



Comparative Economic Burden of Tuberculosis Patients with and Without Diabetes Mellitus in Kupang City, Indonesia: A Comparative Cross-Sectional Study

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ABSTRACT

Background: Tuberculosis and diabetes mellitus are major public health problems with a well-recognized bidirectional relationship. Diabetes mellitus increases the risk of active tuberculosis, while tuberculosis may worsen glycemic control. This comorbidity may also increase household economic burden through higher non-medical expenses, productivity loss, and catastrophic health expenditure. Evidence comparing the economic burden of tuberculosis patients with and without diabetes mellitus in Kupang City remains limited.

Objective: To compare the economic burden between tuberculosis patients without diabetes mellitus and tuberculosis patients with diabetes mellitus in Kupang City, Indonesia, in 2025.

Methods: This comparative cross-sectional study included 86 respondents, consisting of 43 tuberculosis patients without diabetes mellitus and 43 tuberculosis patients with diabetes mellitus who were receiving outpatient treatment at 10 primary health centers in Kupang City.

Results: A significant difference in economic burden was observed between the two groups. The median total cost among tuberculosis patients without diabetes mellitus was IDR 255,000, whereas the median total cost among tuberculosis patients with diabetes mellitus was IDR 850,000. Direct non-medical costs and indirect costs were also higher in the tuberculosis-diabetes mellitus group. Catastrophic costs were significantly more frequent in the TB-DM group than in the TB non-DM group (44.2% vs. 20.9%; $p = 0.021$).

Conclusion: Diabetes mellitus significantly increases the economic burden among tuberculosis patients. Compared with tuberculosis patients without diabetes mellitus, those with tuberculosis and diabetes mellitus incur higher total costs, greater non-medical expenditures, and higher indirect costs. These findings support the need for integrated tuberculosis-diabetes services and stronger financial protection strategies for vulnerable patients.

KEYWORDS: Catastrophic Health Expenditure, Comorbidity, Diabetes Mellitus, Economic Burden, Indonesia, Tuberculosis

INTRODUCTION

Tuberculosis remains a major global public health challenge despite the availability of effective diagnostic and treatment strategies. The World Health Organization reported that tuberculosis continues to impose a substantial burden worldwide, and around half of households affected by tuberculosis still experience catastrophic total costs related to the disease.¹ In Indonesia, the burden remains high and relatively static; in 2023, the estimated incidence reached 387 cases per 100,000 population, equivalent to approximately 1.09 million cases.²



At the same time, diabetes mellitus has emerged as an increasingly important public health concern in Indonesia. National survey analysis showed that diabetes prevalence increased from 10.7% in 2013 to 11.8% in 2018 and remained high at 11.3% in 2023.³ The convergence of tuberculosis and diabetes is particularly important because the relationship is bidirectional and clinically consequential. Diabetes mellitus increases the risk of active tuberculosis, while tuberculosis may worsen glycemic control and complicate disease management.^{4,5} This overlap is therefore not only a clinical issue but also a health systems and socioeconomic problem, particularly in settings with persistent tuberculosis transmission and constrained household resources.^{1,4}

The economic dimension of tuberculosis-diabetes comorbidity deserves specific attention. The End TB Strategy explicitly identifies the elimination of catastrophic costs among tuberculosis-affected households as a core target, with catastrophic cost commonly defined as total tuberculosis-related costs exceeding 20% of annual household income.⁶ Existing evidence suggests that comorbid diabetes may intensify this burden through additional health service use, transport expenses, productivity loss, and repeated facility visits. In western India, coexisting diabetes nearly doubled the median total costs incurred by patients with tuberculosis.⁷ In the Philippines, patients with tuberculosis and diabetes had more frequent treatment-related visits than those with tuberculosis alone, indicating a plausible pathway toward higher patient-side expenditure and household burden.⁸

However, comparative evidence on the economic burden of tuberculosis with and without diabetes mellitus in subnational Indonesian settings remains limited. This gap is important because local health system organization, access barriers, transport requirements, and household socioeconomic conditions may substantially influence the magnitude and pattern of patient costs. Against this background, the present study aimed to compare the economic burden between tuberculosis patients without diabetes mellitus and tuberculosis patients with diabetes mellitus in Kupang City, Indonesia.

METHODS

Study design and setting

This study employed an analytic observational comparative cross-sectional design to compare the economic burden between tuberculosis patients without diabetes mellitus and those with tuberculosis-diabetes mellitus comorbidity. The study was conducted in 10 primary health centers in Kupang City, East Nusa Tenggara, Indonesia, namely Alak, Bakunase, Kota Kupang, Oebobo, Oepoi, Oesapa, Pasir Panjang, Penfui, Sikumana, and Penkase. Data collection was carried out from June to August 2025.

Study population and sample

The study population consisted of outpatients diagnosed with tuberculosis who were receiving treatment at primary health centers in Kupang City. Participants were classified into two groups: tuberculosis patients without diabetes mellitus and tuberculosis patients with diabetes mellitus comorbidity. The sample size for the tuberculosis-diabetes mellitus group was calculated from a source population of 75 patients using the Slovin formula with a 10% margin of error, resulting in a minimum sample of 42.8 participants, which was rounded to 43. To ensure comparability between groups, a 1:1 ratio was applied, yielding a total sample of 86 participants, comprising 43 tuberculosis patients without diabetes mellitus and 43 tuberculosis patients with diabetes mellitus. Sampling was conducted using a stratified random sampling approach. The number of participants recruited from each primary health center was proportionally allocated according to the number of eligible tuberculosis-diabetes mellitus patients registered in each facility.

Participant eligibility

The TB-DM group included patients aged more than 18 years with confirmed tuberculosis and diabetes mellitus who were undergoing outpatient treatment at primary health centers in Kupang City and agreed to participate by signing written informed consent. The TB non-DM group included patients aged more than 18 years with confirmed tuberculosis and no diagnosis of diabetes mellitus based on laboratory findings or medical records, who were receiving treatment in the same setting and also provided written informed consent. Patients were excluded if they had drug-resistant tuberculosis, tuberculosis-human immunodeficiency virus coinfection, were hospitalized during the data collection period, or were not residing in Kupang City at the time of the study.

Study variables

The primary outcome of this study was economic burden. Economic burden was defined as the total financial burden borne by patients and their households during tuberculosis treatment, including direct non-medical costs and indirect costs. The independent variable was patient group, categorized as tuberculosis without diabetes mellitus and tuberculosis with diabetes mellitus. Direct non-medical costs included out-of-pocket expenses related to transportation, food and drink during healthcare visits, caregiver-related



expenses, and supplement costs incurred throughout the treatment period. Indirect costs referred to productivity losses experienced by patients or their households due to illness and treatment, including income loss, reduced working time, or inability to perform usual economic activities. Total cost was calculated as the sum of direct non-medical costs and indirect costs. Catastrophic cost was defined as total tuberculosis-related expenditure exceeding 20% of household income.

Data collection procedures

Data were collected through structured face-to-face interviews using a tuberculosis patient cost questionnaire. Prior to data collection, the researchers coordinated with tuberculosis program officers at each participating primary health center to identify eligible participants based on the predefined inclusion and exclusion criteria. After eligible participants were identified, the researchers explained the purpose of the study and obtained written informed consent. Interviews were then conducted to collect information on sociodemographic characteristics, household income, treatment-related expenditures, and productivity losses. Tuberculosis diagnosis and diabetes mellitus status were verified using medical records available at the respective health facilities.

Operational definitions

Tuberculosis without diabetes mellitus referred to patients with confirmed tuberculosis who had no diagnosis of diabetes mellitus based on medical records or laboratory findings. Tuberculosis-diabetes mellitus referred to patients with confirmed tuberculosis who also had a documented diagnosis of diabetes mellitus. Direct non-medical cost referred to all non-medical expenditures paid by the patient or household in relation to accessing and undergoing treatment, including transportation, meals, caregiver expenses, and supplements. Indirect cost referred to the monetary value of lost productivity attributable to illness and treatment, including lost wages or reduced income. Total economic burden referred to the sum of direct non-medical cost and indirect cost incurred during the treatment period. Catastrophic cost referred to a condition in which total tuberculosis-related expenditure exceeded 20% of household income.

Data management and statistical analysis

All collected data were checked for completeness, coded, and entered into a database for analysis. Descriptive statistics were used to summarize participant characteristics and study variables. Categorical variables were presented as frequencies and percentages, while numerical variables were summarized using means or other appropriate measures of central tendency and dispersion, depending on the distribution of the data. Normality of numerical variables was assessed using the Shapiro-Wilk test. Because the distributions of direct non-medical costs, indirect costs, and total costs were not normally distributed, comparisons between the two study groups were performed using the Mann-Whitney U test. The proportion of catastrophic costs between the two groups was compared using the Pearson Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Ethical considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee of the Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, Indonesia, under Reference No. 53/UN15.21/KEPK-FKKH/2025. The study was reviewed through an expedited procedure and was approved on August 6, 2025. Written informed consent was obtained from all participants prior to enrollment. Confidentiality was maintained by anonymizing participant data and restricting data access to authorized research personnel only.

RESULTS

A total of 86 participants were included in the analysis, comprising 43 patients with tuberculosis and diabetes mellitus (TB-DM) and 43 patients with tuberculosis without diabetes mellitus (TB non-DM).

The largest age group was 51–60 years (30/86), followed by ≥ 61 years (28/86) and 41–50 years (26/86). Only two participants were aged 31–40 years, and none were aged 18–30 years. Male participants were more common than female participants (50/86 vs. 36/86). Overall, most participants had a normal body mass index (66/86), had completed senior high school (32/86), and were employed (60/86). The distribution of sex and employment status was identical across groups, whereas overweight status was more frequent in the TB-DM group.



Table 1. Baseline characteristics of study participants

Characteristic	Category	TB-DM (n=43)	TB non-DM (n=43)	Total (n=86)
Age (years)	18–30	0	0	0
	31–40	0	2	2
	41–50	13	13	26
	51–60	15	15	30
	≥61	15	13	28
Sex	Male	25	25	50
	Female	18	18	36
Body mass index	Normal	28	38	66
	Overweight	15	5	20
Education level	Primary school	6	9	15
	Junior high school	10	8	18
	Senior high school	17	15	32
	Bachelor’s degree	10	11	21
Employment status	Employed	30	30	60
	Unemployed	13	13	26

A total of 28 participants (32.6%) experienced catastrophic costs during treatment, whereas 58 participants (67.4%) did not. Catastrophic costs were more frequent in the TB-DM group than in the TB non-DM group (44.2% vs. 20.9%). This difference was statistically significant based on the Pearson Chi-square test ($p = 0.021$).

Table 2. Distribution of catastrophic costs by study group

Study group	Non-catastrophic, n (%)	Catastrophic, n (%)	Total	p-value
TB-DM	24 (55.8)	19 (44.2)	43	0.021
TB non-DM	34 (79.1)	9 (20.9)	43	
Total	58 (67.4)	28 (32.6)	86	

The Shapiro-Wilk test indicated that direct non-medical costs, indirect costs, and total costs were not normally distributed. Therefore, comparisons between groups were performed using the Mann-Whitney U test.

Patients in the TB-DM group incurred higher costs across all measured components. The median total cost was IDR 850,000 in the TB-DM group and IDR 255,000 in the TB non-DM group. Mean total costs were IDR 1,081,000 and IDR 299,900, respectively. Direct non-medical costs were also higher in the TB-DM group, with a median of IDR 188,000 compared with IDR 95,000 in the TB non-DM group. Likewise, the median indirect cost was substantially higher in the TB-DM group than in the TB non-DM group (IDR 470,000 vs. IDR 88,000).

Statistically significant differences were observed between the two groups for total cost, direct non-medical cost, and indirect cost (all $p < 0.001$).



Table 3. Comparison of treatment-related costs between groups

Variable	TB-DM (n=43) Median (Mean)	Min–Max	TB non-DM (n=43) Median (Mean)	Min–Max	p-value
Total cost (IDR)	850,000 (1,081,000)	325,000–2,300,000	255,000 (299,900)	112,000–580,000	<0.001
Direct non-medical cost (IDR)	188,000 (190,605)	98,000–285,000	95,000 (99,407)	48,000–160,000	<0.001
Indirect cost (IDR)	470,000 (565,930)	0–1,420,000	88,000 (147,651)	0–500,000	<0.001

Overall, the TB-DM group demonstrated higher total costs, higher direct non-medical costs, and higher indirect costs than the TB non-DM group. Catastrophic costs were also significantly more frequent in the TB-DM group than in the TB non-DM group (44.2% vs. 20.9%; $p = 0.021$).

DISCUSSION

This study showed that tuberculosis patients with diabetes mellitus (TB-DM) experienced a markedly greater economic burden than tuberculosis patients without diabetes mellitus. The difference was evident across all cost domains assessed in this study, including direct non-medical costs, indirect costs, and total costs. These findings are consistent with the broader literature showing that diabetes mellitus worsens tuberculosis-related vulnerability, not only clinically but also economically, by increasing the complexity of care and the likelihood of adverse treatment trajectories.^{9–11}

The higher direct non-medical costs observed in the TB-DM group are plausible and clinically coherent. Patients with TB-DM commonly require more frequent health service contacts, additional laboratory monitoring, stricter follow-up, and more sustained engagement with health facilities than patients with tuberculosis alone. In practical terms, this translates into repeated transportation costs, meal expenses during visits, and additional out-of-pocket spending related to accompanying family members or supportive care. Previous evidence has shown that diabetes can worsen tuberculosis treatment outcomes and is associated with more complicated management, which provides a reasonable explanation for why patient-side expenditures may increase in this group.^{9,11}

The difference in indirect costs is particularly important. In this study, indirect costs constituted a substantial component of the total economic burden, especially among TB-DM patients. This pattern is not incidental. A large body of evidence has shown that income loss and productivity reduction often represent the largest share of tuberculosis-related costs at household level.^{12,13} Diabetes mellitus likely amplifies this effect because it may reduce physical resilience, prolong functional impairment, and increase time away from work or normal income-generating activity. The result is a compounded economic penalty: patients not only spend more to obtain care, but also lose more productive capacity while undergoing treatment.^{14,15}

The difference in catastrophic costs between groups is also important. In this study, catastrophic costs were significantly more frequent in the TB-DM group than in the TB non-DM group (44.2% vs. 20.9%; $p = 0.021$), indicating greater household financial vulnerability among patients with tuberculosis-diabetes mellitus comorbidity. This is consistent with prior tuberculosis cost research showing that catastrophic expenditure remains common even in settings where tuberculosis diagnosis and treatment are nominally free.^{12–15} Free medical treatment does not eliminate transport costs, food costs, time costs, or income loss. In Indonesia, previous work has already shown that tuberculosis-affected households remain at risk of catastrophic total costs despite the implementation of universal health coverage.¹⁴

The present study is also broadly aligned with findings from other countries. In western India, Rupani and Vyas reported considerable costs among patients with TB-DM and highlighted the operational burden associated with this comorbidity.¹⁷ In the Philippines, Yamanaka and colleagues found that patients with co-morbid tuberculosis and diabetes and their households incurred substantial costs before and after diagnosis, reinforcing the argument that TB-DM is associated with an added household financial burden.¹⁸ Evidence from the United States likewise indicates that diabetes among adults with tuberculosis is associated with poorer outcomes and more demanding care trajectories, which supports the biological and health-service logic behind higher costs in TB-DM populations.²⁴ Taken together, these studies support the interpretation that the excess burden observed in Kupang is not an isolated anomaly, but part of a reproducible pattern across settings.



From a health systems perspective, these results support the need for stronger integration of tuberculosis and diabetes services. Fragmented care pathways are inefficient for patients with dual disease. Separate appointments, multiple queues, repeated clinical encounters, and uncoordinated monitoring can all increase non-medical costs and opportunity costs. Earlier policy and review literature has repeatedly argued for coordinated TB-DM responses, including bidirectional screening, integrated follow-up, and alignment of service delivery at facility level.¹⁹⁻²¹ The implication of the current findings is therefore straightforward: if health systems continue to treat tuberculosis and diabetes as parallel rather than linked conditions, patient costs will remain unnecessarily high.

The findings also have implications for financial protection policy. The traditional focus on medical cost coverage is insufficient. What this study shows, again, is that the burden lies heavily in non-medical spending and lost productivity. That is precisely why social protection has become central to the tuberculosis policy agenda. Evidence suggests that social protection interventions may improve tuberculosis treatment outcomes, and recent guidance has emphasized the need to combine health benefits with broader social support for tuberculosis-affected households.^{16,22,23} For TB-DM patients, this may include transport support, nutritional assistance, income replacement mechanisms, or employment-sensitive treatment arrangements. Without such measures, the strategy of offering “free treatment” remains economically incomplete.

This study has several strengths. It provides comparative evidence from primary care facilities in Kupang City, a setting in which local data on the economic burden of TB-DM are limited. It also assessed both direct non-medical and indirect costs, which is methodologically preferable to narrowly focusing on medical expenditure alone. That matters because the tuberculosis-poverty relationship is driven not only by healthcare spending, but also by broader socioeconomic constraints, including employment vulnerability, household poverty, and structural barriers to access.²⁵⁻²⁷

Several limitations must also be stated explicitly. First, the study was conducted in a single city with a relatively small sample size, which limits external generalizability. Second, the cost estimates relied on participant recall and are therefore vulnerable to recall error. Third, because this was a comparative cross-sectional study, the findings do not support strong causal inference, and residual confounding remains possible. Variables such as severity of diabetes, glycemic control, treatment phase, distance to health facilities, and baseline household economic status may have influenced cost differences but were not fully modeled.

Despite these limitations, the overall interpretation remains robust. Tuberculosis patients with diabetes mellitus in this study bore a consistently greater economic burden than those without diabetes mellitus. The burden was not confined to one cost category, but extended across direct non-medical expenses, productivity loss, and total cost. In policy terms, this suggests that effective TB-DM management requires not only clinical integration, but also deliberate financial-risk protection. That conclusion is fully compatible with the End TB agenda, which places the elimination of catastrophic costs among tuberculosis-affected households at the center of strategy, while also recognizing the broader role of social determinants and social protection in tuberculosis control.²⁸⁻²⁹ Broader evidence from Indonesia and other countries similarly shows that tuberculosis-related income loss can become severe, especially when the affected patient is economically productive or serves as the household breadwinner.³⁰

CONCLUSION

Tuberculosis patients with diabetes mellitus in this study experienced a substantially greater economic burden compared with tuberculosis patients without diabetes mellitus. This difference was consistently observed across total costs, direct non-medical costs, and indirect costs. In addition, catastrophic costs were significantly more frequent among patients with tuberculosis-diabetes mellitus comorbidity.

These findings indicate that diabetes mellitus contributes to increased financial vulnerability among tuberculosis-affected households. The economic burden was driven not only by out-of-pocket expenses related to accessing care but also by productivity loss, highlighting the limitations of approaches that focus solely on medical cost coverage.

From a policy perspective, the results support the need for integrated tuberculosis and diabetes management at the primary care level, alongside strengthened financial protection strategies that address both non-medical costs and income loss. Without such measures, patients with tuberculosis-diabetes mellitus remain at increased risk of economic hardship during treatment.



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