

# UNDERSTANDING COST PRIORITIES IN DOTS IMPLEMENTATION FOR TUBERCULOSIS: A CONSENSUS FROM PUBLIC HEALTHCARE PERSONNELS

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**Abstract.** Adherence to tuberculosis (TB) treatment is essential for effective TB control. However, inadequate documentation of the specific cost drivers associated with the implementation of Directly Observed Therapy, Short-course (DOTS) in routine care hinders evidence-based resource planning. This study employed a modified nominal group technique with TB healthcare workers in Malaysian government healthcare facilities to reach consensus on essential cost factors in standard DOTS management for treatment adherence. Participants achieved agreement on six key cost domains, encompassing both provider and patient perspectives. These include investment in digital monitoring tools, staff fieldwork allowances, additional human resources, infrastructure support, patient financial support, and patient transportation. Digital DOTS tools, such as video-observed therapy, along with workforce incentives, have been identified as primary priorities. The findings offer valuable insights for health policymakers, emphasizing areas where targeted resource allocation can enhance cost-effectiveness and improve TB programme efficiency. The results provide a framework for optimizing tuberculosis programme budgets by clarifying cost priorities in DOTS implementation and guiding resource planning. The insights derived from consensus facilitate strategic policy decisions aimed at enhancing treatment adherence and ensuring the sustainability of tuberculosis control programs.

**Keywords:** *tuberculosis, DOTS, health economics, digital adherence technologies, nominal group technique*

## Introduction

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*, mostly affecting the lungs and capable of infecting other organs. It continues to be a significant global health concern, especially in low and middle-income nation (Lv et al., 2024). The World Health Organization (WHO) reports that tuberculosis (TB) ranks among the ten leading causes of mortality globally, with around 10.6 million individuals diagnosed with the disease and 1.3–1.6 million deaths in 2022 (Yang et al., 2024). Nevertheless the existence of efficacious treatment, tuberculosis control is hindered by obstacles associated with early detection, treatment compliance, and the rise of drug-resistant strains (Heidary et al., 2022). Tuberculosis remains a serious public health challenge in Malaysia. The government has achieved considerable advancements in tuberculosis control over recent decades via national tuberculosis programs. However, the annual incidence rate still increases from 92 per 100,000 populations in 2019 to 122 per 100,000 populations in 2023 and it is alarming (Fadzil and Ramli, 2025). Factors contributing to the issue encompass urbanization, migration, congested living conditions, and socioeconomic inequities, which collectively impede access to prompt diagnosis and treatment. Notwithstanding the provision of complimentary anti-TB medications at public healthcare institutions, ensuring treatment adherence continues to be a significant issue (Goroh et al., 2020). Non-compliance with treatment not only

compromises individual patient outcomes but also heightens the danger of transmission and the emergence of multidrug-resistant tuberculosis (MDR-TB), hence employing further strain on an already overburdened healthcare system.

The Directly Observed Therapy, Short-course (DOTS) concept, established by the WHO and embraced by the Malaysian Ministry of Health, constitutes the foundation of national tuberculosis treatment protocols. Under DOTS, patients must ingest their prescriptions in the presence of a healthcare professional, thereby assuring compliance and minimizing the risk of incomplete therapy (Karumbi and Garner, 2015). Although DOTS has demonstrated efficacy in enhancing treatment rates and diminishing defaults, its implementation necessitates considerable logistical and financial resources. The technique requires ongoing involvement from healthcare personnel, patient transportation to medical institutions, schedule coordination, and the upkeep of precise treatment records. Moreover, DOTS may unintentionally impose indirect costs on patients, including transportation expenses, income loss from clinic visits, and time constraints, elements that might adversely affect adherence (Aibana et al., 2020). There exists limited documentation regarding the specific cost components associated with the DOTS technique, especially from the provider's perspective. Current research frequently consolidates or generalizes expenses, impeding the identification of essential cost drivers or opportunities for efficiency enhancement. This disparity poses a problem in resource allocation and economic assessment, particularly in scenarios evaluating alternative or adjunct strategies to enhance TB treatment adherence.

A modified Nominal Group Technique (NGT) was utilized to collect structured insights from healthcare personnels that were directly engaged in tuberculosis treatment services (Lee et al., 2024). It enabled the discovery and prioritizing of essential cost elements in the standard DOTS implementation, including the pooled thoughts of front-line providers. This study analyses practitioner opinion on the most resource-intensive components of DOTS, providing practical guidance for future programmatic modifications and establishing a framework for cost data collecting in forthcoming economic reviews (Holzman et al., 2018). The findings enhance the effectiveness and sustainability of tuberculosis treatment adherence techniques in the Malaysian public health framework.

## **Materials and Methods**

NGT involves several key steps which are introduction and explanation, silent idea generation, sharing ideas, group discussion, and independent voting or ranking. This ensures all participants contribute and that ideas are prioritized systematically (Harvey and Holmes, 2012). However, in this study, a modified NGT was employed to identify and prioritize the cost components related to the routine implementation of Directly Observed Therapy, Short-course (DOTS) for TB patients in Malaysia (Ridzuan et al., 2023). This study altered the NGT methodology was to accommodate logistical restrictions and participant availability by utilizing asynchronous online forms (Lee et al., 2024).

### ***Study design & participants***

A modified NGT technique consisting of two rounds was employed. In the initial phase, open-ended enquiries were distributed to a group of healthcare professionals possessing direct knowledge in the implementation of DOTS. Responses were gathered

through a standardized Google Form, enabling participants to articulate essential cost components, identify potential resource deficiencies, and propose enhancements for DOTS delivery. In the second round, the responses were collected from Round 1 and were converted into prioritized themes. Participants were subsequently requested to evaluate the significance of each theme utilizing a 5-point Likert scale (1 = not significant at all, 5 = extremely important). The implementation of scoring allowed for the quantifying of consensus and enabled the prioritization of cost elements according to their perceived significance. Participants were purposively selected from healthcare personnels directly involved in TB treatment services at government facilities, including medical officers and paramedics with experience in the logistics and management of DOTS.

### ***Justification for modified NGT approach***

The traditional NGT generally consists of in-person workshops where participants engage in discussions and rank items within a structured, face-to-face environment. However, several practical considerations warranted the adoption of a modified asynchronous format in this study. As for feasibility and geographical dispersion, in coordinating concurrent involvement from a diverse assembly of occupied healthcare personnels presented significant logistical difficulties. Participants were sourced from various places across numerous healthcare facilities, rendering physical meetings unfeasible. The Google Form methodology provided participants with the flexibility to answer at their convenience and ensured anonymity, so minimizing the possibility for social desirability bias influenced by group dynamics. Although real-time interaction was lacking, the revised methodology maintained the fundamental advantages of NGT: systematic idea generating, clear synthesis of responses, and prioritization determined by participants.

### ***Data collection and analysis***

Responses from Round 1 were systematically coded and thematically categorized by two independent reviewers to identify specific cost-related themes. Descriptive statistics were employed to summarize the scores from Round 2. Mean significance scores were computed for each theme and subsequently ranked. Furthermore, qualitative quotations from Round 1 were aligned with each theme to enhance the interpretation. All NGT sessions, including both rounds of idea generation and scoring, were conducted in the Malay language to ensure participant comfort and clarity, as all participants were native Malay speakers. The responses were initially documented in Malay and subsequently translated into English for thematic analysis. To preserve meaning and minimize interpretation bias, two bilingual researchers (including the lead author) independently reviewed, translated, and coded the responses. Discrepancies were resolved through consensus to ensure semantic accuracy and cultural relevance in the final English thematic categories. This study received ethical approval from the Universiti Teknologi MARA (UiTM) Research Ethics Committee (REC) with reference number REC/01/2024 (PG/MR/41) and the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia (MOH) under NMRR ID: 23-03410-K8W (IIR). Participation was optional, and data were anonymized to ensure confidentiality. The consensus findings established a critical foundation for defining cost components in future economic evaluation models and contributed meaningfully to a more

comprehensive assessment of the efficiency of tuberculosis treatment programmes in the Malaysian context.

## Results and Discussion

Table 1 shows a summary of the participants in the modified Nominal Group Technique to generate idea and rank the cost factors in the standard implementation of Directly Observed Therapy, Short-course (DOTS) for managing tuberculosis (TB). Eight healthcare personnels took part in this NGT. There were two Medical Officers and six Assistant Medical Officers in the group. Four of them worked in hospitals, and the other four worked at public health clinics (Klinik Kesihatan). The input from both primary and secondary healthcare settings made sure that there was a wide range of views on the operational and financial issues at different TB care delivery points (Burman et al., 2024). The participants had worked in TB care or related clinical services for 8 to 15 years, with most of them having done so for more than a decade. The two Medical Officers had the most experience, 13 and 15 years, respectively, which was helpful for both clinical and supervisory purposes. The Assistant Medical Officers, on the other hand, brought real-world knowledge from their front-line roles in putting DOTS into action. Many of them had been working for more than 10 years. This mix of different roles, work environments, and lengths of service helped create a balanced and informed group dynamic during the consensus-building exercise, which improved the quality of the ideas and priorities that came out of the NGT sessions.

**Table 1.** Participants in modified nominal group technique.

No	Position & Grade	Grade	Workplace	Years of Service
1	Medical Officer	UD13	Klinik Kesihatan (PR1)	15
2	Medical Officer	UD13	Klinik Kesihatan (PR1)	13
3	Assistant Medical Officer	U6	Klinik Kesihatan (PR1)	12
4	Assistant Medical Officer	U6	Hospital	10
5	Assistant Medical Officer	U5	Hospital	9
6	Assistant Medical Officer	U5	Hospital	9
7	Assistant Medical Officer	U5	Klinik Kesihatan (PR2)	8
8	Assistant Medical Officer	U5	Klinik Kesihatan (PR1)	8

Table 2 shows the results of both rounds of the Nominal Group Technique (NGT), which were used to find and rank the cost related factors that affect the standard implementation of Directly Observed Treatment, Short-course (DOTS) in tuberculosis (TB) care. A structured consensus process that included medical officers and assistant medical officers from both health clinics and hospitals led to the creation of six main themes, which were then ranked by how important they were thought to be. The top priority theme identified was Electronic Equipment for DOTS (mean score: 4.88), which shows that everyone agreed that digital tools like tablets or electronic systems are needed to make real-time online monitoring easier, make things more efficient, and cut down on the need for paper records. Participants stressed that this kind of technology would make it easier to keep track of who was following the rules and make the supervision process more efficient. Staff Allowance (mean score: 4.88) was next, which shows how important it is to pay staff enough money to do their DOTS duties off-site or in the field. Participants emphasized that the absence of travel allowances or hardship incentives might discourage staff and threaten the continuity of care. The third ranked

theme, Additional Human Resources (mean score: 4.75), highlighted the current lack of staff in TB services. Respondents consistently reported feeling overwhelmed because there were not enough staff members, which made it harder to follow up with patients on time and keep an eye on their treatment. The fourth and fifth places went to Infrastructure Support and Patient Financial Support, both with a mean score of 4.38. Infrastructure support was connected to the presence of designated, comfortable, and private areas in healthcare facilities for DOTS related interactions. At the same time, it was thought that patients needed financial help to pay for things like food and other small necessities while they were getting treatment, especially those from low income families. Transportation Cost for Patients (mean score: 4.12) was ranked sixth, but it is still a very important issue. Numerous participants indicated that patients, particularly those from rural or isolated regions, encounter difficulties in affording consistent travel to healthcare facilities, which directly affects treatment adherence and effective tuberculosis control. These thematic priorities bring up two main issues: the costs on the provider side, like equipment, staffing, and infrastructure, and the costs on the patient side, like direct and indirect costs of treatment (Asres et al., 2018). This layered understanding of cost factors gives a solid base for later economic evaluations and policy changes that aim to improve TB treatment adherence through DOTS.

**Table 2.** Findings from Nominal Group Technique (NGT) on cost factors in the standard implementation of DOTS for TB treatment.

No	Theme / Idea Generated	Frequency of Mention (Round 1)	Ranked Importance (Mean Score)	Final Priority Rank	Example Responses
1	Electronic Equipment for DOTS	10	4.88	1	<i>Perlu sediakan tablet untuk petugas agar mudah pantau DOTS guna sistem online.</i>
2	Staff Allowance	8	4.88	2	<i>Elaun perjalanan atau tugas luar bagi staf jalankan DOTS di lapangan perlu dipertimbang.</i>
3	Additional Human Resources	7	4.75	3	<i>Bilangan staf tidak mencukupi untuk pantau pesakit TB, perlu tambah petugas.</i>
4	Infrastructure Support	6	4.38	4	<i>Keperluan ruang khas untuk pelaksanaan DOTS di klinik agar lebih selesa dan sistematik.</i>
5	Patient Financial Support	5	4.38	5	<i>Bantuan kewangan terus kepada pesakit TB untuk transport atau makan semasa rawatan.</i>
6	Transportation Cost for Patients	4	4.12	6	<i>Kos tambang untuk ke klinik menjadi kekangan utama pesakit untuk patuh rawatan.</i>

Even though DOTS is a key part of Malaysia's TB control policy, the different costs that healthcare workers and patients face when using it were insufficiently reported (Abd Rahim et al., 2020). This study fills that gap by getting experienced TB staff from both clinics and hospitals to agree on a structured way to do things. A modified Nominal Group Technique (NGT) was used to systematically find, improve, and rank the most important cost drivers for the implementation of DOTS. The prioritized themes underscore the practical challenges of frontline service delivery, encompassing both provider side constraints, such as limitations in digital infrastructure, staffing, and physical workspace and patient side barriers, including transportation difficulties and financial hardship (Endo et al., 2022). These findings offer a grounded perspective on

were resource gaps most significantly hinder TB treatment adherence, thereby equipping implementers to prioritize cost components with the greatest potential impact. The prioritized themes in this study generally correspond with both international and local literature regarding cost barriers to tuberculosis adherence. For example, earlier study by Portnoy et al. (2023) found that both direct costs (medical fees, transport, food, accommodation) and indirect costs (lost income, time away from work) were problems for patient compliance and the long-term success of the program. Research from Southeast Asia and Sub-Saharan Africa often identifies systemic challenges in sustaining effective health programs, including human resource constraints, logistical difficulties, and inadequate patient support (Iwelunmor et al., 2015).

The focus on digital tools and electronic equipment (which ranked highest in this study) is an important change in the way people talk about controlling TB around the world, especially the growing interest in digital adherence technologies (DATs) (Ridho et al., 2022). The World Health Organization (WHO) and the Stop TB Partnership have been pushing for digital changes in TB services more, such as video-observed therapy (VOT) and app-based monitoring (Guo et al., 2020). Prior research has concentrated on assessing the efficacy of these technologies. However, this study demonstrates that implementers prioritize digital tools not only for their efficiency but also to reduce the administrative load of manual documentation and enhance real-time monitoring. There was a digital medication monitor in Ethiopia automated dose tracking and reminders, achieving non-inferior adherence rates compared to in-person DOT while drastically cutting staff time and documentation load (Manyazewal et al., 2022). The ranking of staff allowances and human resource increase validates findings in the literature concerning under compensation, burnout, and coverage deficiencies in tuberculosis programs. Previous research has highlighted how these workforce constraints result in missed follow-ups and treatment discontinuations, especially within underfunded healthcare systems (Belling et al., 2012). The emphasis on infrastructure and financial assistance for patients reinforces these findings and highlights the ongoing dual burden faced by healthcare facilities and TB patients (Marme et al., 2023).

### ***Understanding the cost factors that are most important***

The study's most important cost driver, electronic equipment for DOTS implementation shows that frontline implementers really want digitized monitoring systems. Participants viewed these not merely as "tools of convenience," but as facilitators of enhanced accountability, diminished paperwork, and more efficient workflows (Sekandi et al., 2025). This finding came from real-world experience, which is important because it shows that digital integration is not something that needs to be done from the top down, but rather from the bottom up. Staff allowance, especially for travel and field visits, came in second place. Respondents said that the lack of specific rewards for off-site monitoring duties made it less likely that supervisors would do their jobs consistently, which could lead to patients not following through with their treatment (Volmink and Garner, 1997). Because DOTS is so intensive and face-to-face verification is still common in many places, this cost factor shows how important it is to plan for realistic costs when designing a program. The third most important thing was to get more people to work. Participants consistently reported strain from being overextended, often balancing DOTS with multiple other clinical duties (Figueroa-Munoz et al., 2005). Because of this shortage, they cannot do timely follow-up, home visits, or adherence counselling, especially in districts with a lot of cases. The need for

operational scalability, not ad-hoc management, is what the call for more staff, including support staff, shows.

Infrastructure support and financial help for patients came in fourth and fifth, with the same score. Participants called for separate DOTS areas in clinics to protect patient privacy, make it easier for patients, and keep their dignity (Koontalay et al., 2021). They also said that even small amounts of financial help, like food or transport subsidies, could make a big difference for low-income TB patients and lower the number of people who do not follow through on their treatment (Kadota et al., 2021). Lastly, transport costs for patients were still a concern, even though they were ranked sixth. Many people who answered said they had heard stories of patients missing appointments because they lived too far away, especially in rural and semi-urban areas (Herrero et al., 2015). Even when drugs are free, the hidden costs incurred to them are still a major reason patient defaulted to their treatment plans. This confirms previous studies indicating that tuberculosis control cannot be effective solely through pharmaceutical interventions; it must also challenge structural barriers. These findings together give us a multi-layered view of the costs involved in DOTS practice. They say that to effectively control TB, we need to invest not only in treatment supplies but also in the whole system of care delivery, which includes things like workforce support, digital systems, infrastructure readiness, and incentives for patients.

### ***Limitations and recommendations***

Several limitations were identified in this study. First, even though the study wanted to represent a wide range of people, the fact that there were not many people in each session might make it hard to apply the results to the whole healthcare workforce, especially in other Malaysian states or non-governmental settings. Secondly, the dependence on perceived importance scores introduces subjectivity, which may not accurately reflect actual expenditure patterns in DOTS programmes. Another possible limitation has to do with how the NGT process has changed. Asynchronous rounds had the absence of a conventional, real-time consensus session may have limited interactive deliberation that can enhance and elucidate perspectives. Also, no patients or community members were involved in the process, which makes it harder to understand what factors on the demand side or at the household level might affect adherence. Finally, while scoring dispersion was utilized to evaluate levels of agreement, the study did not perform subsequent validation interviews to validate or enhance thematic interpretation.

It is suggested that digital infrastructure should be given priority to help put in place a DOTS strategy for TB treatment adherence that is effective, long-lasting, and cost-effective. This includes providing tablets or other electronic devices to make monitoring and reporting more accurate and cut down on the amount of work that needs to be done by hand (Kafie et al., 2024). These kinds of investments should be backed up by a fair pay system for healthcare workers, especially those who work in the field on DOTS. These financial incentives might make people more motivated and make sure they keep following up with patients (Lutge et al., 2015). At the same time, strategic planning should look at how to make the current workforce stronger by better distributing tasks and pushing for more support staff when the workload is too much for the current staff (Aytona et al., 2022). In addition, to lower treatment dropout rates, targeted patient-centered strategies like travel vouchers, food supplements, or short-term financial help should be investigated. Policymakers might also think about changing the way clinics

work and the way they are set up so that DOTS-specific tasks can be done more easily, which would improve service delivery. The results of this study ought to guide subsequent budgeting processes and be integrated into tuberculosis program planning at both district and state levels. Moreover, subsequent research should investigate the scalability of these cost factors and assess the actual budgetary implications of interventions designed to improve TB treatment adherence.

## Conclusion

This study effectively identified and ranked the most important cost factors that affect the implementation of DOTS from the point of view of frontline healthcare workers. The study established a structured consensus utilizing a modified Nominal Group Technique (NGT) approach, resulting in an evidence-based framework of the most significant cost components for implementers. The results show that it is important to invest in both system enablers, like digital infrastructure and staff support, and patient-centered inputs, like financial help and easy-to-reach transportation. These findings are essential for more thorough economic assessments of TB adherence interventions and facilitate more focused planning of DOTS service delivery. Lastly, it is important to make sure that cost structures match the realities of frontline implementation to keep TB control strategies in Malaysia and other high-burden areas effective and fair.

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## Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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