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# Entrepreneurship and Innovation in Telemedicine Adoption Among Physicians in Indonesia

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**ABSTRACT**

**This study examines** the factors driving telemedicine adoption among physicians in Indonesia, employing an integrated framework based on the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). **The framework** investigates the influence of performance expectancy, effort expectancy, facilitating conditions, social support, and economic value on physicians behavioral intention and actual use of telemedicine, with attitude acting as a key mediating variable. Additionally, demographic characteristics, including age, practice type, and practice duration, are explored as potential moderators in these relationships. Data was gathered from a cross-sectional survey of 244 physicians across various specialties and regions in Indonesia. **The study** findings, analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), reveal that effort expectancy, facilitating conditions, social support, and economic value significantly influence both behavioral intention and actual use. In contrast, performance expectancy does not have a significant effect. Attitude plays a crucial mediating role in translating physicians perceptions into adoption behaviors. Moreover, practice type moderates the path from behavioral intention to actual use, with general practitioners more likely to adopt telemedicine than specialists. **The results** emphasize that telemedicine strategies should prioritize usability, economic value, social support, and institutional backing. **This study** contributes to the telemedicine adoption literature by extending TAM and UTAUT with attitudinal mediation and economic value, while highlighting emerging psychosocial factors in Southeast Asia. These insights offer practical guidance for healthcare managers and policymakers.



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## 1. INTRODUCTION

Telemedicine, the remote delivery of healthcare through digital platforms, has become essential in post pandemic healthcare systems [1–3]. It helps overcome challenges such as limited access, high costs, and chronic disease management, serving as a scalable solution for continuous care. The COVID-19 pandemic accelerated its integration, but adoption remains uneven due to regulatory gaps, low digital literacy, and physician

workload [4–7]. In Southeast Asia, adoption grows amid infrastructure and regulatory disparities [8–10], while Indonesia still faces communication and workflow challenges between physicians and patients [11, 12].

Physician acceptance is crucial for successful telemedicine implementation, influenced by perceived usefulness, usability, and integration into clinical practice [5, 13]. The TAM and the UTAUT explain these behaviors through factors such as psychosocial support, interaction quality, and financial incentives [14, 15]. This study integrates both frameworks by positioning attitude as a mediating construct and examining demographic moderators such as age, practice type, and practice duration, while also considering emerging factors like technology fatigue, E-health literacy, and evolving physician patient relationships.

While TAM and UTAUT have been widely used in telemedicine research, prior studies have focused primarily on usability and performance dimensions, with less attention to attitudinal mediation and contextual determinants like economic value, especially in resource constrained settings [16, 17]. Furthermore, psychosocial factors such as E-health literacy and technology fatigue are often overlooked in adoption models. This study addresses these gaps by proposing an integrated TAM UTAUT framework that incorporates attitude and economic value, as well as psychosocial factors, to better capture the multifaceted nature of telemedicine adoption among Indonesian physicians.

This study addresses the following research questions:

- RQ1: What factors influence physicians telemedicine adoption in Indonesia?
- RQ2: How does attitude mediate the relationship between technology perceptions and telemedicine adoption?
- RQ3: Do demographic characteristics moderate these relationships?

This study contributes to telemedicine adoption literature by integrating TAM and UTAUT, positioning attitude as a central mediating construct and addressing the affective and motivational aspects of physician adoption behavior [18, 19]. It incorporates economic value to account for financial and operational factors relevant to resource-constrained settings and integrates emerging factors such as E-health literacy, technology fatigue, and evolving physician patient relationship dynamics that remain underexplored in telemedicine models [20]. This comprehensive framework captures the complexities of digital healthcare transformation in Southeast Asia while aligning with SDG 3 (Good Health and Well being) and SDG 9 (Industry, Innovation, and Infrastructure), contributing to improved healthcare access, quality, and innovation in digital health infrastructure [21, 22].

## 2. LITERATURE REVIEW

The TAM, introduced by [23], remains a foundational framework for explaining technology adoption behavior by emphasizing Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) as key determinants of attitude influencing behavioral intention and actual use. Its simplicity and explanatory power have led to widespread application in healthcare contexts, including telehealth and mobile health platforms [24–26]. However, telemedicine adoption involves broader contextual, social, and organizational influences. To capture this complexity, this study integrates TAM with the UTAUT framework, which identifies Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC) as key determinants of behavioral intention and use [27, 28]. The hybrid model further incorporates Social Support (SS) and Economic Value (EV) as essential predictors, particularly relevant in resource-constrained healthcare environments [29, 30].

The combination of TAM and UTAUT provides a comprehensive framework for understanding physician adoption behavior, especially in Southeast Asia where regulatory and system readiness significantly affect telemedicine implementation. While UTAUT effectively captures organizational and social influences, TAM remains superior in modeling individual level attitudinal and motivational drivers [31]. This study integrates both frameworks to form a robust model that unites attitudinal pathways and contextual factors, emphasizing TAM's parsimony and predictive validity while leveraging UTAUT constructs to account for demographic moderators such as age, practice type, and practice duration, alongside emerging factors including technology fatigue, E-health literacy, and evolving physician-patient relationships.

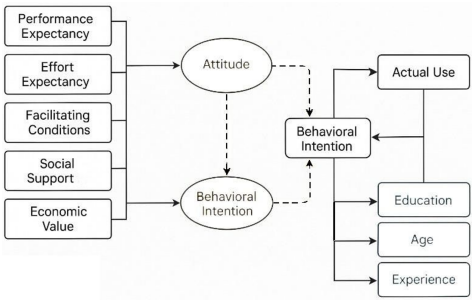


Figure 1. Conceptual Framework

Figure 1 presents the conceptual framework of this study, showing how key factors influence attitude. The research team operationalized the Attitude construct using validated items adapted from [15, 28, 32]. These items include statements indicating that telemedicine enhances patient satisfaction, improves comfort in patient interaction, supports the sustainability of medical practice, and provides more benefits than challenges. All items were measured using a 5-point Likert scale, ranging from strongly disagree to strongly agree.

To ensure construct validity, the study adapted these items to capture both cognitive aspects such as perceived value and affective aspects, including enjoyment and positive feelings toward use. High factor loadings and AVE values above 0.50 confirmed convergent validity, while discriminant validity was supported through the HTMT and Fornell Larcker criteria, thereby establishing confidence in the central mediating role of attitude within the model [33, 34].

## 3. RESEARCH METHOD

This study employed a quantitative, cross-sectional survey design to examine the determinants of physicians telemedicine adoption in Indonesia. The study tested the research model using Partial Least Squares Structural Equation Modelling (PLS-SEM), an approach well suited for exploratory research, complex models that integrate formative and reflective constructs, and data with non normal distributions. Compared to CB-SEM, PLS-SEM prioritizes predictive validity, making it appropriate for understanding adoption behavior and for the model's emphasis on attitudinal pathways.

### 3.1. Sampling and Participants

The target population comprised licensed physicians (general practitioners and specialists) currently practicing in Indonesia with prior exposure to or experience in telemedicine. The study employed a purposive and voluntary sampling approach to ensure diversity in practice type, experience, and geographical distribution. The final sample included 244 respondents representing various regions and healthcare settings across Indonesia. This study recruited participants through professional associations, hospital networks, and digital health platforms, consistent with recent methodological recommendations for post pandemic telemedicine studies.

All participants provided informed consent prior to participation. The study adhered to ethical guidelines for human subjects research and received ethical clearance from IPB University No 1543/IT3.KEPMSM-IPB/SK/2024. Inclusion criteria required respondents to be licensed physicians (general practitioners or specialists) with active clinical practice in Indonesia and prior telemedicine experience. The study explicitly excluded veterinarians (doctors serving animal patients), as the research focused on telemedicine use in human healthcare. Retired physicians and those without prior telemedicine exposure were also excluded. Participants were recruited through professional associations, hospital networks, and one major national digital health platform offering telemedicine services. No financial or material incentives were provided to participants.

### 3.2. Survey Instrument

The survey instrument used validated multi-item scales adapted from prior studies [35], measuring constructs such as Performance Expectancy (PE), Effort Expectancy (EE), Facilitating Conditions (FC), Social Support (SS), Economic Value (EV), Attitude (AT), Behavioral Intention (BI), and Actual Use (AU), with items rated on 5-point Likert scales, except for actual use, which used frequency based measures. The operationalization of constructs and measurement items followed best practices for SEM-based research. Prior to full deployment, the instrument was pilot tested with 30 physicians to ensure content validity, clarity, and contextual relevance, leading to revisions based on the feedback to enhance clarity and alignment.

### 3.3. Data Collection

This study collected data through an online survey (Google Form) between December 2024 and January 2025, enabling efficient access to physicians across diverse regions, consistent with recent post pandemic telemedicine research methodologies. The study also acknowledged potential limitations, such as selection bias and respondent authenticity, and addressed them through verification steps and consistency checks. As with any online survey, using Google Forms carries limitations such as potential sampling bias, lack of identity verification, and reliance on self reported data. To mitigate these risks, consistency checks, and verification of institutional email addresses were employed where possible, and participation was limited to verified healthcare networks.

### 3.4. Data Analysis

This study employed PLS-SEM analysis using SmartPLS 4.0, following key steps, measurement model assessment (reliability, convergent validity, internal consistency, and discriminant validity), structural model evaluation (path coefficients, t-values, p-values, $R^2$, effect sizes, predictive relevance, and multicollinearity), mediation analysis (indirect effects through attitude), and multi-group analysis (testing moderation effects of age, practice type, and practice duration). Predictive accuracy was assessed using PLS-Predict and $Q^2$ redundancy. The study selected PLS-SEM over CB-SEM due to its focus on exploratory analysis, integration of established and emerging constructs (e.g., economic value, social support, technology fatigue), and its ability to handle non-normal data distributions in physician behavioral research.

To mitigate Common Method Bias (CMB), the survey incorporated item randomization and respondent anonymity. Full collinearity VIFs were examined, with all values falling below the threshold of 3.3, indicating no substantial CMB. This approach follows best practices for assessing CMB in PLS-SEM models [36, 37]. Configural, compositional, and scalar invariance were established across age, practice type, and gender groups, ensuring the validity of multi-group comparisons.

## 4. RESULT AND DISCUSSIONS

The study collected data via an online survey administered through Google Forms, targeting physicians in telemedicine across Indonesia. The final sample comprised 244 respondents (general practitioners and specialists) representing diverse geographic regions, including DKI Jakarta, Java, Sumatra, Kalimantan, Sulawesi, Papua, Maluku, and other provinces. This broad distribution supports the generalizability of the findings to the Indonesian healthcare context.

### 4.1. Demographic Profile of Respondents

Of the 244 physicians surveyed, 44.3% were male (n = 108) and 55.7% female (n = 136). The majority (76.2%, n = 186) were classified as Millennials (born 1981–1996), while 23.8% (n = 58) were non-millennials (born before 1981). Regarding professional background, 61.5% (n = 150) were general practitioners, and 38.5% (n = 94) were specialists. These distributions indicate a diverse respondent pool across gender, age, and professional roles, which enhances the robustness of the study's conclusions regarding telemedicine adoption behavior.

Table 1. Demographic Profile of Respondents

| Variable | Respondent Group | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 108 | 44.3% |
| | Female | 136 | 55.7% |
| Age | Millennial (1981–1996) | 186 | 76.2% |
| | Non-Millennial (<1981) | 58 | 23.8% |
| Education | General Practitioner | 150 | 61.5% |
| | Specialist | 94 | 38.5% |

As shown in Table 1, the respondent demographics reflect a diverse sample in terms of gender, age group, and professional background. This balanced distribution strengthens the credibility of the findings, as it captures varied perspectives from both general practitioners and specialists across different age categories.

### 4.2. Descriptive and Normality Statistics

Descriptive statistics demonstrated item loadings between 0.829 and 0.969, indicating strong convergent validity. Mean scores ranged from 3.029 to 3.955, with standard deviations between 0.892 and 1.161, reflecting adequate variability. Skewness and kurtosis values were within ±2 thresholds, confirming the approximate normality of data distributions and supporting the appropriateness of parametric analysis via SEM.

### 4.3. Convergent Validity and Internal Consistency Reliability

The measurement model demonstrated excellent psychometric properties. All indicator loadings exceeded 0.70, and all constructs exhibited Average Variance Extracted (AVE) values above 0.50, confirming convergent validity. Internal consistency was strong across all constructs, with Cronbach's alpha and composite reliability values exceeding 0.875, establishing the reliability of the scales for subsequent structural modeling. Convergent Validity and Internal Consistency Reliability.

Table 2. Convergent Validity and Internal Consistency Reliability

| Construct | Code | Item | Loading | AVE | Cronbach's alpha | CR (rho_a) | CR (rho_c) |
|---|---|---|---|---|---|---|---|
| PE | PE1 | Provides faster medical advice | 0.844 | 0.727 | 0.875 | 0.876 | 0.914 |
| | PE2 | Improves clinical time efficiency | 0.861 | | | | |
| | PE3 | Supports accurate diagnosis and treatment | 0.838 | | | | |
| | PE4 | Enables effective patient monitoring | 0.867 | | | | |
| EE | EE1 | Facilitates patient interaction | 0.862 | 0.781 | 0.906 | 0.909 | 0.935 |
| | EE2 | Assists with routine administrative tasks | 0.844 | | | | |
| | EE3 | Easy to learn to use | 0.910 | | | | |
| | EE4 | The system features are readily learnable | 0.918 | | | | |
| SS | SS1 | Family encourages telemedicine use | 0.842 | 0.786 | 0.909 | 0.913 | 0.936 |
| | SS2 | Senior/mentor recommends telemedicine | 0.921 | | | | |
| | SS3 | Colleagues recommend telemedicine | 0.904 | | | | |
| | SS4 | Supervisor supports telemedicine use | 0.879 | | | | |
| FC | FC1 | Organization provides telemedicine training | 0.928 | 0.888 | 0.958 | 0.959 | 0.969 |
| | FC2 | Provides supporting materials | 0.959 | | | | |
| | FC3 | Technical support is available | 0.954 | | | | |
| | FC4 | Platform is user-friendly | 0.927 | | | | |
| EV | EV1 | Reduce operational costs | 0.855 | 0.830 | 0.931 | 0.935 | 0.951 |
| | EV2 | Enables serving more patients | 0.940 | | | | |
| | EV3 | Saves time on administrative tasks | 0.932 | | | | |
| | EV4 | Adds economic value | 0.914 | | | | |
| BI | BI1 | Intend to use telemedicine consistently | 0.942 | 0.913 | 0.968 | 0.968 | 0.977 |
| | BI2 | Intend to integrate telemedicine in practice | 0.969 | | | | |
| | BI3 | Will continue using for patient convenience | 0.959 | | | | |
| | BI4 | Will optimize telemedicine use | 0.952 | | | | |
| AU | AU1 | Routinely uses telemedicine weekly | 0.831 | 0.734 | 0.880 | 0.888 | 0.917 |
| | AU2 | Significant practice time on telemedicine | 0.885 | | | | |
| | AU3 | Uses telemedicine for chronic patient monitoring | 0.881 | | | | |
| | AU4 | Consultation duration comparable to in-person | 0.829 | | | | |

As Illustrated in Table 2 The measurement model demonstrated excellent psychometric properties. All indicator loadings exceeded 0.70, and all constructs exhibited AVE values above 0.50, confirming convergent validity. Internal consistency was strong across all constructs, with Cronbach's alpha and composite reliability values exceeding 0.875, establishing the reliability of the scales for subsequent structural modeling.

### 4.4. Discriminant Validity

Discriminant validity was verified using the Heterotrait Monotrait Ratio (HTMT) and the Fornell Larcker criterion. HTMT values ranged from 0.519 to 0.836, below the 0.90 threshold, indicating acceptable discriminant validity. Additionally, Fornell Larcker's analysis confirmed that the square roots of AVE exceeded inter construct correlations. These results affirm that all constructs are conceptually distinct and suitable for structural path analysis. All constructs demonstrated satisfactory convergent validity, with AVE values exceeding 0.50 and CR values above 0.70. Discriminant validity was confirmed as all HTMT values were below the recommended threshold of 0.85.

Table 3. Discriminant Validity Heterotrait-Monotrait Ratio Statistics (HTMT)

| Construct | AU | BI | EE | EV | FC | PE | SS |
|---|---|---|---|---|---|---|---|
| AU | - | - | - | - | - | - | - |
| BI | 0.594 | - | - | - | - | - | - |
| EE | 0.519 | 0.792 | - | - | - | - | - |
| EV | 0.621 | 0.815 | 0.836 | - | - | - | - |
| FC | 0.554 | 0.748 | 0.768 | 0.705 | - | - | - |
| PE | 0.557 | 0.675 | 0.779 | 0.740 | 0.698 | - | - |
| SS | 0.622 | 0.531 | 0.658 | 0.639 | 0.661 | 0.780 | - |

As shown in Table 3, all HTMT values fall below the recommended 0.90 threshold, confirming that each construct demonstrates acceptable discriminant validity. These results indicate that the constructs are conceptually distinct and suitable for further structural analysis, reinforcing the robustness of the measurement model.

### 4.5. Predictive Relevance ($Q^2$)

The study assessed the model's predictive relevance using blindfolding and PLS Predict procedures. Blindfolding generated $Q^2$ values of 0.666 (Attitude), 0.656 (Behavioral Intention), and 0.298 (Actual Use), indicating strong to moderate predictive relevance. PLS Predict further validated these results, yielding $Q^2$ Predict values of 0.660 (Attitude), 0.619 (Behavioral Intention), and 0.272 (Actual Use). All key endogenous constructs showed lower RMSE values in the PLS SEM model compared to a Linear Regression (LM) benchmark, confirming superior predictive performance and out of sample accuracy.

### 4.6. Hypothesis Testing

The study tested eleven hypotheses, eight supported and three not as seen in Table 4. Performance Expectancy (PE) did not significantly influence Behavioral Intention (BI) ($\beta$ = 0.079, $p > 0.05$) or Actual Use (AU) ($\beta$ = 0.002, $p > 0.05$), indicating limited relevance of performance expectations in this context. Effort Expectancy (EE) positively impacted BI ($\beta$ = 0.217, $p < 0.05$) but negatively affected AU ($\beta$ = -0.177, $p < 0.05$), suggesting that ease of use fosters intention but does not guarantee sustained use.

Facilitating Conditions (FC) significantly influenced BI ($\beta$ = 0.314, $p < 0.001$), though its effect on AU was not significant ($\beta$ = 0.078, $p > 0.05$). Social support (SS) showed contrasting effects, a negative impact on BI ($\beta$ = -0.126, $p < 0.05$) and a positive effect on AU ($\beta$ = 0.327, $p < 0.001$). Economic Value (EV) demonstrated strong positive effects on both BI ($\beta$ = 0.422, $p < 0.001$) and AU ($\beta$ = 0.239, $p < 0.05$), highlighting its importance in adoption of driving telemedicine. Behavioral intention significantly predicted AU ($\beta$ = 0.287, $p < 0.05$), confirming the mediating role of intention.

The model explained 69.9% of the variance in BI ($R^2$ = 0.699). Variance Inflation Factors (VIF) for all paths remained below 5, indicating no multicollinearity. Effect sizes ($f^2$) ranged from minor to moderate, supporting model robustness.

Table 4. Summary of Hypotheses Testing

| Path Coefisient | Std. Beta | Std. Error | t-value | p-value | Bias | 5% | 95% | VIF | $R^2$ | $f^2$ | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PE → BI | 0.079 | 0.062 | 1.280 | 0.100 | 0.004 | -0.032 | 0.175 | 2.652 | 0.699 | 0.008 | Not Significant |
| PE → AU | 0.002 | 0.087 | 0.020 | 0.492 | 0.004 | -0.116 | 0.165 | 2.672 | | 0.000 | Not Significant |
| EE → BI | 0.217 | 0.084 | 2.569 | 0.005 | -0.003 | 0.087 | 0.365 | 3.214 | | 0.049 | Significant |
| EE → AU | -0.177 | 0.101 | 1.753 | 0.040 | -0.002 | -0.289 | 0.036 | 3.370 | | 0.016 | Significant |
| FC → BI | 0.314 | 0.070 | 4.499 | 0.000 | 0.000 | 0.202 | 0.430 | 2.454 | | 0.133 | Significant |
| FC → AU | 0.078 | 0.109 | 0.718 | 0.236 | -0.003 | -0.005 | 0.352 | 2.780 | | 0.004 | Not Significant |
| SS → BI | -0.126 | 0.061 | 2.065 | 0.019 | 0.002 | -0.224 | -0.023 | 2.214 | | 0.024 | Significant |
| SS → AU | 0.327 | 0.081 | 4.059 | 0.000 | 0.006 | 0.149 | 0.417 | 2.267 | | 0.084 | Significant |
| EV → BI | 0.422 | 0.081 | 5.179 | 0.000 | -0.001 | 0.286 | 0.553 | 2.788 | | 0.212 | Significant |
| EV → AU | 0.239 | 0.106 | 2.251 | 0.012 | 0.003 | 0.197 | 0.508 | 3.378 | | 0.039 | Significant |
| BI → AU | 0.287 | 0.125 | 2.301 | 0.011 | 0.003 | 0.081 | 0.492 | 3.320 | 0.439 | 0.044 | Significant |

As presented in Table 4, the results of the hypothesis testing indicate that several constructs significantly influence behavioral intention and actual use, while others show limited or nonsignificant effects. The varying significance levels highlight the distinct roles each factor plays in shaping telemedicine adoption, reinforcing the model's explanatory power.

### 4.7. Indirect Effects and Mediating Role of Attitude

Indirect effect analysis confirmed Attitude (AT) as a key mediator shaping BI and AU (Table 5). Economic Value (EV → AT → BI, $p = 0.001$) exhibited the most substantial indirect effect, indicating that perceptions of economic benefits foster positive attitudes, enhancing adoption intentions. Similarly, Facilitating Conditions (FC), Performance Expectancy (PE), and Effort Expectancy (EE) significantly influenced BI through attitude.

Two sequential mediation pathways FC → AT → BI → AU ($p = 0.031$) and EV → AT → BI → AU ($p = 0.042$) significantly impacted actual use, underscoring the importance of supportive infrastructure and perceived value in sustaining adoption. Conversely, mediation paths involving Social Support (SS) and complete chains from PE and EE to AU were non significant, suggesting that favourable attitudes and intentions alone are insufficient to drive actual usage without additional contextual enablers.

Table 5. Summary of Indirect Hypotheses Testing

| Indirect Path | Original Sample | Std. Error | t-value | p-value | Result |
|---|---|---|---|---|---|
| EE → AT → BI | 0.076 | 0.038 | 1.974 | 0.024 | Significant |
| EV → AT → BI | 0.157 | 0.048 | 3.241 | 0.001 | Significant |
| FC → AT → BI | 0.078 | 0.031 | 2.538 | 0.006 | Significant |
| PE → AT → BI | 0.050 | 0.025 | 1.982 | 0.024 | Significant |
| SS → AT → BI → AU | 0.009 | 0.008 | 1.122 | 0.131 | Not Significant |
| SS → AT → BI | 0.033 | 0.023 | 1.456 | 0.073 | Not Significant |
| PE → AT → BI → AU | 0.014 | 0.010 | 1.404 | 0.080 | Not Significant |
| FC → AT → BI → AU | 0.022 | 0.012 | 1.864 | 0.031 | Significant |
| EE → AT → BI → AU | 0.022 | 0.016 | 1.362 | 0.087 | Not Significant |
| EV → AT → BI → AU | 0.045 | 0.026 | 1.732 | 0.042 | Significant |

Overall Table 5 summarize, attitude emerged as a critical mechanism linking perceptions of value, usability, and support to adoption outcomes. Strengthening positive attitudes remains essential to bridging the gap between intention and sustained use.

### 4.8. Latent Variable Score

The study analyzed Latent Variable Scores (LVS) across seven constructs PE, EE, FC, SS, EV, BI, and AU (Table 6). Constructs were categorized as above average (3.5–5.0) or below average (1.0–3.49). Only 50% of respondents perceived telemedicine as Enhancing Performance (PE), while perceptions of usability (EE, 68.0%) and infrastructural support (FC, 57.8%) were more favorable.

Economic value was perceived positively by 67.2% of respondents, and behavioral intention was similarly firm (68.0%). In contrast, social support was relatively low (38.5%), reflecting limited normative

or peer reinforcement. Notably, a substantial gap emerged between BI and AU, with only 32.4% reporting consistent use, highlighting a common intention behavior gap in technology adoption.

Table 6. Latent Variable Score

| LVS Category | PE | EE | FC | SS | EV | BI | AU |
|---|---|---|---|---|---|---|---|
| Above Average | 122 | 166 | 141 | 94 | 164 | 166 | 79 |
| (3.5–5) | (50.0%) | (68.0%) | (57.8%) | (38.5%) | (67.2%) | (68.0%) | (32.4%) |
| Below Average | 122 | 78 | 103 | 150 | 80 | 78 | 165 |
| (1–3.49) | (50.0%) | (32.0%) | (42.2%) | (61.5%) | (32.8%) | (32.0%) | (67.6%) |

These results suggest that external barriers (institutional support, infrastructure) and internal factors (attitudes, readiness) influence usage. Addressing these barriers through targeted interventions enhancing motivation, institutional incentives, and workflow integration will be essential to translating physicians favorable perceptions and intentions into sustained telemedicine adoption.

## 4.9. Moderating Effects of Demographic Factors

### 4.9.1. Age Group (Millennials vs. Above Millennials)

Measurement invariance across Millennial and Above Millennial groups was confirmed through the MICOM procedure, ensuring model stability. Permutation based Multi Group Analysis (MGA) revealed no statistically significant moderating effects of age on any structural path (all $p > 0.05$). Although insignificant, the path from BI to AU was stronger among Millennials ($\beta = 0.393$) than older physicians ($\beta = -0.026$), suggesting younger physicians may more readily translate intention into usage. Similarly, Effort EE to BI was marginally stronger for Millennials, while Facilitating FC to AU was somewhat stronger among older physicians. However, these differences did not reach statistical significance.

Age did not significantly moderate the model. Telemedicine adoption mechanisms appear invariant across age cohorts, suggesting that adoption strategies should focus on universal enablers such as usability, infrastructural support, and perceived value, rather than age specific interventions.

### 4.9.2. Practice Type (General Practice vs. Specialist)

Measurement invariance between general practitioners and specialists was largely supported, with minor divergence in SS weights. Significant differences in mean scores were observed for AU, PE, and SS, though variances were homogeneous. MGA results indicated that practice type significantly moderated the BI $\rightarrow$ AU path, general practitioners exhibited a strong positive relationship, whereas specialists showed a negative association. The analysis detected no significant moderation by practice type for other structural paths.

These findings suggest that general practitioners are more likely to translate adoption intentions into actual use, potentially due to greater workflow flexibility and institutional support. In contrast, specialists may face contextual or structural barriers limiting adoption. Tailored interventions addressing these barriers are needed to promote balanced telemedicine uptake across practice types.

### 4.9.3. Practice Duration

Measurement invariance across practice duration groups (<5 years, 5–10 years, >10 years) was fully supported. MGA revealed no significant moderation effects across most model pathways (all p > 0.05), indicating model consistency across experience levels.

An exception emerged for the BI $\rightarrow$ AU path, physicians with <5 years of experience demonstrated a stronger relationship than those with >10 years (p = 0.045), suggesting that less experienced physicians may be more inclined to adopt telemedicine. However, this isolated effect does not compromise the model's overall stability.

Overall, telemedicine adoption mechanisms appear largely unaffected by years of clinical experience. Strategies should focus on strengthening core enablers system usability, perceived value, and organizational support rather than segmenting by practice duration.

### 4.9.4. Physicians Telemedicine Participation Patterns

Analysis of participation patterns revealed notable variation across platform usage, weekly telemedicine practice duration, and clinical experience. Physicians with less than ten years of experience demonstrated the

highest adoption levels, typically using a single platform for under four hours per week. Younger physicians represented a substantial portion of this cohort.

Conversely, physicians with over fifteen years of clinical experience exhibited lower adoption, limited platform diversity, and no reports of telemedicine use exceeding eight hours weekly. Across all experience levels, multi platform usage remained modest, with higher intensity usage uncommon.

Adoption is strongest among younger, digitally adept physicians, while more experienced practitioners show lower engagement. Targeted interventions such as enhanced training, workflow integration, and peer mentoring may be needed to support sustained adoption among senior physicians.

#### 4.9.5. Physicians Preferences for Telemedicine Features

Among the 226 respondents to this section, chat based communication emerged as the most frequently used feature (62.4%), reflecting the value placed on asynchronous, flexible communication that aligns with clinical workflows. The use of digital medical records was reported by 20.4%, highlighting the growing emphasis on structured documentation and continuity of care.

In contrast, respondents used video consultations (8%) and prescription management (6.2%) less frequently. A few physicians reported employing additional features like image sharing and phone-based consultations. Only one respondent reported using a hospital integrated telemedicine system.

These findings suggest that current telemedicine practices prioritize communication efficiency and basic data management while adopting advanced, integrated features remains limited. Further development of platform capabilities and user support may be required to drive broader and deeper feature utilization.

#### 4.9.6. Key Challenges in Telemedicine Implementation

Despite recent growth in adoption, physicians continue to face several persistent barriers to telemedicine use, spanning six key domains, Technological infrastructure, Frequent disruptions due to unstable internet connectivity, bandwidth limitations, and platform malfunctions, particularly in rural areas [38, 39]. Clinical examination limitations, The inability to conduct physical examinations remains a significant constraint, particularly for specialties requiring direct assessment. Physician patient communication, digital interactions often lack the depth of in-person consultations, compounded by patients limited digital literacy and reduced non verbal cues [40, 41]. Time and workload management, on demand telemedicine services contribute to fragmented workflows and elevated burnout risk. Improved scheduling and workflow design are required to ensure sustainability [42, 43].

Ethical and privacy concerns, data security, informed consent processes, and regulatory clarity remain critical in maintaining trust and compliance [44, 45]. Operational support limitations, inadequate reimbursement models and logistical barriers (e.g., medication availability) hinder broader adoption and scalability [46, 47]. These findings indicate that while telemedicine adoption in Indonesia has advanced, systemic barriers technological, clinical, communicative, ethical, and operational persist. Addressing these barriers through coordinated investments in infrastructure, regulatory frameworks, physician training, and workflow optimization will support telemedicine's long-term integration into clinical practice.

### 4.10. Discussions

These findings advance the understanding of physician telemedicine adoption by extending prior literature in several keyways. First, by demonstrating the central mediating role of attitude, the study reinforces the importance of affective and motivational pathways in shaping adoption behavior an aspect often underexplored in healthcare technology acceptance research. Second, the significant influence of economic value highlights the need to account for financial and operational considerations, particularly in resource constrained healthcare settings, where practical incentives strongly shape behavioral intentions. Third, the differentiated effects of social support and facilitating conditions underscore the complex interplay between organizational, social, and individual factors in driving sustained telemedicine engagement. Collectively, these insights contribute to a more holistic understanding of telemedicine adoption in digitally evolving healthcare systems, particularly within the nuanced Southeast Asian context.

From a methodological perspective, key measurement indicators such as AVE, CR, and HTMT further validate the model. AVE assesses how well each construct explains its measurement items, with higher values indicating stronger construct validity. CR evaluates internal consistency beyond Cronbach's alpha, ensuring reliable measurement of latent constructs. HTMT examines whether different constructs are empirically distinct. Together, these metrics confirm that the model's constructs are both valid and distinct, reinforcing

the robustness of the study's findings. Conversely, performance expectancy did not significantly influence behavioral intention or actual use, aligning with post pandemic findings that clinical performance gains alone are insufficient to drive sustained adoption. Physicians prioritize practical usability, workflow integration, and patient interaction quality over abstract performance improvements.

Observed differences in adoption patterns across practice types underscore the influence of clinical context in shaping technology use, aligning with prior studies that highlight the role of workflow integration and patient interaction norms in telemedicine engagement [48]. Meanwhile, the relative homogeneity of adoption mechanisms across age and experience cohorts may reflect the shared professional training of Indonesian physicians and the uniform digital transformation pressures experienced during the pandemic. Such convergence suggests that while clinical context differentiates adoption, demographic factors exert less influence in settings characterized by collective exposure to telemedicine technologies. Sample characteristics may explain the limited moderating effects of demographic variables. Most respondents shared similar professional training, and many experienced a uniform shift toward digital practice during the COVID-19 pandemic. Such shared exposure likely reduced variance across age and experience cohorts. Cultural factors, such as collective attitudes toward technology and the rapid normalization of telemedicine in Indonesia's healthcare system, may have further contributed to the homogeneity of adoption pathways across demographic subgroups.

Emerging constructs such as E-health literacy, technology fatigue, and evolving physician patient relationship dynamics further enrich the explanatory framework. Addressing technology fatigue through optimized workflows and fostering E-health literacy can enhance long term engagement with telemedicine platforms. Such an approach aligns with Social Cognitive Theory [49], which emphasizes self efficacy as a determinant of behavior. In this study, 60.9% of physicians reported high self efficacy in using telemedicine, though some expressed concerns regarding technical challenges and clinical decision making in virtual environments. E-health literacy reinforces self efficacy by equipping physicians with the skills to effectively access, interpret, and apply digital health information. Fostering cognitive (literacy) and affective (self efficacy) competencies are essential to sustaining telemedicine adoption in clinical practice.

These findings align with recent Southeast Asian research, which underscores that while technological readiness is necessary, psychosocial readiness and institutional support remain decisive in shaping adoption trajectories. Studies from Malaysia [20], Vietnam, and Indonesia [11, 12] further emphasize the critical role of communication quality and regulatory maturity. The study's findings also align with institutional theory, highlighting that physician adoption of telemedicine is shaped not only by individual level factors but also by broader organizational and market dynamics. Similar to firm exit decisions under economic uncertainty [50], healthcare organizations may strategically adjust service offerings including accelerating digital health adoption in response to shifting external conditions.

Infrastructure disparities and evolving policy landscapes continue to influence adoption across Southeast Asia. Emerging evidence from Southeast Asia reinforces the importance of institutional support and physician readiness in shaping telemedicine adoption [51, 52]. Recent findings highlight that regional infrastructure and policy maturity variations influence regional adoption patterns.

Global comparisons reveal similar patterns. In Europe and the US, sustained telemedicine adoption faces ongoing challenges related to physician workload, digital literacy, and policy clarity. In Brazil, national surveys report comparable enablers and barriers in post pandemic telemedicine use. Cross country evidence reinforces the need for a balanced approach that addresses both technological infrastructure and human factors to ensure sustainable adoption.

This research offers theoretical contributions by extending the TAM UTAUT framework with the addition of attitude as a mediator and economic value as a determinant, addressing a gap in current models of physician telemedicine adoption. By highlighting the conceptual role of emerging constructs E-health literacy, technology fatigue, and physician patient relationship dynamics this study paves the way for future model refinements that better capture the complexities of telemedicine adoption in digitally evolving healthcare systems. These insights advance the theoretical discourse and inform practical strategies for healthcare organizations and policymakers aiming to foster sustainable telemedicine engagement.

While both TAM and UTAUT offer valuable explanatory power for healthcare technology adoption, this study's emphasis on physicians attitudinal and motivational processes justified the prioritization of TAM pathways within the integrated framework. Existing comparative studies suggest that UTAUT's strong predictive utility for organizational and infrastructural factors complements TAM's superior capacity to model individual behavioral intentions. Thus, integrating both frameworks enables a richer, more context sensitive

understanding of telemedicine adoption among Indonesian physicians.

Although this study employed PLS-SEM due to its suitability for exploratory modeling and the integration of both reflective and formative constructs, future research may benefit from comparative analysis using Covariance Based SEM (CB SEM). Such comparison could provide additional insights into model fit, measurement invariance, and structural stability, particularly when validating the integrated TAM UTAUT model across larger or cross national samples. Integrating CB SEM robustness checks would further enhance the methodological rigor and generalizability of telemedicine adoption studies in diverse healthcare contexts.

## 5. MANAGERIAL IMPLICATIONS

The findings of this study provide practical insights for healthcare managers and policymakers to accelerate and sustain telemedicine adoption in Indonesia. Strengthening digital literacy and readiness among physicians is crucial to fostering long term engagement, supported by targeted training and continuous professional development to bridge competency gaps. Addressing technology fatigue through optimized workflows and supportive environments can reduce barriers to sustained use, while institutional efforts to enhance infrastructure, establish clear guidelines, and provide organizational support remain essential in resource limited healthcare systems. Enhancing physicians attitudes toward telemedicine is also key, with strategies emphasizing perceived usability, economic value, and supportive work environments. Fostering peer support and leadership endorsement through effective change management can embed telemedicine into clinical practice. However, readiness alone is insufficient without motivational and attitudinal interventions, as workload and technology fatigue continue to hinder adoption even in advanced systems.

Emerging barriers such as technology fatigue and evolving physician-patient relationships require targeted management through balanced consultation schedules, improved workflow design, and strategies to maintain communication quality and therapeutic relationships in digital settings. Promoting E-health literacy among physicians and patients enhances equitable access and strengthens digital healthcare delivery. Healthcare managers in Southeast Asia, including Indonesia, must address regional challenges like regulatory inconsistency, infrastructure gaps, and policy changes. Emphasizing telemedicine's economic value including efficiency gains, cost savings, and financial sustainability can enhance motivation and consistent use. Sustaining post pandemic momentum requires collaboration among healthcare leaders, policymakers, and technology developers. Strengthening strategic readiness through a marketing oriented approach focused on perceived value, user attitude, and behavioral intention can ensure long term adoption and sustainable digital healthcare transformation.

## 6. CONCLUSION

Grounded in the well-established TAM and UTAUT models, this study advances the understanding of telemedicine adoption by applying an integrated framework incorporating attitudinal mediation and demographic moderation. The findings provide a nuanced view of physician adoption behavior through localized empirical validation in the Indonesian context. Effort expectancy, facilitating conditions, social support, and economic value emerged as primary determinants of adoption, with attitude playing a pivotal mediating role in linking perceptions to behavioral intention and actual use. In contrast, performance expectancy did not significantly predict adoption, underscoring that usability, practical support, and perceived value are more influential drivers than abstract performance gains.

Demographic moderators exhibited limited effects, except for practice type, where general practitioners were more likely to translate intention into usage than specialists. These results suggest that adoption strategies should focus on universally relevant enablers such as ease of use, institutional and technical support, economic incentives, and social validation while addressing context specific needs among specialist groups. Integrating TAM and UTAUT constructs provides a robust foundation for designing targeted interventions to promote widespread telemedicine utilization. Furthermore, the study highlights emerging constructs such as E-health literacy, technology fatigue, and evolving physician patient relationship dynamics as critical factors that warrant deeper empirical exploration. Although conceptually acknowledged, these variables remain untested in the current model and warrant integration in future extensions.

Future research should also pursue multi country comparative studies, particularly within Southeast Asia, where evolving regulatory frameworks, infrastructure disparities, and healthcare system dynamics present unique adoption challenges and opportunities. Global momentum will require coordinated efforts among

healthcare leaders, policymakers, and technology developers to foster culturally responsive and contextually grounded telemedicine strategies. Future research may also explore the role of dynamic managerial capabilities and strategic agility in mediating the relationship between institutional pressures and telemedicine adoption outcomes. This study extends existing technology acceptance frameworks and informs practical pathways for advancing telemedicine adoption in post pandemic healthcare landscapes. While the study conceptually highlights emerging constructs such as E-health literacy, technology fatigue, and changes in physician patient relationships, it does not formally operationalize these variables in the current model. Future research should empirically integrate these constructs to capture telemedicine adoption's evolving psychosocial and contextual dimensions. Future research should explore the dynamic interplay of psychosocial, technological, and institutional factors shaping telemedicine adoption and empirically validate emerging constructs such as technology fatigue and E-health literacy through longitudinal and cross country comparative studies. Empirically integrating these constructs in future models will provide a more comprehensive understanding of psychosocial and contextual factors influencing sustained telemedicine adoption. Recent systematic reviews highlight that post pandemic physician adoption of telemedicine remains influenced by both technological barriers and shifting professional expectations. Emphasized that sustained engagement requires addressing emerging psychosocial and operational challenges.

## 7. DECLARATIONS

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### 7.2. Author Contributions

Conceptualization: ES, HH, RN, and LN; Methodology: ES; Software: ES; Validation: ES; Formal Analysis: ES; Investigation: ES; Resources: ES; Data Curation: ES; Writing Original Draft Preparation: ES, HH, RN, and LN; Writing Review and Editing: ES; Visualization: ES; All authors, ES, HH, RN, and LN, have read and agreed to the published version of the manuscript.

### 7.3. Data Availability Statement

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

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### 7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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