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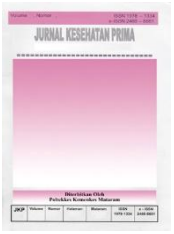

An Explanatory Sequential Mixed-Methods Study of Five-Year Trends (2020-2025) and Characteristics of Drug-Resistant Tuberculosis Cases

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Abstract

Drug-resistant tuberculosis (DR-TB) remains an important challenge for tuberculosis (TB) control. District-level descriptions based on routinely collected surveillance data can provide a local baseline for understanding the distribution and characteristics of recorded DR-TB cases. This study described the annual distribution and selected characteristics of DR-TB patients recorded in Central Lombok Regency during 2020–2024. We conducted a retrospective descriptive study using routinely collected surveillance data from the Tuberculosis Information System (Sistem Informasi Tuberkulosis, SITB) of Central Lombok Regency from 1 January 2020 to 31 December 2024. The source file contained 34 rows; we excluded one blank record, leaving 33 records with complete core variables. We manually reviewed four pairs of records sharing a patient name and confirmed they represented different patients; therefore, we retained all 33 records. We calculated annual DR-TB proportions using notified TB cases as the denominator. We summarised age, sex, and previous treatment history descriptively. Annual proportions were presented with 95% Wilson confidence intervals (CIs), and a Cochran–Armitage test for trend was used to assess ordered annual proportions. We included 33 DR-TB patient records: 3 in 2020, 8 in 2021, 6 in 2022, 7 in 2023, and 9 in 2024. The annual proportion of recorded DR-TB among notified TB cases was 0.32% (95% CI 0.11–0.93), 0.79% (0.40–1.55), 0.49% (0.22–1.06), 0.45% (0.22–0.93), and 0.60% (0.32–1.14), respectively. The Cochran–Armitage test showed no statistically significant linear trend ($z = 0.30$; $p = 0.761$). The mean age was 46.7 ± 13.0 years (median 49; interquartile range 38–53; range 21–73), and 29 records (87.9%) were aged 15–64 years. Eighteen records (54.5%) were male, and 15 (45.5%) were female. Nineteen records (57.6%) were classified as new cases and 14 (42.4%) as treatment after failure. The proportion of recorded DR-TB among notified TB cases fluctuated during 2020–2024, with no evidence of a statistically significant linear trend. Most recorded cases were aged 15–64 years, while the sex distribution was relatively balanced. Interpret the findings as a descriptive surveillance profile rather than an estimate of population-based incidence, transmission, or program effectiveness.

Keywords: Drug-Resistant Tuberculosis; Surveillance; Tuberculosis; Treatment History

INTRODUCTION

Tuberculosis (TB) remains a major global public health problem caused by Mycobacterium tuberculosis. An estimated 10.7 million people developed TB disease. Approximately 1.23 million deaths were attributed to TB in 2024, and an estimated 390,000 people developed multidrug-resistant or rifampicin-resistant TB (MDR/RR-TB) in the same year (WHO, 2025). Globally, MDR/RR-TB was estimated to occur in 3.2% of new TB cases and 16% of previously treated TB cases in 2024, while only about two in five people who developed rifampicin-resistant TB were reported to have started treatment (WHO, 2025). Indonesia ranks second after India among countries with the highest TB burden worldwide and carries a substantial burden of drug-resistant tuberculosis. (KemenKes RI, 2025; WHO, 2025)

Drug-resistant tuberculosis (DR-TB) is an umbrella term for tuberculosis caused by Mycobacterium tuberculosis complex strains that are resistant to one or more anti-TB medicines. Rifampicin-resistant TB (RR-TB) refers to TB caused

by a strain resistant to rifampicin, with or without resistance to other anti-TB medicines. Multidrug-resistant TB (MDR-TB) refers to TB caused by a strain resistant to at least both rifampicin and isoniazid. Under the WHO definitions introduced in 2021, pre-extensively drug-resistant TB (pre-XDR-TB) refers to MDR/RR-TB with additional resistance to any fluoroquinolone. In contrast, XDR-TB refers to MDR/RR-TB with additional resistance to any fluoroquinolone and at least one additional Group A drug, currently bedaquiline or linezolid. These categories are distinct and should not be used interchangeably(WHO, 2021). For the present study, all records classified as DR-TB in the district-level SITB dataset were eligible; because the analytical extract did not retain sufficient resistance-subtype information, individual records were not independently reclassified as RR-TB, MDR-TB, pre-XDR-TB, or XDR-TB. The definitions above are for terminology only and were not used to reclassify the 2020–2024 records retrospectively.

Indonesia contributes approximately 7.4% of the global DR-TB burden, and a large share of this burden is thought to remain undiagnosed; national DR-TB case detection in 2023 reached only about 40% of the estimated number of cases, well below the national target (Farkhan et al., 2026). A four-year cascade-of-care analysis in an Indonesian referral setting documented substantial attrition and delay between presumptive rifampicin-resistant TB testing, confirmed diagnosis, and treatment initiation, indicating that recorded DR-TB reflects the performance of the diagnostic and referral pathway as much as the underlying occurrence of resistance (Lestari et al., 2024). Because DR-TB detection depends heavily on how widely and consistently drug-resistance testing is applied, district-level surveillance data describe the cases a local program identified and recorded rather than the underlying occurrence of resistance in the community. This distinction is central to interpreting all district-level DR-TB figures, including those reported here.

In Central Lombok Regency, the annual number of notified TB cases recorded in the district SITB rose from 949 in 2020 to 1,545 in 2023, before falling to 1,493 in 2024. This rising denominator aligns with the national recovery in TB case-finding after the pandemic-related disruption that reduced Indonesia's TB case notification rate by 26% during 2020–2021 (Surendra et al., 2023). A district-level count of DR-TB cases cannot be interpreted on its own against such a changing background, and annual counts are also difficult to interpret when the absolute number of DR-TB cases is small. Presenting recorded DR-TB case counts alongside the corresponding notified TB denominator, confidence intervals, and selected patient characteristics provides a more transparent description of the observed pattern (Ledesma et al., 2023).

Unlike a routine annual program report that primarily presents case counts, this study provides a five-year standardized descriptive surveillance profile by combining annual recorded DR-TB counts with the corresponding notified-TB denominator, 95% Wilson confidence intervals, a formal test for linear trend, and a consistent description of age, sex, and previous treatment history. The contribution is therefore a transparent, reproducible local surveillance baseline that improves interpretation of small annual case counts; it is not intended to replace routine reporting, estimate population-based DR-TB incidence, or identify causal determinants.

The objective of this study was to describe (i) the annual number of recorded DR-TB cases and their proportion among notified TB cases in Central Lombok Regency during 2020–2024, and (ii) the age, sex, and previous treatment-history characteristics of these patients. The study was not designed to establish causality, estimate population-based incidence, or determine program effectiveness.

METHOD

Study design and setting

This retrospective descriptive study used routinely collected TB surveillance data from the Tuberculosis Information System (Sistem Informasi Tuberkulosis, SITB). The observation period covered 1 January 2020 to 31 December 2024, and the study setting was Central Lombok Regency, West Nusa Tenggara Province, Indonesia.

Data sources

We used two data sources, both derived from the same district-level SITB reporting system of Central Lombok Regency. First, a line-listed extract of records registered as DR-TB during 2020–2024 provided the numerator and all patient-level variables. Second, the annual district recapitulation of notified TB cases for the same five calendar years provided the denominator for calculating annual proportions. We obtained both extracts from the Central Lombok District Health Office on 9 September 2025. No formal data-access

permission letter was issued; the data were provided as routinely collected program surveillance data for secondary analysis. The two sources refer to the same district, reporting system, and calendar years, so the numerator and denominator are drawn from a consistent reporting frame.

The notified TB denominator comprises all TB cases notified in the district, including both bacteriologically confirmed and clinically diagnosed cases, irrespective of whether drug-resistance testing was performed. This denominator is broader than that used in studies reporting resistance among bacteriologically confirmed or drug-susceptibility-tested patients, and the difference matters when comparing the present figures with published estimates.

Record selection

The analytical dataset contained 34 rows retrieved from the district-level SITB surveillance dataset. We excluded one blank record because it contained no patient information. The remaining 33 records had complete core variables (age, sex, previous treatment history, and year of diagnosis) and were included in the descriptive analysis.

Four pairs of records (eight records in total) shared a patient name and were reviewed for possible duplication. Manual verification confirmed that the four repeated-name pairs represented different patients. Consequently, we retained all 33 eligible records, and the unit of analysis was the patient record. The analytical tables, figures, and reported results did not include patient names.

Eligibility criteria

Inclusion criteria were: (1) a record registered as DR-TB in the Central Lombok district-level SITB dataset; (2) a diagnosis date from 1 January 2020 through 31 December 2024; and (3) availability of the core variables required for the planned descriptive analysis (age, sex, previous treatment history, and year of diagnosis). Because the supplied analytical extract was a district surveillance extract, residence was not independently reclassified beyond the dataset's district registration context. Exclusion criteria were: blank records; records outside the study period; records lacking the core variables required for analysis; and confirmed duplicate records. Transfer status was not retained as a sufficiently complete variable for secondary reclassification; therefore, transfer-in or transfer-out status could not be excluded or analyzed separately. The analytical extract was not a longitudinal treatment-episode file, so repeated treatment episodes could not be independently identified beyond the manual duplicate review. No imputation was performed.

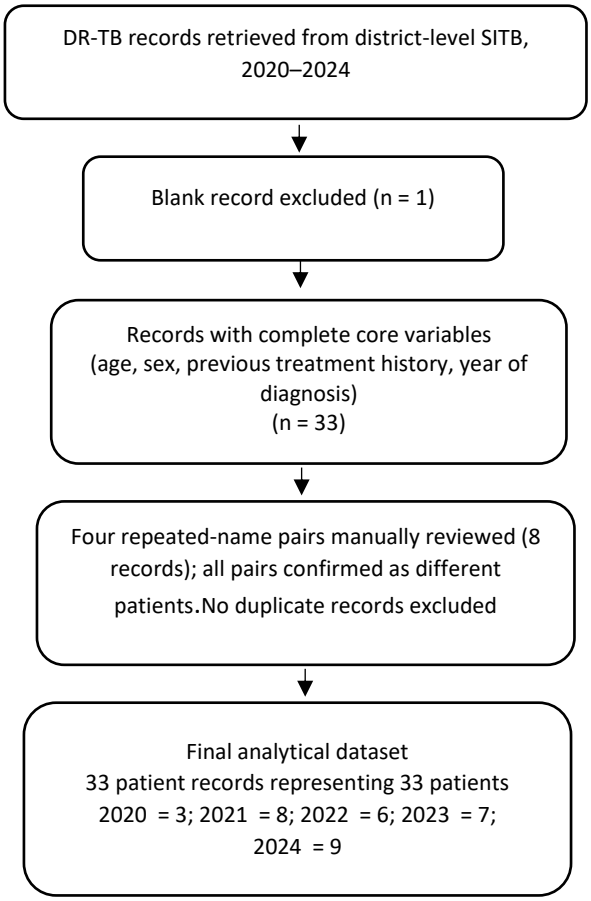

Figure 1. Flow diagram of DR-TB record selection from the Central Lombok surveillance dataset, 2020–2024.

Variables and operational definitions

Age was recorded in completed years and analyzed as a continuous variable and in predefined age groups. Sex was recorded as male or female. Previous treatment history was reported using the categories available in the analytical extract: new case and treatment after failure. Following the national TB program definitions, a new case is a patient who has never been treated for TB or who has taken anti-TB medicines for less than one month. In contrast, treatment after failure refers to a patient who was previously treated for TB for one month or more and whose most recent treatment episode was declared a treatment failure (Ma et al., 2023; Rupani, 2024). The supplied extract did not retain the detailed clinical circumstances underlying each label; therefore, the

analysis retained the two recorded categories without combining or retrospectively reclassifying records. We used year of diagnosis to describe the annual distribution of cases.

For this study, we defined a DR-TB case as a record classified as drug-resistant tuberculosis in the district-level SITB surveillance dataset during the study period. In routine practice in Indonesia, this classification follows a rapid molecular test (Tes Cepat Molekuler, typically Xpert MTB/RIF), with further drug-susceptibility testing where indicated (KemenKes RI, 2024). However, the analytical extract available for this study did not retain individual test results, so it was not possible to verify, record by record, which diagnostic pathway was applied or to reclassify resistance subtype. We therefore used the recorded SITB DR-TB classification as the case definition for this descriptive surveillance analysis, and we did not attempt independent adjudication of diagnostic confirmation (World Health Organization, 2024). This constraint is common in Indonesian district settings, where drug-resistance testing relies predominantly on Xpert MTB/RIF and downstream confirmatory results are not consistently captured in routine records (Lestari et al., 2024).

The primary annual indicator was the proportion of recorded DR-TB cases among notified TB cases, calculated as the number of recorded DR-TB cases in a given year divided by the total number of notified TB cases in the same year, multiplied by 100. The denominator was not a population denominator; therefore, the resulting measure represents a proportion among notified TB cases and not a population-based incidence rate.

Statistical analysis

We used descriptive statistics to summarise the data. We summarised continuous age as mean ± standard deviation, median with interquartile range, and range. We summarised categorical variables using frequencies and percentages. We presented annual DR-TB proportions with 95% Wilson confidence intervals, as reporting interval estimates alongside counts is recommended when routine surveillance indicators are based on small numbers (WHO, 2025). We used a Cochran–Armitage test for trend to assess evidence of a linear trend in annual proportions across the ordered years 2020–2024. We used $p < 0.05$ as the significance threshold. All analyses were performed in Python version 3.13.5 using the NumPy and SciPy libraries. No imputation was performed: the single blank record was excluded, and the 33 retained records had complete core variables required for the descriptive analysis.

Because the annual number of DR-TB cases was small, we interpreted annual estimates cautiously. In particular, a difference of one or two cases can materially change the annual proportion.

Ethical considerations

This study analyzed routinely collected, program-generated TB surveillance data. It involved no direct contact with patients, no intervention, and no additional specimen collection. Permission to access and analyze the district-level SITB extract was granted administratively by the Central Lombok District Health Office. No formal permission letter was issued. Ethical review was not required because this study used routinely collected, program-generated secondary TB surveillance data, involved no direct participant recruitment or intervention, and involved no additional specimen collection.

The research team could see patient names only during manual verification of repeated-name records. Names and all other direct identifiers were removed before analysis, were not retained as analytical variables, and do not appear in any table, figure, or section of this manuscript. Results are reported only in aggregate form, and no cell of any table permits the identification of an individual patient. Because the study used pre-existing program surveillance records and involved no direct participant contact, we did not obtain individual informed consent.

RESULTS AND DISCUSSION

Table 1. Annual distribution of recorded DR-TB cases among notified TB cases, Central Lombok Regency, 2020–2024

Year	Notified TB cases (n)	DR-TB cases (n)	Proportion (%)	95% Wilson CI (%)
2020	949	3	0.32	0.11–0.93
2021	1,011	8	0.79	0.40–1.55
2022	1,230	6	0.49	0.22–1.06
2023	1,545	7	0.45	0.22–0.93
2024	1,493	9	0.60	0.32–1.14
Total	**6,228**	**33**	**0.53**	**0.38–0.74**

From Table 1. The annual number of notified TB cases was 949 in 2020, 1,011 in 2021, 1,230 in 2022, 1,545 in 2023, and 1,493 in 2024. The corresponding DR-TB proportions were 0.32%, 0.79%, 0.49%, 0.45%, and 0.60%, respectively. The highest observed proportion was in 2021 (0.79%), whereas the highest absolute number of recorded DR-TB cases occurred in 2024 (9 cases). Across the whole period, 33 DR-TB cases were recorded among 6,228 notified TB cases (0.53%; 95% CI 0.38–0.74).

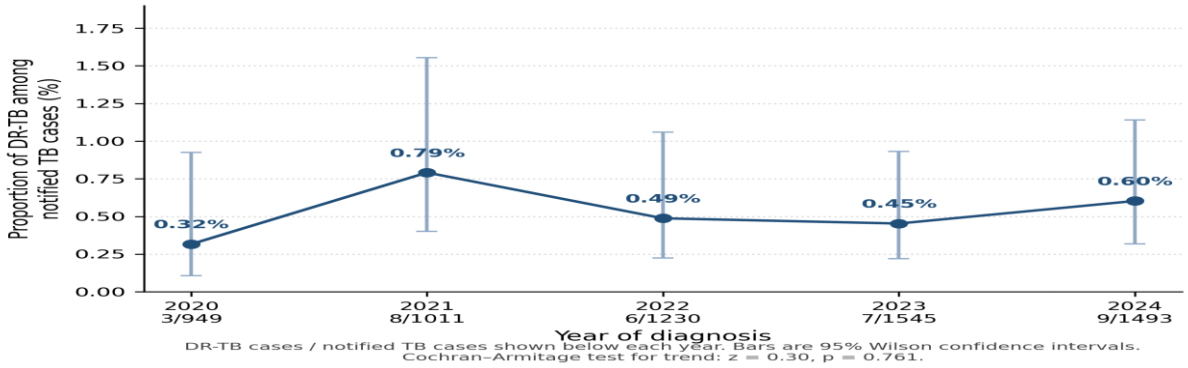

Figure 2. Annual proportion of DR-TB among notified TB cases, Central Lombok Regency, 2020–2024. Points show annual proportions, and vertical bars represent 95% Wilson confidence intervals. Numbers below each year indicate DR-TB cases/notified TB cases.

Figure 2 describes the Cochran–Armitage test for trend, which yielded z = 0.30 and p = 0.761, indicating no statistically significant linear trend in the annual proportion of DR-TB among notified TB cases over the five years.

Table 2. Age and sex distribution of recorded DR-TB patients, Central Lombok Regency, 2020–2024 (n = 33)

Age group (years)	Male n (%)	Female n (%)	Total n	Total %
<15	0 (0.0)	0 (0.0)	0	0.0
15–24	0 (0.0)	1 (6.7)	1	3.0
25–34	1 (5.6)	4 (26.7)	5	15.2

Age group (years)	Male n (%)	Female n (%)	Total n	Total %
35–44	7 (38.9)	2 (13.3)	9	27.3
45–54	5 (27.8)	7 (46.7)	12	36.4
55–64	1 (5.6)	1 (6.7)	2	6.1
≥65	4 (22.2)	0 (0.0)	4	12.1
Total	**18 (100.0)**	**15 (100.0)**	**33**	**100.0**

Table 2. The age of the 33 patients ranged from 21 to 73 years. The mean age was 46.7 ± 13.0 years, with a median of 49 years (interquartile range 38–53). Twenty-nine patients (87.9%) were aged 15–64 years. The largest age group was 45–54 years (12 patients, 36.4%), followed by 35–44 years (9 patients, 27.3%). No patient was younger than 15 years. Eighteen patients (54.5%) were male, and 15 (45.5%) were female. This difference of three patients indicates a relatively balanced sex distribution in this small dataset.

Table 3. Previous treatment history of recorded DR-TB patients, Central Lombok Regency, 2020–2024 (n = 33)

Previous treatment history	n	%
New case	19	57.6
Treatment after failure	14	42.4
Total	**33**	**100.0**

Table 3. Nineteen patients (57.6%) were classified as new cases, while 14 (42.4%) were classified as treatment after failure. These were the only previous-treatment categories represented in the supplied analytical extract; other categories used in the national TB program terminology, such as relapse, treatment after loss to follow-up, and unknown previous-treatment history, were not present in the extract and were not combined with the two observed categories.

Annual pattern

The five-year distribution fluctuated rather than showing a consistent increase or decrease. The annual proportion was highest in 2021 (0.79%) and lowest in 2020 (0.32%), while the absolute number of recorded DR-TB cases was highest in 2024 (9 cases). The absence of a statistically significant linear trend (Cochran–Armitage $z = 0.30$; $p = 0.761$) indicates that the observed year-to-year variation should not be characterized as a statistically demonstrated temporal trend.

The small annual numbers further constrain interpretation. The confidence intervals around the annual proportions are relatively wide and overlap substantially, and a change of one or two cases can noticeably change the percentage. Differences in diagnostic access, referral patterns, testing intensity, service utilization, and surveillance completeness could also affect the number of cases recorded in a given year. These are plausible explanations rather than findings of this study, because the supplied dataset did not include the relevant factors.

The lowest recorded proportion and the lowest case count both occurred in 2020, the year in which TB services in Indonesia were widely disrupted; nationwide analyses have described a corresponding trough in TB notifications during the pandemic period, with the largest reductions in districts of lowest health-system capacity (Farkhan et al., 2026; Surendra et al., 2023). The present data cannot determine whether service disruption, reduced health-seeking, or reduced resistance testing contributed to the low 2020 figure in Central Lombok. This explanation is offered only as a hypothesis for future evaluation, since this study measured none of these factors.

Comparison with published DR-TB figures requires close attention to the denominator used.

Globally, WHO estimated that 3.2% of new TB cases and 16% of previously treated TB cases had MDR/RR-TB in 2024 (WHO, 2025). The first national drug-resistance survey in Indonesia reported MDR-TB in 3.4% of sputum culture-positive pulmonary TB patients (Lolong et al., 2025), and an Indonesian hospital-based study in Aceh reported rifampicin resistance in 14.1% of bacteriologically confirmed TB cases over seven years (Maulina et al., 2024). Those indicators are calculated among patients who were bacteriologically confirmed or actually tested for drug resistance. The present indicator uses all notified TB cases as the denominator, including clinically diagnosed cases that may never have undergone resistance testing. Hence, the two sets of figures are not directly comparable. The numerically much lower values reported here (0.32–0.79%) should not be read as evidence of a lower underlying prevalence of resistance in Central Lombok.

A more likely interpretation is that the proportion reported here reflects how much drug-resistance testing and DR-TB registration are captured in routine district records. This reading is consistent with national evidence that a large share of DR-TB in Indonesia remains undiagnosed and that DR-TB case detection reached only about 40% of estimated cases in 2023 (Farkhan et al., 2026), as well as with cascade-of-care evidence showing that a large fraction of presumptive drug-resistant patients is lost before diagnosis is confirmed. Treatment begins (Lestari et al., 2024). Comparing the present indicator with population-based incidence per 100,000 population is inappropriate, because the denominator is not the population at risk.

Age distribution

Most recorded patients were aged 15–64 years, with the largest proportion in the 45–54-year group. A nationwide district-level analysis of Indonesian DR-TB notifications for 2017–2022 similarly found that recorded cases were concentrated among people aged 25–54 years (Farkhan et al., 2026). Thus, the pattern observed here broadly aligns with the national notification profile. This remains a descriptive characteristic of the observed surveillance records: because the age structure of the underlying notified TB population and the district population was not incorporated, the distribution does not, by itself, indicate elevated risk in any age band. The present dataset also contains no occupational, mobility, or socioeconomic variables and therefore cannot establish why this age distribution occurred. Explanations such as workplace exposure, mobility, or economic circumstances should be regarded only as contextual hypotheses drawn from the broader literature, not as study findings.

Sex distribution

Male patients represented 54.5% of the total and female patients 45.5%. A male excess in TB notifications is commonly reported. An updated systematic review and Bayesian meta-analysis of 102 prevalence surveys conducted in low- and middle-income countries between 1993 and 2025 confirmed a persistently higher male-to-female TB prevalence ratio, together with evidence that men remain disadvantaged in seeking or accessing diagnosis (Swartwood et al., 2026). The present difference of only three records in a dataset of 33 is too small to interpret in that light. It should be described as a slight numerical difference rather than a substantive male predominance. The present dataset did not measure potential explanations such as smoking, occupational exposure, healthcare-seeking behavior, or treatment adherence, so these cannot be evaluated here.

Previous treatment history

New cases represented 57.6% of the patients, while 42.4% were classified as treatment after failure. The presence of DR-TB among records classified as new cases is compatible with, but does not demonstrate, the possibility of primary transmission of resistant strains. Population-based genomic evidence from high-burden settings indicates that a substantial share of resistant disease arises from person-to-person transmission rather than from resistance acquired during treatment; a whole-genome sequencing study in western China inferred that most resistant strains had been transmitted rather than generated within individual patients (FAN et al., 2024), which makes resistance among patients without previous treatment epidemiologically plausible. Plausibility is not evidence, however: distinguishing primary from acquired resistance requires reliable previous-treatment histories and detailed epidemiological information, and is best addressed using molecular epidemiological methods, including whole-genome sequencing, which has already been applied to rifampicin-resistant isolates in Indonesia to

characterize lineage distribution and infer transmission (FAN et al., 2024; Rukmana et al., 2024; WHO, 2021).

The proportion classified as treatment after failure is also an important descriptive characteristic. However, because the dataset contains only DR-TB records and no drug-susceptible comparison group, treatment failure cannot be evaluated as a risk factor for DR-TB from these data. Meta-analytic evidence consistently identifies previous TB disease and prior anti-TB therapy as the strongest risk factors for MDR-TB (Xi et al., 2022), and the Indonesian national survey similarly reported markedly higher odds of MDR-TB among previously treated patients (Lolong et al., 2025); establishing such associations, however, requires the comparison group that the present dataset lacks. The observed category should therefore be interpreted as a frequent characteristic among the recorded cases rather than an estimate of risk or association (Figueiredo et al., 2025).

Data quality and repeated-name verification

The record-selection process highlights a data-quality issue related to repeated names. Four pairs of records shared a patient name, involving eight records. Manual verification confirmed that these repeated-name pairs represented different patients; consequently, all 33 records were retained. This review was important to ensure that patients with similar names were not incorrectly treated as duplicate registrations.

For future surveillance analyses, maintain a validated unique patient identifier or linkage procedure to distinguish unique patients from repeat registrations accurately. This would strengthen the reliability of district-level case counts and longitudinal surveillance.

Study Limitations

Several limitations should be considered. First, the study used secondary surveillance data collected for program purposes, so completeness and accuracy depend on routine recording quality; underreporting and underdiagnosis cannot be excluded. Second, the dataset includes only recorded DR-TB cases and may not represent all DR-TB in the population; because DR-TB detection depends on how widely resistance testing is applied, the reported proportion is best understood as a measure of recorded cases rather than underlying resistance. Third, the denominator comprises all notified TB cases, including clinically diagnosed patients who may never have been tested for resistance, which limits comparability with studies that restrict the denominator to bacteriologically confirmed or tested patients. Fourth, the total number of records was small (n = 33), limiting the precision of annual estimates and preventing meaningful subgroup or multivariable analysis.

Fifth, eight records formed four repeated-name pairs and were manually reviewed; all four pairs were confirmed to represent different patients, so no records were removed for duplication. Nevertheless, the analytical extract did not provide a robust unique patient identifier for independent longitudinal linkage and was not structured to reliably identify repeated treatment episodes. Sixth, the extract did not retain sufficient information to independently verify individual diagnostic confirmation methods or resistance subtypes, so DR-TB could not be disaggregated into RR-TB, MDR-TB, pre-XDR-TB, or XDR-TB. Other clinically relevant variables, including HIV status, diabetes, nutritional status, smoking, occupation, treatment initiation, treatment outcome, transfer status, and molecular epidemiological data, were unavailable or insufficiently detailed. Linkage of such variables is feasible in Indonesian settings and has been used to identify determinants of unfavorable TB treatment outcomes (Sugiyono et al., 2025).

Seventh, changes in diagnostic access, referral patterns, testing intensity, service utilization, and surveillance completeness may influence observed annual counts. However, these factors were not measured and cannot be attributed to the observed variation. Eighth, routine secondary data may contain classification or recording errors. Finally, because the design was descriptive and lacked a comparison group, the study cannot establish causal relationships or identify risk factors for DR-TB.

CONCLUSION

We analyzed 33 recorded DR-TB patient records from the Central Lombok surveillance dataset for 2020–2024. The annual number of recorded cases ranged from 3 in 2020 to 9 in 2024, while the proportion among notified TB cases fluctuated between 0.32% and 0.79%. The Cochran–Armitage test did not demonstrate a significant linear trend ($z = 0.30$; $p = 0.761$). Most recorded cases were among adults aged 15–64 years (87.9%), with the

largest age group being 45–54 years. The sex distribution was relatively balanced, and new cases accounted for 57.6% of records. These findings provide a local descriptive surveillance profile and should not be interpreted as evidence of changing population-level incidence, transmission dynamics, risk factors, or program effectiveness.

RECOMMENDATIONS

Routine DR-TB surveillance should maintain a validated unique patient identifier and a standardised duplicate-checking procedure to distinguish unique patients from repeat registrations and prevent double counting, Annual district reporting should present DR-TB counts together with the corresponding notified TB denominator and uncertainty intervals to improve interpretation of year-to-year variation, District reporting should additionally record the number of notified TB patients who underwent drug-resistance testing, so that recorded DR-TB can be expressed among patients actually tested and distinguished from limitations in testing coverage, Future analyses should link diagnostic records with treatment initiation and treatment outcomes and incorporate resistance category, diagnostic method, HIV and comorbidity status, and other clinically relevant variables where available, Future analytical research should use an appropriate comparison group and a design capable of estimating associations if determinants of DR-TB are to be evaluated. Future studies may consider molecular epidemiological methods, including whole-genome sequencing, and detailed contact investigation to distinguish primary transmission from acquired resistance when resources and data permit (Fan et al., 2024; Rukmana et al., 2024).

DECLARATION

Author Contributions:

MSSN conceived the study, curated the data, performed the analysis, and drafted the manuscript. N, DI, and MSD contributed to the study design, interpretation of results, and critical revision of the manuscript. All authors read and approved the final manuscript.

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The researcher independently funded this study. The researcher covered all costs associated with preparation, data collection, data analysis, reporting, and publication, with no external financial support.

Ethical Considerations:

Ethics approval and consent to participate. This study used routinely collected secondary TB surveillance data and involved no direct participant recruitment, intervention, or additional specimen collection. Ethical review was not required because the study used routinely collected, program-generated secondary TB surveillance data. We obtained the data from the Central Lombok District Health Office on 9 September 2025 for secondary analysis; no formal data-access permission letter was issued. The analytical dataset was de-identified for analysis and reporting; patient names were used only during manual verification of repeated-name records and were not retained in the analytical variables, tables, figures, or manuscript. The study did not obtain individual informed consent because it used pre-existing program surveillance records and involved no direct participant contact.

Competing Interests:

The authors declare no competing interests.

Acknowledgments:

The authors acknowledge the Central Lombok District Health Office for providing access to the routine TB surveillance data used in this study.

Availability of Data and Materials:

The datasets generated and analyzed during the current study are not publicly available because they contain potentially identifiable participant information. De-identified data may be made available by the corresponding author upon reasonable request and subject to ethical and institutional approval.

Generative AI:

During the preparation and revision of this manuscript, the authors used AI-assisted technology solely for language editing, including improving grammar, spelling, sentence structure, and English-language clarity. The authors critically reviewed and verified all AI-assisted revisions and take full responsibility for the manuscript's accuracy, integrity, and originality. AI-assisted technology was not used for participant recruitment, data collection, statistical analysis, qualitative coding,

interpretation of the findings, or scientific decision-making.

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