Factors Delaying Treatment of Drug-Sensitive TB Patients in South Sulawesi Province, Indonesia: A Retrospective Observational Study

Bustanul Arifin[1,2*], Nina Fitriyah[1], Jamaluddin Madolangan[3,4], Latifah Mahaya Sarifah[5], Akhmad Ardiansyah[6], Muhammad Syahrir[7], Sylmina D. Alkaff[8]

[1] Department of Pharmacy, Faculty of Pharmacy, Hasanuddin University, Makassar, South Sulawesi, Indonesia.
[2] Department of Health Sciences, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands.
[3] Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia.
[4] Department of Pulmonology, Labuang Baji Regional Hospital, South Sulawesi, Indonesia.
[5] Department of Pharmacy, Labuang Baji Regional Hospital, South Sulawesi, Indonesia.
[6] Department of Pharmacy, Sembilanbelas November University of Kolaka, Southeast Sulawesi, Indonesia.
[7] Faculty of Public Health, Tompotika University of Luwuk, Central Sulawesi, Indonesia.
[8] Robotics and Artificial Intelligence, Department of Engineering, Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga, Surabaya, Indonesia.
b.arifin@umcg.nl; bustanul.arifin.ury@unhas.ac.id

Abstract. This study analyzed factors associated with delayed treatment initiation among patients with drug-sensitive tuberculosis (TB) in South Sulawesi, Indonesia. A retrospective observational study was conducted using medical records of drug-sensitive TB patients registered between January and December 2023 at Labuang Baji Hospital, a TB referral center, and the Makassar Health Office. Delayed treatment initiation was defined as starting anti-tuberculosis therapy more than 15 days after diagnosis. Binary logistic regression identified factors associated with treatment delay, reported as odds ratios and adjusted odds ratios. A total of 8,258 patients were included. Most delays occurred among men (59.2%) and patients aged 18–30 years (24.3%). Delays of more than 30 days were common and were associated with older age, comorbidities, lack of insurance, referral from other facilities, and pulmonary TB. Strengthening local services, referral systems, and education for vulnerable groups is essential to reduce treatment delays and improve TB care outcomes locally.

Keywords: Health Care Factors, Indonesia, Patient Factors, Treatment Delay, Tuberculosis.

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1 Introduction

Tuberculosis (TB) remains a major global public health problem and is one of the leading causes of death from infectious diseases, particularly in developing countries [1,2]. According to the World Health Organization (WHO), an estimated 10.4 million new TB cases occurred globally, with substantial morbidity and mortality across all age groups [2]. Indonesia is among the countries with the highest TB burden worldwide, ranking third after India and China. In 2021, the estimated TB incidence in Indonesia reached 969,000 cases (354 per 100,000 population), indicating that TB continues to pose a substantial challenge to the national healthcare system [3].

Timely diagnosis and initiation of anti-tuberculosis treatment are essential components of the WHO End TB Strategy, which aims to substantially reduce TB incidence and mortality by 2035 [4]. To achieve this goal, the WHO emphasizes the need to avoid delays in TB diagnosis and treatment. Delays in TB diagnosis and treatment increase the risk of disease progression, ongoing community transmission, and the development of drug resistance [5,6]. Previous studies have categorized delays in TB treatment initiation can be caused by patient delays (delayed symptoms), healthcare provider delays (failure of the health system to diagnose TB), or total treatment delays (delays due to late presentation and diagnosis of TB, including living in rural areas) [7-10]. Patient delay refers to the interval between symptom onset and the first healthcare consultation, whereas health system delay describes the period from initial consultation to treatment initiation. Several factors have been reported to contribute to delayed treatment initiation, including older age, limited mobility, comorbidities, low socioeconomic status, inadequate knowledge of TB, stigma, occupational constraints, and inefficient referral systems [12–14]. However, evidence regarding the factors associated with delayed treatment initiation remains inconsistent across settings, particularly in the high-burden regions of Indonesia.

Despite the substantial TB burden in South Sulawesi Province, few studies have specifically evaluated treatment initiation delays and associated factors among patients with drug-sensitive TB in this setting. Understanding these factors is important for improving early treatment initiation and optimizing TB control programs in referral health care systems. Therefore, this study aimed to identify the sociodemographic, clinical, and healthcare-related factors associated with delayed initiation of treatment among patients with drug-sensitive tuberculosis in South Sulawesi Province, Indonesia.

2 Methods

2.1 Study design

This retrospective observational study analyzed routinely collected medical record data from patients with drug-sensitive tuberculosis registered between January and December 2023. The study was conducted in South Sulawesi Province, Indonesia, using data obtained from the Labuang Baji Hospital and Makassar City Health Office. Labuang Baji Hospital serves as a TB referral hospital, while the Makassar City Health

Office manages programmatic TB registry data from public health facilities in Makassar City. Therefore, the dataset included hospital-based referral cases and broader TB program records reported through the city's health system. Data extraction and analysis will be conducted between January and July 2024. The referral structure involved patients diagnosed or managed at primary healthcare facilities who were subsequently referred to Labuang Baji Hospital when specialist evaluation or hospital-based TB management was required. Ethical approval for this retrospective study using anonymized secondary data was granted by the Public Health Research Ethics Committee of Hasanuddin University (No. 4632/UN4.14.1/TP.01.02/2023). Because the data consisted solely of de-identified medical records and government health reports, the requirement for informed consent was waived by the Institutional Review Board. All data were handled confidentially, and personal identifiers were removed before the analysis to maintain patient privacy.

2.2 Data collection procedure

Patient data were collected retrospectively from the Tuberculosis Information System (SITB) and were cross-checked with hospital medical records and the patient database maintained by the South Sulawesi Provincial Health Office. Eligible records were those of patients aged >18 years, diagnosed with drug-sensitive tuberculosis (DS-TB), registered in the participating facilities between January and December 2023, and had complete SITB records, including diagnosis date, treatment initiation date, and key demographic and clinical variables. Records were excluded if essential information was incomplete, particularly missing treatment initiation dates, diagnosis dates, or key demographic variables that were required for the analysis. To ensure data accuracy, hospital medical records were compared with the SITB and Provincial Health Office records. Major discrepancies and incomplete records were excluded from the final dataset. Minor inconsistencies were resolved by verifying with hospital data officers or by checking duplicate entries in parallel reporting systems when available. The data extraction process included demographic characteristics, diagnostic information, treatment history, dates of diagnosis and treatment initiation, referral sources, and healthcare facility information. Data were extracted using standardized abstraction forms by trained personnel. A subset of records was independently verified to ensure accuracy and consistency of the data. All eligible patient records that met the inclusion criteria during the study period were included in the analysis. The Provincial Health Office database was used to verify the consistency between facility-level records and government TB program data. The total number of records screened, excluded, and included in the final analysis should be reported in the Results section to provide a clear participant flow, consistent with the STROBE recommendations. Several potential sources of bias were identified. Selection bias may have occurred because of the use of facility-based registry data. Information bias may have arisen from incomplete or inaccurately documented medical records. Residual confounding may persist due to unmeasured socioeconomic and healthcare access factors.

2.3 Data analysis

We used binomial logistic regression analysis to evaluate the factors influencing treatment delays in patients with TB. We selected treatment delays as the dependent variable in this analysis using binary categories: 0 for not late and 1 for late. Patients were categorized as having "late" treatment if the initiation of anti-TB therapy occurred more than 14 days after diagnosis, while those who began treatment within 14 days were classified as "not late." The independent variables analyzed included several potential risk factors, patient sociodemographic data, economic status, distance to health facilities, and clinical information. These factors were selected based on their relevance to the accessibility of health services and patient compliance with TB treatment. We used two main parameters, the Odds Ratio (OR) and adjusted odds ratio (aOR), to measure the relationship between these risk factors and treatment delays. Variables with $p<0.25$ in the bivariate analyses were entered into multivariable logistic regression models. Multicollinearity was assessed prior to modelling, and adjusted odds ratios (aORs) with 95 % confidence intervals were reported. The odds ratio (OR) estimates the direct relationship between each independent variable and treatment delays without considering the effects of other variables, providing an initial overview of the factors influencing delays. The adjusted odds ratio (OR) was used to calculate the relationship after controlling for the influence of other variables, resulting in a more controlled and accurate analysis. This approach helps identify significant factors that can be targeted for interventions to reduce treatment delays in patients with TB.

3 Results

Patients in rural districts presented both challenges and opportunities for improving health services, especially in the 18 years – 30 years age group (21.8 %), which was predominantly male (60 %). The majority of the participants were not formally employed, including housewives, the unemployed, and those with unknown status (59.6 %). Most patients were from rural areas (65.2 %), had insurance (97.2 %), and had comorbidities (6.4 %). However, pulmonary tuberculosis (99.8 %) remains a concern. A large number of cases (79.9 %) and referrals (66.7 %) and cases of delayed treatment indicated obstacles in accessing and preparing local health facilities. The low relapse rate (4.1 %) indicates the effectiveness of the treatment; however, prevention must be prioritized for younger age groups. By strengthening health facilities at the local level, optimizing the referral system, and providing preventive education on healthy lifestyles, especially for men of productive age, these challenges can be transformed into opportunities to create more inclusive and efficient health services (Table 1).

Table 1. Participant Characteristics (n=8258)

Participant characteristics	n (%)	Delay time		
		1-14 days	15-30 days	>30 days
Age (years)				
18-30	1798 (21.8)	1701	43	54
31-40	1308 (15.8)	1237	37	34
41-50	1677 (20.3)	1575	43	59
51-60	1790 (21.7)	1673	54	63
> 60	1685 (20.4)	1537	86	62
Gender				
Male	4957 (60)	4639	155	163
Female	3301 (40)	3086	106	109
Occupation				
Unemployed	695 (8.4)	664	14	17
Employed	3333 (40.4)	3117	108	108
Housewife	1717 (20.8)	1613	49	55
Unknown	2513 (30.4)	2329	92	92
Regency				
Rural	5384 (65.2)	4998	192	194
Urban	2874 (34.8)	2725	71	78
Insurance				
Uninsured	228 (2.8)	215	2	11
Insured	8030 (97.2)	7508	261	261
Comorbidity				
None	1720 (20.8)	1641	39	40
Diabetes Mellitus	496 (6)	449	28	19
HIV	35 (0.4)	15	9	11
HIV and DM	1 (0.1)	0	0	1
Unknown	6006 (72.7)	5618	187	201
Contact Investigation				
No	4971 (60.2)	4596	174	201
Yes	3287 (39.8)	3127	89	71
TB Classification				
Extrapulmonary TB	13 (0.2)	9	1	3
Pulmonary TB	8245 (99.8)	7714	262	269
TB History				
New Case	6596 (79.9)	6185	195	216
Relapsed Case	340 (4.1)	312	12	16
Treatment Failure	156 (1.9)	141	12	3
Unknown	1166 (14.1)	1085	44	37
Referral				
No	2752 (33.3)	2549	106	97
Yes	5506 (66.7)	5174	157	175

Participant characteristics	n (%)	Delay time		
		1-14 days	15-30 days	>30 days
TCM Examination				
Rif Indet	81 (1)	69	6	6
Rif Sen	8177 (99)	7654	257	266

The relationship between patient characteristics and the potential for delay in TB treatment showed variations in risk based on the 1-to 30-day and >30-day delay groups, with several significant factors. Patients aged 41–60 years had a 1-fold greater risk of treatment delay, even after considering other factors. Sex also affected delays, with female patients having a 1-fold greater risk than male patients. In addition, participants living in rural areas had significantly higher odds of experiencing treatment delays than those in urban areas, indicating that rural residence is a risk factor; however, after considering other factors, the risk increased by 1.51 times. Compared with participants without comorbidities, those with HIV had a markedly higher risk of experiencing treatment delays, and those with diabetes mellitus also showed a significantly increased risk, indicating that both HIV and diabetes are predictors of delayed tuberculosis treatment. Participants who did not undergo contact investigation had significantly higher odds of experiencing delayed tuberculosis treatment than those who did, highlighting the critical role of contact investigation in promoting timely TB care in the community. Participants with extrapulmonary TB had significantly higher odds of experiencing treatment delays than those with pulmonary TB, suggesting that atypical or less symptomatic presentations may contribute to delayed diagnosis and therapy initiation (Table 2).

Table 2. Factors influencing delay time of 1-30 days (n=7986) and >30 days (n=272) (Binomial Logistic Regression)

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		≤30	>30		
Age (Years)					
18–30	1798 (21.8)	1744	54	REF	-
31–40	1308 (15.8)	1274	34	0.86 (0.56–1.33)	-
41–50	1677 (20.3)	1618	59	1.18 (0.81–1.71)	-
51–60	1790 (21.7)	1727	63	1.18 (0.81–1.71)	-
> 60	1685 (20.4)	1623	62	1.23 (0.85–1.79)	-
Sex					
Female	3301 (40)	3192	109	REF	-
Male	4957 (60)	4794	163	0.99 (0.78–1.28)	-
Occupation					

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		≤30	>30		
Unemployed	695 (8.4)	678	17	REF	-
Employed	3333 (40.4)	3225	108	1.34 (0.8–2.24)	-
Housewife	1717 (20.8)	1662	55	1.32 (0.76–2.29)	-
Unknown	2513 (30.4)	2421	92	1.52 (0.9–2.56)	-
District					
Urban	2874 (34.8)	2796	78	REF	REF
Rural	5384 (65.2)	5190	194	1.34 (1.03–1.75)*	1.51 (1.14–2.0)*
Insurance					
Insured	8030 (97.2)	7769	261	REF	-
Uninsured	228 (2.8)	217	11	1.51 (0.81–2.8)	-
Comorbidity					
None	1720 (20.8)	1680	40	REF	REF
Diabetes Mellitus	496 (6)	477	19	1.67 (0.96–2.92)	1.79 (1.02–3.14)*
HIV	35 (0.4)	24	11	19.25 (8.83–41.97)**	23.62 (10.45–53.37)**
HIV and DM	1 (0.1)	0	1	N/A	N/A
Unknown	6006 (72.7)	5805	201	1.45 (1.03–2.05)*	1.66 (1.17–2.37)*
Contact Investigation					
Yes	3287 (39.8)	3216	71	REF	REF
No	4971 (60.2)	4770	201	1.91 (1.45–2.51)**	1.9 (1.44–2.51)**
TB Classification					
Pulmonary TB	8245 (99.8)	7976	269	REF	REF
Extrapulmonary TB	13 (0.2)	10	3	8.9 (2.43–32.51)**	7.35 (1.73–31.18)*
TB History					
New Case	6596 (79.9)	6380	216	REF	-
Relapsed Case	340 (4.1)	324	16	1.46 (0.87–2.45)	-
Treatment Failure	156 (1.9)	153	3	0.58 (0.18–1.83)	-
Unknown	1166 (14.1)	1129	37	0.97 (0.68–1.38)	-
Referral					
No	2752 (33.3)	2655	97	REF	-

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		≤30	>30		
Yes	5506 (66.7)	5331	175	1.11 (0.87–1.43)	-
TCM Examination					
Rif Sen.	8177 (99)	7911	266	REF	REF
Rif Indet	81 (1)	75	6	2.38 (1.03–5.51)*	2.56 (1.08–6.03)

Note: "REF" indicates the reference category used in binary logistic regression analysis; "Rif Sen" Rifampicin Sensitive; "Rif Indet" Rifampicin Indeterminate; * p-value <0.05; ** p-value <0.001.

TB treatment delays in the 1 – 14 days and >14 days groups indicated risks based on demographic and clinical factors. In this age group, participants aged >60 years had significantly higher odds of experiencing delayed TB treatment after adjustment, indicating that older adults are more vulnerable to delays, possibly due to factors such as comorbidities, limited mobility, and delayed health-seeking behavior.

Participants residing in rural areas had significantly higher odds of experiencing delayed TB treatment than those in urban settings, suggesting that geographical and infrastructural barriers in rural areas contribute to treatment delay. Participants with diabetes mellitus had more than twice the odds of experiencing delayed TB treatment compared to those without comorbidities, while those with HIV faced a markedly higher risk, indicating that both conditions are strong predictors of treatment delay in patients with TB. Participants who did not undergo contact investigation had significantly higher odds of delayed TB treatment, emphasizing the importance of contact tracing to facilitate timely care. Additionally, patients with extrapulmonary TB are substantially more likely to experience treatment delays than those with pulmonary TB, likely due to diagnostic challenges and atypical clinical presentations. Participants with indeterminate rifampicin results from TCM examination had significantly higher odds of experiencing delayed TB treatment than those with rifampicin-sensitive results, suggesting that diagnostic uncertainty contributes to delays in the initiation of appropriate therapy (Table 3).

Table 3. Factors influencing delay time of 1-14 days (n=7723) and >15 days (n=535) (Binomial Logistic Regression)

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		1–14	>14		
Age (Years)					
18–30	1798 (21.8)	1701	97	REF	REF
31–40	1308 (15.8)	1237	71	0.59 (0.45–0.77)**	0.95 (0.68–1.32)
41–50	1677 (20.3)	1575	102	0.6 (0.45–0.8)**	1.11 (0.82–1.5)

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		1–14	>14		
51–60	1790 (21.7)	1673	117	0.67 (0.52–0.87)*	1.17 (0.88–1.58)
> 60	1685 (20.4)	1537	148	0.73 (0.56–0.94)**	1.67 (1.26–2.2)**
Sex					
Female	3301 (40)	3086	215	REF	REF
Male	4957 (60)	4637	320	0.99 (0.83–1.19)	-
Occupation					
Unemployed	695 (8.4)	664	31	REF	REF
Employed	3333 (40.4)	3117	216	1.48 (1–2.18)*	1.37 (0.92–2.05)
Housewife	1717 (20.8)	1613	104	1.38 (0.92–2.08)	1.29 (0.84–1.99)
Unknown	2513 (30.4)	2329	184	1.69 (1.15–2.5)*	1.4 (0.9–2.19)
District					
Urban	2874 (34.8)	2725	149	REF	REF
Rural	5384 (65.2)	4998	386	1.41 (1.16–1.72)**	1.5 (1.23–1.84)**
Insurance					
Insured	8030 (97.2)	7508	522	REF	
Uninsured	228 (2.8)	215	13	1.15 (0.65–2.03)	
Comorbidity					
None	1720 (20.8)	1641	79	REF	REF
Diabetes Mellitus	496 (6)	449	47	2.17 (1.49–3.17)**	2.15 (1.46–3.16)**
HIV	35 (0.4)	15	20	27.70 (13.66–56.14)**	40.25 (19.33–83.84)**
HIV and DM	1 (0.1)	0	1	N/A	N/A
Unknown	6006 (72.7)	5618	388	1.44 (1.12–1.84)*	1.61 (1.25–2.08)**
Contact Investigation					
Yes	3287 (39.8)	3127	160	REF	REF
No	4971 (60.2)	4596	375	1.6 (1.32–1.93)**	1.6 (1.32–1.94)**
TB Classification					
Pulmonary TB	8245 (99.8)	7714	531	REF	REF
Extrapulmonary TB	13 (0.2)	9	4	6.46 (1.98–21.04)*	5.41 (1.46–20.02)*
TB History					

Characteristics	n (%)	Delay (days)		OR (95% CI)	AOR (95% CI)
		1–14	>14		
New Case	6596 (79.9)	6185	411	REF	REF
Relapsed Case	340 (4.1)	312	28	1.35 (0.91–2.01)	1.33 (0.88–2.02)
Treatment Failure	156 (1.9)	141	15	1.6 (0.93–2.75)	1.55 (0.89–2.7)
Unknown	1166 (14.1)	1085	81	1.12 (0.89–1.44)	1.01 (0.78–1.3)
Referral					
No	2752 (33.3)	2549	203	REF	REF
Yes	5506 (66.7)	5174	332	1.24 (1.04–1.49)*	1.22 (0.93–1.6)
TCM Examination					
Rif Sen.	8177 (99)	7654	523	REF	REF
Rif Indet	81 (1)	69	12	2.55 (1.37–4.73)*	2.7 (1.44–5.09)*

Note: "REF" indicates the reference category used in binary logistic regression analysis; "Rif Sen" Rifampicin Sensitive; "Rif Indet" Rifampicin Indeterminate; * p-value <0.05; ** p-value <0.001.

4 Discussion

We identified 8,258 drug-sensitive patients with TB in South Sulawesi between January 1 and December 31, 2020. Most patients begin treatment within 1–14 days of diagnosis. However, we identified that approximately 6.5 % of patients (n=535) experienced delays of more than 15 days, and another 3.3 % (n=272) experienced delays of more than 30 days. Our analysis revealed six factors that were significantly associated with an increased risk of treatment delays exceeding 30 days: (i) residing in a rural area, (ii) living with HIV (with or without diabetes), (iii) having extrapulmonary TB, (iv) having an indeterminate TCM test result (rifampicin indeterminate), (v) not undergoing contact investigation, and (vi) no record of comorbidity status in the patient data. These findings indicate that treatment delays are caused not only by the patient's clinical condition but also by geographical constraints, weaknesses in the medical record system, and inadequate follow-up efforts by healthcare professionals and facilities.

This is in line with a systematic review and meta-analysis conducted in low-and middle-income countries, which found that the average total delay in tuberculosis treatment was 30 days [15]. However, a previous study from Jakarta reported a waiting time lower than that in our study [16]. This suggests the possibility of variations in the causes of delays, such as access to health services, public awareness, and the efficiency of health systems in different regions. The shorter duration of delays observed in this study is likely due to several factors. The decentralization of health services facilitates increased community access to TB diagnostic and treatment facilities in the country. In addition, the active role of health extension workers in identifying suspected TB cases

and referring them to health facilities for microscopic examination of smears also contributes to accelerating the diagnosis and treatment [17,18].

We found that patients living in rural areas with greater distances from health facilities were one of the factors contributing to delays in initiating TB treatment. Two studies from Ethiopia consistently reported that patients with TB living >10 km from health facilities were more than twice as likely to experience delays than those living closer [19,20]. In our study, TB patients living in rural areas were also found to have an increased risk of treatment delays exceeding 30 days, with an adjusted odds ratio (AOR) of 1.51 (95 % CI: 1.14–2.0) compared to patients in urban areas. Additionally, limited diagnostic facilities and a shortage of healthcare workers in rural areas exacerbate this situation, as reported in a qualitative study in Ethiopia, which emphasized the importance of physical access to services as a key requirement for accelerating diagnosis and treatment [21]. However, a study in Iran reported differently; it was found that TB service systems were evenly distributed between villages and cities [22]. Nevertheless, we highlight that, in general, distance and geographical location remain the primary barriers in resource-limited countries.

We also found that patients with TB with comorbidities such as HIV and diabetes mellitus (DM) were another major factor that could prolong the delay in initiating TB treatment. In this study, patients with TB living with HIV had a very high risk of treatment delay exceeding 30 days, with an adjusted odds ratio (AOR) of 23.62 (95 % CI: 10.45 – 53.37), which increased dramatically to an AOR of 39.49 (95 % CI: 15.88–98.25) in patients with both HIV and DM. Our findings indicate a much stronger association than that observed in other countries. For example, a study in Zhejiang, China, found that patients with TB and DM experienced lower healthcare delays than non-DM patients (7.0 % vs. 18.0 %; $p<0.05$), and no significant difference was found in total delay (median 19 vs. 21 days; $p>0.05$). However, patients aged <60 years and those with mild TB-DM were significantly more likely to experience total delays exceeding 14 days (AOR = 3.42 and AOR = 9.73, respectively) [23]. Additionally, a study in Portugal found that pulmonary comorbidities, such as lung cancer and sarcoidosis, also prolonged delays in the healthcare system (e.g., lung cancer: $\text{Exp}(\beta) = 2.391$; sarcoidosis: $\text{Exp}(\beta) = 3.316$) [24]. These findings indicate that the impact of comorbidities on delays in TB treatment is context dependent. In South Sulawesi, the significantly higher likelihood of delays among patients with HIV and DM is likely due to the low integration of TB-HIV-DM services, lack of early screening, and stigma or fear of accessing health care services. This underscores the importance of integrated programmatic approaches and systematic recording of comorbidity status to accelerate TB treatment initiation.

In South Sulawesi, we found that delays in TB treatment are not solely influenced by clinical factors but are also closely related to weak healthcare systems, low levels of patient knowledge about the disease, and social and economic barriers faced by patients with TB. A systematic review showed that delays in TB diagnosis in low- and middle-income countries (LMICs) are often associated with low levels of education, long distances from healthcare facilities, a tendency to use traditional medicine, and a lack of awareness of symptoms by patients and their families [25]. This is reinforced by a study in Peru, which highlighted that perceptions of mild symptoms, fear of receiving

a TB diagnosis, and limited access to laboratory testing also contribute to delays [26]. In Myanmar, showed that a community-based integrated approach through home visits and education significantly improved TB detection among household contacts [27]. Yassin et al. reported that household contacts of TB patients who are not immediately screened have an incidence of TB approximately eight times higher than that in the general population [28]. Our findings in South Sulawesi indicate that delays are more common among patients with unclear TCM test results (rifampicin indeterminate) and those not included in contact investigations. This aligns with global findings and underscores the need for early TB detection in resource-limited countries to address individual barriers (e.g., perceptions and knowledge), structural barriers (access to services and diagnostic capacity), and behavioral barriers (stigma, fear, or preference for alternative treatments). Therefore, strengthening household-based active surveillance systems, community engagement, and systematic integration of health education are important steps in shortening the time to effective TB diagnosis and treatment.

The findings of this study have important clinical and programmatic implications for strengthening TB services at the primary healthcare facility level. Significant delays in treatment among patients with HIV, DM, and extrapulmonary TB, inconclusive TCM results, and patients not covered by contact investigation indicate that barriers exist at both the individual and service-system levels. Clinically, this necessitates an enhanced capacity for systematic screening of comorbidities, training of healthcare workers to recognize non-specific TB symptoms, and the provision of efficient referral pathways and diagnostic confirmation. From a programmatic perspective, our findings underscore the need for more active contact investigations, more accurate data recording, and integration between TB, HIV, and non-communicable disease programs. This strategy will support accelerated detection and initiation of treatment, as well as strengthen national TB elimination efforts. As a practical implication, we recommend that TB program staff at each health center prioritize screening family members of patients with TB, especially those living in the same household or having close contact. Given the high risk of transmission and delayed diagnosis in this group, screening needs to be conducted actively and continuously. However, we also noted from field observations and interviews with several TB officers in South Sulawesi that the implementation of contact investigation and TB preventive therapy (TPT) is still hindered by logistical constraints, including the availability of prophylactic medications for immediate family members of TB-positive patients. Therefore, through this study, we urge the government, both at the central and regional levels, to strengthen TB prophylaxis programs by providing more adequate logistical support, equitable distribution of medications, and more integrated access to distribution systems with frontline TB services.

This study had several strengths that support the validity of our findings. The use of large amounts of routine data from the National TB Information System (SITB) allows for the analysis of treatment delay factors with high statistical power. Additionally, the use of multivariate analysis strengthened the conclusions by controlling for confounding variables. However, this study had some limitations. First, the retrospective design based on secondary data does not allow for independent

verification of data quality, particularly regarding the recording of comorbidity status, contact investigation results, and TCM outcomes. Second, some data groups (e.g., patients with rifampicin-indeterminate TCM results) were very small, resulting in risk estimates with wide confidence intervals. Third, patient behavioral and social factors could not be analyzed in depth because they were not available in routine data. Further studies using a mixed-methods approach (quantitative and qualitative) are urgently needed to comprehensively understand the barriers and opportunities for improving TB programs at the community level.

5 Conclusion

This study shows that delays in tuberculosis (TB) treatment of more than 30 days are a complex issue influenced by multiple factors, including individual, clinical, and systemic determinants. Increasing age is a significant factor because older patients often rely on family members for mobility and healthcare access, thereby extending the treatment initiation time. Gender disparities further exacerbate delays, as women frequently face domestic responsibilities, limited autonomy, and stigma when seeking care. Clinical comorbidities, such as diabetes mellitus (DM) and HIV infection, pose additional challenges owing to the complexities of disease management. Moreover, systemic barriers, such as administrative inefficiencies in health insurance systems and poorly coordinated referral mechanisms, also contribute significantly to prolonged delays. Based on these findings, we recommend several actionable strategies: strengthening referral coordination through standardized protocols and effective communication between primary and secondary care providers; simplifying insurance administrative procedures to minimize treatment initiation delays, particularly in rural populations; training healthcare workers to recognize TB symptoms early, especially in high-risk groups such as the elderly and those with comorbidities; and deploying mobile health teams or outreach programs to improve early case detection and service access in remote or underserved areas. These interventions are essential for reducing delays in TB treatment and improving patient outcomes in resource-limited settings.

Ethical Compliance. This study was conducted in accordance with the ethical principles of the 1964 Declaration of Helsinki and its later amendments, as well as applicable institutional and national ethical standards for research involving human participants. This was a cross-sectional study conducted in South Sulawesi Province, Indonesia, from January to July 2024. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Public Health, Universitas Hasanuddin (No. 4632/UN4.14.1/TP.01.02/2023; approved on 1 August 2023). Research permission was granted by the Regional Government of South Sulawesi Province (No. 15503/S.01/PTSP/2023; issued on 1 July 2023).

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preparation. AA also supported the analytical review and critical revisions of the manuscript. BA conceived and supervised the study. All the authors have reviewed and approved the final version of the manuscript.

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