resulting in three fatalities. A Kaplan-Meier survival analysis unveiled marked disparities in the survival probabilities of pulmonary tuberculosis patients contingent on their hypertension status (p=0.000). In the Cox Regression analysis, the hazard ratio associated with hypertension in the context of treatment failure in pulmonary tuberculosis patients was determined to be HR= 10.216. These findings suggest the necessity of incorporating hypertension screening and management into existing TB care protocols.
Conclusion: Evidence-based interventions should be implemented, particularly among patients with concomitant hypertension. Strengthening the integration of hypertension management into TB treatment guidelines may improve patient outcomes and reduce treatment failures.

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INTRODUCTION

Tuberculosis (TB) is a chronic infectious disease primarily affecting the lungs and caused by Mycobacterium tuberculosis (1). Despite being a preventable and treatable infectious disease, TB remains a significant global health concern and is identified as a priority target in the Sustainable Development Goals (SDGs) for 2035. The objective is to end the TB epidemic by achieving a 90% reduction in TB incidence (less than 10 cases per 100,000 population), a 95% decrease in TB-related mortality (compared to 2015), and ensuring no families bear catastrophic financial burdens due to TB (2).

While TB is a preventable and generally curable ailment, recent data from 2022 reveal it as the second leading cause of global mortality attributed to a single infectious agent, trailing only behind COVID-19. TB-related deaths surpass those caused by HIV/AIDS by nearly twice the number. Over 10 million people continue to suffer from TB annually. Urgent actions are imperative to halt the global spread of TB by 2030, aligning with a goal adopted by all United Nations Member States and the World Health Organization (3,4).

In Indonesia, tuberculosis (TB) ranks second only to India in terms of prevalence, with an annual incidence of 969,000 cases and 93,000 deaths, equating to 11 deaths per hour (5). According to the 2022 Global TB Report, the highest incidence of TB cases globally occurs within the productive age group, particularly among individuals aged 25 to 34. In the Indonesian context, the highest number of TB cases is observed in the practical age group, specifically within the 45 to 54 age range (6).

In 2018, the Provincial Health Office of Gorontalo recorded the highest number of pulmonary tuberculosis (TB) cases with positive acid-fast bacilli (BTA+) in Gorontalo District, totaling 1002 cases, while the lowest number was observed in Boalemo District, accounting for 70 issues. The average Case Notification Rate (CNR) for Gorontalo Province was 179 per 100,000 population. It is essential to note that these figures may only partially depict the actual situation on the ground, as case detection relies on the performance of field personnel. Compared to 2013, this achievement represents an increase when the CNR was 163 per 100,000 population. In 2018, the prevalence of tuberculosis in Gorontalo Province continued to rise, reaching 2280 cases by December, compared to 2032 cases in 2017, including both new and existing patients. According to data from the Provincial Health Office of Gorontalo, a total of 2280 individuals were diagnosed with tuberculosis, and an additional 4580 were identified as TB suspects. Based on the 2018 data, Gorontalo District recorded approximately 1002 TB cases with positive BTA, making it the district with the highest number of TB patients in Gorontalo Province (7).

According to the data from the Limboto Community Health Center, from 2017 to 2019, there has been a continuous increase in Pulmonary Tuberculosis (TB) in the Limboto sub-district over the past three years. In 2017, 97 cases increased to 144 patients with positive Acid-Fast Bacilli (BTA) in 2018. Furthermore, in 2019, there was a further increase to 163 patients. This trend suggests a consistent rise in Pulmonary TB in the Limboto sub-district during the specified period (8).

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Tuberculosis (TB) remains a major global health concern, particularly in high-burden countries such as Indonesia. Despite being a preventable and curable disease, TB continues to cause significant morbidity and mortality. While TB control efforts have been largely successful in many regions, comorbid conditions such as hypertension are increasingly recognized as critical factors influencing treatment outcomes. However, research addressing the role of hypertension in TB survival is limited, particularly in Indonesia. This study aims to bridge this gap by examining how hypertension affects TB treatment failure and survival outcomes, thereby providing insights for more integrated management strategies.

Previous studies indicate that hypertension can affect TB progression and treatment outcomes due to its impact on immune function and cardiovascular complications (1,2,6). The integration of hypertension screening in TB programs has been suggested to improve treatment adherence and success rates (10–12). Survival analysis is commonly employed to analyze data about the time until a specific event occurs, with time being the primary variable of interest (13). One of the objectives of survival analysis is to discern the correlation between survival time and suspected influencing variables. This correlation can be modeled using the Cox proportional hazards (PH)

regression model, which is utilized to investigate the relationship between independent and dependent variables. The data used in this context typically involves the survival time of an individual until the occurrence of a specific event. The events, in this case, may include outcomes such as death, relapse, or recovery (14).

This research aims to observe and analyze the survival rates of patients and the factors associated with pulmonary tuberculosis at the Limboto Health Center.

METHOD

This research employs an analytical observational study with a Retrospective Cohort approach, which involves tracking respondents to observe events from the initial diagnosis of pulmonary tuberculosis until the observation period. The study was conducted from December 2019 to March 2020. The population under investigation comprises all pulmonary tuberculosis patients diagnosed at the Limboto Community Health Center.

One hundred forty-four pulmonary tuberculosis patients from 2018 were selected as the research sample, meeting the criteria of having complete medical records. The independent variables in this study include hypertension status, age, and occupation, while the dependent variable is the final status of pulmonary tuberculosis patients, either treatment failure or death. Hypertension was chosen due to its documented impact on immune function and chronic disease progression, while age and occupation were selected based on prior research suggesting their potential influence on TB treatment adherence and disease severity (15,16).

Data collection involved tracing the medical records of pulmonary tuberculosis patients at the Limboto Community Health Center. A potential limitation of using secondary data is the risk of incomplete or inconsistent records, which could introduce bias. To mitigate this, only medical records with complete treatment and follow-up data were included, and cross-validation with health center staff was conducted. Additionally, potential misclassification bias was minimized by standardizing data extraction procedures and using predefined diagnostic criteria from medical records (9).

Descriptive analysis and survival analysis were performed using the SPSS software. Kaplan-Meier analysis assessed the differences in the survival probability of pulmonary tuberculosis patients based on hypertension status, age, and occupation. Subsequently, Cox Regression analysis was carried out to determine the magnitude of the risk of independent variables concerning treatment failure in pulmonary tuberculosis patients.

RESULTS

The study analysed 144 pulmonary tuberculosis patients, with an average age of 45.33 years (SD: 15.25). The majority were male (61.8%) and had primary school education (79.9%) (Table 1). The key finding was that hypertension significantly increased the risk of treatment failure (p=0.000; HR=10.216). However, age (p=0.068) and occupation (p=0.290) were not significant predictors (Table 2).

Table 1. The socio-demographic characteristic of participants (n: 144).

Characteristics	Groups	Number (n)	Percentage (%)
Age (years)	Mean ± SD	45.33 ± 15.25	
	≤ 20	9	6.3
	21 – 40	40	27.8
	41 – 60	72	50.0
	60 above	23	16.0
Gender	Male	89	61.8
	Female	55	38.2
Education	Primary School	115	79.9
	Junior High School	12	8.3
	Senior High School	10	6.9
	Bachelor-level or above	7	4.9
Final Status	Deceased	3	2.1
	Failed treatment	17	11.8

Characteristics	Groups	Number (n)	Percentage (%)
	Recovered	124	86.1
Address	Bionga	3	2.1
	Bolihuangga	11	7.6
	Bongohulawa	7	4.9
	Bulota	5	3.5
	Dutulanaa	12	8.3
	Hepuhulawa	14	9.7
	Hunggaluwa	17	11.8
	Hutuo	22	15.3
	Kayu Bulan	29	20.1
	Kayu Merah	9	6.3
	Malahu	3	2.1
	Pentadio Barat	1	0.7
	Polohungo	5	3.5
	Tenilo	3	2.1
	Tilihua	3	2.1

Source: Secondary Data, 2020

Table 2 Results of Bivariate Analysis on the Survival of Pulmonary Tuberculosis Patients

Independent Variable	Final Status of Survival of Pulmonary Tuberculosis Patients		p*	HR**
	Failed Treatment (N = 21)	Recovered (N = 123)		
Hypertension status				
Hypertension	11 (52.4%)	6 (4.9%)	0.000	0.094
Non-Hypertension	10 (47.6%)	117 (95.1%)		
Age				
At risk (12-60 y.o)	15 (71.4%)	108 (87.8%)	0.068	2.418
Not at risk (<12 and >60 y.o)	6 (28.6%)	15 (12.2%)		
Occupation				
At risk	17 (81.0%)	85 (69.1%)	0.290	0.556
Not at risk	4 (19.0%)	38 (30.9%)		

*The p-value is significant if <0.05. ** HR = Hazard Ratio
Source: Secondary Data, 2020

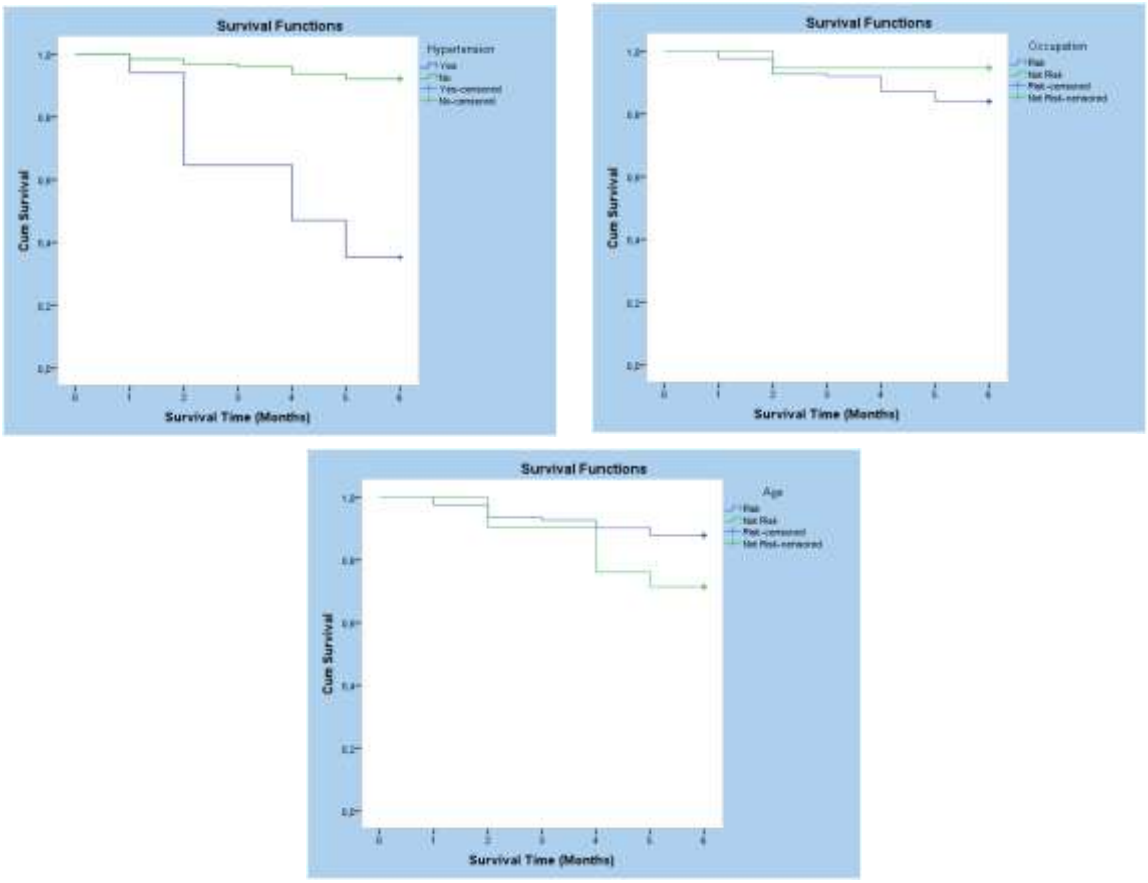

Figure 1. Kaplan-Meier Survival Curve of Pulmonary Tuberculosis Patients

Kaplan-Meier survival curves showed a clear difference in survival probabilities based on hypertension status, whereas survival curves for age and occupation overlapped (Figure1). This indicates that hypertension is a major factor influencing treatment outcomes, while other variables may have weaker or indirect effects (Table 3).

Table 3 Analysis of Cox Regression on Independent Variables concerning Survival of Pulmonary Tuberculosis Patients

Variable	P	HR	95% CI
Hypertension	0.000	10.216	4.155-25.121
Age	0.610	0.773	0.287-2.079

Source: Secondary Data, 2020

DISCUSSION

In this research, we investigated and examined the factors associated with and the probability of survival among pulmonary tuberculosis patients concerning treatment failure. Tuberculosis is a chronic disease with a treatment duration of 6 months or more, depending on patient compliance. Regular medication intake for six months is essential to achieve recovery and prevent disease transmission (17).

This research was conducted by reviewing the medical records of pulmonary tuberculosis patients at the community health center; in contrast, previous studies employed a survival time observation approach by recruiting volunteers for follow-up (12,18).

In conducting a survival data analysis using Kaplan-Meier, the findings indicate that hypertension status significantly influences the probability of survival among pulmonary tuberculosis patients at the Limboto Community Health Center. Conversely, age and occupation variables were found to be non-significant in affecting the differences in the probability of survival among pulmonary tuberculosis patients.

The findings diverge from prior literature that identified age as a risk factor for tuberculosis patient survival, wherein an increase in age correlated with a 5.9% rise in mortality (19). As one age, the immune response tends to decline, and various comorbidities, including hypertension, may adversely impact the resilience of individuals with tuberculosis, affecting their overall survival (20).

In the elderly population, a tendency towards irregularity in the implementation of treatment has been observed, which can be attributed to a weaker motivation to achieve optimal health and a lack of attention to health aspects. It often leads to higher social isolation and a decline in social functioning, including intellectual factors, memory abilities, and problem-solving skills. Conversely, in the adolescent and adult age groups, the body still tends to be productive, maintaining a high motivation to adhere to treatment plans. Similar phenomena are also observed in children, where parental supervision plays a crucial role in increasing compliance with treatment (21).

Regarding the occupation variable, this aligns with the study conducted by Fakhira Modeong et al. regarding the most influential factors affecting the recovery rate of Pulmonary Tuberculosis patients using the Cox Proportional Hazard model. The research on secondary data of TB patients at Aloei Saboe Gorontalo Regional General Hospital indicates the absence of a significant difference between the survival curves of working patients and non-working patients (p-value 0.3193) (22).

Within the graphical representation, one can observe a gradual decline in the survival function at each temporal juncture, signifying that as the duration of pulmonary tuberculosis affliction prolongs, the resilience for survival diminishes correspondingly (23). Additionally, the outcomes of the investigation reveal that among the 21 individuals undergoing an event (treatment failure/death), 52.4% exhibited a concurrent status of hypertension.

Following the study by Briliant & Kurniawan, which delved into the determinants impacting the recovery duration in individuals with Tuberculosis, the research outcomes reveal various factors that influence the recovery period for pulmonary tuberculosis patients. These factors encompass gender, patient age, complications arising from other illnesses, including a history of hypertension, educational background, and occupation (24). Additional research findings similarly highlight a noteworthy correlation between hypertension and the occurrence of pulmonary Tuberculosis (25).

This study confirms that hypertension is a significant predictor of TB treatment failure. The absence of significant associations for age and occupation may be due to confounding factors such as medication adherence, nutritional status, or socioeconomic conditions, which were not explicitly controlled in this study.

Previous studies have reported varying impacts of age on TB survival, with some suggesting that older patients have higher mortality due to weakened immune responses. However, our findings indicate that within the study population, age alone did not determine treatment failure. This discrepancy highlights the need for further research exploring interactions between age, comorbidities, and socioeconomic status (19).

From a public health perspective, integrating hypertension management into TB treatment programs could enhance patient survival. International studies have also identified similar trends, reinforcing the need for a more holistic approach to TB care. For instance, a study in Liberia found that TB patients with hypertension had worse treatment outcomes, supporting the argument that comorbidity management should be prioritized in TB control policies (12).

These findings highlight the importance of tailored interventions for TB patients with hypertension. For healthcare providers, routine screening and monitoring of hypertension in TB patients should be integrated into standard care, including early detection and aggressive hypertension management to improve treatment adherence and outcomes. Meanwhile, for policymakers, national TB control programs should incorporate guidelines addressing comorbid conditions, particularly hypertension, into their strategies. Expanding access to integrated TB-hypertension management services in primary healthcare facilities has the potential to significantly improve patient survival.

This research still has several limitations. Firstly, it relies solely on secondary data. Secondly, the number of independent variables under investigation is limited, comprising only three. Thirdly, the sample size is relatively small, potentially influencing the generalizability of the research findings.

CONCLUSION

This study highlights hypertension as a critical factor affecting TB treatment outcomes. Health centers should integrate hypertension screening and management into TB treatment protocols to improve survival rates. Future

research should explore additional comorbidities and behavioral factors influencing TB treatment success to develop more comprehensive intervention strategies.

AUTHOR'S CONTRIBUTION STATEMENT

ZAA was responsible for the conception and design of the study, analysis and interpretation of results, and manuscript preparation. SH was responsible for the conception and design of the study. NHN was responsible for the design of the study, analysis and interpretation of results. SNM was responsible for the interpretation of the results. MA was responsible for the data collection

CONFLICTS OF INTEREST

All authors declare no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors state that the primary scientific substance of this article-including concepts, data analysis, interpretation,and conclucions-was neither produced nor composed using generative AI technology. Any AI-based technology used here is restricted to helping with grammar, spelling and sentence structure; it has no bearing on the writing's content or scientific value.

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