Effectiveness of Tuberculosis Surveillance System in Remote Areas Through A Mixed-Methods Approach: A Case Study in Kabawo District, Muna Regency

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Abstract.

Tuberculosis (TB) remains a public health problem, especially in remote areas with limited resources and access to health services. The effectiveness of the TB surveillance system is crucial for successful disease control. This study aimed to assess the effectiveness of the TB surveillance system in Kabawo District, Muna Regency, using a mixed-methods approach. This study employed a mixed-methods design with a concurrent triangulation strategy. Quantitative data were analyzed univariately using SPSS to assess the components of the surveillance system, while qualitative data were obtained through in-depth interviews and analyzed descriptively. The quantitative analysis showed that the availability and capacity of human resources had an average score of 3.28, the TB case reporting system 3.83, the TB treatment success process 3.52, and the availability of facilities and infrastructure 2.89. The TB case detection process had an average score of 0.87. The overall effectiveness of the TB surveillance system was categorized as effective with an average score of 0.85. Qualitative findings revealed barriers such as social stigma, trust in traditional medicine, and limited geographic access that impacted the implementation of TB surveillance. The TB surveillance system in Kabawo District is considered effective, but still requires strengthening in the aspects of active case detection, utilization of facilities and infrastructure, as well as socio-cultural and geographic access-based interventions to increase effectiveness in a sustainable manner.

Keywords: *Tuberculosis (TB); surveillance system; effectiveness; remote areas and mixed-methods.*

I. INTRODUCTION

Tuberculosis (TB) is one of the leading causes of death in the world caused by Mycobacterium tuberculosis through the air.(WHO, 2024), which spreads when the sufferer coughs or sneezes(Nasution et al., 2023)TB control strategies have been implemented, both in terms of regulations, case detection, and success in local control, but they still show varying results across regions. Therefore, the success of TB programs is determined not only by the availability of diagnostic and treatment services, but also by the effectiveness of the surveillance system as a means of controlling the disease.(WHO, 2023). Indonesia is the second largest contributor of TB sufferers in the world (WHO, 2024), with the death rate continuing to increase from 2021 to 2024, namely 10 per 100,000 population in 2021, 52 per 100,000 population in 2022.(BPS, 2022;(BPS, 2023), and continues to increase until in 2024 to 286 per 100,000 population(BPS, 2025;Ministry of Health of the Republic of Indonesia, 2024; WHO, 2024). These data show that TB control targets still face significant challenges, particularly in optimizing case detection and treatment success, which are highly dependent on the performance of the surveillance system.Public health surveillance is an effort to carry out early detection, prevention and control of disease to reduce the risk of disease spread.(Muamalah et al., 2025)In the context of TB, surveillance serves to monitor disease trends, detect epidemiological changes, and evaluate the performance of control programs. However, in remote areas, TB surveillance implementation often faces several obstacles, particularly in terms of human resources (HR), infrastructure, socio-cultural and geographic access (WHO, 2022).

Kabawo District, Muna Regency, is a remote area with geographic and social characteristics that potentially impact TB surveillance implementation. Therefore, an evaluation of the TB surveillance system that integrates quantitative and qualitative analysis is needed to gain a more comprehensive understanding of the system's effectiveness in remote areas. The aim of this study was to assess the effectiveness of the TB surveillance system through a mixed-methods approach. Mixed-methods research is a research design that

combines quantitative and qualitative methods by measuring numerical phenomena, understanding processes, contexts, and non-technical factors.(Judijanto et al., 2023), by emphasizing the alignment between research objectives, data collection strategies, and data integration techniques so that the findings can complement each other.(Sudarmanto et al., 2025)In public health research, particularly in TB surveillance, the mixed-methods approach is considered appropriate because it is able to link the achievements of surveillance indicators with the reality of implementation in the field.(Rachmad et al., 2024).Most previous TB surveillance evaluation studies have focused on assessing system attributes in isolation, such as data quality, timeliness, and system stability.

This approach has not fully captured the effectiveness of a surveillance system as a whole, which is influenced by the interaction between inputs, processes, and implementation context, particularly in remote areas.(Al kalali et al., 2021). Furthermore, there is limited research integrating quantitative indicator achievements with qualitative findings to explain non-technical factors that influence the effectiveness of TB surveillance.Based on these conditions, this study aims to assess the effectiveness of the TB surveillance system in Kabawo District, Muna Regency, using a mixed-methods approach. This research is expected to provide a comprehensive overview of the achievements and challenges of TB surveillance implementation in remote areas, as well as serve as a basis for formulating policy recommendations and strategies for strengthening TB surveillance in a more contextual and sustainable manner.TB surveillance is a TB disease control system that carries out systematic and continuous health data collection, analysis and interpretation activities, and is published for the purpose of planning, implementing and evaluating public health programs.(WHO, 2023)WHO emphasizes that an effective TB surveillance system must be able to produce accurate, timely data that can be used for decision-making.(WHO, 2021). To support the performance of surveillance officers, there are training efforts at the Community Health Center level, early case detection, treatment assistance, and psychological support for TB patients.(Adrian et al., 2020).Surveillance system evaluation is generally conducted through the assessment of system attributes, such as data quality, stability, and acceptability.

However, this approach does not fully integrate the interactions between inputs, processes, and implementation contexts to assess the effectiveness of a surveillance system as a whole.(Sutriyawan et al., 2020)The effectiveness of a TB surveillance system is influenced by several factors, both quantitative and qualitative. Quantitative factors represent measurable aspects related to the availability and quality of human resources.(Uddin et al., 2021)However, there are also obstacles if there is a limited number of surveillance officers, a lack of ongoing training, and minimal competence in early detection and optimal use of reporting systems.(Hasnanisa et al., 2022).Certain indicators in TB surveillance evaluation research largely emphasize the assessment of system attributes. Consequently, this approach tends to assess components separately and fails to fully capture the effectiveness of the system as a whole, which is influenced by the context of implementation in the field. Surveillance effectiveness, however, is strongly influenced by the interaction between input, process, and sociocultural context.(Al kalali et al., 2021).Human resources are the main component in the surveillance system that plays a direct role in the effectiveness of surveillance, where the limitations of human resources, both in terms of numbers and epidemiological competence, have an impact on the suboptimal implementation of TB surveillance, such as the dominance of passive surveillance and low data analysis.(Rahmi & Mitra, 2025)TB cases can be detected through diagnostic tests, such as the Molecular Rapid Test (TCM) and radiological examinations that ensure the accuracy of a TB diagnosis.(Rahma et al., 2024)This proves that infrastructure has an impact on the quality of surveillance data.(Ersanti et al., 2016), thus enabling more optimal monitoring of TB treatment and being able to meet national targets.(Benu et al., 2024).

II. METHODS

This study employed a mixed-methods design with a concurrent triangulation strategy, which involves the simultaneous collection and analysis of quantitative and qualitative data, which are then integrated during the interpretation stage. This approach was used to gain a comprehensive understanding of the effectiveness of the TB surveillance system in remote areas.Quantitative data were obtained through

questionnaires addressed to TB personnel in three Community Health Centers (Puskesmas) in Kabawo District, Muna Regency. The variables measured included the availability and capacity of human resources, the TB case detection process, the case reporting system, the treatment success process, the availability of facilities and infrastructure, and the effectiveness of the TB surveillance system. Quantitative data analysis was conducted univariately using SPSS version 25 software, with the presentation of average values and assessment categories to describe the condition of each variable. The category ranges were 1.00–1.75 (poor), 1.76–2.50 (sufficient), 2.51–3.25 (good), and 3.26–4.00 (very good). The assessment of the TB case detection coverage process and the effectiveness of the surveillance system had a value range of 0–1 with categories ≤0.50 (poor/less effective), 0.51–0.75 (sufficient/quite effective), and 0.76–1.00 (good/effective). This category classification is a researcher's modification used to describe the condition of each TB surveillance variable.

However, this study focused more on administrative aspects and surveillance system attributes in areas with relatively good infrastructure. Few studies have in-depth examined the challenges of implementing a TB surveillance system in remote areas with complex socio-cultural and geographic contexts such as Muna Regency.*Novelty*The essence of this research lies in a comprehensive mixed-methods approach, combining quantitative and qualitative data. Case studies were chosen because they allow researchers to deeply understand complex phenomena in real-world contexts, particularly the interaction between technical factors (reporting, human resources, infrastructure) and social factors (stigma, local beliefs, and geographic access). This approach does not aim to make statistical generalizations, but rather to produce analytical generalizations in the form of insights and recommendations that can be applied to areas with similar characteristics.Qualitative data were collected through in-depth interviews with key informants selected using purposive sampling, consisting of health workers and community members directly involved in the implementation of the TB program. Qualitative data analysis was conducted descriptively through a process of data reduction, grouping themes, and drawing conclusions to identify challenges, sociocultural contexts, and geographic factors that influence the implementation of the TB surveillance system.Integration of quantitative and qualitative data was carried out at the stage of interpreting the results by comparing and linking the findings from both approaches, so that a complete picture of the effectiveness of the TB surveillance system in Kabawo District, Muna Regency was obtained.

III. RESULT AND DISCUSSION

A univariate quantitative analysis was conducted to describe the performance of each variable in TB surveillance in Kabawo District. All variables are presented concisely in a single table to provide a comprehensive overview of the input, process, and output of the TB surveillance system in remote areas. The results of the quantitative study are presented in Table 1.

Table 1. Univariate Distribution of Tuberculosis Surveillance System Variables in Kabawo District, Muna Regency

Variables	Average Score	Category
Availability and Capacity of Human Resources	3.28	Very good
TB Case Detection Process	0.87	Good
TB Case Reporting System	3.83	Very good
TB Treatment Success Process	3.52	Very good
Availability of Facilities and Infrastructure	2.89	Good

Table 1 shows that most components of the TB surveillance system in Kabawo District are in the good to very good category. Case reporting and treatment success rates have the highest average scores, while case detection and the availability of facilities and infrastructure remain in the good category and require further strengthening.Furthermore, to assess the overall performance of the system, the effectiveness of the TB surveillance system was measured using the effectiveness index which is presented separately in Table 2.

Table 2. Tuberculosis Surveillance System Effectiveness Score

Surveillance System Components	N	Minimum	Maximum	Average	Standard Deviation
Human Resources (HR)	3	0.79	0.88	0.82	0.05
TB Case Detection Process	3	0.80	1.00	0.87	0.12
TB Case Reporting System	3	0.92	1.00	0.96	0.04
TB Treatment Success Rate	3	0.81	0.97	0.88	0.85
Facilities and infrastructure	3	0.63	0.83	0.72	0.11
Effectiveness of TB Surveillance System	**3**	**0.79**	**0.94**	**0.85**	**0.08**

Based on Table 2, all components of the TB surveillance system demonstrated relatively high effectiveness, with average scores ranging from 0.72 to 0.96. The TB case reporting system had the highest effectiveness score, while the availability of facilities and infrastructure showed the lowest. Overall, the effectiveness of the TB surveillance system was categorized as effective, with an average score of 0.85, indicating that surveillance implementation has been running quite optimally, although strengthening of supporting facilities is still needed.Qualitative analysis results indicate that the implementation of the TB surveillance system in Kabawo District, Muna Regency, still faces challenges stemming from socio-cultural factors and the region's geographic conditions. Informants cited socio-cultural factors and the region's geographic conditions. Informants revealed that the stigma against TB sufferers remains strong, with TB often perceived as a hereditary disease or due to mystical factors.

This perception has led some residents to be reluctant to seek early screening and delay access to formal health services, preferring traditional medicine in the early stages of the disease.Furthermore, low public understanding of the importance of close contact testing also hampers optimal TB case detection. Several informants reported that household contacts often refuse testing because they feel asymptomatic or fear social stigma from their neighbors. This situation contributes to the continued dominance of the sand surveillance approach in the study area.Geographical barriers are also a significant factor influencing the effectiveness of TB surveillance. Long distances between homes and health facilities, inadequate road infrastructure, and limited transportation facilities contribute to low frequency of visits by health workers and decreased patient adherence to regular treatment. These findings confirm that the effectiveness of a TB surveillance system is not solely determined by its technical performance but is also heavily influenced by the local social and geographic context.

Discussion

Quantitative results showed an average score of 3.28 for human resources, categorized as very good. This was supported by qualitative findings that TB personnel had more than three years of work experience and had received training to support staff stability. Furthermore, to support human resources for TB surveillance, TB personnel collaborated with several other health workers, such as village midwives, health promotion workers, and nurses, ensuring optimal case detection and outreach. These findings align with research by Hasnanisa et al. (2022) and Uddin et al. (2021), which found that adequate human resources influenced the implementation of active surveillance and high data analysis at the primary care level. These findings are also consistent with studies showing that adequate health workers and continuous training improve surveillance implementation capabilities, active detection, and the quality of primary care data analysis.(Benu et al., 2024). Evaluative studies in several regions also found a positive relationship between human resource readiness and the performance of the TB surveillance system.(Alsdurf et al., 2024). A TB case detection process score of 0.87, categorized as good, indicates that the diagnostic and referral mechanisms are technically adequate. However, qualitative data revealed delays caused by stigma and preference for traditional medicine, as well as geographic barriers that limit access to health facilities. Recent literature confirms that even when diagnostic facilities and referral pathways are available, stigma and contextual barriers delay seeking a diagnosis, thus reducing the effectiveness of active detection in the community.

(Silva et al., 2024)This has also been reported in systematic reviews and field studies in various countries including findingsSatav et al. (2025)which identified that limited knowledge, social stigma, distance to health facilities, and transportation constraints are dominant factors that hinder early detection of TB in remote communities and areas with strong socio-cultural characteristics. Average The TB case

reporting score of 3.83 is categorized as very good, indicating relatively well-structured reporting and complete data at the Community Health Center (Puskesmas) level. However, in-depth interviews revealed operational issues such as network and access to the TB service, which sometimes hampered timeliness. National and regional evaluations also found that reporting systems can achieve high performance if the process is simple and users are trained, but infrastructure and public-private integration are often weak points.(WHO, 2023;Febriani et al., 2024).ProcessTreatment success with an average value of 3.52 indicates that treatment is good in several health facilities in Kabawo District. Evaluative studies state that high treatment success values correlate with the mentoring system, drug availability, and community support, but barriers such as geographic access and stigma reduce compliance in some locations.(Khader et al., 2024). Similar findings were reported byFaryabi et al. (2024)Successful treatment requires appropriate programs for early TB diagnosis, adherence to treatment duration, and training of private and public centers to strengthen care systems.

Furthermore, strengthening the process of short-term treatment programs with close supervision is crucial.The availability of facilities and infrastructure, with a score of 2.89, falls into the good category, indicating that basic surveillance facilities are relatively available, but their utilization is not yet optimal. This finding is consistent with Ersanti et al. (2016), who emphasized that the availability of facilities does not necessarily guarantee surveillance quality without strong human resource support systems. Qualitative findings through in-depth interviews emphasized shortcomings in the utilization and distribution of equipment, such as geographic access, transportation, and TCM tools. Inadequate infrastructure can limit staff mobility and patient access.The effectiveness of the TB surveillance system, with a value of 0.85, categorized as effective, indicates that the system is capable of producing adequate performance in aggregate. This value indicates that the surveillance system is capable of carrying out its primary function of recording, reporting, and monitoring TB cases. This achievement aligns with quantitative findings on system components, particularly the availability and capacity of human resources with an average value of 3.28 and the case reporting system with a value of 3.83, indicating excellent performance.

However, qualitative findings indicate that this effectiveness does not fully reflect ideal conditions in the field. Barriers such as stigma against TB patients, reliance on traditional medicine, low public awareness, and limited geographic access still affect the early detection process and treatment continuity. This condition indicates that the effectiveness of the surveillance system is not only determined by technical and structural aspects, but is also strongly influenced by social, cultural, and environmental factors. These findings align with research conducted bySatav et al. (2025), which emphasizes that the effectiveness of TB surveillance in remote areas and vulnerable communities is often hampered by a complex interaction between individual, community, and health system factors. Although reporting systems and formal surveillance mechanisms may function well, community knowledge, social stigma, transportation barriers, and lack of operational support contribute to a gap between the performance of administrative systems and case detection outcomes at the community level. Thus, the effectiveness of the TB surveillance system in Kabawo District can be categorized as technically effective, but it still requires strengthening in non-technical aspects, particularly reducing stigma, increasing community engagement, and improving health services. Integrating surveillance system components with community-based social interventions is key to comprehensively and sustainably improving the effectiveness of TB surveillance.

IV. CONCLUSION

The Tuberculosis (TB) surveillance system in Kabawo District has generally been running quite well and has demonstrated adequate effectiveness. Quantitative analysis results indicate that the availability and capacity of human resources with an average score of 3.28, the TB case reporting system with an average score of 3.83, and the TB treatment success process with an average score of 3.52 are in the very good category. The TB case detection process with an average score of 0.87 and the availability of facilities and infrastructure with an average score of 2.89 are in the good category. Overall, the effectiveness of the TB surveillance system is in the effective category with an average score of 0.85. Qualitative findings revealed that the implementation of TB surveillance still faces challenges stemming from social stigma, reliance on

traditional medicine, limited geographic access, and low community participation in early screening. These findings indicate that the effectiveness of the TB surveillance system is not only determined by technical and administrative performance, but is also influenced by the local socio-cultural and environmental context. Therefore, strengthening the TB surveillance system needs to be done through the integration of technical capacity building with contextual and sustainable community-based interventions.

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