Digital Poverty and Tuberculosis Health Literacy: Implications for Treatment-Seeking Behaviour among Rural Communities in Keningau, Sabah

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ABSTRACT

Tuberculosis (TB) remains one of the world's leading infectious diseases, yet efforts to control the disease continue to be constrained by persistent social inequalities. While previous studies have largely emphasised conventional determinants such as poverty, education, and healthcare accessibility, the role of digital poverty as an emerging structural determinant of TB prevention and treatment-seeking behaviour remains insufficiently understood, particularly in rural settings. This study explores how digital poverty shapes tuberculosis health literacy and healthcare-seeking behaviour among rural communities in Keningau, Sabah. Using a qualitative case study approach, semi-structured interviews were conducted with six purposively selected rural participants, and the data were analysed manually using Braun and Clarke's thematic analysis. The findings reveal that digital poverty represents a form of layered deprivation, where economic disadvantage intersects with limited digital access, unstable internet connectivity, affordability constraints, and inadequate digital capabilities to restrict access to reliable health information. This condition creates a form of informational silence, reducing community understanding of tuberculosis symptoms and treatment while contributing to delayed healthcare utilisation. Nevertheless, participants demonstrated positive attitudes towards digital health interventions when information was delivered through accessible platforms and complemented by face-to-face community engagement. The study argues that digital poverty should be recognised as an emerging social determinant of health that influences tuberculosis health literacy and treatment-seeking behaviour in rural communities. By extending the Social Determinants of Health perspective through the lens of digital inequality, this research provides new empirical evidence that effective tuberculosis control requires not only biomedical interventions but also strategies that strengthen digital inclusion and health literacy. The findings offer important implications for policymakers seeking to integrate digital equity into tuberculosis prevention and control programmes, particularly among underserved rural populations.

Keywords: Digital poverty, Tuberculosis, Health literacy, Treatment-seeking behaviour, Social determinants of health, Rural communities.

INTRODUCTION

According to the World Health Organization (WHO, 2025), tuberculosis (TB) remained a major global public-health challenge in 2024. The local relevance is particularly important in Sabah. On 21 February 2026, the Malaysian Ministry of Health reported 3,161 cumulative TB cases nationwide by Epidemiological Week 6 of 2026, including 755 cases in Sabah, the highest state total at that reporting point (Bernama, 2026). These are surveillance counts to a defined epidemiological week, not estimates of incidence or proof of a local outbreak in Toboh Laut. TB is an airborne infection, and the Ministry advised people with a cough lasting more than two weeks or other related symptoms to seek medical attention (Bernama, 2026). Malaysia has experienced substantial growth in digital infrastructure and digital health services over the past decade, yet unequal access to digital technologies remains evident across geographical and socioeconomic groups. This disparity is particularly apparent in Sabah, which consistently records the highest tuberculosis incidence in the country while simultaneously facing challenges related to geographical isolation, dispersed settlements, transportation barriers, and uneven internet connectivity (World Health Organization, 2025). In rural districts such as Keningau, these structural constraints may reduce opportunities to access reliable health information and healthcare services, thereby increasing the risk of delayed diagnosis and continued disease transmission. The unequal distribution of digital resources has been conceptualised through the Digital Divide Theory, which argues that digital inequality extends beyond physical access to technology and encompasses disparities in digital skills and the ability to utilise technology effectively for social participation and personal well-being (Van Dijk, 2020).

Building upon this perspective, Barrantes (2007) introduced the concept of digital poverty, describing a multidimensional form of deprivation characterised by inadequate access to digital devices, unstable internet connectivity, affordability constraints, and limited digital capabilities. Rather than representing a simple technological deficit, digital poverty reflects a condition of layered deprivation, where economic disadvantage intersects with digital exclusion and further limits opportunities for education, employment, and healthcare access.Within the health sector, digital poverty may contribute to a form of informational silence, whereby individuals experience limited access to reliable health information and become increasingly dependent on informal or inaccurate sources of knowledge. Restricted digital access may reduce awareness of tuberculosis symptoms, transmission, prevention, and treatment while delaying appropriate healthcare-seeking behaviour and increasing the risk of community transmission (Cuadros et al., 2025). As healthcare systems increasingly rely on digital communication and online information dissemination, unequal digital access has the potential to widen existing health disparities among vulnerable populations. Despite growing recognition of digital inequality as an emerging social determinant of health, empirical evidence examining the relationship between digital poverty, tuberculosis health literacy, and treatment-seeking behaviour remains limited, particularly within rural communities in Malaysia. Existing studies have largely focused on conventional socioeconomic determinants such as income, education, nutrition, housing conditions, and healthcare accessibility while overlooking the influence of digital exclusion on health literacy and healthcare utilisation.

Local evidence reinforces the need to examine what communities know about TB rather than assuming that awareness alone reflects accurate health literacy. In a qualitative study involving 42 community members in high-TB-endemic localities in northern Sabah, Mujin et al. (2025) reported that most participants had heard of TB, but many did not understand the disease clearly and persistent misconceptions could affect willingness to undergo screening or seek care. A systematic review of Malaysian studies on TB knowledge, attitudes and practices likewise provides a useful national evidence base for identifying gaps between awareness and actionable knowledge (Ithnin et al., 2025). These studies provide a relevant comparison for the present case study, while their different samples and locations mean that their findings should not be treated as estimates for Toboh Laut. This gap is increasingly important because ownership of digital devices does not necessarily translate into meaningful access to health information or the ability to utilise digital technologies effectively. Therefore, this study aims to explore the role of digital poverty in shaping tuberculosis health literacy and treatment-seeking behaviour among rural communities in Keningau, Sabah. Specifically, the study examines how limitations in digital access, internet affordability, and digital capabilities influence community understanding of tuberculosis and decisions to seek healthcare services. By positioning digital poverty as an emerging structural determinant within the Social Determinants of Health framework, this study contributes to a broader understanding of health inequality in the digital era. The findings are expected to inform policymakers

in integrating digital inclusion strategies with tuberculosis prevention programmes, thereby supporting more equitable and sustainable public health interventions in rural communities.

LITERATURE REVIEW

Tuberculosis as a Disease Associated with Poverty

Tuberculosis (TB) is widely recognised as a disease closely associated with poverty and social inequality. Although caused by *Mycobacterium tuberculosis*, its transmission and treatment outcomes are strongly influenced by structural determinants such as low income, inadequate nutrition, overcrowded housing, limited education, and restricted access to healthcare services (Oxlade & Murray, 2012). Individuals living under these conditions are more likely to experience delayed diagnosis, interrupted treatment, and poorer health outcomes. Bhargava et al. (2020) argue that TB should be understood within the Social Determinants of Health (SDH) framework, whereby socioeconomic disadvantage, geographical isolation, and limited social support interact to increase disease vulnerability. Similarly, Cambanis et al. (2005) reported that rural populations frequently delay seeking treatment because of financial constraints, transportation barriers, and limited health knowledge. These findings suggest that effective TB control requires interventions that address both biomedical and structural determinants of health.

The Concept of Digital Poverty

Digital poverty refers to the inability to access and meaningfully utilise digital technologies because of limited digital devices, internet connectivity, affordability, and digital capabilities (Barrantes, 2007). The concept extends beyond physical access to technology and encompasses the capacity to use digital resources for education, communication, and health-related decision-making. Consistent with the Digital Divide Theory, digital inequality includes disparities in both access and effective technology utilisation (Van Dijk, 2020). Recent evidence suggests that digital exclusion has emerged as an important social determinant of health, limiting access to healthcare information and digital health services while widening existing health inequalities (Cuadros et al., 2025). These challenges are particularly evident among rural and low-income populations, where limited digital skills and connectivity restrict meaningful participation in an increasingly digital healthcare environment (Latulippe et al., 2017).

Digital Poverty and Health Literacy

Health literacy refers to an individual's ability to access, understand, evaluate, and apply health information to make informed health decisions (Sørensen et al., 2012). In the digital era, this concept has expanded to include eHealth literacy, which incorporates the ability to search, interpret, and utilise health information obtained through digital technologies (Norman & Skinner, 2006). Individuals experiencing digital poverty often possess lower levels of digital health literacy because restricted internet access and inadequate digital skills limit opportunities to obtain reliable health information. Consequently, they may rely on informal information sources and become more susceptible to misinformation, resulting in poorer understanding of disease prevention and delayed healthcare utilisation (Latulippe et al., 2017). Within the context of tuberculosis, limited digital health literacy may reduce awareness of symptoms, transmission pathways, and the importance of early diagnosis and treatment.

TB Knowledge, Health Literacy, and Care-Seeking in Malaysia and Rural Settings

Health literacy involves more than having heard a disease name: it includes being able to access, understand, appraise, and use relevant information when deciding what action to take (Sørensen et al., 2012). This distinction is pertinent to TB because knowledge of a prolonged cough, transmission, screening, and treatment can be incomplete even when awareness is widespread. Research in Sabah has documented misconceptions about TB causation and symptoms, while Malaysian studies outside Sabah have identified socioeconomic barriers, distance, financial constraints, family support, and health-system experiences as factors relevant to timely diagnosis and treatment (Mujin et al., 2025; Makeswaran et al., 2024; Mohamad et al., 2022). A systematic

review of TB knowledge, attitudes, and practices in middle- and low-income countries also found recurring deficiencies in knowledge of symptoms, prevention, and treatment (Craciun et al., 2023). These studies support considering knowledge and care-seeking together with structural barriers, but they do not establish that digital poverty itself causes delayed TB diagnosis in rural Sabah.

Digital Technology in Tuberculosis Prevention and Management

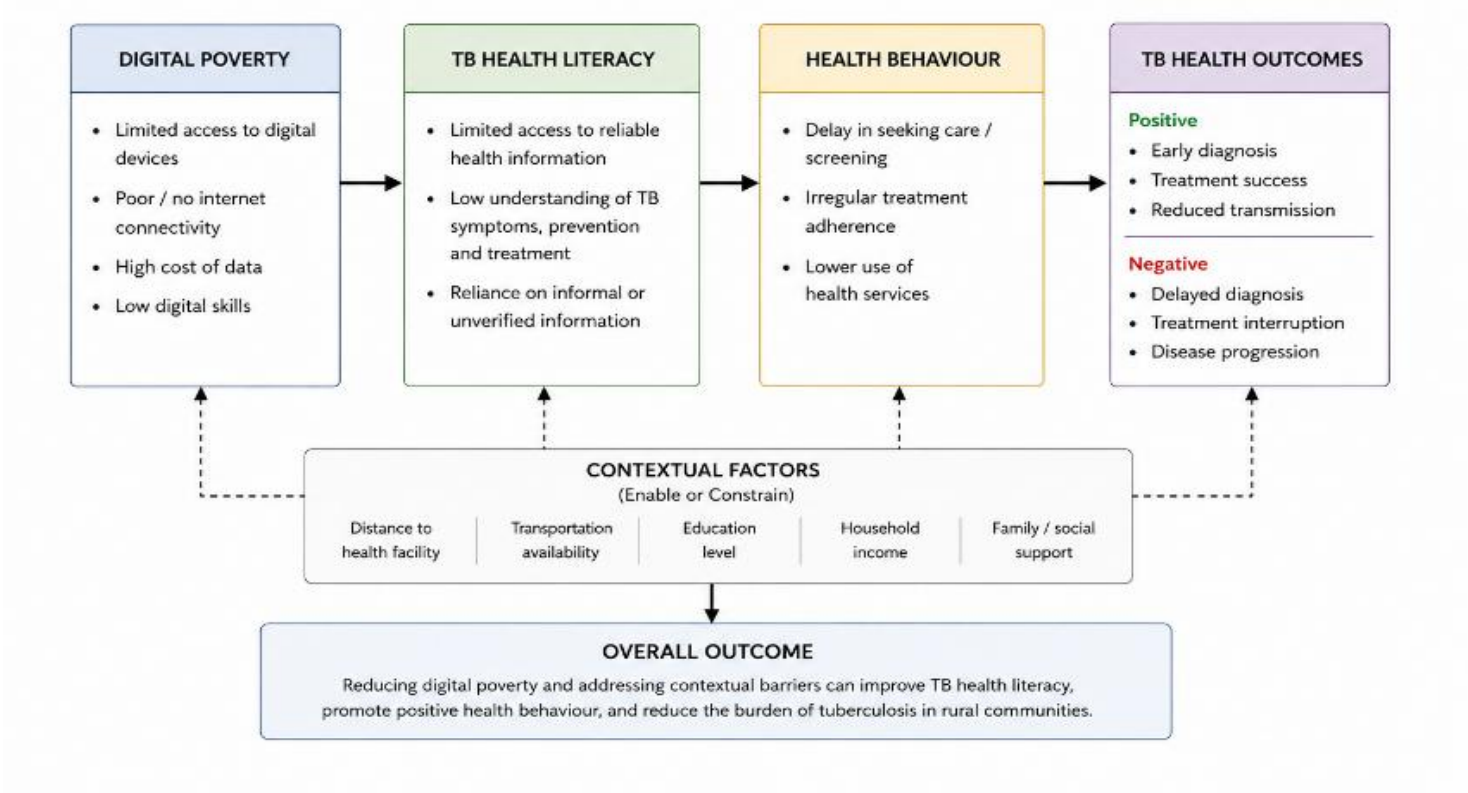
Digital technology has become an increasingly important component of tuberculosis prevention and management through telehealth services, mobile applications, medication reminders, and digital health education. These technologies have the potential to improve patient knowledge, strengthen treatment adherence, and facilitate communication between communities and healthcare providers (Labrique et al., 2018; World Health Organization, 2021). However, the effectiveness of digital health interventions depends on equitable access to digital infrastructure and adequate digital literacy. Communities experiencing digital poverty may be unable to fully benefit from these innovations despite their potential to improve healthcare outcomes (Cuadros et al., 2025). Therefore, strengthening digital inclusion should be regarded as an essential component of comprehensive tuberculosis prevention strategies, particularly in underserved rural communities.

CONCEPTUAL FRAMEWORK

This study is underpinned by the Social Determinants of Health (SDH) framework, the Digital Divide Theory, and Barrantes' (2007) concept of digital poverty to explain how structural inequalities influence tuberculosis (TB) health literacy and healthcare-seeking behaviour among rural communities in Keningau, Sabah. Drawing upon Barrantes (2007), digital poverty is conceptualised as a multidimensional form of deprivation encompassing limited access to digital devices, unstable internet connectivity, affordability constraints, and inadequate digital capabilities that restrict meaningful participation in the digital environment. Similarly, the Digital Divide Theory argues that digital inequality extends beyond physical access to technology and includes disparities in digital skills and effective utilisation of digital resources (Van Dijk, 2020). Within rural settings, these limitations reduce opportunities to access reliable health information and benefit from digital health services. Based on this perspective, the conceptual framework proposes that digital poverty functions as a structural determinant of TB health literacy. Individuals experiencing digital poverty are less likely to obtain accurate information regarding TB symptoms, transmission, prevention, and treatment, resulting in lower levels of health literacy. Limited health literacy may subsequently influence health-seeking behaviour, including delayed screening, reduced utilisation of healthcare services, and poor treatment adherence. In this pathway, TB health literacy serves as an important mechanism linking digital poverty to health-related decision-making and healthcare utilisation among rural populations.

The framework further acknowledges that the relationship between digital poverty and TB health behaviour is influenced by several contextual factors, including geographical accessibility to healthcare facilities, transportation availability, educational attainment, household income, and family or community support. These enabling and constraining factors may either strengthen or weaken individuals' ability to access digital health information and healthcare services, thereby influencing tuberculosis prevention and treatment outcomes. Consistent with the Social Determinants of Health framework, health behaviours are shaped not only by individual knowledge but also by broader social, economic, and environmental conditions that determine opportunities for achieving good health (World Health Organization, 2010). Overall, the conceptual framework suggests that reducing the burden of tuberculosis requires more than biomedical interventions alone. Improving digital inclusion, strengthening TB health literacy, and addressing broader social determinants of health are equally important for promoting timely healthcare-seeking behaviour and equitable access to health information. By integrating these theoretical perspectives, the framework provides a comprehensive explanation of how digital poverty contributes to tuberculosis-related health disparities among rural communities in Keningau, Sabah. Figure 1 illustrates the proposed conceptual pathway, demonstrating how digital poverty influences TB health literacy and treatment-seeking behaviour, while contextual socioeconomic and geographical factors shape the overall relationship and subsequent health outcomes among rural populations.

Figure 1. Conceptual Framework of the Relationship between Digital Poverty and Tuberculosis (TB) Health Literacy and Treatment-Seeking Behaviour among Rural Communities in Keningau, Sabah



Source: Adapted by the authors based on the Social Determinants of Health framework (World Health Organization, 2010), Barrantes' (2007) concept of digital poverty, and the Digital Divide Theory (Van Dijk, 2020).

RESEARCH METHODOLOGY

Research Design

This study adopted a qualitative approach using an intrinsic case study design to explore the relationship between digital poverty and tuberculosis (TB) among rural communities in Keningau, Sabah. A qualitative case study was considered appropriate because it enables an in-depth understanding of participants' experiences and behaviours within their real-life social and geographical contexts while addressing "how" and "why" questions (Yin, 2018). The study specifically examined how digital poverty influences TB health literacy and treatment-seeking behaviour in underserved rural communities.

Study Location

The study setting is described as rural Keningau, Sabah, with a focus on respondents associated with Kampung Toboh Laut. Based on the findings from the interviews, all six informants were identified as originating from Kampung Toboh Laut, Keningau.

Participants and Sampling

The study involved six adult participants purposively selected from Kampung Toboh Laut, Keningau, Sabah. Data were collected through semi-structured interviews conducted on 30 April 2026. The interviews explored participants' experiences concerning digital access, tuberculosis (TB) health literacy, and healthcare-seeking behaviour. The researcher documented the participants' responses and organised the data according to informant number to facilitate systematic comparison and thematic analysis. Selected quotations are presented in the findings to illustrate participants' perspectives and experiences, with each quotation attributed to the respective informant. Where responses were originally provided in Bahasa Malaysia or a local dialect, they were translated into English for presentation in the article. The translations were intended to preserve the original meanings of the participants' responses.The study involved a small, purposively selected sample intended to provide an in-depth understanding of the research phenomenon rather than statistical representativeness. Sample adequacy in

qualitative research can be considered in relation to the specificity of the research objectives, the relevance of the participants, the richness of the data, and the analytical approach. Malterud et al. (2016) proposed the concept of information power as a basis for considering sample adequacy in qualitative studies. However, data saturation should not be claimed unless supported by evidence from the researcher's data collection and analysis process.

Research Instrument

Data were collected using a semi-structured interview guide developed based on the research objectives and relevant literature on digital poverty, health literacy, and tuberculosis (TB). The interview guide covered four main domains: (1) digital access and technology use, (2) TB knowledge and health literacy, (3) healthcare-seeking behaviour, and (4) the role of digital technology in accessing health-related information. The semi-structured format provided a consistent framework for addressing the research questions while allowing the researcher to explore participants' experiences and clarify their responses where necessary. The development of a structured yet flexible interview guide is consistent with recommendations for qualitative semi-structured interviews (Kallio et al., 2016).

Data Collection Procedures

Face-to-face interviews were conducted on 30 April 2026 in Bahasa Malaysia or local dialects, according to participants' language preferences. Each interview was conducted for approximately 30 to 40 minutes per participant to ensure that sufficient information was obtained without causing burden to the participants. The interviews focused on participants' experiences with digital access, their knowledge and understanding of TB, their access to health-related information, and their healthcare-seeking behaviour. The researcher documented participants' responses and organised the information according to informant identification numbers to facilitate systematic analysis. Selected quotations are presented in the findings to illustrate participants' perspectives and experiences. Where responses were originally provided in Bahasa Malaysia or a local dialect, they were translated into English for presentation in the article, with the intention of preserving their original meaning. The wording of translated quotations should be checked against the original interview records or transcripts, where available, to ensure accuracy. Details concerning interview duration, audio recording, field notes, informed consent, and withdrawal procedures should be reported only were confirmed by the researcher's records. Similarly, claims that quotations were verified against audio recordings should be made only if this verification was undertaken.

Data Analysis

The data were analysed manually using thematic analysis, guided by the six-phase approach proposed by Braun and Clarke (2006). The process involved familiarisation with the data, generating initial codes, searching for potential themes, reviewing themes, defining and naming themes, and producing the analytical report. This approach enabled the researcher to identify patterns across participants' responses while considering the context and meaning of individual accounts. During the analysis, responses relevant to the research objectives were examined and assigned initial codes. Related codes were then grouped into broader categories and potential themes concerning digital access, TB knowledge and health literacy, and healthcare-seeking behaviour. The developing themes were reviewed in relation to the coded responses to assess their relevance to the research questions. Informant identification numbers were retained to distinguish participants' accounts and maintain traceability between the reported findings and the original responses. For methodological transparency, the researcher should maintain a coding record linking relevant data extracts to informant identification numbers, initial codes, subthemes, and final themes. This record can support a clear explanation of how interpretations were developed from the data. However, procedures such as independent coding, investigator triangulation, member checking, and audio verification should be reported only if they were conducted. The adequacy of the sample should likewise be considered in relation to the research objectives, participant relevance, and richness of the available data. Malterud et al. (2016) proposed the concept of information power as a framework for considering sample adequacy in qualitative interview studies. As the available methodological records do not establish that a formal saturation assessment was undertaken, the study should not claim that data saturation was achieved without supporting evidence.

Validity and Trustworthiness

The trustworthiness of this qualitative study was considered in relation to credibility, dependability, confirmability, and transferability, following the framework proposed by Lincoln and Guba (1985). To support credibility and dependability, the researcher organised the participants' responses according to informant identification numbers and examined the data systematically during manual coding and theme development. Maintaining a transparent record linking relevant data extracts, initial codes, subthemes, and final themes can further strengthen the traceability of the analytical process. The six participants provided accounts that varied in terms of demographic characteristics, internet affordability, digital technology use, and sources of health-related information. These variations offered different perspectives on digital access and TB health literacy. However, variation within a single dataset does not, by itself, constitute data-source triangulation. Similarly, investigator triangulation, member checking, and independent coding should be reported only if these procedures were undertaken and documented. Confirmability was addressed by keeping the interpretation of the findings closely linked to the participants recorded responses. Transferability was supported through a description of the study setting, participant characteristics, and research procedures, while acknowledging the limitations associated with the small, purposively selected sample. The findings are therefore intended to provide contextual insights into the experiences of the participants rather than statistical generalisations to the wider population. These practices are consistent with Lincoln and Guba's (1985) framework for establishing trustworthiness in qualitative research.

Researcher Reflexivity

The researcher's background in communication studies informed the approach to examining how individuals' access, interpret, and use health-related information in their everyday lives. This disciplinary perspective provided a basis for exploring digital communication and TB health literacy, while also recognising the possibility that prior knowledge and assumptions could influence data interpretation. To promote reflexivity, the researcher considered how these perspectives might shape the coding process, the development of themes, and the interpretation of participants' accounts. The analysis was therefore intended to remain grounded in the participants documented responses rather than assumptions about digital access or health literacy. Maintaining a clear connection between the data extracts, codes, and reported themes also supported transparency in the interpretation process. Reflexivity is an important consideration in qualitative research because the researcher plays an active role in data interpretation and knowledge production (Berger, 2015). Claims concerning the use of reflective journals, repeated transcript checking, or comparison with audio recordings should be included only if these activities were undertaken. This distinction helps ensure that the description of reflexive practice accurately represents the procedures used in the study.

Ethical Considerations

The study adhered to established ethical principles for social and health research. Participants' identities were protected using pseudonyms and identification codes, while interview recordings and transcripts were stored securely with access restricted to the researcher. Participation was voluntary, and participants were informed of their right to decline any question or withdraw from the study at any time without penalty.

FINDINGS AND DISCUSSION

This section presents the findings and discussion in an integrated manner based on the thematic analysis conducted manually according to Braun and Clarke's six-phase framework. The integration of findings and discussion is consistent with the qualitative research tradition, which emphasizes in-depth interpretation rather than purely descriptive reporting. The analysis generated five major themes: participants' sociodemographic profiles, digital poverty as a form of layered deprivation, limited access to tuberculosis-related health information, inadequate tuberculosis-related health literacy, and the implications for treatment-seeking behaviour. Collectively, these themes demonstrate that digital poverty functions as a mechanism that reinforces health inequalities among rural communities in Keningau, Sabah.

Sociodemographic Profile of Participants in Keningau, Sabah

The dataset comprises six respondents linked to Kampung Toboh Laut and the wider Keningau area. Five respondents identified as women and one as a man. Four were aged 31–45 years, one was aged 18–30 years, and one was aged 46–60 years. All six reported owning a smartphone. This shared ownership should not be interpreted as proof of equal digital inclusion: respondents differed in data affordability, the functions for which they used their devices, and whether they relied on family or peers for assistance. The spreadsheet also records varied self-reported access to TB information and healthcare, including transport or cost constraints. Since respondents' locations are not identical in every entry, the paper refers to Kampung Toboh Laut and the wider Keningau area rather than treating all six as confirmed residents of the same village.

Table 5.1 Demografic of Participants

CHARACTERISTICS	INFORMANT 1	INFORMANT 2	INFORMANT 3	INFORMANT 4	INFORMANT 5	INFORMANT 6
AGE GROUP	31 - 45	31 - 45	31 - 45	31 - 45	18 – 30	46- 60
GENDER	Man	Woman	Woman	Woman	Woman	Woman
EDUCATION	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
OCCUPATION	Other	Other	Private sector	Private sector	Private sector	Farmer/fisher
MONTHLY INCOME	RM1,000–RM3,000	<RM1,000	RM1,000–RM3,000	<RM1,000	RM1,000–RM3,000	<RM1,000
CLINIC DISTANCE	<5 km	5–10 km	5–10 km	<5 km	5–10 km	5–10 km
SMARTPHONE	Yes	Yes	Yes	Yes	Yes	Yes
DIGITAL USE / ACCESS	WhatsApp/Facebook; no difficulty	Moderate use; family support	Facebook; sometimes lacks data	Social media/music; reload cost	Social media/music; reload cost	Business/shopping/gaming; family support
PROVISIONAL CATEGORY	Connected	Connected	Digitally poor	Digitally poor	Connected	Connected

Table 5.1 indicates that all six respondents owned smartphones, but ownership did not remove affordability or capability constraints. Informants 3 and 4 explicitly described mobile-data affordability problems; Informant 5 reported social media and music as everyday uses but no internet difficulty. The categories in the final column are provisional interpretations, not results from a validated digital-poverty scale, and must be checked against the full interview material. "Digitally poor" here refers to reported affordability or capability constraints; "connected" is used only provisionally where access is reported but use appears mainly communicative or informational. Informant 6 reported business and shopping use, so active-use patterns should be clarified before assigning a passive-use category.

In terms of physical access to healthcare, most participants lived between five and ten kilometers from the nearest clinic or hospital. Although this distance may appear moderate, its practical implications depend heavily on road conditions, transportation availability, and travel costs. These factors have been identified as important determinants of delayed TB diagnosis and treatment in rural communities (Cambanis et al., 2005; Bhargava et al., 2021). Overall, the participants' sociodemographic characteristics indicate that they were situated within a context of layered deprivation involving limited income, moderate educational attainment, unstable employment, and rural geographical conditions. These characteristics provide an important social backdrop for understanding how digital poverty shapes access to health information, knowledge of tuberculosis, and decisions to seek treatment. In this study, digital poverty does not emerge as an isolated phenomenon but rather as part of a broader structure of social inequality.

Digital Poverty as Layered Deprivation

The data indicate that digital poverty in this small case is not reducible to smartphone ownership. All six respondents reported owning a smartphone, but their answers differed with respect to mobile-data affordability, everyday use, and assistance. Informant 3 described a constraint directly: "Sometimes, because of insufficient data" (Informant 3; translated from Malay). Informant 4 connected this constraint with living costs: "Because prices have gone up and fuel is more expensive, I cannot afford to buy a data reload" (Informant 4; translated

from Malay). These statements suggest that affordability can interrupt use even when a device is available. By contrast, Informant 1 reported using social media, specifically "browsing social media such as WhatsApp and Facebook" and stated "No, I have no difficulty" when asked about internet difficulties (Informant 1). Informant 5 reported, "I often use social media and listen to music," and stated, "I do not experience any difficulties" (Informant 5). These contrasting accounts indicate different types of digital participation within the same small sample.

The responses also show that digital engagement may be supported socially. Informant 2 identified "Family members/siblings" as people who help when she does not know how to use a phone or the internet, while Informant 3 answered "My child" and Informant 6 listed "My husband, children, younger siblings, and in-laws" (Informants 2, 3, and 6). Informant 5, by contrast, wrote "I learn by myself" (Informant 5). Such differences are important analytically: reliance on family support is not the same as having no access, but it may affect how independently a person can find, evaluate, and use health information. Because the questionnaire includes short responses rather than a full dialogue, this interpretation is presented as a pattern in reported responses, not as proof that family dependence delayed access to TB information. This reading is consistent with the distinction between device access and effective use in digital-divide research (Barrantes, 2007; Van Dijk, 2020).

From a broader perspective, digital poverty should be recognised as an emerging social determinant of health. Cuadros et al. argue that digital exclusion increasingly shapes access to healthcare information, preventive services, and health outcomes (Cuadros et al., 2025). Within the context of tuberculosis, restricted digital engagement may delay symptom recognition, reduce exposure to preventive information, and weaken treatment adherence through limited access to digital health resources. This condition is particularly concerning in rural settings where tuberculosis incidence is already disproportionately high (World Health Organization, 2025).

Critically, these findings challenge policy approaches that equate digital inclusion solely with technological availability or network expansion. Providing internet infrastructure or digital devices alone is unlikely to reduce health inequalities if affordability, digital literacy, and social capability remain unaddressed. As tuberculosis continues to disproportionately affect socioeconomically disadvantaged populations (Bhargava et al., 2020; Oxlade & Murray, 2012), digital poverty represents an additional layer of structural vulnerability that reinforces existing health disparities. Therefore, strategies aimed at tuberculosis prevention and control in rural Sabah should integrate affordable internet access, digital literacy development, and community empowerment alongside conventional public health interventions to promote more equitable access to health information and healthcare services.

Limited Access to Tuberculosis-Related Health Information and Inadequate Health Literacy

The six responses show that participants obtained TB-related information through several channels, including health programmes, talks, media, social media, and digital devices. Awareness of TB was reported by all six respondents, but their descriptions of transmission were not uniformly accurate or complete. Informant 1 answered "Through communication" (Informant 1), Informant 3 referred to "Through saliva and infected respiratory air" (Informant 3), and Informant 6 wrote "Through saliva" (Informant 6). These responses should be interpreted cautiously: the questionnaire wording shows how respondents described transmission, but it does not constitute a validated TB-knowledge test. Informant 2 identified multiple symptoms, including "A cough lasting more than two weeks, weight loss, loss of appetite, and fever" (Informant 2), while Informant 5 mentioned a cough that does not stop over a long period (Informant 5). The contrast between symptom recognition and incomplete descriptions of transmission supports the need to distinguish having heard of TB from comprehensive health literacy.

Participants generally considered online information useful, while also describing health workers and community programmes as important sources. Informant 1 said health information in the village was "limited" and proposed "a dedicated free internet portal for searching for health information" (Informant 1). Informant 5 stated that the internet was important "To find out about a disease or its symptoms before seeing a doctor" (Informant 5). Informant 6 wrote "Yes, but an explanation from healthcare staff or a doctor is still needed" (Informant 6). These questionnaire extracts suggest that digital channels may help with initial information-seeking but do not replace the role of health professionals in clarifying information. They align with the eHealth-

literacy concept, which concerns the ability to find, understand, and use electronic health information (Norman & Skinner, 2006), and with reviews that identify digital skills and social support as relevant to digital health equity (Latulippe et al., 2017; Richardson et al., 2022). Because no standardised health-literacy measure was administered, the study describes reported experiences and understanding rather than assigning a formal health-literacy score.

Sørensen et al. (2012) similarly identify health literacy as a key determinant of health equity because it shapes individuals' capacity to access, understand, appraise, and apply health information in everyday decision-making. In the present study, participants recognised the usefulness of digital information but simultaneously highlighted the continuing importance of healthcare workers in translating information into meaningful knowledge, indicating that digital technology should complement rather than replace conventional health education. Therefore, improving internet infrastructure alone is unlikely to reduce health inequalities associated with tuberculosis unless accompanied by initiatives that strengthen digital literacy, health literacy, and community-based health promotion. Integrating accessible digital information with face-to-face health education may improve early symptom recognition, encourage timely healthcare-seeking behaviour, and support more equitable tuberculosis prevention among rural populations.

The observation that health literacy is shaped not only by individual competencies but also by the accessibility, reliability, and cultural appropriateness of the health information environment is consistent with the integrated model proposed by Sørensen et al., which positions health literacy as a multidimensional construct situated at the intersection of personal skills, contextual resources, and broader social conditions (Sørensen et al., 2012). Accordingly, the present findings reinforce the argument that digital interventions intended to strengthen tuberculosis health literacy must be accompanied by broader efforts to improve community-level digital and health competence. Strengthening only the technological infrastructure, without addressing affordability, digital skills, and cultural relevance of health communication, is unlikely to disrupt the cycle of informational inequality that contributes to delayed tuberculosis diagnosis among rural populations.

Integrating accessible digital information with face-to-face health education may improve early symptom recognition, encourage timely healthcare-seeking behaviour, and support more equitable tuberculosis prevention among rural populations. The observation that health literacy is shaped not only by individual competencies but also by the accessibility, reliability, and cultural appropriateness of the health information environment is consistent with the integrated model proposed by Sørensen et al., which positions health literacy as a multidimensional construct situated at the intersection of personal skills, contextual resources, and broader social conditions (Sørensen et al., 2012). Accordingly, the present findings reinforce the argument that digital interventions intended to strengthen tuberculosis health literacy must be accompanied by broader efforts to improve community-level digital and health competence. Strengthening only the technological infrastructure, without addressing affordability, digital skills, and cultural relevance of health communication, is unlikely to disrupt the cycle of informational inequality that contributes to delayed tuberculosis diagnosis among rural populations."

Treatment-Seeking Behaviour and Delayed Tuberculosis Diagnosis

The responses suggest that treatment-seeking decisions involve symptom concerns as well as practical constraints. Informant 1 reported seeking a clinic examination when experiencing a prolonged or unusual cough, but also indicated having postponed treatment “because I was busy with work” (Informant 1). Informant 3 said she would seek hospital examination and identified “Transportation” as a difficulty (Informant 3). Informant 4 identified “Vehicles/transport and finances” as the main difficulty (Informant 4), while Informant 5 reported “Transportation problems” and noted rising fuel costs (Informant 5). In contrast, Informant 2 reported no difficulty or treatment postponement, demonstrating that barriers were not identical across respondents. These answers support a contextual interpretation in which cost, transport, work commitments, and symptom appraisal may shape care-seeking. They do not establish actual diagnostic delay, TB status, or treatment adherence because the study did not verify clinical records or recruit a documented cohort of TB patients.

A cautious interpretation is that digital affordability and the quality of TB information may be relevant to when people recognise symptoms and decide to ask for professional advice, but they operate alongside transport,

financial, and work-related constraints. This interpretation is consistent with broader TB literature. A qualitative study in northern Sabah identified misconceptions and concerns that may affect willingness to undergo screening (Mujin et al., 2025), while a Malaysian qualitative study in Selangor identified financial constraints, distance, TB knowledge, and family or social support as factors related to delayed presentation and diagnosis (Makeswaran et al., 2024). A study of TB management delays in Sarawak also reported associations involving healthcare visits, stigma, and treatment-related factors (Mohamad et al., 2022). These studies support the relevance of multiple interacting barriers; however, because the current respondents were not verified TB patients and no date of symptom onset or clinical diagnosis was measured, the present study cannot claim that digital poverty caused delayed TB diagnosis.

From a critical perspective, the findings challenge conventional explanations that attribute delayed treatment primarily to poor health awareness. Instead, healthcare-seeking behaviour reflects a rational adaptation to limited financial resources, transportation difficulties, and restricted access to health information. This interpretation is consistent with Rosenstock's (Rosenstock, 1974) Health Belief Model, which proposes that perceived barriers often outweigh perceived benefits when individuals decide whether to seek healthcare. Therefore, tuberculosis prevention strategies should combine community-based screening, transportation support, digital health education, and targeted social protection initiatives to promote earlier diagnosis and reduce health inequalities among rural populations.

Towards Community-Responsive Digital and Health Interventions

Participants' recommendations consistently favoured accessible information combined with direct community contact. Informant 1 recommended village outreach and "Free screening activities and TB talks" (Informant 1). Informant 2 suggested "Talks and free health check-ups" (Informant 2), and Informant 3 proposed "Talks, sharing sessions, and examinations" (Informant 3). Informant 6 noted that programmes organised in villages were helpful and stated that online information still required "an explanation from healthcare staff or a doctor" (Informant 6). Informant 5 suggested recurring briefings and village visits for health checks (Informant 5). Across these responses, participants favoured face-to-face health promotion, free screening, and clear explanations, with digital information as a complementary resource. These are stated preferences in the dataset rather than evidence that any intervention has already improved TB outcomes.

The synthesis of participants' experiences suggests that hybrid communication strategies are more appropriate than purely digital approaches for rural tuberculosis prevention. While social media platforms provide accessible channels for rapid information dissemination, face-to-face health programmes remain essential for strengthening trust, clarifying misconceptions, and supporting individuals with limited digital literacy. This finding highlights that community engagement remains central to effective health communication despite increasing digitalisation. These findings are consistent with Netto et al. (Netto et al., 2025), who argue that digital health technologies can improve tuberculosis prevention and treatment adherence. Similarly, the World Health Organization Global Strategy on Digital Health 2020–2025 (WHO, 2021) advocates people-centred digital health systems that complement existing healthcare services through equitable implementation. Labrique et al. (2018) likewise emphasise that successful digital health interventions require simultaneous investments in infrastructure, governance, digital capability, and community participation rather than technological deployment alone.

The discussion suggests that community-based communication may be more appropriate than relying on digital channels alone, but this proposition should be treated as an implication for programme design rather than demonstrated intervention effectiveness. Participants' responses identify several desired channels: village visits, health talks, free screening, and information shared through digital platforms. In line with digital health equity research, access to technology needs to be accompanied by meaningful capability and accessible professional support (Richardson et al., 2022; Del Pilar Arias López et al., 2023). Given the exploratory design, further work is required before concluding that a hybrid approach would reduce diagnostic delay or improve treatment adherence in this population.

CONCLUSION AND IMPLICATIONS OF THE STUDY

This qualitative case study explored how smartphone access, data affordability, reported TB knowledge, and

healthcare-seeking considerations intersect in accounts from six respondents associated with Kampung Toboh Laut and the wider Keningau area. The findings suggest that smartphone ownership did not remove all barriers to meaningful digital use: respondents described intermittent data affordability, reliance on family assistance, different sources of health information, and transport or work-related constraints. All six had heard of TB, but some descriptions of transmission were incomplete, indicating that awareness should not be equated with comprehensive TB health literacy. These findings are exploratory and should not be interpreted as demonstrating a causal relationship between digital poverty and delayed TB diagnosis, because the study did not measure standardised health literacy, confirm TB diagnoses, or assess clinical records. The contribution of the study is to highlight, through locally grounded accounts, how digital affordability and health-information access may sit alongside the recognised socioeconomic and geographical barriers to TB prevention and care.

The practical implications are to strengthen TB education in locally understandable language, continue in-person village outreach and screening, share verified health information through channels villagers already use, and provide opportunities to ask healthcare workers questions. Recommendations should complement rather than replace clinical services. Study limitations include the small purposive sample, reliance on short self-reported questionnaire responses, lack of healthcare-worker interviews and clinical-service data, and the absence of a validated TB-knowledge or health-literacy instrument. Interview duration, thematic saturation, member checking, and triangulation therefore require verification from the research log before they can be stated as established procedures.

Future research should include a larger and more varied sample across rural districts, interview healthcare workers or community health personnel, and include participants with documented TB-care experiences to enrich the findings and strengthen the understanding of TB health literacy. A mixed-methods design could use a validated TB knowledge instrument and digital-access indicators, while a prospective design could investigate whether these factors are associated with screening uptake or time to diagnosis. Intervention research could evaluate community-based programmes that combine affordable digital information, health-worker explanation, and face-to-face outreach. These approaches would help determine whether the mechanisms suggested by this exploratory study are reproducible and whether specific interventions improve health outcomes.

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