

Identifying Cost-Effective Strategies to Optimize Tuberculosis Case Detection Rate: A Qualitative Case Study from Jember Regency

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ABSTRACT

This study aimed to identify cost-effective strategies to increase the *case detection rate* (CDR) of tuberculosis (TB) in Jember district, Indonesia. This study used a qualitative approach with a case study design, involving 22 informants, including medical personnel, health cadres, and Health Office officials. Data collection techniques were conducted through in-depth interviews, field observations, and documentation analysis related to the implementation of the TB control program in Jember District. Data analysis techniques used a thematic analysis approach. The data validity of this study used source triangulation by comparing the results of interviews with observation and documentation. The findings show that active detection, empowerment of health cadres, and use of information technology can significantly increase CDR, despite challenges related to limited resources, social stigma, and inadequate infrastructure

INTRODUCTION

Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis* with the lungs as the main infected organ. Indonesia ranks second reaching 1,060,000 cases in 2023 (*Global TB Report, 2023*). Based on data from the Tuberculosis Information System (SITB) in 2023, confirmed TB cases reached 64% of the set target of 90%, which is still below the national target. According to Tuberculosis Prevention Therapy (TPT) data, among household contacts, the achievement reached 1.9% of the target of 58%, indicating weaknesses in detection and prevention, so strategies are needed to address these gaps. *Active case finding* (ACF) strategies are very important.

Unlike *passive case finding* (PCF), which waits for patients to come to health facilities, ACF is conducted by directly combing high-risk communities. Data from the Jember District Health Office's Disease Prevention and Control Division in 2024 showed that ACF achievement consistently failed to reach the target for three consecutive years. In 2022, 76% of the 90% target was achieved, in 2023 87% of the 90% target was achieved, and in 2024 88% was achieved but there was an increase in the target to 95%. The data shows that achievements have always increased every year but have not yet reached the target.

Tuberculosis (TB) is recognized as an infectious disease that remains a major challenge in the global health system, especially in developing countries, including Indonesia. According to a World Health Organization (WHO) report in 2020, Indonesia had one of the highest TB burdens in the world, with approximately 845,000 new cases and 93,000 deaths from TB. The Indonesian government has launched various programs to tackle the disease, but TB cases in many regions, including Jember District, are still high. This suggests problems with early detection and effective treatment, leading to wider transmission and increased mortality (World Health Organization, 2020). Therefore, an in-depth evaluation of existing strategies to improve TB case detection rates in the region is needed. Data from the Jember District Health Office's Disease Prevention and Control Division in 2024 showed that ACF achievement consistently failed to reach the target for three consecutive years. In 2022, 76% of the 90% target was achieved, in 2023 87% of the 90% target was achieved, and in 2024 88% was achieved but the target was increased to 95%.

The data shows that achievements have been increasing every year but have not yet reached the target. Active TB detection strategies have proven effective in increasing the number of cases detected, especially in high prevalence areas. A study by Prasetyono et al. (2017) in Jakarta found that active detection through home visits to identify people with TB can increase the detection rate of previously undetected cases. However, this approach is costly, especially in terms of logistics and human resources involved. This raises the question of how

to optimize the approach to make it more cost-effective without compromising its effectiveness. In Jember District, where resources are limited, an efficient and cost-effective approach is needed.

Alternatively, community-based approaches have also been shown to be effective in improving TB case detection in resource-limited settings. Research conducted by Aini et al. (2019) showed that involving health cadres in TB early detection programs can be a more cost-effective solution. With adequate training, health cadres can help detect TB symptoms faster, which in turn will speed up treatment and reduce the risk of transmission. This approach is not only cost-effective, but also strengthens community involvement in TB control at the local level.

The use of information technology to improve TB case detection is increasingly being applied in various countries. Utami et al. (2019) revealed that the utilization of mobile applications for TB symptom reporting has been shown to increase public awareness of TB and speed up the diagnosis process. The technology also enables more effective data collection, which is crucial in planning appropriate health interventions. In Jember district, although the technological infrastructure is still developing, the implementation of a mobile application-based system could be a promising step to improve TB detection efficiently.

However, a major challenge in TB control efforts is the limited funding and resources available. Rachmawati et al. (2021) showed that efficient drug logistics management is essential to lower operational costs in TB treatment. In Jember, timely and organized distribution of TB drugs will reduce waste and speed up the treatment process, which has an impact on improving the quality of TB control. Therefore, strengthening drug logistics and distribution systems needs to be one of the main focuses in efforts to improve TB detection and treatment.

Social factors also play an important role in the success of TB detection strategies. Dewi et al. (2020) showed that intensive health education campaigns can increase community knowledge about TB symptoms and the importance of treatment. In areas such as Jember, where the level of public awareness about TB is low, these campaigns are essential to accelerate early detection. Through an approach based on community understanding, it is expected that the number of patients seeking treatment sooner will increase, ultimately reducing TB transmission and mortality rates.

One solution that can improve the efficiency of TB detection is to utilize big data to map high-prevalence areas. Suryani et al. (2020) suggested using big data to identify areas with high TB rates, so that detection programs can be more targeted. In Jember, more in-depth data analysis can help in planning more

focused interventions, as well as allocating resources more appropriately. This technology can also improve program effectiveness by providing real-time information on the progress of TB cases in the area.

In addition to big data, collaboration between the public and private sectors is also crucial in improving TB case detection. Surya et al. (2021) found that collaboration between the government and private sector in TB control can expand community access to health services and improve early detection. In Jember district, the private sector can play a role in providing more affordable health facilities, as well as assisting in the provision of more efficient reporting and treatment services. This collaboration will allow for more optimal allocation of funds and accelerate the implementation of TB detection programs.

In addition, an evidence-based approach that considers the cost-effectiveness of different detection strategies needs to be developed to determine which ones are most effective in Jember District. This study aims to identify the strategies already implemented in Jember and analyze whether they are cost-effective. Evaluation of different TB detection methods, such as active detection, technology utilization, and community-based approaches, may provide a clearer picture of the advantages and disadvantages of each strategy in the local context.

The importance of this study also lies in its efforts to provide evidence-based policy recommendations that can be used by local governments to design more efficient TB control programs. The results of this study will provide insight into how to optimize the use of limited funds to increase TB case detection without compromising service quality. With a more structured and cost-effective approach, it is hoped that TB control in Jember District can be more successful, and can serve as an example for other regions facing similar problems.

Through a more in-depth cost-effectiveness analysis, this study is expected to provide concrete solutions to improve the TB case detection rate in Jember. By considering various local factors, such as social, economic, and geographical conditions, appropriate strategies can be identified to maximize existing resources. It is hoped that the results of this study will not only benefit Jember, but also contribute to TB control policy in Indonesia as a whole.

LITERATURE REVIEW

Cost Effective Analysis (CEA)

Cost-Effectiveness Analysis (CEA) is an economic evaluation method used to compare the costs and outcomes (effectiveness) of two or more interventions or programs. In CEA, outcomes are measured in natural units (e.g. years of life saved, cases prevented, or quality of life improved), and costs are calculated in monetary units. The goal is to determine which intervention provides the best outcomes at the most efficient cost. CEA is commonly used in healthcare to aid decision-making regarding medical interventions or public health policy (Drummond, et al., 2015). It involves assessing alternatives based on different costs, effectiveness, and safety, ensuring the evaluation is thorough and fair. Bertorio (2020) defines cost-effectiveness analysis as a method to evaluate one or more programs that produce identical clinical outcomes in a physical examination. This cost-effectiveness analysis involves comparing the cost-outcome ratio to the total cost of the program.

Meanwhile, according to P. Musgrove and J. Fox-Rushby in Ardani et al (2012), CEA is the main tool for comparing the cost of a health intervention with the expected health benefits. An intervention can be understood as any activity, using human, financial, and other inputs, that aims to improve health.

Below is a chart of alternative comparisons of the health interventions provided, as shown in Figure 1 below.

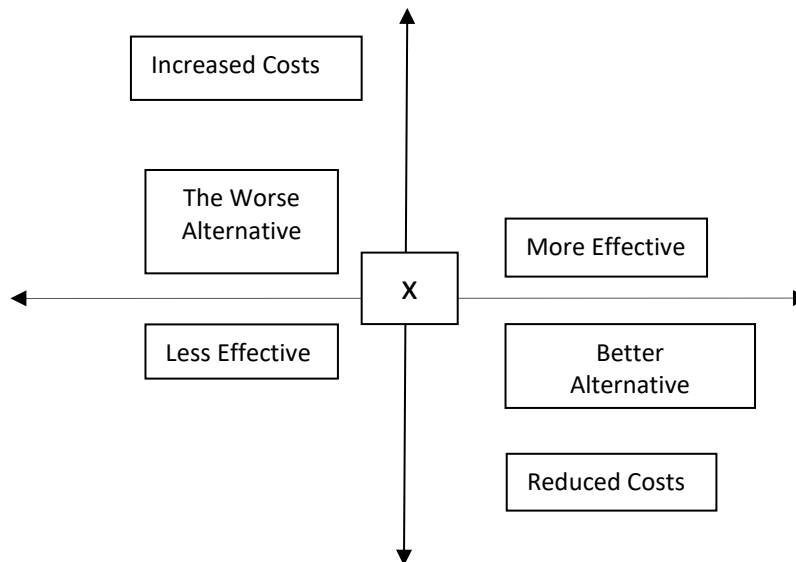


Figure 1. Comparison of Health Intervention Alternatives (Source: P. Musgrove and J. Fox-Rushby in Ardani, 2012)

Other sources indicate that Cost Effectiveness Analysis is a method to assess the potential impact of a program on overall health outcomes. A cost-effective policy is expected to result in a positive net health impact, as the resulting health benefits will exceed the health losses associated with diverting funds from

alternative health programs. A policy that is not cost-effective will likely result in a negative net health impact, as the health losses from allocating funds from other health programs will exceed the health benefits gained. CEA assists policy makers in identifying investments that are economically feasible and improve overall health, while steering them away from investments that are not economically feasible and are detrimental to overall health (Cookson, et al., 2017).

CEA aims to provide policy makers with a comprehensive understanding of the costs, side effects and benefits associated with different treatment options. This approach combines various factors into a single metric, the incremental cost-effectiveness ratio (ICER), which serves as an important tool for decision-making under conditions of resource constraints. (Kim, et al., 2018).

Case Detection Rate Tuberculosis

Case Detection Rate Tuberculosis is an important measure in evaluating the success of a TB control program in a region, indicating the percentage of TB cases detected and reported compared to the estimated number of cases actually present in the community. A high CDR indicates that more individuals with TB are detected, which allows for early treatment and reduces the likelihood of further transmission. According to WHO (2020), a low CDR usually reflects the inability of the health system to detect TB cases at an early stage, which can contribute to the wider spread of the disease and increased mortality. Therefore, CDR is a key indicator in assessing the effectiveness of TB control and achieving the global goal of ending the TB epidemic by 2035.

Various factors can influence the low CDR in an area, including limited access to health facilities, lack of training for medical personnel, and delays in the use of diagnostic technology. Research by Bhatia et al. (2017) suggests that active detection, which involves searching for people with TB in high-risk communities, can help improve CDR, especially in areas with high TB prevalence but limited resources. In Indonesia, where TB prevalence remains high, low CDR is often due to a lack of early detection, resulting in high rates of transmission and death from the disease. By using active detection, such as home visits or symptom monitoring through mobile apps, more TB cases can be found and treated more quickly.

In addition, social factors and stigma towards TB play an important role in low CDR. Dewi et al. (2020) found that social stigma against TB patients discourages them from seeking treatment or reporting symptoms to health workers, which contributes to low case detection rates. This social stigma is often linked to fear of discrimination or exclusion from society, which worsens the psychological state of patients. Therefore, reducing stigma through health education campaigns involving community and religious leaders is critical to

increasing CDR. Community understanding of TB and the treatment that can cure it greatly influences awareness to seek treatment sooner.

Technology also has great potential to improve CDR, especially by using faster and more efficient diagnostic tools. Research by Malik et al. (2019) showed that the use of technology, such as mobile applications for symptom reporting or molecular-based diagnostic tools such as GeneXpert, can accelerate TB detection. In many developing countries, including Indonesia, these technologies are still not optimally used due to limited access and infrastructure. However, if implemented properly, technology can help speed up the detection process and ensure that more TB cases are detected early, which will ultimately increase CDR and decrease prevalence rates.

Finally, to improve CDR, it is important for the government and health institutions to conduct continuous evaluation and improvement of the existing TB control system. Mulyadi et al. (2018) suggest that cost-effectiveness analysis is important in allocating resources to TB detection programs. More cost-effective detection strategies, such as empowering health cadres or community-based detection, should be prioritized in a budget-constrained environment. The government should allocate funds more efficiently to programs that have a significant impact on increasing CDR. This also involves strengthening the capacity of the health system at the puskesmas and hospital levels, so that more individuals can access quality diagnostic services and receive timely treatment.

METHODOLOGY

This study used a qualitative approach with a case study design to identify cost-effective strategies to increase the Tuberculosis (TB) *case detection rate* in Jember District. A case study design was chosen as it allows researchers to understand in-depth the local context and factors that influence TB case detection in the region. The main focus in this study was to explore and evaluate the strategies implemented, taking into account their cost and effectiveness, and to identify possible solutions that could be implemented more efficiently.

This study will be conducted in Jember District, an area with a high prevalence of TB in Indonesia, but significant resource constraints. Jember was chosen as the research site because it is representative of many regions in Indonesia that face similar challenges in TB control. Jember District also has various ongoing TB control programs, which can be the object of analysis for this study. This location allows researchers to directly assess the field conditions and efforts that have been made to increase TB case detection, including the obstacles faced in implementing the program.

The number of informants in this study is 22 people, consisting of stakeholders, such as doctors, nurses, health cadres, Jember District Health Office officials, and community members involved in the TB control program. Data

collection techniques will be conducted through in-depth interviews using a semi-structured interview guide. These interviews aim to elicit information on the TB detection strategies implemented, an evaluation of the cost-effectiveness of each strategy, and challenges faced in its implementation. Data will also be collected through direct observation of processes that occur in the field, as well as documentation in the form of reports or data related to existing TB control programs.

The data analysis technique uses a thematic analysis approach, where the data obtained will be grouped into relevant themes to answer the research questions. This process will be carried out with steps of in-depth understanding of informants' narratives, as well as systematic coding of data to identify emerging patterns. Data validity techniques will be carried out by triangulating sources, namely by comparing interview results with data obtained through observation and documentation. In addition, data validity will also be strengthened through member checking, by asking for confirmation from informants regarding temporary findings that emerged during the interview process, to ensure the accuracy and credibility of the data collected.

RESEARCH RESULT

Based on interviews with medical personnel in Jember District, it was found that despite the active detection program implemented, there are still many TB cases that are not detected at an early stage. This is due to limited human resources and lack of training for health cadres directly involved in early detection. Some medical personnel revealed that although they are trained in diagnostics, the lack of adequate facilities, such as test kits and laboratories, hinders the process of more accurate detection. In addition, the time required for the testing process also slows down the identification of TB cases, leading to late treatment. With these limitations, they suggested that the government should pay more attention to training medical personnel and providing more adequate facilities.

Interviews with health cadres at the village level showed that they play an important role in detecting TB symptoms in the community. However, they also complained about the lack of support from the larger system, such as the District Health Office, regarding more intensive training and counseling. Health cadres stated that they are only involved in basic detection and do not yet have the capacity to conduct diagnosis or advanced tests, which often makes them feel ineffective. They also revealed that community education about TB symptoms is still lacking, resulting in many patients being reluctant to seek care. This indicates the need for a more comprehensive approach to engaging health cadres and providing them with more adequate training.

From field observations, researchers found that although health education campaigns have been conducted by the Health Office, the community still lacks knowledge about the symptoms and dangers of TB. These campaigns are often limited to printed materials or less interactive outreach, making them ineffective in reaching the community at large. Many individuals know that TB is curable, but they do not understand the importance of early detection. Researchers also observed that people tend to avoid treatment due to the social stigma attached to people with TB. Therefore, a more innovative approach to delivering health information that actively engages the community is needed.

In terms of technology use, observations show that although there are several applications designed to assist in monitoring and reporting TB symptoms, many communities are not familiar with these technologies. Even in some areas, access to information technology is limited, and the use of mobile applications to report TB symptoms is not very effective. Information technology, while having great potential, requires strong infrastructure support to be optimally utilized. In some places, there is no adequate internet network, which limits the use of these applications. Therefore, it is important to ensure that the technology used is accessible to all levels of society, including in more remote areas.

Documentation obtained from the Jember District Health Office shows that although there is a budget allocation for TB control, the funds are often insufficient to meet all program needs. In the annual report, there is a shortfall in the allocation of funds for the purchase of drugs and training of medical personnel. This suggests that despite good intentions to control TB, limited budgets are one of the factors hindering the success of the program. Local governments often have to make difficult decisions about budget priorities, which results in delays in procurement of goods and services. Therefore, better budget evaluation and planning is needed to optimize the use of available funds.

Interviews with Health Office officials also revealed that despite efforts to increase TB case detection through active detection, they face constraints in terms of inter-agency coordination. TB control programs are often hampered by a lack of communication between the Health Office and other relevant agencies, such as hospitals and puskesmas. Some existing programs are not well coordinated, resulting in overlapping resource allocation. This has led to non-optimal achievement of TB detection program objectives, especially in reaching a wider community. Therefore, it is important to strengthen coordination between agencies so that each TB control program can run more efficiently.

From the documentation received, it appears that the use of technology such as health information systems (HIS) is still not well integrated in the TB data management system in Jember District. Although there is a digital-based

reporting system, most of the data received is still manual, which causes the data analysis process to be slower and less accurate. The non-real-time data collection process also affects the effectiveness of TB case detection. Speed in accessing and processing data is a key factor in designing more targeted TB control strategies. Therefore, there is a need for better system integration to accelerate the flow of information related to TB cases.

During observations, researchers also noted that some health facilities in Jember District do not have adequate medical equipment to support faster TB detection. Many hospitals and health centers still lack rapid test equipment, such as sputum tests or molecular tests, which can speed up the diagnosis process. This hampers efforts to detect TB cases at an early stage, which is essential to prevent further spread. In addition, this lack of facilities also affects the quality of care provided to patients. Therefore, it is important to improve facilities and infrastructure in health facilities so that TB detection can be carried out more effectively.

Community interviews show that many people with TB are reluctant to disclose their health status for fear of being labeled as sufferers of a dangerous infectious disease. The social stigma against TB is a major barrier to detection and treatment. People often do not know that TB is curable with proper treatment, and they are afraid of being recognized as TB sufferers. This leads them to prefer not to seek medical attention, which in turn worsens their condition. Reducing the social stigma against TB is crucial to improving case detection rates, so that communities can be more open to seeking treatment.

From the documentation, it was found that a large amount of funds allocated to the TB program are often not used optimally. Financial reports from the Jember District Health Office indicate that there is waste in the allocation of funds for less prioritized activities. This wastage occurs because there is no adequate monitoring system in place to oversee the proper use of the budget. This led to funds that should have been used for drug procurement or training of medical personnel being wasted. By improving budget transparency and monitoring, funds can be allocated more efficiently and focused on the most pressing needs.

Observations of the implementation of active detection showed that although the program has been implemented in some areas, achievement is still low. The main factor found was the lack of health workers trained to effectively conduct TB detection in the field. In addition, coordination between local governments and larger health institutions such as hospitals is often suboptimal. The active detection program is often constrained by a lack of funding and available facilities, which hampers the distribution of resources. Therefore, there

is a need to evaluate this active detection program, by adjusting strategies that are more suitable for the conditions and limitations that exist in the area.

Overall, the results of observations, interviews, and documentation show that although many TB control programs have been implemented in Jember District, their effectiveness is still hampered by various factors, including limited resources, lack of training, and imperfect coordination systems. Therefore, greater efforts are needed to strengthen detection systems, increase health worker training, and improve budget management and distribution systems. If these challenges can be overcome, it is expected that the TB case detection rate in Jember district will increase, which in turn will reduce the prevalence and mortality rates of the disease.

DISCUSSION

In the face of the ever-increasing challenge of Tuberculosis (TB), an evidence-based approach is crucial in designing strategies to control the disease. According to a study by Bhatia et al. (2017), early detection through active detection has been shown to significantly reduce TB prevalence in areas with high TB rates. Active detection enables the discovery of TB cases at an earlier stage, which reduces the risk of further transmission and increases the success rate of treatment. In Indonesia, active detection is often conducted through home visits and community counseling. However, the main challenge in implementing this strategy is limited funding and human resources, which makes it difficult to implement widely, especially in resource-constrained areas such as Jember District (Bhatia et al., 2017).

The active detection strategy in Jember is faced with the problem of the availability of trained and evenly distributed health workers throughout the region. A study by Kamran et al. (2018) showed that many regions in Indonesia still lack trained health workers who have the skills to effectively detect TB cases. In addition, health workers in rural areas often do not have adequate diagnostic tools, which slows down the detection process. Therefore, there is a need for continuous training for health workers in Jember as well as increased access to faster and more accurate diagnostic tools. Molecular testing-based technologies such as GeneXpert, which have proven effective in detecting TB more quickly, could be one solution to overcome this obstacle (Kamran et al., 2018).

The empowerment of health cadres as part of active detection has also received attention in several studies. For example, a study conducted by Suryani et al. (2020) showed that empowering health cadres in areas with limited access can significantly improve TB detection. Health cadres empowered to screen and facilitate referral of TB cases to health facilities were better able to detect TB symptoms earlier, allowing treatment to begin sooner. In Jember, by utilizing

local health cadres who are more familiar with local community conditions, active detection programs can be more successful in detecting missed cases. However, to maximize the role of cadres, there needs to be comprehensive training and support from the larger health system (Suryani et al., 2020).

The use of information and communication technology (ICT) in TB control is an increasingly recognized approach in various countries. According to a study by Malik et al. (2019), ICT can play an important role in increasing public awareness of TB and speeding up the case reporting process. Mobile-based applications, for example, allow communities to report their symptoms and receive information on treatment measures to be taken. Although the use of this technology is still limited in Jember, the implementation of TB reporting applications in large urban areas such as Surabaya and Jakarta has shown positive results. With better technological infrastructure, Jember could adopt this technology to support faster TB detection and engage more communities in the disease control process (Malik et al., 2019).

Another obstacle found in TB control is the problem of social stigma attached to TB patients. Research by Dewi et al. (2020) revealed that the social stigma towards TB in Indonesian society is very high, which causes many people to be unwilling to seek treatment. TB sufferers are often seen as individuals who transmit dangerous diseases, so they are isolated and afraid to disclose their health status. Therefore, more effective educational campaigns are needed to reduce this stigma. Campaigns involving local community and religious leaders can help change community perceptions of TB and increase awareness of the importance of early detection (Dewi et al., 2020).

Cost-effectiveness analysis is critical in designing TB control strategies, especially in resource-limited areas such as Jember District. As described by Mulyadi et al. (2018), effective TB control not only depends on the right approach but must also consider the available budget. They emphasized the importance of evaluating the costs and benefits of each TB control strategy, especially in terms of budget allocation for early detection, treatment, and prevention programs. In Jember, this evaluation is important to ensure that any allocated funds are used in the most efficient way and have maximum impact on TB control. Given the limited funds available, a cost-effectiveness approach can help prioritize programs that will have the greatest impact on reducing TB cases (Mulyadi et al., 2018).

A big data approach to mapping the spread of TB has also received attention in TB control. Suryani et al. (2020) showed that the use of big data in geographic mapping can provide very useful insights for designing more targeted control strategies. In Jember, using existing TB prevalence data, the local government was able to identify areas with high TB cases and customize

detection and intervention strategies according to local characteristics. The use of big data also helps in planning a more appropriate allocation of resources, avoiding wastage, and focusing efforts on areas most in need of intervention (Suryani et al., 2020).

In addition, efficient logistics management is also an important aspect of TB control. Rachmawati et al. (2021) showed that good drug distribution management greatly affects the sustainability of treatment and control of disease spread. In Jember, despite efforts to improve the distribution of anti-TB drugs, some puskesmas and hospitals still face obstacles in the procurement and timely distribution of drugs. A poor logistics management system can cause delays in treatment and worsen patients' conditions. Therefore, there is a need for improvement in the logistics system, using technology to monitor drug stocks and ensure real-time drug availability across health facilities (Rachmawati et al., 2021).

Strengthening the capacity of the health system in Jember, especially at the puskesmas level, is also a necessary step. Research by Tushar et al. (2019) revealed that a strong and integrated health system is essential for TB control. In Jember, puskesmas, which are at the forefront of TB control, still face challenges in terms of capacity and facilities. Therefore, strengthening the capacity of PHC centers by providing further training to medical personnel, as well as improving facilities for TB diagnosis and treatment, will go a long way in improving detection and control of the disease. In this regard, cooperation between local governments and hospitals is also needed to optimize available resources (Tushar et al., 2019).

In addition, collaboration between the public and private sectors also plays an important role in TB control. Research by Surya et al. (2021) shows that collaboration between the government and the private sector can accelerate TB control by providing more resources and health facilities. In Jember, collaboration with the private sector can expand community access to health services and ensure that more TB patients are detected and receive timely treatment. This collaboration can also help in providing additional facilities for patients who require hospitalization or intensive treatment (Surya et al., 2021).

The importance of inter-agency coordination in TB control is also evident in the findings of research in Jember. A study by Rachmawati et al. (2021) shows that often the lack of coordination between agencies leads to wasted resources and inefficient budget allocation. In Jember, many TB control programs are run by various government and non-government agencies, but the lack of coordination between these agencies leads to overlap in resource allocation. Therefore, there is a need for a better coordination system between the Health

Office, hospitals, and the private sector to ensure that each program runs effectively and efficiently.

In addition to external factors, changing the mindset of the community is also very important in efforts to improve TB detection and treatment. Research by Dewi et al. (2020) showed that changes in community behavior that are more open in seeking treatment are very important in TB control. In Jember, social stigma towards TB patients is still a major obstacle in improving early detection. Therefore, a more inclusive and community-based approach is needed to reduce the stigma against TB and increase public awareness of the importance of early treatment (Dewi et al., 2020).

Although active detection has significant potential to increase TB case detection, major challenges remain in terms of efficient implementation in Jember district. Bhatia et al. (2017) showed that while active detection is theoretically more effective, the costs involved in implementing it are often disproportionate to the benefits, especially in resource-constrained areas. In Jember, this is further complicated by the uneven health infrastructure across the region. Therefore, this study explored the need to tailor the implementation of active detection to local conditions, leading to the need for a more community-based approach and involving local health cadres as key agents in detecting TB cases early. In this regard, more cost-effective strategies, such as community-based detection and training of health cadres, may be more effective in the long run.

In addition, digital technology may also play a greater role in TB control in Jember, although infrastructure constraints in remote areas are a major challenge. Research by Malik et al. (2019) showed that a mobile application for reporting TB symptoms has proven effective in increasing community awareness as well as speeding up the diagnosis process. However, to maximize the potential of this technology, improved internet access is needed in more remote areas, as well as training for communities and health workers in using these applications. Without adequate infrastructure and proper training, information technology will be difficult to optimize in areas such as Jember, where most people are not familiar with the use of digital health applications.

Social stigma towards TB is also a major problem that hinders early detection in Jember District. As found in Dewi et al. (2020), the stigma against people with TB not only affects their seeking medical care but also worsens their social conditions. In Jember, this stigma is exacerbated by the community's lack of understanding about how TB spreads and how successful treatment can be if done correctly. Therefore, a health campaign is needed that targets changes in community behavior by emphasizing the importance of TB treatment and reducing fear of treatment. These campaigns should involve community leaders

and religious leaders to help reduce stigma and reinforce the health education messages delivered to the community.

The importance of cost-effectiveness analysis in the management of TB control should also be considered. Mulyadi et al. (2018) emphasized that with limited funding, every strategy implemented should be evaluated based on the resulting costs and benefits. In Jember, active detection programs and empowering health cadres could be a more cost-effective solution, but careful planning is needed to ensure proper allocation of funds. Community-based strategies have the potential to reach more individuals at a lower cost, although adequate support from the government and private sector is needed to ensure long-term success. Therefore, it is important to conduct continuous evaluation of existing programs and adjust budget allocations based on the results obtained.

Lastly, strengthening the capacity of the health system in Jember district is crucial to improving TB detection. Research by Tushar et al. (2019) suggests that without a strong and integrated health system, TB control programs will not succeed. Puskesmas as the frontline of health services in Jember often lack facilities and trained medical personnel, leading to late or even neglected TB detection. Therefore, it is important for the local government to increase the capacity of health centers by providing better training for medical personnel and improving facilities and infrastructure at the health center level. This will not only speed up TB case detection, but will also improve the quality of treatment provided to patients, thereby reducing the spread of TB more effectively.

Overall, TB control in Jember requires a more holistic and integrated approach, involving various stakeholders, including the government, community, and private sector. By taking into account social and economic factors, as well as infrastructure readiness, it is expected that TB control in Jember can be carried out more effectively and efficiently. In addition, evaluating the cost-effectiveness of each program implemented is also crucial to ensure that any strategies taken have maximum impact in reducing TB prevalence in the region.

CONCLUSIONS AND RECOMMENDATIONS

This study emphasizes the importance of identifying and implementing cost-effective strategies to improve Tuberculosis (TB) case detection rates in Jember District, given the limited resources available. Active detection approaches, empowerment of health cadres, and use of information technology have been shown to have great potential to improve early detection, but the main challenge remains limited infrastructure and lack of adequate training for health workers. Reducing the social stigma of TB is also crucial in encouraging communities to be more open to seeking treatment. In addition, careful cost-effectiveness analysis is needed to ensure that limited resources are optimally utilized in implementing various TB control strategies. Strengthening the

capacity of the local health system, especially puskesmas, as well as better coordination between agencies, are important steps towards creating a more effective, efficient, and sustainable TB control system in Jember District.

The Jember district government should conduct a cost-effectiveness evaluation of the various TB control programs already in place, to ensure that limited funds are optimally utilized. Programs that have proven to be effective and cost-effective, such as community-based detection and empowerment of health cadres, should be expanded and prioritized. With a detailed evaluation, budget allocations can be focused on strategies that have the greatest impact on TB control.

ADVANCED RESEARCH

Advanced research on the topic of identifying cost-effective strategies to optimize tuberculosis (TB) case detection rates in Jember Regency could explore the integration of multi-faceted interventions, including machine learning and data analytics, to enhance early detection and treatment adherence. This research could investigate the potential of using predictive modeling to identify high-risk populations and areas with undiagnosed TB cases based on demographic, socioeconomic, and health data. Additionally, exploring the feasibility of telemedicine for remote consultations and monitoring, particularly in underserved rural areas, could be a critical component in reducing delays in diagnosis and treatment.

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