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A Mixed-Methods Design for Analyzing Telemedicine Adoption: An Information Systems Approach Integrating TAM–ISS, Digital Literacy, and Usability

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Abstract

This research employs a mixed-methods design to analyze telemedicine adoption in rural Indonesia by integrating the Technology Acceptance Model (TAM) and the Information System Success Model (ISS), extended with digital literacy and usability. A quantitative survey of 314 respondents was complemented by in-depth interviews with 50 participants and demographic analysis using chi-square and logistic regression. The quantitative findings reveal that the primary adoption construct is Usability → Perceived Ease of Use (PEOU) → Perceived Usefulness (PU) → Intention to Use (ITU) → Net Benefit (NB). Perceived usefulness emerged as the strongest predictor of both satisfaction and intention. Information Quality significantly influenced satisfaction, whereas System Quality did not, indicating that clear medical information outweighs technical system performance in shaping satisfaction. Similarly, usability directly did not affect PU but indirectly through PEOU, and digital literacy influenced PU but not PEOU. Demographic analysis confirmed that occupation was significant—students and healthcare workers acted as early adopters—while age and prior training were not, suggesting that adoption transcends generational boundaries due to the widespread penetration of the JKN Mobile platform. Qualitative insights enriched these findings by highlighting key barriers and enablers such as inconsistent interfaces, infrastructure limitations, privacy concerns, community-based socialization, and expectations for adaptive features like AI diagnostics and pharmacy integration. Overall, the research confirms that telemedicine adoption in rural Indonesia is shaped by the synergy of usability, digital literacy, information quality, and social context rather than by training or demographic variables alone.

Keywords: Telemedicine, Digital Literacy, Usability, TAM, ISS, Mixed-Methods, Rural Health Indonesia

1. Introduction

The gap in healthcare services between urban and rural areas remains a global issue, including in Indonesia. Limited infrastructure, distance to healthcare facilities, and a shortage of medical personnel make it difficult for rural communities to obtain adequate healthcare services [1], [2], [3]. Telemedicine has emerged as an innovative solution that can provide remote medical services based on information and communication technology. Research shows that telemedicine can reduce geographical barriers, speed up diagnosis, and improve the efficiency of healthcare services [4], [5], [6].

However, the adoption of telemedicine in rural areas faces significant challenges. The main obstacles include low digital literacy, limited devices, weak internet connections, and concerns about data security [2], [7]. A systematic review by [4] confirms that digital literacy and technological readiness are critical factors in the success of online medical consultations. On the other hand, research [7] in Africa shows that low digital literacy limits people's ability to utilize the advanced features of digital health applications.

In addition to literacy, the usability of the system plays an important role. Telemedicine will only be sustainable if the system is easy to use, the interface is consistent, and the features meet user needs. The ISO 9241-10 standard explicitly

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places the principle of usability as the main benchmark for the effectiveness of interactive systems [8]. Research [9] on healthcare workers shows that poor usability can reduce professionals' motivation to adopt telemedicine, even though they recognize the benefits of the technology. Another equally important factor is trust. Users must be confident that their health data is secure, their privacy is protected, and the results of consultations are reliable. [10] found that trust was the main determinant bridging the gap between risk perception and intention to use telemedicine during the COVID-19 pandemic in Taiwan. Similar findings were reported by [9], who confirmed that trust strengthens the relationship between perceived usefulness and intention to use.

Telemedicine has emerged as one of the most transformative innovations in modern healthcare delivery, enabling remote consultations, digital prescriptions, and continuous patient monitoring across geographical boundaries. In developing countries like Indonesia, telemedicine represents a strategic response to healthcare inequality—particularly between urban and rural regions where medical facilities and professional availability remain limited [4], [6]. Despite its growing presence through platforms such as JKN Mobile, Halodoc, and Alodokter, the adoption rate among rural users remains inconsistent, often constrained by technical usability issues, limited digital literacy, and infrastructural barriers.

Furthermore, recent technological developments have opened up new opportunities for telemedicine innovation. For example, [11] demonstrates that the integration of Artificial Intelligence (AI) and Natural Language Processing (NLP) can enhance the efficiency and personalization of online consultations, while [12] emphasize that e-health applications integrated with pharmaceutical services can expand the benefits of telemedicine for outpatients. These advancements signal a transition toward intelligent and user-centered digital health ecosystems. However, in Indonesia's rural areas, the effectiveness of these innovations still depends heavily on user literacy, system usability, and contextual social support.

Previous research has predominantly explored telemedicine adoption through frameworks such as the TAM, Unified Theory of Acceptance and Use of Technology (UTAUT), and Information System Success Model (ISSM) [13], [14]. While these models have proven predictive in explaining user intention and satisfaction, they often examine cognitive, technical, and contextual factors in isolation rather than as an integrated system. Moreover, most studies focus on urban settings or developed countries, offering limited insight into the behavioral and infrastructural realities of telemedicine adoption in rural areas of developing nations like Indonesia. Empirical research that links user perception to international standards such as ISO 9241-10 (usability), ISO 29995 (digital health competency), and ISO/IEC 27001 (data security) remains scarce, leaving a gap in understanding how these frameworks can ensure the sustainability of telemedicine systems.

To address these gaps, this study integrates Digital Literacy and System Usability into the extended TAM–ISS framework, positioning them as interrelated cognitive and technical enablers that jointly influence user perceptions of ease, usefulness, and behavioral intention. Digital literacy reflects users' ability to access, interpret, and utilize telemedicine technologies, thereby enhancing perceived usefulness through better understanding of service benefits. System usability represents the perceived efficiency and consistency of telemedicine interfaces, directly shaping perceived ease of use and indirectly affecting usefulness and satisfaction. Additionally, the study incorporates community socialization—the influence of peer engagement, local health education, and collective learning—as a sociocultural factor that accelerates telemedicine diffusion in rural contexts.

Methodologically, this research employs a convergent parallel mixed-methods design, combining a quantitative survey of 314 respondents, in-depth interviews with 50 participants, and PLS-SEM analysis to test the structural relationships within the extended model. This dual approach not only strengthens empirical validity but also deepens contextual interpretation by linking statistical outcomes with lived experiences. The mixed-methods design also allows cross-validation between quantitative paths (e.g., US → PEOU → PU → ITU → NB) and qualitative themes (e.g., trust, interface usability, and community learning), providing a richer analytical perspective that is rarely applied in developing-country telemedicine studies.

Empirically, this study contributes new evidence from the rural Indonesian context, which remains underrepresented in global telemedicine research. Practically, it offers ISO-based recommendations for improving system usability, data security, and user satisfaction to promote inclusive digital health transformation. Conceptually, it extends the TAM–

ISS framework by bridging individual-level cognitive readiness (digital literacy), system-level usability, and community-driven socialization.

Based on this conceptual and methodological foundation, the study aims to examine (1) how digital literacy affects the adoption and effectiveness of telemedicine; (2) the role of system usability in shaping user perceptions of ease, usefulness, and satisfaction; (3) how demographic factors moderate these relationships; and (4) how community socialization accelerates adoption and sustained use. Ultimately, this research provides both theoretical and practical insights for understanding telemedicine adoption in rural Indonesia and contributes to the broader agenda of equitable digital health transformation in developing countries.

2. Literature Review

Research on telemedicine adoption in information systems and public health has shown that technology acceptance is influenced by technical, psychological, and social factors. To explain these factors, several theoretical frameworks have been widely applied in prior studies, most notably the TA) introduced by [13]. TAM highlights two core constructs: PU and PEOU as primary determinants of technology adoption. Recent studies confirm that PU consistently serves as the strongest predictor of ITU, while PEOU contributes indirectly by enhancing PU [10], [15]. In the context of telemedicine, both ease of use and perceived usefulness emerge as central drivers of adoption.

Another widely used framework is the Information System Success Model (ISSM) developed by [14]. ISSM expands TAM by incorporating Information Quality (IQ), System Quality (SYQ), and Service Quality (SEQ), which in turn influence User Satisfaction (SAT) and NB. This model emphasizes that system success is measured not only by usage but also by user satisfaction and tangible benefits. In telemedicine, empirical evidence suggests that the quality of medical information—clarity, accuracy, and relevance—plays a more decisive role in user satisfaction than technical system quality alone [4], [16].

Beyond the core constructs of TAM and ISSM, recent literature highlights the importance of digital literacy as an external factor shaping both PU and PEOU. [7] demonstrate that low levels of digital literacy restrict users from accessing advanced features of telemedicine, while [1] shows that community-based digital literacy programs can broaden acceptance of digital health services. Equally critical is system usability, which according to ISO 9241-10 includes consistency, ease of navigation, and conformity with user expectations [8]. Poor usability has been shown to reduce adoption motivation even when users recognize the technology's potential benefits, as reported by [9].

From a psychological perspective, trust in technology is a key factor mediating the relationship between perceived risk and behavioral intention. [17] conceptualized trust as a mediator in technology adoption, while [10] found that trust was a critical determinant of telemedicine use during the COVID-19 pandemic. Similarly, Schürmann et al. (2025) demonstrated that trust strengthens the relationship between PU and ITU, underscoring that data security and system reliability are essential for sustainable telemedicine adoption.

The rural context introduces additional challenges related to digital infrastructure and community socialization. The UTAUT [18] identify facilitating conditions such as technical support and infrastructure as prerequisites for adoption. Barriers including poor internet connectivity, low-specification devices, and high data costs are consistently reported as obstacles in rural telemedicine adoption [2], [4], [6]. On the other hand, Diffusion of Innovation (DoI) theory [19] emphasizes the role of change agents and socialization in accelerating technology adoption. Studies in India and the UK show that community health workers, students, and volunteers are effective in promoting telemedicine in rural areas [1], [6].

Furthermore, the Task–Technology Fit (TTF) framework [20], [21] posits that technology is only perceived as useful when it aligns with user needs and tasks. In telemedicine, this is evident in users' expectations for adaptive features such as AI-based diagnosis, voice interfaces for the elderly, and pharmacy integration. Recent studies confirm this trend, highlighting the potential of AI and integrated e-health applications to enhance telemedicine effectiveness [11], [12].

Taken together, the literature shows that telemedicine adoption is shaped by an interplay of technical factors (usability, system quality, adaptive features), psychological factors (trust, perceived usefulness), and social factors (digital

literacy, community socialization). This research contributes by integrating the TAM–ISSM framework, extended with digital literacy and system usability, while also accounting for trust, facilitating conditions, and diffusion of innovation. This integrative approach offers a more comprehensive understanding of telemedicine adoption in rural Indonesia, addressing a research gap in prior studies that have largely focused on urban contexts or developed countries.

3. Methodology

This research utilizes a mixed-methods approach with a convergent parallel design [22], in which quantitative and qualitative data are collected simultaneously, analyzed separately, and then integrated to produce a comprehensive interpretation. This approach was chosen because studies on telemedicine adoption require not only statistical testing of relationships between variables, but also a deep understanding of the experiences, barriers, and expectations of users in the field.

3.1.Population And Sample

The population of this study consists of residents in Kuningan Regency, West Java, Indonesia—a rural area chosen due to its limited access to healthcare services yet increasing exposure to telemedicine platforms. A purposive sampling technique was employed to select respondents who had previously used or were likely to use telemedicine applications such as JKN Mobile, Halodoc, or Alodokter.

Before the main research was conducted, a pilot study was carried out involving 26 respondents to refine the questionnaire items and ensure conceptual clarity. The results of this preliminary test indicated several aspects that required improvement. In the System Usability variable, particularly indicator US1, the wording was clarified to avoid interpretative ambiguity, as its Cronbach's alpha value (0.687) was still slightly below the acceptable threshold of 0.70. Similarly, the instruments for System Quality and Digital Literacy were reviewed to enhance their clarity and content validity. The analysis showed that the indicators within System Quality and System Usability needed strengthening because their Average Variance Extracted (AVE) values were relatively low but still above the recommended minimum of 0.5—specifically 0.559 and 0.541, respectively—while other constructs achieved higher AVE values ranging between 0.652 and 0.876. Based on these pilot results, adjustments were made to improve interpretability and reliability, and the main quantitative survey was subsequently expanded to 314 respondents, complemented by 50 qualitative interview participants representing diverse demographics such as students, healthcare workers, housewives, farmers, and traders, to enhance the external validity of the research.

This sample size meets the minimum threshold recommended by [23] for Partial Least Squares Structural Equation Modelling (PLS-SEM), ensuring methodological reliability through statistical adequacy, representativeness, and power estimation. Additionally, the sampling process demonstrated practical reliability, as it accounted for real-world feasibility—such as respondents' internet accessibility, literacy level, and willingness to participate within rural contexts. This dual consideration enhances both the robustness and field applicability of the study's empirical findings.

3.2. Research Instruments

The quantitative research instruments can be seen in table 1, arranged in the form of a structured questionnaire developed based on the integration of the TAM [13] and the Information System Success Model [14], and expanded with the variables of Digital Literacy (LD) and System Usability (US). The TAM model contributes through the constructs of P), PEO), and ITU, which have been widely used to explain technology adoption behavior in the field of digital health [15]. Meanwhile, the ISS Model enriches the research framework with the constructs of IQ, SYQ, SEQ, SAT, and NB, which according to [16] are relevant for evaluating the success of health information systems.

Table 1. Variable Operational

Construct	Items and Statements	References
Digital Literacy (LD)	LD1: I can search for health information on the internet for health-related needs.	[1], [7]
	LD2: I can assess whether the health information I find online is trustworthy.	
	LD3: I am accustomed to using digital-based applications for telemedicine services like Halodoc, Alodokter, JKN Mobile, etc.	

	LD4: I understand the common terms used in health service applications.	
Usability System (US)	US1: The interface of health apps like telemedicine (Halodoc, Alodokter, JKN Mobile) is easy to read and navigate.	[8], [9]
	US2: Even if I rarely use telemedicine apps, I remember how to operate them.	
	US3: I can easily access services like consultation, lab results, and prescriptions using these apps.	
	US4: The telemedicine system interface is consistent and allows me to complete tasks without confusion	
Perceived Ease of Use (PEOU)	PEOU1: I feel that telemedicine apps like Halodoc, Alodokter, JKN Mobile are easy to use.	[13], [15], [24]
	PEOU2: I do not have to put in much effort to operate these apps.	
	PEOU3: I can easily obtain the services I need through these apps.	
Perceived Usefulness (PU)	PU1: These apps help speed up my healthcare process.	[10], [13], [24]
	PU2: The quality of healthcare services improves with these apps.	
	PU3: They support me in making better health decisions.	
Intention to Use (ITU)	ITU1: I plan to continue using telemedicine apps like Halodoc, Alodokter, JKN Mobile.	[9], [13], [24]
	ITU2: I will recommend these apps to others.	
	ITU3: I am willing to use these apps long-term.	
Information Quality (IQ)	IQ1: The health information provided by these apps is very accurate.	[14], [16]
	IQ2: The health info in these apps is always up-to-date.	
	IQ3: They provide comprehensive info according to my needs.	
	IQ4: The info I get is relevant to my health condition.	
System Quality (SYQ)	SYQ1: These apps run quickly and rarely experience disruptions.	[8], [14]
	SYQ2: My personal and medical data are secure when using these apps.	
	SYQ3: They operate reliably and are rarely error-prone.	
	SYQ4: They work well on my device (phone, laptop, tablet).	
Service Quality (SEQ)	SEQ1: Technical support is easy to access if I face issues.	[6], [14]
	SEQ2: Customer support responds quickly to my questions.	
	SEQ3: Help centers understand my technical problems well.	
	SEQ4: Service providers pay attention to user experience and technical issues.	
User Satisfaction (SAT)	SAT1: I am satisfied using these telemedicine apps.	[10], [14]
	SAT2: These apps meet my expectations.	
	SAT3: I have a positive experience using these apps.	
Net Benefit (NB)	NB1: With these telemedicine apps, I can access healthcare anytime and anywhere.	[2], [14]
	NB2: Using these apps helps me save costs related to healthcare visits.	
	NB3: The information and services provided by these apps help me make faster, more accurate medical decisions.	

The addition of the Digital Literacy variable was done to measure respondents' ability to search for, understand, and utilise technology-based digital information, which has been proven to be an important determinant in the adoption of telemedicine in rural areas [1], [7].

In this study, the term US refers to the user's perception of the system's interface design and operational simplicity, consistent with ISO 9241-10 and ISO 9241-11 standards as well as Nielsen's usability framework. It encompasses the principles of consistency, clarity, learnability, and ease of navigation, which together define the ergonomic quality of human–system interaction. Within the TAM–ISS framework, usability is conceptualized as a technical and interactional construct that directly influences PEOU and indirectly affects PU . This aligns with [9], who emphasized that systems that are difficult to understand or operate hinder users' perception of usefulness and satisfaction. Therefore,

usability in this study does not represent the overall user experience, but rather focuses on interface-level design and interaction efficiency. Broader experiential factors—such as satisfaction or emotional comfort—are instead measured through the SAT construct. The proposed research model and the hypotheses developed are shown in figure 1 below.

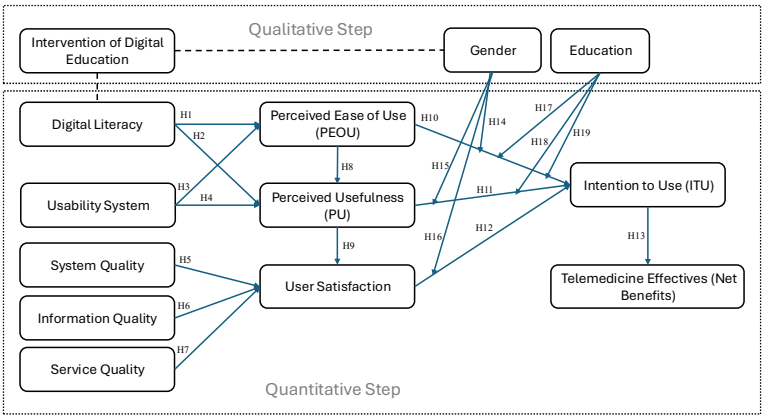

Figure 1. Proposed Model

Each construct was measured using several indicators adapted from previous literature, such as [13], [14], [15], [18], [25], [26], [27] and adapted to the context of rural telemedicine in Indonesia. The digital literacy indicator, for example, refers to basic technical skills and understanding of digital health applications as highlighted by [7]. The usability indicators refer to the ISO 9241-10 guidelines and the results of research [8] that emphasize the importance of interface consistency. The questionnaire uses a five-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree).

In this study, LD and US are integrated into the TAM–ISS framework not merely as exogenous factors, but as foundational cognitive and technical enablers that influence user perceptions and behavioral outcomes. Digital literacy represents users' capability to access, interpret, and utilize digital health technologies, which theoretically enhances PU by improving understanding of telemedicine benefits. Meanwhile, system usability refers to the perceived ease and efficiency of interacting with telemedicine platforms, directly influencing *PEOU* and, indirectly, PU. Thus, both constructs serve as antecedents that shape users' cognitive evaluations before forming intention and satisfaction, bridging technical design aspects (ISS dimension) with behavioral responses (TAM dimension).

The qualitative instrument is a semi-structured interview guide developed to explore user experiences in greater depth. The interview questions cover aspects of digital literacy, experiences with system usability, infrastructure barriers, trust levels, the role of community socialization, and expectations for future telemedicine features. Qualitative analysis aims to enrich quantitative results and provide a broader context, in accordance with the principle of triangulation in mixed-methods research [22].

3.3. Research Hypotheses

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive."

Based on figure 1. This study proposes a model that develops a series of hypotheses reflecting the theoretical relationships between constructs within the extended TAM–ISSM framework. The model positions LD and US as key exogenous determinants influencing users' cognitive evaluations of PEOU and PU . Meanwhile, the ISSM quality dimensions—SYQ, IQ, and SEQ—are hypothesized to predict User SAT. In alignment with TAM, PEOU and PU are expected to shape both satisfaction and ITU, which ultimately drives Telemedicine Effectiveness or Net Benefits (NB). Additionally, figure 1 incorporates demographic moderators, specifically gender and education, to capture potential variations in adoption behaviour across user groups. Consistent with the structural pathways outlined in figure 1, the following hypotheses are formulated:

3.3.1. *Effects of Digital Literacy*

Digital literacy represents a fundamental capability that enables users to access, navigate, and understand telemedicine services. Prior research highlights that digital literacy plays a crucial role in enhancing users' ability to operate digital

health applications, particularly in rural communities [1], [7]. Within the TAM framework, digital literacy functions as an external factor that strengthens both PEOU and PU , as digitally skilled users tend to perceive telemedicine applications as easier to use and more beneficial [13]. Recent telemedicine studies further emphasize that digital literacy influences how users evaluate clinical benefits and service efficiency [2], [10]. Therefore, digital literacy is expected to exert a positive effect on both PEOU and PU.

H1. Digital Literacy has a positive effect on Perceived Ease of Use.

H2. Digital Literacy has a positive effect on Perceived Usefulness.

3.3.2. *System Usability Based on ISO 9241 Human–System Interaction*

Usability is a critical determinant of telemedicine success, especially in rural areas where digital skills vary widely. According to ISO 9241-10 and ISO 9241-11, usability encompasses interface consistency, ease of navigation, and learnability—features that enable users to achieve their goals effectively and efficiently. Prior studies indicate that digital health systems adhering to ISO usability principles can enhance users' PEOU and reduce cognitive load [8].

In telemedicine contexts, intuitive interface design plays a central role in shaping technology acceptance. [9] found that inconsistent or frequently changing layouts hinder user engagement, even when the clinical benefits of telemedicine are well understood. Similarly, [2] reported that rural users are particularly sensitive to navigation difficulties, often perceiving them as more burdensome than minor technical issues. Human–computer interaction research further shows that predictable and well-structured interfaces contribute to stronger PU by aligning system design with user expectations [11], [20].

Accordingly, grounded in ISO usability standards and prior empirical evidence, System Usability is assumed to influence both PEOU and PU. Thus, two hypotheses are proposed:

H3. System Usability has a positive effect on Perceived Ease of Use.

H4. System Usability has a positive effect on Perceived Usefulness.

3.3.3. *ISS Model Quality Dimensions (SYQ, IQ, SEQ) and Satisfaction*

In the Information System Success Model [14], SYQ, IQ, and SEQ are core determinants of User SAT. In telemedicine research, SYQ—stability, speed, and reliability—can enhance satisfaction [16], although its influence may weaken when users experience uniformly similar technical performance, as in public platforms like JKN Mobile [4].

By contrast, Information Quality is consistently the strongest predictor of satisfaction, as users value clear, accurate, and relevant medical information [2], [4]. Service Quality also contributes to satisfaction through responsiveness and effective follow-up, as demonstrated in recent e-health studies [12].

Based on this foundation, the following hypotheses are proposed:

H5. System Quality positively influences User Satisfaction.

H6. Information Quality positively influences User Satisfaction.

H7. Service Quality positively influences User Satisfaction.

3.3.4. *Core TAM Relationships: PEOU, PU, and SAT*

In the TAM, PEOU directly influences PU because easier systems reduce cognitive effort and enhance users' perception of benefits [13], [26]. Recent telemedicine studies confirm this pattern, showing that simple navigation and stable interfaces strengthen users' understanding of digital health value [10], [15].

PU is also a strong predictor of User SAT, as satisfaction increases when users experience tangible benefits such as time savings and improved access to medical services [12], [14], [16]. Thus, the foundational relationships PEOU → PU → SAT remain central to explaining telemedicine adoption in rural contexts.

H8. Perceived Ease of Use positively influences Perceived Usefulness.

H9. Perceived Usefulness positively influences User Satisfaction.

3.3.5. *Effects of Perceived Ease, Usefulness, and Satisfaction on Intention to Use*

Within the TAM framework, PU is the strongest predictor of ITU. [13] demonstrated that users adopt a technology when they perceive clear benefits—a finding consistently reaffirmed in recent telemedicine studies [10], [15]. PEOU also shapes ITU directly and indirectly by enhancing PU, particularly among users with lower digital literacy [18].

From the ISSM perspective, User SAT further contributes to ITU as a reflection of positive user experience [14], [16]. Together, these theoretical foundations support the proposition that PU, PEOU, and SAT jointly drive telemedicine adoption intentions in rural Indonesia.

H10. Perceived Ease of Use positively influences Intention to Use.

H11. Perceived Usefulness positively influences Intention to Use.

H12. User Satisfaction positively influences Intention to Use.

3.3.6. *Intention to Use as the Antecedent of Net Benefits*

In the Information System Success Model [14], ITU is a direct antecedent of NB, as system benefits manifest only when users actively apply the technology. Telemedicine studies similarly show that strong usage intention drives improvements in cost efficiency, access to care, and health management—particularly in resource-limited rural settings [1], [4], [6]. Based on this foundation:

H13. Intention to Use has a positive effect on Telemedicine Effectiveness (Net Benefits).

3.3.7. *Moderation Effects of Gender and Education*

Technology adoption research indicates that gender and education can shape the strength of TAM relationships, with men typically more influenced by perceived usefulness and women more sensitive to ease of use [18], [26]. However, recent telemedicine studies show that demographic differences often become insignificant once digital health platforms are widely adopted [9], [10]. Education is also associated with digital literacy and the ability to interpret telemedicine benefits [1], [7], yet users across educational backgrounds in rural settings often report similar experiences, with technical factors such as usability and information clarity exerting stronger influence.

Accordingly, the following moderation hypotheses are proposed:

H14. Gender moderates the relationship between Perceived Ease of Use and Intention to Use.

H15. Gender moderates the relationship between Perceived Usefulness and Intention to Use.

H16. Gender moderates the relationship between User Satisfaction and Intention to Use.

H17. Education moderates the relationship between Perceived Ease of Use and Intention to Use.

H18. Education moderates the relationship between Perceived Usefulness and Intention to Use.

H19. Education moderates the relationship between User Satisfaction and Intention to Use.

3.4. Data Collecting

The quantitative survey was conducted online using a digital form distributed through community networks, health workers, and students. Qualitative interviews were conducted face-to-face according to the respondents' circumstances, with each session lasting between 30 and 45 minutes. Before data collection, respondents were provided with information about the purpose of the research and agreed to a participation consent form.

3.5. Data Analysis Techniques

Quantitative data were analyzed using PLS-SEM with the assistance of SmartPLS 4.0 software. The analysis was conducted in two stages, namely evaluation of the outer model (convergent validity, discriminant validity, construct reliability) and evaluation of the inner model (path hypothesis testing, R^2, f^2, Q^2, and predictive relevance). Qualitative data were analyzed using thematic analysis. Interview transcripts were transcribed manually and Ms. Excel software was used to identify main themes consistent with the TAM–ISS framework. Qualitative findings were then compared with quantitative results to strengthen the interpretation.

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3.6. Data Integrations

To strengthen the validity of the mixed-methods design, this study systematically integrates quantitative and qualitative findings through thematic triangulation. Quantitative results derived from the extended TAM–ISS model reveal significant structural pathways that explain telemedicine adoption behavior in rural Indonesia. However, the qualitative phase provides contextual depth, illustrating *how* and *why* these relationships manifest in real user experiences. By aligning statistical outcomes—such as *System Usability → Perceived Ease of Use → Perceived Usefulness → Intention to Use → Net Benefit*—with narratives from 50 interview participants, this integration bridges the gap between numerical evidence and human-centered insights.

The following table 2 presents the mapping between quantitative constructs and qualitative themes, highlighting key illustrative quotes that exemplify users' cognitive, technical, and social experiences. This synthesis underscores that telemedicine adoption is not merely a function of technological performance, but also a reflection of literacy, usability perception, and social influence operating within Indonesia's rural healthcare context.

Table 2. Mapping Between Quantitative Constructs and Qualitative Themes

Quantitative Construct (TAM–ISS)	**Related Qualitative Theme**	**Illustrative Finding / Quote**	**Integrative Interpretation**
System Usability (US)	Interface consistency, navigation difficulty	"After the app update, the icons moved and I got confused again."	Qualitative data support the quantitative path *US → PEOU* (β=0.610, p<0.001), showing that usability primarily affects *ease of use* rather than *usefulness*. Users only perceive benefits once ease and stability are achieved (ISO 9241-10 conformity).
Perceived Ease of Use (PEOU)	Familiarity, accessibility, simplicity	"As long as the buttons stay the same, I can find my doctor easily."	Reinforces the role of *PEOU* as a bridge between usability and usefulness. Ease of learning and stable design reduce cognitive load and drive acceptance among low-literacy users.
Perceived Usefulness (PU)	Efficiency, cost savings, convenience	"It saves time because I don't need to go to the clinic for a prescription."	The path *PEOU → PU → ITU* (β=0.512; β=0.683) is mirrored in qualitative responses emphasizing tangible benefits. Users equate *usefulness* with daily life efficiency, aligning with TAM and IS-Success.
Digital Literacy (LD)	Basic vs. advanced usage capability	"I can only open consultation, not the medical record part."	The low effect of *LD → PEOU* but significant *LD → PU* confirms that literacy strengthens understanding of value rather than ease. Literate users explore advanced features, enhancing perceived usefulness.
Information Quality (IQ)	Clarity and accuracy of doctor responses	"When the doctor's advice is clear, I trust the app more."	Supports *IQ → SAT* significance. Users are satisfied when the information is reliable and actionable, even when system quality fluctuates.
System Quality (SYQ)	Technical performance, app stability	"Sometimes the app lags, but I still prefer it because the doctor explains well."	The non-significant *SYQ → SAT* path is clarified: satisfaction depends more on information quality than technical perfection. Users tolerate minor technical issues if service remains responsive.
Intention to Use (ITU)	Repeated use, trust, habit formation	"I use JKN Mobile every month for chronic medicine refill."	ITU strongly predicts *NB* (β=0.766, f^2=1.422). Repeated usage leads to efficiency, confirming telemedicine as a habit-forming tool among rural users.
Net Benefit (NB)	Time and cost efficiency, access equality	"Now my mother in the village can consult without traveling far."	Qualitative evidence reinforces *ITU → NB* as the dominant pathway. Benefits are realized through improved accessibility and reduced physical barriers, reflecting digital inclusion outcomes.

Community Socialization (contextual factor)	Peer influence, health worker outreach	"We learned to use telemedicine from university students during community service."	Social diffusion supports adoption, resonating with [19]. Socialization enhances both digital literacy and intention to use.

The integration of quantitative and qualitative findings reveals a consistent pattern in which System Usability and Digital Literacy serve as foundational enablers influencing PEOU and PU , which in turn shape SAT and ITU. The dominant pathway (US → PEOU → PU → ITU → NB) represents the core adoption mechanism in rural telemedicine, indicating that interface simplicity and stable functionality act as the entry points toward sustained technology utilization.

Qualitative narratives further explain why these relationships emerge. Users consistently emphasized interface stability, navigation clarity, and daily efficiency over purely technical performance. Although SYQ showed no significant statistical effect on satisfaction, interview data revealed that users prioritize clarity of medical explanations and responsiveness over technical reliability, explaining the stronger IQ → SAT relationship observed in the model.

Meanwhile, LD emerged as a critical cognitive differentiator. Respondents with higher literacy levels could explore advanced features—such as digital medical records, e-prescriptions, and online payments—enhancing perceived usefulness, even without necessarily improving perceived ease of use. This suggests that literacy enhances value comprehension rather than interactional skill, especially in low-resource environments.

Finally, community socialization and trust act as contextual accelerators of telemedicine adoption. Field narratives from students, local health workers, and family members illustrate how peer learning compensates for low literacy and limited infrastructure. Thus, successful telemedicine adoption in rural areas depends not only on technical usability but also on the strength of social embeddedness that builds confidence, reinforces learning, and sustains long-term use.

4. Results and Discussion

This section presents the findings obtained through a mixed-methods approach, combining quantitative analysis with SmartPLS 4.0, qualitative insights from in-depth interviews, and demographic tests using chi-square and logistic regression. The integration of these methods provides a comprehensive picture of the factors influencing telemedicine adoption in rural Indonesia, including variations by age, occupation, and training experience.

4.1. Respondents' Demographics Findings

This research involved 314 respondents as shown in table 3. In terms of gender, the distribution was relatively balanced, with slightly more females than males. Age ranged from 17 to over 60 years, with the productive age group (20–40 years) dominating, indicating that telemedicine is used across generations. Regarding occupation, students and healthcare workers formed the majority, followed by housewives, farmers, traders, and informal workers. This aligns with the [19], which suggests that educated and professional groups tend to be early adopters. The data also revealed that occupation was significantly related to telemedicine use, while age was not. More than 90% of respondents reported having used telemedicine, with JKN Mobile as the dominant platform, mainly for chronic disease consultations, prescriptions, and referrals.

Table 3. Respondents Demography

Characteristics	Category	Total (n)	Percentage (%)
Gender	Male	148	47.1%
	Female	166	52.9%
Age	17–25 years	120	38.2%
	26–40 years	102	32.5%
	41–60 years	70	22.3%
	>60 years	22	7.0%
Occupation	Student	90	28.7%
	Healthcare worker	72	22.9%

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	Housewife	56	17.8%
	Farmer/trader/informal	60	19.1%
	Others	36	11.5%
Ever Used Telemedicine	Yes	287	91.4%
	No	27	8.6%
Dominant Application	JKN Mobile	210	67.0%
	Private applications (Halodoc, Alodokter, etc.)	65	20.7%
	Others	39	12.3%

Note: The category "Farmer/trader/informal" combines respondents working in non-formal or self-employed sectors with irregular income patterns. This grouping was applied to ensure statistical feasibility due to small subgroup sizes. While this aggregation provides a general representation of informal livelihoods, it may mask behavioral differences among farmers, traders, and informal workers.

The chi-square test was employed in the demographic analysis to evaluate the goodness-of-fit between observed and expected frequencies and to assess potential associations among independent categorical variables such as age, occupation, and training experience. This statistical procedure is widely used in social and health sciences to determine whether observed differences in categorical data are attributable to random variation or indicate the presence of significant relationships. In this research, the chi-square test provided a robust means of identifying whether demographic characteristics, including occupational status and age groups, were significantly related to the adoption and utilization of telemedicine services in rural Indonesia. Table 4 shows the results of Chi square Test.

Table 4. Chi square Test Results

Test	**Chi-square**	**df**	**p-value**
Gender x Using Telemedicine	3.0708	4	0.546
Status x Using Telemedicine	23.91	13	0.0319
Training x Using Telemedicine	1.3047	1	0.253

The chi-square analysis revealed a significant relationship between occupational status and the use of telemedicine ($\chi^2 = 23.91$; $p = 0.0319$). Students and healthcare professionals were found to use telemedicine more frequently compared to other groups, such as informal workers or housewives. In contrast, age was not significantly associated with telemedicine use ($\chi^2 = 3.07$; $p = 0.546$), suggesting that adoption is relatively evenly distributed across different age groups. Likewise, prior participation in training programs related to digital literacy or telemedicine also showed no significant association with usage status ($\chi^2 = 1.30$; $p = 0.253$).

The distribution of respondents highlights the dominance of the productive age group. Approximately 50.32% of participants were aged 21–30 years, followed by 20.70% in the 41–50 age group, and 14.33% in the 31–40 age group. In terms of occupation, non-healthcare students formed the largest group (27.71%), followed by healthcare workers (21.02%) and office employees (10.83%). This pattern underscores that younger respondents, particularly students, were the dominant contributors and among the fastest adopters of telemedicine.

Interestingly, although 53.18% of respondents reported having attended training, workshops, or seminars on digital literacy or telemedicine, such experiences were not significantly associated with usage status. This suggests that training serves more as a long-term investment in building perceived ease of use and continuance intention, rather than directly influencing initial adoption. In other words, training enhances the quality of interaction and readiness for sustained use, rather than simply determining whether someone has ever used telemedicine.

The non-significance of age is also noteworthy, given that much of the global literature highlights generational gaps in adopting health technologies. In Indonesia, this finding may be explained by the widespread penetration of the national JKN Mobile platform, which appears to have successfully bridged generational divides and reached a more diverse user base.

4.2. Qualitative Interview Findings

The qualitative findings were derived from in-depth interviews with 50 participants, producing six key themes that reflect the real experiences of rural communities in using telemedicine. These insights not only complement the demographic patterns but also help explain why certain variables in the quantitative model emerged as significant.

Participants with low digital literacy often struggled to navigate beyond basic functions such as general consultations or appointment booking. As one respondent explained, “I only use the app to check my queue number; other buttons make me confused.” In contrast, those with higher literacy explored advanced features like electronic prescriptions, online payments, and digital medical records. These supports [7], who emphasized that digital literacy expands the effective use of health technologies. Within the TAM framework, digital literacy thus acts as an external enabler strengthening both PU and PEOU.

Nearly all respondents noted usability issues after the app’s interface updates. “After the last update, I can’t find the doctor’s list anymore—it looks completely different,” said one health worker. The inconsistency in navigation and icons led some users to abandon certain features. This aligns with ISO 9241-10, which highlights consistency and navigability as essential usability principles. The pattern also explains why the US → PEOU path was significant, while US → PU was not—users perceived usefulness only after they found the system easy to use.

Although most participants trusted telemedicine because it is an official government service (e.g., JKN Mobile), concerns about data privacy persisted. One respondent stated, “I worry when the app asks for my ID card and health documents. What if someone misuses them?” These finding echoes [10], who identified trust as a psychological bridge linking ease of use, usefulness, and behavioral intention in digital health systems.

Respondents from remote areas repeatedly mentioned unreliable internet and low-end devices as barriers. “Sometimes the call freezes or gets cut off completely, and I have to walk to another spot for better signal,” explained a farmer from Kuningan. These limitations correspond with [2], [4], who identified weak infrastructure as a critical constraint to telemedicine adoption in rural settings. Within the UTAUT framework, these conditions are part of facilitating conditions that directly affect satisfaction and continuance intention.

Many respondents learned about telemedicine only after exposure to community-based outreach programs. “Students from the university showed me how to register on JKN Mobile. Before that, I didn’t even know I could see a doctor online,” said one elderly respondent. Such initiatives, often led by village health workers or university students, functioned as change agents in line with [19] Diffusion of Innovation theory. This also supports [1], [6], who emphasized community education as a driver of rural telemedicine adoption.

Several respondents expressed expectations for more adaptive and intelligent system features. “It would help if the app could talk, so elderly people like me don’t have to read everything,” one respondent remarked. Another participant mentioned, “If the system could suggest medicine automatically, it would save time.” These expectations highlight the need for Task–Technology Fit [28], [29], as reinforced by [11], [12], showing how AI-based triage, voice-assisted interfaces, and pharmacy integration could enhance usability and perceived value.

Overall, the interviews emphasize that the success of telemedicine adoption in rural Indonesia depends on an interplay of six factors: digital literacy as the foundation, usability as the experiential enabler, trust as the psychological anchor, infrastructure as the technical condition, socialization as the adoption accelerator, and feature fit as the sustainability factor. These findings provide contextual depth to the significant paths identified in the quantitative analysis and reinforce the integrated TAM–ISS framework as appropriate for explaining telemedicine adoption in rural environments.

4.3. Quantitative Findings

The analysis was conducted to test the conceptual model that integrates TAM and ISS, extended with digital literacy and system usability variables. The quantitative tests included an evaluation of the measurement model (outer model) to ensure the validity and reliability of the instruments, as well as an evaluation of the structural model (inner model) to examine the relationships among variables. These results provide empirical insights into both significant and non-significant contructs, thereby explaining the factors that drive or hinder telemedicine adoption in rural Indonesia.

4.3.1. Measurement Model (Outer)

The measurement model evaluation was conducted to ensure that each construct within the extended TAM–ISS framework met the required criteria for reliability, convergent validity, and discriminant validity. Following the guidelines of [23], [30], the analysis confirmed that all constructs demonstrate strong psychometric properties and are suitable for further structural modeling.

All outer loadings exceeded 0.70, indicating strong consistency between indicators and their latent constructs. The highest outer loading was observed for PEOU1 (0.910), while the lowest was LD1 (0.719), both within acceptable ranges. Cronbach's Alpha (CA) values ranged from 0.757 (LD) to 0.910 (SAT), and Composite Reliability (CR) values ranged from 0.845 (LD) to 0.943 (SAT), confirming excellent internal consistency.

The Average Variance Extracted (AVE) values ranged between 0.578 (LD) and 0.847 (SAT), exceeding the 0.50 threshold for convergent validity. These results validate that each construct adequately captures the variance of its indicators and that all measurement items consistently represent their underlying theoretical dimensions.

Discriminant validity was assessed using three complementary tests: HTMT ratio, Fornell–Larcker criterion, and cross-loading. All HTMT values were below 0.90, with the highest correlation found between PU–SAT (0.871) and the lowest between SEQ–ITU (0.524), confirming satisfactory discriminant validity. In the Fornell–Larcker matrix, the square roots of AVE values (e.g., SAT = 0.920; ITU = 0.911; PU = 0.891) were greater than their correlations with other constructs, ensuring that each variable is empirically distinct. Similarly, cross-loading analysis showed that every indicator loaded highest on its intended construct (e.g., SAT2 = 0.929; ITU3 = 0.929), further supporting discriminant validity.

Variance Inflation Factor (VIF) values for all items were below the cutoff value of 5, indicating no multicollinearity problems. The highest VIF was observed for SAT2 (3.358), and the lowest for LD1 (1.443). This suggests that all indicators contribute unique variance to their constructs without redundancy, thereby supporting the model's stability and interpretability.

The model fit indices demonstrated an excellent fit between empirical data and the theoretical framework. The Standardized Root Mean Square Residual (SRMR) was 0.057 (< 0.08), and the Normed Fit Index (NFI) was 0.799, both within acceptable thresholds. These results confirm that the measurement model accurately represents the observed data structure and is adequate for structural model analysis. Summary of Measurement Model Results can be seen in table 5 below.

Tables 5. Summary of Measurement Model Results

Evaluation Criteria	Key Results	Highest & Lowest Indicators / Constructs	Interpretation
Outer Loading	0.719 – 0.929	Highest: PEOU1 = 0.910, SAT2 = 0.929 Lowest: LD1 = 0.719	Indicators validly reflect constructs; convergent validity achieved.
Cronbach's Alpha (CA)	0.757 – 0.910	Highest: SAT = 0.910 Lowest: LD = 0.757	High internal consistency across constructs.
Composite Reliability (CR)	0.845 – 0.943	Highest: SAT = 0.943 Lowest: LD = 0.845	Excellent construct reliability confirmed.
Average Variance Extracted (AVE)	0.578 – 0.847	Highest: SAT = 0.847 Lowest: LD = 0.578	Convergent validity achieved for all constructs.
HTMT	0.524 – 0.894	Highest: PU–SAT = 0.871 Lowest: SEQ–ITU = 0.524	Discriminant validity confirmed; constructs are empirically distinct.
VIF	1.443 – 3.358	Highest: SAT2 = 3.358 Lowest: LD1 = 1.443	No multicollinearity detected among indicators.
Model Fit (SRMR, NFI)	SRMR = 0.057; NFI = 0.799	—	Good model fit and acceptable overall adequacy.

Overall, the measurement model demonstrates excellent reliability, convergent validity, and discriminant validity, with all values meeting or exceeding the recommended statistical thresholds. The constructs of LD and Usability System (US), newly integrated into the extended TAM–ISS framework, show robust psychometric properties and contextual relevance for explaining telemedicine adoption in rural Indonesia. These findings confirm that the measurement model is both theoretically sound and empirically stable for subsequent structural analysis.

4.3.2. Structural Model Evaluation (Inner)

The structural model evaluation was conducted through four main stages: analysis of R-square (R^2), effect size (f^2), predictive relevance (Q^2), and significance testing, following the recommendations of [31].

4.3.2.1. R2 Analysis

The R-square (R^2) value analysis can be seen in table 6, which shows the explanatory power of the model on endogenous variables. According to [23], an R^2 value of 0.75 is considered strong, 0.50 moderate, and 0.25 weak. The findings of this research indicate that most constructs achieve explanatory power in the moderate to strong range.

Table 6. R^2 Results

Construct	R^2	Adjusted R^2	Classification [31]	Brief Notes
SAT	0.667	0.662	Moderate (high)	Satisfaction is strongly explained by PU and IQ (SYQ is not significant).
NB	0.587	0.586	Moderate	Net benefits are primarily driven by ITU (very strong construct).
PU	0.547	0.543	Moderate	Usefulness is influenced by PEOU and LD; US → PU not direct (via PEOU).
PEOU	0.487	0.484	Moderate (Marginal)	Ease is mainly influenced by US; LD → PEOU is marginal.
ITU	0.467	0.465	Moderate (Marginal)	Intention is dominated by PU; room for additional predictors.

The small differences between R^2 and adjusted R^2 (≤ 0.005) indicate that the model is stable and free from overfitting. SAT achieved an R^2 of 0.667 (adjusted 0.662), showing that user satisfaction is strongly explained by PU and IQ, while System Quality was not significant. NB also recorded a high R^2 of 0.587 (adjusted 0.586), with ITU as the strongest predictor, highlighting that repeated use is the bridge to real benefits such as efficiency and improved access.

PU obtained an R^2 of 0.547 (adjusted 0.543), indicating moderate influence from PEOU and digital literacy. The non-significant direct path from usability to PU reinforces the mediating role of PEOU, consistent with [28], [32]. PEOU reached an R^2 of 0.487 (adjusted 0.484), close to moderate, mainly driven by system usability, with digital literacy playing only a marginal role. This underscores the need for interface design improvements, consistent navigation, and interactive guidance.

Finally, ITU had an R^2 of 0.467 (adjusted 0.465), still meaningful but not fully moderate, with PU as its main predictor. This suggests opportunities to strengthen ITU through additional variables such as social influence, facilitating conditions, or habit, as proposed in [33], [34]. Overall, the R^2 analysis confirms that the model demonstrates solid explanatory power, especially for SAT and NB, with PU and ITU serving as central bridges linking literacy, usability, and ease of use to satisfaction and tangible benefits of telemedicine in rural areas.

4.3.2.2. f2 Analysis

The f^2 analysis is used to assess the extent to which predictor variables contribute to endogenous variables. The results of this research show varying effect sizes, ranging from small to very large, as shown in table 7.

Table 7. Effect Size (f^2) Analysis

Construct	f^2	Classification [23]	Interpretation
IQ → SAT	0.055	Small	Information quality slightly increases satisfaction, but is not a dominant factor.
ITU → NB	1.422	Very large	Intention to use is the main driver of actual benefits.

LD → PEOU	0.012	Very small	Digital literacy has minimal influence on perceived ease.
LD → PU	0.043	Small	Digital literacy slightly reinforces perceived usefulness.
PEOU → PU	0.297	Moderate	Ease of use has a fairly strong contribution to perceived usefulness.
PU → ITU	0.876	Large	Perceived benefits are the key predictor of intention to use.
PU → SAT	0.345	Large	Perceived benefits also significantly contribute to user satisfaction.
SEQ → SAT	0.024	Small	Technical experience has a minimal effect on satisfaction.
SYQ → SAT	0.008	Very small	System quality almost does not contribute to satisfaction.
US → PEOU	0.344	Large	Usability is a strong predictor of perceived ease.
US → PU	0.010	Very small	Usability does not directly affect perceived usefulness; its effect is minimal.

The strongest effect was found in the path ITU → NB ($f^2 = 1.422$), far exceeding the "large" threshold suggested by Hair et al. (2022). This confirms that intention is the main driver of telemedicine benefits, consistent with the IS Success Model. The path PU → ITU also showed a large effect (0.876), highlighting usefulness as the strongest predictor of intention in line with TAM.

Several other paths showed medium to large effects, including PU → Satisfaction (0.345), Usability (US) → PEOU (0.344), and PEOU → PU (0.297), demonstrating that usability strongly shapes ease of use, which then influences usefulness and ultimately satisfaction. Smaller effects were observed for IQ → SAT (0.055), LD → PU (0.043), SEQ → SAT (0.024), LD → PEOU (0.012), US → PU (0.010), and SYQ → SAT (0.008). While minor, these paths still provide additional contributions, especially in rural contexts where digital literacy and technical quality play supporting roles.

Overall, the f^2 results emphasize three critical construcs with strong effects: ITU → NB, PU → ITU, and the chain US → PEOU → PU → SAT. This suggests that strategies to strengthen telemedicine adoption should focus on enhancing perceived usefulness, fostering intention to use, and ensuring simple, user-friendly system design. Meanwhile, digital literacy, information quality, and system quality remain relevant as secondary contributors. Together, the f^2 analysis complements the R^2 findings by not only showing the model's explanatory power but also identifying the constructs with the greatest impact.

4.3.2.3. Q2 Analysis

The Q^2 analysis, as shown in table 8, indicates that most endogenous constructs have good to strong predictive relevance, suggesting that the model can adequately predict indicators. SAT recorded the highest Q^2 value (0.558), confirming that the combination of PU and IQ strongly explains satisfaction. NB also had a high value (0.450), consistent with the dominant path ITU → NB, indicating that intention to use is the main predictor of net benefit. PU achieved a Q^2 of 0.426, indicating that PEOU and digital literacy are strong contributors to perceived usefulness. Similarly, ITU (0.384) and PEOU (0.358) fall into the strong category, highlighting the role of system utility and perceived usefulness. Conversely, exogenous constructs such as IQ, LD, SEQ, SYQ, and US recorded $Q^2 = 0.000$, which is expected as they function as predictors rather than being predicted by other variables.

Table 8. Q^2 Analysis

Construct	Q^2	Category	Interpretation
IQ	0.000	None	Exogenous, not a predictor variable.
ITU	0.384	Strong	PU effectively predicts intention to use.
LD	0.000	None	Exogenous, not a predictor variable.
NB	0.450	Strong	ITU strongly explains net benefit.
PEOU	0.358	Strong	System usability effectively predicts perceived ease.
PU	0.426	Strong	Perceived usefulness is well predicted by PEOU & LD.
SAT	0.558	Strong	Satisfaction is highly predicted by PU & IQ.
SEQ	0.000	None	Exogenous, not a predictor variable.
SYQ	0.000	None	Exogenous, not a predictor variable.

US	0.000	None	Exogenous, not a predictor variable.

Overall, the research model demonstrates strong predictive power for the main constructs (SAT, NB, PU, ITU, PEOU), with all Q^2 values exceeding 0.35 (strong category). These results reinforce the model's validity, showing that the selected predictors are relevant and effective in explaining telemedicine adoption in rural areas.

4.3.2.4. Direct Effects Results

Path coefficient analysis, as shown in table 9, reveals several significant relationships. Ease of use influences PEOU ($\beta = 0.610$, $p < 0.001$), PEOU influences PU ($\beta = 0.512$, $p < 0.001$), PU influences both ITU ($\beta = 0.683$, $p < 0.001$) and SAT ($\beta = 0.499$, $p < 0.001$), and ITU significantly affects NB ($\beta = 0.766$, $p < 0.001$). On the other hand, the paths US → PU and SYQ → SAT are not significant. These findings highlight PU as a central variable in the model.

Table 9. Direct Significance Test Results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
IQ → SAT	0.218	0.221	0.080	2.712	0.007
ITU → NB	0.766	0.767	0.028	27.348	0.000
LD → PEOU	0.116	0.118	0.061	1.912	0.056
LD → PU	0.203	0.207	0.062	3.284	0.001
PEOU → PU	0.512	0.512	0.056	9.168	0.000
PU → ITU	0.683	0.684	0.039	17.338	0.000
PU → SAT	0.499	0.494	0.077	6.460	0.000
SEQ → SAT	0.130	0.134	0.067	1.949	0.051
SYQ → SAT	0.078	0.078	0.059	1.310	0.190
US → PEOU	0.610	0.609	0.054	11.284	0.000
US → PU	0.114	0.111	0.072	1.584	0.113

The SmartPLS 4.0 analysis shows that system usability has a strong influence on PEOU. Better interface quality and user experience lead to higher perceived ease. This aligns with ISO 9241-10 standards on consistency and navigation ease. Interviews support this, with many respondents feeling confused after app updates and interface changes, reducing PEOU. Demographic analysis indicates that formal training does not significantly impact usage; ease of use is mainly determined by system design rather than training experience.

Furthermore, PEOU significantly affects PU , with ease encouraging perceived benefits. Novice users find the app useful when basic services like consultations or appointment checks are easily accessible. Low-literacy users equate ease with usefulness. Conversely, direct usability to PU is not significant; benefits are only perceived once ease is established. Interviews reveal that more digitally skilled users seek advanced features like AI diagnostics or pharmacy integration, with PU forming from feature relevance to user needs.

Other findings show that digital literacy significantly influences PU but not PEOU. More literate users quickly understand telemedicine benefits, although they do not automatically find the app easier to use. High-literacy respondents explore advanced features, whereas low-literacy users stick to basic services. These results support studies indicating digital literacy broadens perceived health service benefits.

PU significantly impacts the ITU and satisfaction, making it the strongest construct in the model. This confirms PU as the main driver of adoption, consistent with TAM. Demographically, students and healthcare workers use telemedicine more often, aligning with the Diffusion of Innovation theory, while the general public values time, cost savings, and quicker access to doctors.

Additionally, IQ significantly impacts satisfaction, but SYQ does not. Satisfaction depends more on clear, accurate, and relevant medical information than on technical system aspects. Respondents expressed satisfaction when explanations were understandable and follow-up was clear, despite internet issues, supporting related studies.

The construct from ITU to NB is the strongest, indicating high intention translates into tangible benefits like cost, time savings, and easier access. Over 90% of respondents already use telemedicine, mostly via the JKN Mobile app. Interviews highlight benefits like easier chronic disease management, prescription refills without queues, and healthcare access from remote villages.

4.3.2.5. Indirect Effects Results

Several significant mediation constructs were identified, such as US→PEOU→PU→ITU, LD→PU→SAT, PEOU→PU→SAT, and PU→ITU→NB. This indicates that PU serves as a primary mediator linking digital literacy, usability, and ease of use with intention to use and satisfaction. Conversely, the construct US→PU→SAT was not significant, suggesting that satisfaction is more influenced by information quality and tangible benefits, as shown in table 10.

The SmartPLS 4.0 analysis reveals that these mediation constracts play a crucial role in explaining how factors like digital literacy, usability, and ease of use contribute to community satisfaction, intention to use, and perceived net benefits in rural telemedicine adoption.

Table 10. Indirect Significance Test Results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
LD → PEOU → PU	0.059	0.060	0.031	1.899	0.058
LD → PU → SAT	0.101	0.102	0.034	2.984	0.003
PEOU → PU → SAT	0.255	0.254	0.054	4.701	0.000
US → PU → ITU	0.078	0.076	0.050	1.557	0.119
PU → ITU → NB	0.524	0.525	0.043	12.265	0.000
LD → PU → ITU → NB	0.106	0.109	0.034	3.156	0.002
US → PEOU → PU	0.312	0.312	0.045	6.934	0.000
US → PU → SAT	0.057	0.054	0.036	1.566	0.117
US → PEOU → PU → ITU	0.213	0.214	0.034	6.288	0.000
LD → PEOU → PU → SAT	0.030	0.030	0.017	1.768	0.077
PEOU → PU → ITU → NB	0.268	0.269	0.037	7.324	0.000
US → PU → ITU → NB	0.060	0.059	0.039	1.538	0.124
US → PEOU → PU → SAT	0.156	0.155	0.034	4.528	0.000
LD → PEOU → PU → ITU	0.041	0.041	0.022	1.882	0.060
LD → PEOU → PU → ITU → NB	0.031	0.032	0.017	1.857	0.063
LD → PU → ITU	0.139	0.141	0.043	3.222	0.001
US → PEOU → PU → ITU → NB	0.163	0.164	0.028	5.775	0.000
PEOU → PU → ITU	0.350	0.350	0.043	8.157	0.000

The SmartPLS 4.0 analysis reveals that system usability has a strong impact on PEOU, with better interface quality and user experience enhancing perceived ease, in line with ISO 9241-10 principles on consistency and navigation. Interviews support this, showing confusion after app updates that reduce ease. Demographically, formal training has no significant effect, indicating that ease of use is primarily influenced by system design rather than training experience.

PEOU significantly influences PU , especially for beginners who find basic services like consultations easily accessible. More digitally skilled users tend to seek advanced features such as AI diagnostics or pharmacy integration, explaining why a direct link between usability and PU is not significant—benefits are only perceived once ease is achieved, consistent with the [28], [32].

Additionally, digital literacy significantly affects PU but not PEOU; highly literate users grasp telemedicine benefits faster, supported by studies [1], [7]. PU is the strongest predictor of the ITU and SAT, confirming TAM frameworks. Demographic analysis shows students and healthcare workers as early adopters, valuing time and cost savings, while the general public primarily benefits from faster access and resource efficiency.

IQ significantly affects satisfaction, whereas SYQ does not, indicating that user satisfaction depends more on clear, accurate, and relevant medical information, supported by interviews where users favor understandable explanations and clear follow-up despite occasional network issues. This aligns with prior research [2], [4] emphasizing the importance of communication and education quality.

The construct from ITU to NB is the most dominant, with high usage intention producing tangible benefits like reduced costs, time savings, and improved healthcare access—over 90% of respondents actively use telemedicine, mainly via JKN Mobile. Many mentioned benefits such as chronic disease control, prescription refills without queues, and remote access from rural areas.

This research shows that the primary adoption construct of telemedicine in rural Kuningan, Indonesia, is System Usability → PEOU → PU → ITU → NB. This reinforces the TAM, which emphasizes PEOU and PU in shaping behavioral intention. In this context, system usability is the main entry point that fosters ease, while perceived usefulness strongly influences both user intention and satisfaction, consistent with (Schürmann et al., 2025), which highlights usability's vital role in motivating healthcare professionals, with benefits primarily mediated through ease of use.

Regarding digital literacy, findings indicate that it significantly impacts PU but not PEOU, aligning with [1], [7], who state that digital literacy broadens understanding of telemedicine benefits, though it doesn't automatically make applications easier to use. Interviews confirm that low-literacy respondents only access basic services, whereas digitally literate ones utilize advanced features like digital medical records and online payments.

The results also show that IQ significantly influences satisfaction, but SYQ does not, implying that users value accurate, clear, and relevant medical information over technical system stability. This aligns with studies [2], [4] emphasizing the importance of communication quality for user trust and satisfaction.

From the perspective of behavioural intention (ITU) and benefits (NB), the construct ITU → NB is the strongest, indicating that high intent to use translates into tangible benefits such as cost efficiency, time savings, and improved access—over 90% of respondents actively use telemedicine, mainly via JKN Mobile, with many mentioning benefits like chronic disease management, medicine refill without queues, and remote access from villages.

Demographically, employment status significantly affects usage, with students and healthcare workers adopting telemedicine more than others, supporting [19]'s Diffusion of Innovation theory, which designates these groups as early adopters. Age and training experience are not significant, suggesting widespread adoption across generations due to the success of national apps like JKN Mobile, differing from global trends of generational gaps.

Interviews also highlight that trust plays an important role, especially regarding data security and privacy concerns, which influence long-term adoption—an aspect supported by [10] as a mediator between risks and intention. Community socialization, through student activities, health cadres, or family recommendations, accelerates adoption, emphasizing the importance of community-based approaches [1], [6]. Expectations for more adaptive features like AI integration, voice interfaces, and digital pharmacy services indicate that adoption depends not only on basic factors like ease and benefits but also on how well systems meet specific user needs. This aligns with the Task–Technology Fit theory [20] and findings ([11], [12], which highlight the potential of smart technologies to enhance telemedicine effectiveness.

This research demonstrates that telemedicine adoption in rural areas is influenced by a combination of usability, digital literacy, information quality, behavioral intention, and community support. It extends existing literature by integrating an extended TAM–ISS framework and provides empirical evidence from Indonesia's rural context, which remains underexplored.

4.4. Discussion

This study demonstrates that the primary adoption pathway of telemedicine in rural Kuningan, Indonesia, follows a cascading mechanism of System Usability → PEOU → PU → ITU → NB. This pathway reinforces the TAM [13] by showing that usability indirectly shapes behavioral intention through perceived ease and usefulness. Rather than exerting a direct effect, system usability fosters a sense of ease that enhances users' perception of usefulness, which in

turn strengthens their intention to use telemedicine and the resulting benefits. This finding aligns with [9], [20], who emphasize that design simplicity and functional clarity serve as psychological gateways to adoption—particularly in low-literacy rural settings. In this context, usability acts as the entry point that drives ease of use, while perceived usefulness emerges as the strongest predictor of user intention and satisfaction, leading ultimately to measurable net benefits in healthcare accessibility and efficiency.

Regarding digital literacy, findings indicate that it significantly impacts PU but not PEOU, aligning with [1], [7], who state that digital literacy broadens understanding of telemedicine benefits, though it doesn't automatically make applications easier to use. Interviews confirm that low-literacy respondents only access basic services, whereas digitally literate ones utilize advanced features like digital medical records and online payments.

The results indicate that IQ significantly influences SAT, while SYQ does not, suggesting that users value accurate, clear, and relevant medical information over purely technical stability. This finding aligns with prior studies [2], [4], which emphasize that communication quality and information clarity are central to user trust and satisfaction. The non-significant effect of SYQ on SAT likely reflects the uniformity of technical experiences among users rather than system inadequacy. Most participants described telemedicine platforms—especially JKN Mobile—as stable and reliable, with few disruptions. As one respondent explained, "The app rarely crashes; what matters is the doctor's quick and clear response." Such uniform performance reduces variance in SYQ, limiting its statistical impact on satisfaction [23]. Hence, once basic system stability is achieved, human interaction, clarity of information, and communication responsiveness emerge as the dominant factors shaping user satisfaction.

From the perspective of behavioral intention (ITU) and benefits (NB), the pathway ITU → NB is the strongest, indicating that high intent to use translates into tangible benefits such as cost efficiency, time savings, and improved access—over 90% of respondents actively use telemedicine, mainly via JKN Mobile, with many mentioning benefits like chronic disease management, medicine refill without queues, and remote access from villages.

Demographically, employment status significantly affects telemedicine usage, with students and healthcare workers emerging as the most active users—supporting [28], [35], which identifies these groups as early adopters. Conversely, age and training experience show no significant influence, suggesting that adoption has become widespread across generations, largely driven by the accessibility and familiarity of national platforms such as JKN Mobile. Although training exhibits no significant statistical association with telemedicine adoption, this finding does not imply that digital literacy initiatives are unimportant. Instead, it likely reflects the limited quality, irregular implementation, and contextual mismatch of current training programs. Many rural digital education efforts emphasize general smartphone use rather than telemedicine-specific competencies, resulting in limited behavioral change. Several respondents also described training sessions as "one-time workshops without follow-up," reducing sustained learning effects. Consistent with [1], [2], this study suggests that training alone seldom drives adoption unless integrated into community-based learning and user-centered design. Thus, in rural Indonesia, usability and peer influence appear to exert a stronger and more immediate impact on adoption than formal training exposure.

Interviews also highlight that trust plays an important role, especially regarding data security and privacy concerns, which influence long-term adoption—an aspect supported by [10] as a mediator between risks and intention. Community socialization, through student activities, health cadres, or family recommendations, accelerates adoption, emphasizing the importance of community-based approaches [1], [6].

Finally, expectations for more adaptive features like AI integration, voice interfaces, and digital pharmacy services indicate that adoption depends not only on basic factors like ease and benefits but also on how well systems meet specific user needs. This aligns with the [20] and findings [11], [12], which highlight the potential of smart technologies to enhance telemedicine effectiveness.

Overall, this research demonstrates that telemedicine adoption in rural areas is influenced by a combination of usability, digital literacy, information quality, behavioral intention, and community support. It extends existing literature by integrating an extended TAM–ISS framework and provides empirical evidence from Indonesia's rural context, which remains underexplored.

5. Conclusion

This research provides a comprehensive overview of the factors influencing telemedicine adoption in rural Indonesia by integrating the TAM and the Information System Success (ISS) Model, extended with digital literacy and system usability variables. Quantitative results show that the main adoption construct is Usability → Perceived Ease of Use → Perceived Usefulness → Intention to Use → Net Benefit. Usability enhances perceived ease, while usefulness is the strongest predictor of intention and satisfaction. Information Quality significantly impacts satisfaction, whereas System Quality does not, emphasizing that clarity and accuracy of medical information are more critical than technical aspects. Qualitative data reinforce these findings, highlighting issues such as low digital literacy, interface inconsistency, privacy concerns, infrastructural limitations, community socialization, and expectations for adaptive features like AI, voice interfaces, and pharmacy integration. Demographic analysis confirms that employment is a significant factor in adoption, with students and healthcare workers as early adopters, while age and training experience are not influential, indicating successful penetration of national apps like JKN Mobile across generations.

Theoretically, this research advances the TAM–ISS framework by including digital literacy and usability, strengthening the literature on health technology adoption in developing countries and affirming the relevance of Diffusion of Innovation and Task–Technology Fit theories. Practically, findings underscore the importance of simple, consistent interface design, enhancing digital literacy to enable users to utilize advanced features, and developing adaptive functionalities to boost satisfaction and sustainability. Policy-wise, the research advocates for equitable digital infrastructure in rural areas, community-based socialization programs, and adherence to international standards like ISO 9241-10 for usability and ISO 27001 for data security to create safer, more inclusive services.

This study has several limitations. The cross-sectional design restricts the ability to capture longitudinal behavioral dynamics and sustained usage patterns of telemedicine. The focus on Kuningan Regency also limits the generalizability of findings to other rural contexts with different digital infrastructures and literacy levels. Furthermore, the qualitative sample of 50 participants, while sufficient for thematic saturation, may not fully represent marginalized or digitally excluded groups. The structural model did not include key constructs such as trust, privacy risk, and organizational support, which could enhance the explanatory scope of telemedicine adoption. Future studies are encouraged to integrate constructs from the UTAUT or information security frameworks and to apply multi-group analysis to compare behavioral variations across demographic segments, such as students vs. non-students or younger vs. older users.

The decision to exclude trust as a quantitative construct was methodologically grounded. First, this study focused on technical and cognitive determinants—namely system usability and digital literacy—as foundational factors for early adoption in rural settings. Including trust at this stage could shift the analytical emphasis from initial adoption to post-adoption behaviors, which were beyond the study's scope. Second, pilot testing revealed a high conceptual overlap between trust and perceived usefulness, indicating redundancy that could compromise model parsimony. Nevertheless, trust emerged prominently in the qualitative findings, particularly concerning data privacy and security on government-endorsed platforms such as JKN Mobile. These insights suggest that trust functions more as a psychological and social mediator influencing user perceptions rather than a directly measurable construct within this framework. Future research should integrate trust through a multilevel approach that combines individual trust (in system reliability and usability) with institutional trust (in data governance and healthcare providers) to achieve a more comprehensive understanding of the socio-technical mechanisms driving telemedicine adoption in developing regions.

Overall, this research emphasizes that successful telemedicine adoption in rural Indonesia requires a holistic approach combining technical, user capability, and social support factors. The findings contribute empirically to international literature and offer practical recommendations for developing more effective, sustainable, and equitable telemedicine services.

6. Declarations

6.1. Author Contributions

Conceptualization: F.Y., Y., and R.P.; Methodology: Y.; Software: F.Y.; Validation: F.Y., Y., and R.P.; Formal Analysis: F.Y., Y., and R.P.; Investigation: F.Y.; Resources: Y.; Data Curation: Y.; Writing Original Draft Preparation:

F.Y., Y., and R.P.; Writing Review and Editing: Y., F.Y., and R.P.; Visualization: F.Y.; All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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