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THE ROLE OF DIGITAL COMPETENCY IN AI-DRIVEN HEALTH MONITORING FOR THE ELDERLY: A QUANTITATIVE STUDY ON SYSTEM EFFECTIVENESS

O PAPEL DA COMPETÊNCIA DIGITAL NO MONITORAMENTO DE SAÚDE COM IA PARA IDOSOS: UM ESTUDO QUANTITATIVO SOBRE A EFICÁCIA DO SISTEMA

EL PAPEL DE LA COMPETENCIA DIGITAL EN LA MONITORIZACIÓN DE SALUD IMPULSADA POR IA PARA PERSONAS MAYORES: UN ESTUDIO CUANTITATIVO SOBRE LA EFECTIVIDAD DEL SISTEMA

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ABSTRACT
This study investigates how real-time health data processing and personalized AI-based recommendations affect the effectiveness of remote health monitoring systems for the elderly. It also examines the role of digital literacy in moderating the link between real-time health data collection and systems effectiveness. using a quantitative approach, data were gathered through an online survey with 385 participants, including elders, caregivers, and health professionals. Responses were measured on a 5-point Likert scale, and the sample was selected using purposive stratified sampling to ensure diversity. Reliability and validity were tested using Cronbach's alpha, exploratory factor analysis, and multiple linear regression. Findings show that both real-time data processing and personalized recommendations significantly enhance system effectiveness. notably, digital literacy strengthens the positive impact of data processing on systems performance, underlining the importance of user skills in maximizing AI's benefits for eldercare. The study adds to existing research by applying Cognitive Fit Theory, Socioemotional Selectivity Theory, and Digital Divide Theory to AI-driven health systems. It offers practical insights for developers, healthcare providers, and policymakers, emphasizing the need for user-centered design and digital inclusion. Overall, it highlights how aligning technology with user capability can improve outcomes in elderly care support more accessible, intelligent health solutions.

KEYWORDS: AI-based Remote Health Monitoring. Elderly Care. Real-time Health Data. Personalized Health Recommendations. Digital Literacy.

RESUMO
Este estudo investiga como o processamento de dados de saúde em tempo real e as recomendações personalizadas baseadas em IA afetam a efetividade dos sistemas de monitoramento remoto para idosos. Também analisa o papel da alfabetização digital na moderação da relação entre a coleta de dados em tempo real e a eficácia do sistema. Utilizando uma abordagem quantitativa, os dados foram coletados por meio de uma pesquisa online com 385 participantes, incluindo idosos, cuidadores e profissionais da saúde.

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As respostas foram medidas em uma escala Likert de 5 pontos, e a amostra foi selecionada por amostragem estratificada intencional para garantir diversidade. A confiabilidade e validade foram verificadas por meio do alfa de Cronbach, análise fatorial exploratória e regressão linear múltipla. Os resultados indicam que tanto o processamento de dados quanto as recomendações personalizadas aumentam significativamente a efetividade do sistema. A alfabetização digital, em especial, fortalece o impacto positivo do processamento de dados no desempenho do sistema, ressaltando a importância das competências do usuário. O estudo aplica as teorias do Ajuste Cognitivo, da Seletividade Socioemocional e da Divisão Digital, oferecendo contribuições práticas para desenvolvedores, profissionais da saúde e formuladores de políticas.

PALAVRAS-CHAVE: *Monitoramento Remoto com IA. Cuidado de Idosos. Dados de Saúde em Tempo Real. Recomendações Personalizadas. Alfabetização Digital.*

RESUMEN
Este estudio analiza cómo el procesamiento en tiempo real de datos de salud y las recomendaciones personalizadas basadas en IA influyen en la efectividad de los sistemas de monitoreo remoto para personas mayores. También examina el papel de la alfabetización digital como variable moderadora entre la recolección de datos y la efectividad del sistema. Se utilizó un enfoque cuantitativo, con una encuesta en línea aplicada a 385 participantes, incluidos adultos mayores, cuidadores y profesionales de la salud. Las respuestas se midieron en una escala Likert de 5 puntos, y la muestra fue seleccionada mediante muestreo estratificado intencional para asegurar diversidad. La confiabilidad y validez se evaluaron con el alfa de Cronbach, análisis factorial exploratorio y regresión lineal múltiple. Los resultados muestran que tanto el procesamiento de datos como las recomendaciones personalizadas mejoran significativamente la efectividad del sistema. En particular, la alfabetización digital refuerza el impacto positivo del procesamiento de datos en el desempeño del sistema, destacando la importancia de las habilidades del usuario. El estudio aplica teorías como Cognitive Fit, Selectividad Socioemocional y Brecha Digital, y ofrece recomendaciones útiles para desarrolladores, profesionales de la salud y responsables de políticas. Destaca la importancia de diseñar tecnologías accesibles y centradas en el usuario.

PALABRAS CLAVE*: Monitoreo Remoto Basado en IA. Cuidado de Ancianos. Datos de Salud en Tiempo Real. Recomendaciones Personalizadas. Alfabetización Digital.*

INTRODUCTION

The escalating advancement of artificial intelligence (AI) into remoted health monitoring systems represents a paradigm shift in elderly care, offering unprecedented opportunities to support aging populations in home-based settings. These AI-driven remote systems – capable of real-time health data collection, predictive analytics, and personalized intervention – promise to enhance early disease detection, reduce unnecessary hospitalizations, and improve quality of life for older adults. Yet, despite their potential in real-world remote environments remains uncertain,

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as barriers such as technological complexity, user resistance, and infrastructural limitations persist. While studies highlight benefit such as early detection of health anomalies (Tsvetanov, 2024) and reduced hospitalization rates (Palanisamy *et al.,* 2023), remote implementation introduces unique challenges. Connectivity issues, data transmission delays, and privacy concerns in remote settings can undermine real-time monitoring reliability (Islam *et al.,* 2015; Pool *et al.,* 2022; Yaqoob *et al.,* 2012). Additionally, elderly users often struggle with self-management of remote devices, leading to inconsistent data collection (Fowe *et al.,* 2023). Furthermore, personalized AI recommendations may lose efficacy if remote systems fail to account contextual factors (e.g., home environment, caregiver support) (Ho, 2020). These challenges highlight the need to assess effectiveness not just in controlled environments but in real-world remote settings, where digital literacy plays a decisive role in adaptation and sustained use (Wang; Luan, 2022). At the core of this study is an investigation of Real-time health data processing – moderated by a critical yet often overlooked factor: the digital literacy of elderly, and personalized AI recommendations as drivers of systems effectiveness. As societies grapple with aging demographics and strained healthcare systems, optimizing remote AI health monitoring is not just an academic pursuit but a socioeconomic imperative. This research seeks to quantify these dynamics, connecting the gap between technological potential and practical, equitable implementation.

The rapidly growing field of AI-driven remote health monitoring for elderly care has demonstrated remarkable potential, with groundbreaking studies revealing its capacity for transformative early disease detection and dramatic reductions in hospital admission rates. But beneath this promising veneer lie critical, unaddressed challenges that threaten to undermine the technology’s real-world impact. While the efficacy of real-time data collection has been well-established in controlled clinical environments (Islam *et al.,* 2022), its translation to unpredictable home settings remains alarmingly understudied, particularly concerning persistent issues of data integrity and elderly user adherence (Ahmed *et al.,* 2023; Evangelista *et al.,* 2015). Even more concerning is the glaring oversight in current AL personalization algorithms, which frequently neglect fundamental gerontological considerations of cognitive decline and physical impairments (Neves, 2023). Most shockingly, the pivotal moderating influence of digital literacy has been virtually ignored in the literature, with researchers hazardously assuming a uniform level of technological competence among elderly users (Shi *et al.,* 2024), despite overwhelming evidence that digital literacy constitutes the single greatest barrier to successful implementations (Wang;

Luan, 2022).

In this study, the authors aim to address two pivotal research questions: (1) To what extent do real-time health data collection and processing and personalized AI-based recommendations independently shape the effectiveness of AI-based remote health monitoring systems for elderly? and (2) How does digital literacy fundamentally moderate the relationship between real-time healthcare data collection and processing and systems effectiveness? The research makes four key contributions by addressing these questions. First, it establishes an integrated evaluation of effectiveness of AI-based remote health monitoring systems for elderly, examining not only clinical outcomes but also user-centric measures – an essential expansion beyond traditional technical metrics that aligns with modern gerontechnology paradigms. Second, it rigorously tests the impact of Real-time data processing on system performance, addressing a crucial knowledge gap in how temporal data reliability translates to real-world elderly care. Third, the study isolates the contribution of personalized AI recommendations, distinguishing their unique role in health improvement versus user satisfaction – a nuanced perspective often overlooked in current literature. Finally and most critically, introducing Digital literacy as a moderator, but with a deliberate and justified limitation: it examines how user competency amplifies of diminishes the relationship between Real-time data capabilities and system effectiveness. Methodologically, the study used a quantitative design grounded in hypothesis testing, applying structured survey data, Cronbach's Alpha for reliability, Exploratory Factor Analysis to validate factor structure, multiple regression for direct effects, and SPSS Process Macro to assess moderation. The study unfolds through five critical sections: (1) establishing the theoretical framework of digital competency in gerontechnology, (2) analyzing system effectiveness drivers, (3) detailing the mixed-methods validation approach, (4) presenting regression results, and (5) deriving evidence-based design guidelines for age-inclusive AI health systems. With this constructed approach, it provides both theoretical clarity and practical pathways for developing elderly-inclusive AI health solutions.

Effectiveness of AI-based Remote Health Monitoring Systems for Elderly

Remote health monitoring systems have transformed healthcare by enabling providers to track and manage patients' conditions outside traditional settings using technology that collects and securely transmits real-time data (Alexandru *et al.,* 2024). When integrated with AI, these systems gain enhanced efficiency and predictive power – analyzing IoT-gathered data to support early diagnosis, proactive intervention, and highly personalized treatment. Through web or mobile platforms, clinicians can make swift, informed decisions based on deep insights derived from intelligent data processing, mitigating adverse event risks among the elderly, and facilitate timely, targeted access to appropriate medical interventions (Paraschiv *et al.,* 2021; Iqbal, 2023). Grounded in the Technology Acceptance Model (TAM) – a framework adapted to healthcare contexts – emphasizing perceived usefulness (e.g., predictive accuracy) and perceived ease of use (e.g., interface intuitiveness) as critical determinants of adoption and impact (Chow *et al.,* 2012). The TAM's healthcare adaption clarifies why effectiveness transcends technical performance, requiring alignment with elderly users' cognitive and behavioral patterns (Holden; Karsh, 2010). Further contextualized by Self-Determination Theory (SDT), interprets how effectiveness relies on fulfilling elderly users' psychological needs for autonomy (control over health data), competence (ability to use the system), and relatedness (connection to caregivers) – factors that collectively enhance long-term adherence and health outcomes (Ryan; Deci, 2020).

In the broader economic context, effective AI-based monitoring systems can reduce hospitalization costs, alleviate caregiver burdens, and enhance productivity by enabling elderly individuals to live independently for longer periods. These systems facilitate early detection of health issues, allowing for timely interventions that prevent costly hospital admission and support aging in place, thereby reducing the financial strain on healthcare systems and families alike (Ho, 2020). A real-world case study demonstrating the systems effectiveness is the deployment of the CarePredict platform in six assisted living communities, where all residents were older adults requiring daily care. In this study carried out by Wilmink *et al.,* (2020), facilitates using CarePredict – an AI-powered system that tracks seniors' movement and behavior patterns to detect health issues early – experienced a 40% reduction in hospitalization rates, a 69% decrease in falls, and a 67% increase in residents' length of stay compared to those without the system. These results highlight how AI technologies can significantly enhance safety, prolong independent living, and reduce healthcare burdens for elderly populations.

Anchoring Theoretical Frameworks

Technology Acceptance Model (TAM)

Davis (1989) first introduced the Technology Acceptance Model (TAM) as a framework to understand what drives individuals' intention to adopt new technologies. Developed from the Theory of Reasoned Action (TRA) (Fishbein; Ajzen, 1977), a foundational psychological theory aimed at discovering human behavior, TAM emphasizes the cognitive factors that shape a user's willingness to engage with technological innovations (King; He, 2006). TAM pinpointed two pivotal yet often overlooked factors driving user acceptance: perceived usefulness and perceived ease of use. These perceptions shape user attitudes, forming a casual link between system design and acceptance – core elements that remain central to the model today (Davis *et al.,* 2024). When examining AI-based remote health monitoring systems for the elderly, TAM offers a robust lens to analyze how older adults interact with such advanced solutions. The effectiveness of the system is not directly dictated by technological capabilities alone but is profoundly influenced by elderly users' perceptions of the AI system's utility and accessibility. In the healthcare context, these perceptions are often filtered through individuals' existing beliefs with digital tools – making TAM's application especially relevant in sensitive, high-stakes environments such as elder care.

The Real-time health data collection and processing capability powerfully demonstrates the construct of perceived usefulness, as elderly users exhibit significantly higher adoption rates when they recognize the system's ability to improve the precision and responsiveness of medical care (Sun *et al.,* 2024). Equally critical are personalized AI-driven health recommendations, which directly enhance perceived ease of use by ensuring that interactions with the system are intuitive and user-friendly, thereby fostering sustained engagement and reducing the cognitive burden of navigating complex interfaces (Liu *et al.,* 2022). With these two constructs, therefore, act as critical mediators, effectively translating the system's advanced technical features into measurable improvements in healthcare outcomes. Beyond this, user trust and sustained engagement, cultivated through positive perceptions of usefulness and ease of use, further amplify the system's effectiveness, solidifying TAM's enduring relevance in healthcare technology adoption (Holden; Karsh, 2010).

A particularly groundbreaking extension of TAM in this setting is the moderating influence of Digital literacy. Since older adults typically have less lifelong exposure to digital technologies, their familiarity and confidence with such tools greatly influence how they perceive and engage with AI-driven health systems (Charness; Boot, 2009). For elderly users, Digital literacy not only shapes technical interaction but also determines how information is cognitively processes and emotionally received. Those with higher levels digital competency are better equipped to recognize the relevance of Real-time data, interpret system feedback, and navigate interface features with minimal frustrations (Li *et al.,* 2023). Greater Digital literacy for elderly users not only elevates perceived ease of use but also intensifies the positive relationship between Real-time data collection and processing and overall system efficacy. This finding resonates with advanced

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theoretical expansions of TAM, including TAM2 and the Unified Theory of Acceptance and Use of Technology (UTAUT), which account for contextual moderators such as prior experience, age, and educational background (Venkatesh *et al.,* 2003).

TAM operates on the premise that technology adoption is primarily driven by rational evaluations of usefulness ad ease of use. It assumes users engage in a deliberate decision-making process, where intention precedes actual use, and attitudes shape behavioral outcomes. Additionally, the model presupposes that users have sufficient exposure to the technology in question and that intention metrics reliably predict future usage patterns. The model also implies that external factors (e.g., social influence or facilitating conditions) do not override core perceptions, and that user resistance – stemming from privacy concerns or technophobia – does not significantly disrupt the acceptance process unless explicitly modeled.

Cognitive Load Theory (CPT)

Revolutionizing the way we understand learning and user interaction, Cognitive Load Theory (CLT) emerged from Sweller's (1988) pioneering work in the late 1980s, shedding light on the critical limitations of working memory in shaping human cognition (Van Merriënboer; Sweller, 2010). The groundbreaking framework redefines learning and task performance as dynamic processes influenced by how information is perceived, structured and stored in long-term memory (Kirschner, 2002). At its core, CLT identifies three distinct cognitive loads: intrinsic (the inherent complexity of the task), extraneous (wasted mental effort due to inefficient design), and germane (the strategic cognitive investment that drives meaningful learning) (Van Merriënboer; Sweller, 2010). In today's tech-driven world, CLT becomes indispensable in evaluating AI-powered systems like health monitoring platforms, where Real-time data and AI recommendations can either enhance or overwhelm users based on their digital fluency. The theory takes on even greater significance for older adults, whose cognitive processing and tech-savviness often differ from younger users, leaving them more vulnerable to cognitive overload in high-demand digital interactions (Sweller *et al.,* 2019).

A defining strength of CLT lies in its powerful three-party framework – intrinsic, extraneous, and germane cognitive loads – each shaping user interaction in profound ways. Intrinsic load captures the inherent complexity of the task; in this research, it could involve understanding biometric data or alerts provided by AI system. Extraneous load pertains to how information is presented – for instance, cluttered dashboards or unfamiliar navigation – which

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tends to disproportionately affect older users. Germane load, however, represents the cognitive effort that promotes learning and mastery, enabling users to internalize system functionalities over time (Sweller *et al.,* 2019). In AI-driven health systems, effectively balancing these types of loads – by reducing extraneous strain while fostering germane engagement – can dramatically enhance usability, trust, and long-term adoption.

Furthermore, CLT provides a valuable lens to understand how differing levels of digital literacy influence individuals' experiences with AI-driven health systems. Older adults with limited familiarity in navigating digital technologies are more likely to encounter cognitive overload when faced with continuous real-time updates or complex health metrics. Prior research has demonstrated that when tasks are perceived as excessively demanding, older users may experience mental fatigue that impairs their ability to process and respond to health information effectively (Chin *et al.,* 2014). In contrast, those with greater digital fluency are typically better equipped to manage and interpret such inputs, leading to more accurate understanding and interaction with the system (Tran *et al.,* 2024). In this regard, digital literacy plays a pivotal role in shaping how effectively users are able to engage with real-time data collection and processing functions, CLT, therefore, offers an integrated approach to understanding how personal capabilities—such as digital literacy—shape the degree to which features like Real-time data collection and processing contribute to users' overall perceptions of system value and effectiveness. By minimizing cognitive load in system design, health platforms can be made more accessible and user-friendly for individuals with varying levels of technological competence.

At its foundation. Cognitive Load Theory operates on the key premise that human cognitive capacity – especially working memory – has inherent limitations and can easily become overloaded by excessively complex or poorly presented information. The theory posits that peak learning and decision-making occur when cognitive load is strategically balanced, achieved by reducing unnecessary mental strain (extraneous load) while maximizing meaningful cognitive as age-related cognitive changes and varying levels of digital literacy – play a decisive role in shape cognitive efficiency. These differences directly impact how users perceive, process, and apply information, particularly in digital health settings where clarity and usability are paramount (Sweller *et al.,* 2019).

The impact of real-time health data collection and processing on the effectiveness of ai-based remote health monitoring systems for elderly

Real-time health data collection and processing (RTHDCP) represents a transformative paradigm in modern healthcare, characterized by the seamless, automated and instantaneous capture transmission, and computational interpretation of physiological, behavioral, and environmental health indicators via interconnected digital ecosystems (Paganelli *et al.,* 2022). The sophisticated infrastructure integrates wearable biosensors (e.g., smart watches, ECG patches, continuous glucose monitors), ambient IoT-enabled devices (e.g., smart beds, environmental sensors), and clous-edge hybrid computing platforms to aggregate multidimensional data streams – including heart rate viability, blood pressure trends, respiratory dynamics, glycemic fluctuations, thermoregulatory patterns, and kinematic signatures (Dhar *et al.,* 2023; Hennebelle *et al.,* 2024; Paganelli *et al.,* 2022; Sarkar *et al.,* 2024). Advanced algorithmic frameworks then process these datasets in near real-time (latency within milliseconds to seconds), facilitating immediate health insights, preemptive anomaly identification, and personalized clinical interventions (Batool, 2025; Hong *et al.,* 2020). The critical distinction of this paradigm lies in its temporal immediacy – not merely capturing data continuously but transforming it into actionable intelligence with minimal delay. This capability enables the deployment of early-warning systems for acute medical events (Ye *et al.,* 2019), supporting dynamic risk stratification based on real-time physiological data (Chen *et al.,* 2023), and facilitate automated care coordination through integration with electronic health records (EHRs) and predictive analytics models (Capan *et al.,* 2018). For AI-driven elderly health monitoring, RTHDCP serves as the central nervous system, supplying the computational engine with high-fidelity, temporally resolved inputs that enable adaptive learning, context-aware recommendations, and closed-loop decision support. Consequently, this technology transcends mere technical utility, emerging as a cornerstone of proactive, precision geriatric care.

Through the scope of health informatics, RTHDCP exemplifies the transition toward data-driven healthcare, where empirical analytics traditional reactive or heuristic-based decision-making models. This shift enables the continuous collection monitoring, proactive interventions, and improved diagnostic accuracy various care settings (Coiera, 2015). Philosophically, the development and deployment of these systems align with the framework of Value-Sensitive Design (VSD), emphasizing the integration of human vales such as privacy, autonomy, and informed consent into technological innovation. The framework also challenges the conventional techno-deterministic view by promoting stakeholder involvement during the design phase to ensure that ethical and societal concerns are addressed systematically (Cummings, 2006). The

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concept of Digital Self-Determination emerges here, as the theory advocates for individuals' rights to govern their digital presence and personal data. The principle is rooted in the broader framework of human rights, emphasizing the protection of personal autonomy in the digital age (Verhulst, 2023). In economic context, Real-time health monitoring aligns with preventive healthcare principles by enabling early interventions – like detecting heart irregularities or blood sugar changes – which lower costs linked to hospitalizations and severe illness (Oh *et al.,* 2024), this approach is specifically vital in aging populations, where healthcare systems face rising chronic conditions and staffing shortages. The wearable medical devices market, projected to reach $69.2 billion by 2028 (MarketandMarkets, 2024), reflects a shift toward scalable, home-based chronic disease management. In nations like Japan, such technologies are transforming elder care, balancing independence with medical supervision (Jafleh *et al.,* 2024). Collectively, these perspectives reinforce the dual imperative of designing intelligent monitoring systems that are not only clinically effective but also ethically defensible and economically sustainable.

The integration of RTHDCP has significantly boldened the Effectiveness of AI-based remote health monitoring systems for elderly, as proven by several groundbreaking studies. Wang & Hsu (2023) carried out a research which demonstrated that combining AI with wearable Internet of Things (IoT) devices in long-term care environment enables continuous monitoring of vital signs, facilitating early detection of health deterioration and timely interventions, thereby improving patient outcomes. Similarly, a study by Lee *et al.,* (2024) evaluated AI and IoT-based healthcare programs for older adults, revealing major improvements in various health factors, including cognitive function and physical activities levels, after six months of participation. Additionally, a scoping review by Ma *et al.,* (2023) pointed out the substantial positive influence of AI technologies on elderly healthcare, noting enhancements in disease management and overall quality of care. These findings share the common ground with the principles of Cognitive Fit Theory (CFT) (Vessey, 1991) which posits that decision-making performance improves when the format of information presentation matches the task requirements. Translating into elderly healthcare context, CFT stresses that when Real-time presentation of relevant health data through intuitive AI systems facilitates better interpretation and decision-making by caregivers and patients alike, thereby increasing the practical effectiveness of remote health monitoring solutions.

Conversely, some studies suggest that the impact of RTHDCP on AI-based remote monitoring systems for elderly may not have such strong impact in certain conditions. Ho (2020), for instance, discusses potential challenges, including privacy concern, data accuracy, and the risk of over-reliance on technology, which may limit the effectiveness of these systems, as the study also emphasizes the importance of ethical considerations and the need for a balanced approach that incorporates human oversight. Aligning with this perspective is the Socio-Technical Systems Theory (Trist, 1981), which underscores the interdependence of social and technical factors in system design and implementation. According to this theory, the success of technological interventions in healthcare depends not only the technical capabilities but also on the social context, including user engagement, organizational culture, and ethical standards.

Taken together, the literature underscores a strong understanding of how Real-time health data collection and processing influences the effectiveness of AI-based remote health monitoring systems for the elderly. Its capacity to enable continuous physiological monitoring, rapid anomaly detection, and personalized intervention significantly improves health outcomes and systems responsiveness. Although some studies note potential limitations related to ethical concerns and data interpretation, these factors are often contextual rather than inherent barriers. Thus, while the overall impact remains overwhelming positive, acknowledging these nuances highlight the need for adaptive system design that accommodates user diversity and operational realities.

Building on the core perspectives previously examined, we integrate them into the theoretical framework, thereby deriving the first hypothesis presented below:

H1: Real-time health data collection and processing have a positive impact on the effectiveness of AI-based remote health monitoring systems for the elderly.

The impact of personalized ai-based health recommendations on the effectiveness of AI-based remote health monitoring systems for elderly

Personalized AI-based health recommendations (PAIHR) refer to tailored health guidance generated by cutting-edge artificial intelligence based on an individual's real time physiological data, medical records, biometric indicators, behavioral trends, and personal preferences (Habibi *et al.,* 2025). These recommendations – such as hyper-customized interventions (Li et al., 2024), real-time alerts (Feng *et al.,* 2022), and precision lifestyle guidance (Nurani *et al.,* 2025) – are continuously refined through machine learning algorithms to adapt to the user's changing health status. Unlike generic alerts, PAIHR deliver targeted, context-aware

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interventions that enhance user engagement, support preventive care, and improve long-term health outcomes, particularly among elderly individuals with chronic conditions.

From a social perspective, PAIHR's influence is deeply rooted in Bandura's (1986) Social Cognitive Theory, which underlines the interplay of self-efficacy, observational learning and behavioral reinforcement in shaping health decision. PAIHR enhances self-efficacy by delivering individualized feedback that empowers elderly users to monitor and improve their health practices autonomously, reinforcing health habits through real-time, context-specific cues. Beyond social, Value-Based Healthcare advocates that healthcare systems should prioritize interventions that optimize patient outcomes relative to cost (Porter; Teisberg, 2006). A principle that PAIHR aligns with by enabling early intervention, reducing unnecessary hospitalizations, and personalizing chronic disease management, therefore, not only PAIHR elevates care quality but also drives systemic efficiency, easing the financial burden on strained health systems (Mbata *et al.,* 2024). This is critical as aging populations and rising chronic disease rates escalate healthcare expenditures; PAIHR emerges as a scalable, cost-efficient solution, shifting care from reactive hospital visits to proactive, AI-guided home-based interventions (Reddy *et al.,* 2019). For instance, Japan has demonstrated increased interest in AI-powered personalized health technologies into national strategies to manage elder care, chronic disease prevention, and healthcare resource optimization (Katirai, 2023). In these contexts, PAIHR serves as mechanism for reducing avoidable hospital visits and supporting remote, cost-efficient patient management, reflecting a broader global trend emphasizing the economic sustainability of AI-enhanced preventive health models over reactive, hospital-based systems (Mbata *et al.,* 2024).

By optimizing cutting-edge personalized AI-driven health recommendations (PAIHR) systems, the healthcare systems can revolutionize the efficacy of AI-powered remote health monitoring systems for the older adults, delivering unparalleled improvements in patient outcomes. As evidently proven, for example, from a retrospective case-control study by Brown *et al.,* (2023) that demonstrated integrating artificial intelligence (AI) insights into transitional care models for elderly led to a 21% reduction in 30-day rehospitalization rates. Similarly, a systematic review by Lopez-Barreiro *et al.,* (2024) found that AI-powered recommender systems effectively promote health habits and active aging among older adults, leading to improvements in physical activity levels, mobility and overall well-being, supporting the effectiveness of AI-driven personalized health recommendations driving physical activity and well-being among older adults. Ma *et al.,* (2024) also made an impressive study that demonstrated an AI-based health coaching

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mobile app significantly slowed the progression of nondialysis-dependent chronic kidney disease in elderly patients, as evidenced by improved estimated glomerular filtration rate (eGFR) slopes and reduced albumin-to-creatinine ratios (ACR) over a 2.1-year follow-up period. These transformative findings underscore how AI-driven, context-aware personalization empowers the systems effectiveness through putting individualized insights into care routines, thereby allowing elder people to adopt more sustainable health behaviors, improve clinical outcomes, and reduce avoidable health events. Borrowing the lens of Socioemotional Selectivity Theory (SST) (Carstensen, 1993), the impact through these findings can be understood that as individuals age, they increasingly prioritize emotionally meaningful, personally relevant interactions. PAIHR systems capitalize on this motivational shift by bringing highly contextualized, emotionally salient recommendations that resonate with elderly user's values and cognitive priorities. Aligning technological outputs with psychological predispositions, these systems not only drive informational clarity but also elevate emotional engagement, obtain higher adherence, improve trust, and long-term behavioral change. In doing so, PAIIHR systems redefine passive monitoring and emerge as a dynamic facilitator of personalized, emotionally intelligent, and outcome-oriented geriatric care.

Despite its demonstrated clinical effectiveness in empirical studies, the influence of PAIHR on the Effectiveness of remote health monitoring systems for the elderly exhibits significant variability across demographic groups, revealing critical limitations in real-world applicability. Emerging research challenges its universal efficacy, highlighting profound disparities in user engagement. The study of Kyung & Kwon (2022) revealed that individuals exhibit less trust in preventive care interventions suggested by AI compared to those recommended by human experts, showing a trust deficit in AI-driven health recommendations. Wong *et al.,* (2025) identified that elder people expressed concerns about the usability of AI technologies, underscoring the need for a better user-friendly and tailored AI solutions. The qualitative interviews in the study presented frustrations with overly technical language, lack of personalization, and difficulty navigating interfaces, especially among users over the age of 75. These insights can be framed within the scope of Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.,* 2003), a framework that asserts an individual's intention to adopt technology is shaped by four key factors: performance expectancy, effort expectancy, social influence, and facilitating conditions. As for the aging populations, particularly, inadequate digital proficiency and absent support structures – key facilitators under UTAUT – cripple effort expectancy, resulting in the abandonment of even the most advanced recommendation systems. The emotional and motivational dimensions central in Socioemotional Selectivity Theory (SST) (Carstensen, 1993) underscore a crucial caveat: PAIHR interventions resonate deeply with users' emotional needs and aspirational objectives, even well-designed systems may fail to yield desired outcomes.

Collectively, the provided literature emphasizes the profound impact of Personalized AI-based health recommendations (PAIHR) on the Effectiveness of AI-driven remote health monitoring for the elderly, by delivering hyper-personalized guidance, instant alerts, and adaptive feedback mechanisms; not only PAIHR boosts user engagement and sustains healthy behaviors the system also drives superior clinical outcomes – especially in older adults managing chronic conditions. Incorporating social and economic theoretical frameworks uncovers its dual advantage: empowering individuals while streamlining healthcare systems efficiency. The gaps between digital trust, usability, and technological adoption, however, show an indispensable need for inclusive, emotionally resonant, and accessible systems as factors like declining cognitive function and heightened emotional sensitivity necessitate systems that are not only technologically sophisticated but also empathetically attuned. Thus, although PAIHR represents a transformative advancement in eldercare, its full potential will depend on how effectively stakeholders tackle contextual barriers to ensure equitable, adaptable, and emotionally intelligent healthcare solutions.

Accordingly, we align the theoretical framework with the central arguments discussed above, which informs the construction of the second hypothesis stated here:

H2: Personalized AI-based health recommendations positively impact the effectiveness of AI-based remote health monitoring systems for elderly.

The moderating role of digital literacy

Seen as the ability to read and write, literacy has been on the rise of digital technologies and the Internet, reshaping its definition and scope. Living in the current dominant age of Information, being digitally literate has become an essential title for every individual around the world (Reddy *et al.,* 2022). The definition of digital literacy can be varied across researchers' views; some agree that it is the ability to understand and use digital resources since evolved to encompass multiple dimensions; some look at it as a blend of Internet, media, Information Communication Technology (ICT) skills; or even involving the skills to access, evaluate, and

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create information using digital tools for effective participation in society (Chen *et al.,* 2024). The aging population, often classified as late adopters, faces significant challenges in acquiring unfamiliar digital skills due to their limited access to online technologies, low digital proficiency, and lifelong familiarity with analog systems and traditional information structures (Castilla *et al.,* 2018; Reddy *et al.,* 2022). Due to today's aging and digital era, it forms the urgency to develop Digital literacy for elderly users and, therefore, simplifying the definition as older adults' capacity to effectively interact with digital platforms, including the ability to operate devices, interpret digital information, and manage digital health tools autonomously (Li *et al.,* 2023).

Given the existing digital disparities, older adults often lack the modern day's skills to engage with emerging health technologies effectively. To further understand this gap, from the Digital Divide Theory standpoint (Van Dijk, 2005), which outlines three progressive access levels – material, skills, and usage – and posits digital inequality results in limited societal participation, reduced autonomy, and diminished well-being for marginalized populations. In elderly care, insufficient digital literacy contributes not only to health information exclusion but also to decreased patient empowerment and suboptimal use of remote monitoring systems (Tran *et al.,* 2024; Wang; Luan, 2022). In addition, the development of digital skills for the older population can be captured in lens of Threshold Concepts (Meyer; Land, 2003), which are the ideas that transform understanding once grasped; for elderly users, digital literacy acts as the gateway to accessing AI health tool, requiring not just technical skill but a significant cognitive and psychological shift. A recent large-scale cross-sectional study by Tran *et al.,* (2024), surveying community-dwelling older adults in Taiwan, revealed that only 37.4% of participants demonstrated adequate digital health literacy, identifying key associations between digital literacy levels and factors such as education, age, and prior technology experience. The study concluded that older adults with low literacy were less likely to engage with heath technologies, even when access was available, therefore, highlighting digital literacy among the elderly remains uneven and insufficient – posing a substantial barrier to the equitable deployment of AI-driven healthcare technologies in aging populations.

Equipping the elderly with the skills to competently access and interpret complex digital content, Digital literacy for elderly users comes as a critical catalyst in strengthening the synergy between Real-time health data collection and processing (RTHDCP) and the overall Effectiveness of AI-driven health monitoring systems. Once achieved higher levels of digital fluency, elderly individuals are more than capable of interacting with rich data streams, interpreting alerts, and

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executing timely actions based on real-time health feedback. Proven in the study of Li *et al.,* (2023), the authors found that older Chinese adults with higher digital skills were more likely to efficiently use health apps for chronic disease self-monitoring, evoking the amplifying effect of literacy on system utility. Fowe *et al.,* (2023) also conducted a scoping review across multiple wearable and AI-assisted platforms and came with the conclusion that digital skills proficiency was the single strongest predictor of consistent data collection and responsive engagement among elderly users. Further affirming this moderating impact, Tran *et al.,* (2024) made a research on Taiwanese seniors demonstrated that those with high digital health literacy were substantially more engaged with remote monitoring systems and experienced improved care outcomes. In particular, the study revealed how digital fluency enabled elderly users to understand real-time data trends – such as heart rate variability or glucose levels – and initiate health behaviors or communicate timely concerns to caregivers. A scoping review by Ma *et al.,* (2023) dived into AI applications in elderly healthcare and emphasized that the effectiveness of these technologies was heavily mediated by users' digital capabilities. The review found that AI systems showed the most consistent positive outcomes – such as improved chronic disease management, increased adherence to treatment, and enhanced caregiver coordination – when deployed among elder users who had either high digital skills or were supported with digital literacy interventions. With these findings, digital literacy can be confirmed that it is not merely subsidiary skill, but a functional catalyst that transforms RTHDCP from passive information provision into actionable insight. Anchoring in Cognitive Fit Theory (CFT) (Vessey, 1991), which explains how decision-making peaked when information presentation parallels with a user's cognitive style, in this context, digital literacy sharpens this alignment, allowing elderly users to effortlessly decipher health dashboards, alerts, and visual data – turning complexity into actionable insights. Communication-Human Information Processing (C-HIP) model (Wogalter *et al.,* 1999), a conceptual lens that portrays how users receive, process, and act upon system-generated warnings and feedback. In AI health monitoring, digitally literate elderly users ware more capable of detecting, interpreting, and responding to real-time alerts – enabling timely and informed health actions.

While strong evidence supports Digital literacy foe elderly users as critical moderator, research indicates that its influence may be contextually neutralized or may be even limited under certain conditions. In a qualitative study, Wong *et al.,* (2025) discovered that older adults face with certain usability challenges and emotional barriers, such as trust and privacy concerns, which

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can impede the effective use of these technologies; suggesting perhaps digital literacy, while important, requires user-friendly design and emotional support mechanism to truly drive systems effectiveness. Likewise, Ho (2020) echoes this concern by arguing that digital literacy is only part of this equation; cognitive overload, privacy fears, and limited trust in AI outputs can still hinder effective engagement with real-time health systems. Grounded in Socio-Technical Systems Theory (Trist, 1981) which stress the success of any technological system depends not only on user capabilities but also on the social design environment in which it operates – explaining why even digitally literate seniors may struggle if systems are not intuitively designed or lack caregiver integration and emotional support. Constructivist Learning Theory (Vygotsky, 1978) further supports this with the emphasis of effective technology use can develop through guided, contextual learning over time, therefore, without ongoing support or co-designed interactions, digital literacy may not translate into confident, sustained engagement – particularly among older adults facing cognitive or emotional barriers.

With these insights, digital literacy of elderly users holds substantial potential as a positive moderator in the link between Real-time health data collection and processing and the effectiveness of Ai-driven health monitoring, but with important caveats. When older adults possess strong digital skills, they are better equipped to interpret, trust, and act on real-time feedback, leading to more proactive and effective care. But with inclusive design or adequate support structures, its moderating influence may be neutralized by emotional, cognitive, or structural barriers. With that being said, though digital literacy can be viewed as technical skill, but it must also be looked at as a strategic foundation for designing intelligent, human-centered health technologies tat are truly accessible, empowering, and equitable for aging populations.

As a result, the theoretical framework is synthesized with the key perspectives outlined earlier, culminating in the development of the third hypothesis outlined below:

H3: Digital literacy of elderly users positively moderates the relationship between real-time health data collection and processing and the effectiveness of ai-based remote health monitoring systems for elderly.

Conceptual Framework

This paper synthesizes the Technology Acceptance Model with Cognitive Load Theory to construct a holistic framework for evaluating the effectiveness of AI-based remote health

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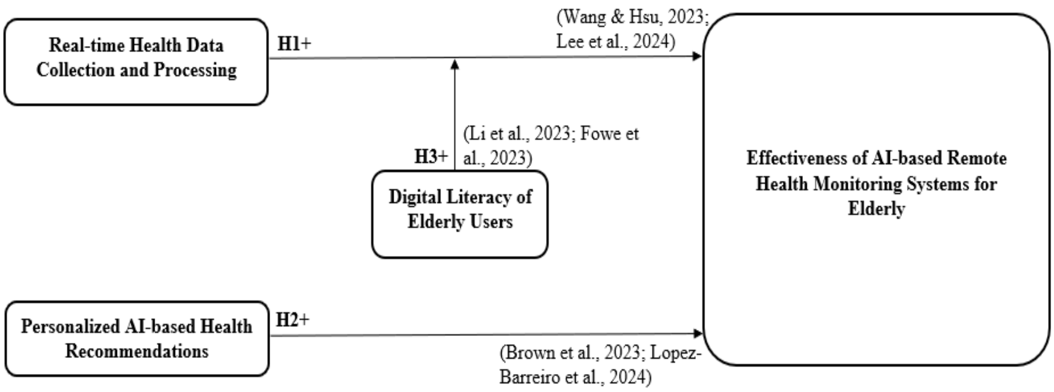
monitoring systems for elderly. it dives into the dynamic interplay between users' logical assessments of real-time health data collection and processing interact with their cognitive experiences of using AI-based personalized recommendations. Critically, the study identifies digital literacy for elderly users as a moderating factor that either amplifies or diminishes the impact of real-time health data collection and processing on system effectiveness.

Figure 1. The paper's conceptual framework



Source: The authors, 2025

METHOD

Research approach and strategy

This adopts a quantitative approach, which is well-suited for collecting and analyzing numerical data to uncover patterns and test relationships between key variables (Creswell, J. W.; Creswell, J. D., 2017). By applying statistical tools, this method allows for an objective examination of the data and the development of measurable, evidence-based conclusions (Babbie, 2010). This approach was chosen to directly address the research questions and evaluate the links among the main variables. In line with the quantitative tradition, the study also follows a deductive methodology – enabling hypothesis testing, predictive insights, and conclusions firmly grounded in statistical analysis.

Sampling technique and procedure

To provide strong empirical grounding and contextual relevance in the field of digital health for older adults, this study used a purposive stratified method. It focused on individuals actively involved in the use, development, or support of AI-driven remote health monitoring

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systems for elderly care. Participants were grouped into four key stakeholder categories, each reflecting distinct roles within the digital health ecosystems and varying levels of interaction with both older users and AI-based technologies. These groups included: (1) Elderly Users aged 60 and above, who had consistently used AI-based health monitoring tools – such as wearable devices or mobile health apps – for at least six months, demonstrated adequate cognitive functioning, and self-reported regular engagement; (2) Primary Caregivers or Family Members who played a central role in assisting elderly individuals with the operation of AI health tools, including interpreting alerts and managing day-today digital health tasks; (3) Healthcare Professionals such as general practitioners, geriatricians, and telehealth nurses who relied on AI-generated data dashboards or predictive analytics to oversee patient conditions remotely; and (4) Digital Health Developers ad System Integrators who had directly involved in creating or refining AI system components, such as real-time monitoring interfaces, algorithm-based health recommendations, and digital literacy features tailored to older populations.

Eligibility required participants to have at least 12 months of consistent, hands-on experience with AI-powered health monitoring systems, whether as users, supporters, or professional facilitators, along with verifiable involvement in elderly healthcare settings. Further stratification considered geographical diversity (urban vs. rural areas in Vietnam), the type of digital platform used (e.g., real-time health tracking, AI-driven recommendations).

Data collection was conducted through an online survey, distributed via specialized elderly care forums, healthcare technology networks, and professional communities. In Vietnam, outreach was supported by the Vietnam Association for the Elderly (VAE), regional public health agencies, and digital telehealth providers. Additional participants were recruited through caregiver associations digital health accelerators, and LinkedIn groups focused on AI in healthcare and health informatics.

The final instrument was a structured questionnaire using a 5-poit Likert scale (1 = “Strongly disagree” to 5 = “Strongly agree”) to assess across four key areas: system effectiveness, the usefulness of real-time data, the value of personalized AI recommendations, and the role of digital literacy. Of the 492 responses received, 385 met the inclusion criteria after thorough checks for response completeness, role alignment, and relevant experience. This well-balanced, role-specific sample provided a strong foundation for analyzing how AI-based personalization and

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real-time tracking tools impact healthcare outcomes for older adults, especially when moderated by the user's level of digital literacy.

Data analysis description

The analysis began in SPSS with a basic overview of the survey data using descriptive statistics. To check how consistently the survey items measured each concept, Cronbach's Alpha was calculated. Next, Exploratory Factor Analysis (EFA) helped uncover underlying patterns among the sub-variables, grouping them into broader, more meaningful factors.

To test the proposed hypothesis, multiple linear regression analysis was conducted. This assessed how Real-time Health Data Collection and Personalized AI Recommendations influenced the perceived effectiveness of remote monitoring systems for the elderly. Followed by the SPSS Process Macro to enable an in-depth examination of how digital literacy acted as a moderator – specifically influencing the strength of the relationship between Real-time Data Processing and systems effectiveness, highlighting the critical role of user capability in optimizing AI health tools for the elderly.

RESULTS

Reliability Analysis

Table 1. Reliability analysis of the dependent variable "effectiveness of AI-based remote health monitoring systems for elderly".

Reliability Statistics

Cronbach's Alpha	N of Items
.614	4

Item-Total Statistics

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	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
EAIRHMSE1	7.678	8.313	.546	.606
EAIRHMSE2	8.459	9.088	.569	.583
EAIRHMSE3	7.333	8.667	.528	.594
EAIRHMSE4	8.021	9.000	.573	.590

Source: The authors, 2025.

Where EAIRHMSE1 to EAIRHMSE4 correspond to survey items 1 through 4 measuring effectiveness of AI-based remote health monitoring systems for elderly.

As shown in Table 1, all items related to the dependent variable demonstrated adjusted item–total correlation coefficients of at least 0.3, indicating acceptable internal consistency. The calculated Cronbach's alpha was 0.614, which not only exceeds the commonly accepted threshold of 0.6 but also remains higher than any alpha values that would result from the exclusion of individual items. Additionally, each item's Cronbach's alpha continued to surpass its corresponding adjusted item–total correlation, even under hypothetical item removal scenarios. Therefore, all items were retained in the analysis. Similar reliability results were also found for the remaining variables in the study.

Exploratory Factor Analysis (EFA)

Table 2. Rotated Component Matrix.

Rotated Component Matrix[a]			
Component with loading factors			
1	2	3	4
EAIRHMSE1 .558	RTHDCP 1 .648	PAIHR 1 .620	DLEU 1 .691

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EAIRHMSE2 .610	RTHDCP 2 .645	PAIHR 2 .573	DLEU 2 .690
EAIRHMSE3 .569	RTHDCP 3 .668	PAIHR 3 .532	DLEU 3 .501
EAIRHMSE4 .778	RTHDCP 4 .597	PAIHR 4 .626	DLEU 4 .564

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Source: The authors, 2025.

Where RTHDCP 1 to RTHDCP 4, PAIHR to PAIHR 4, and DLEU 1 to DLEU 4 represent survey items 1 through 4 corresponding to the two independent variables and the moderator, respectively.

As shown in Table 2, the rotated component matrix successfully grouped the 16 sub-variables into four distinct factors, each corresponding to the dependent variable, the two independent variables, and the moderator variable. No sub-variables were eliminated during this factor extraction process. Furthermore, all sub-variables exhibited factor loadings greater than 0.5, indicating strong construct validity.

Multiple Linear Regression

Table 3. Coefficients[a].

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.233	.845		4.111	.000
	RTHDCP	.484	.611	.470	4.551	.000
	PAIHR	.602	.679	.590	4.278	.000

a. Dependent Variable: EAIRHMSE

Source: (The authors, 2025)

Where **EAIRHMSE**: mean of EAIRHMSE 1 to EAIRHMSE 4; **RTHDCP**: mean of RTHDCP1 to RTHDCP4; **PAIHR**: mean of PAIHR1 to PAIHR4

As illustrated in Table 3, the significance (Sig.) values obtained from the t-tests are .000, both of which fall well below the conventional alpha level of 0.05. This indicates that the

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independent variables— real-time health data collection & processing and personalized AI-based recommendations—have a statistically significant effect on the dependent variable, the effectiveness of AI-based remote health monitoring systems for elderly. Accordingly, both hypotheses are validated.

Moderator analysis

Table 4. Results analysis of Digital Literacy.

Model : 1
Y : EAIRHMSE
X : RTHDCP
W : DL
Sample Size: 385
****

OUTCOME VARIABLE:

EAIRHMSE

Model Summary

R	R-sq	MSE	F	dl1	dl2	p
.548	.536	.491	4.628	3.000	381.000	.000

Model

	coeff	se	t	p	LLCI	ULCI
constant	7.112	.774	71.929	.000	5.340	5.141
RTHDCP	.572	.427	4.480	.000	.456	.438
DL	.614	.531	4.295	.000	.405	.396
Int_1	.560	.481	4.335	.000	.341	.330

Where **DL**: mean of DL1 to DL4

Source: (The authors, 2025)

As presented in Table 4, the p-value for the interaction term (Int_1) is 0.000, which is well below the standard significance level of 0.05, indicating a statistically significant interaction effect between digital literacy and real-time healthcare data collection & processing in shaping the

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effectiveness of AI-based remote health monitoring systems for elderly. The interaction coefficient of 0.560 suggests that digital literacy amplifies the positive influence of real-time healthcare data collection & processing on the effectiveness of AI-based remote health monitoring systems for elderly. Therefore, hypothesis H3 is supported.

DISCUSSION

Summary Results

The linear regression results indicate that personalized AI-based health monitoring recommendations (PAIHR) have the strongest positive impact on the effectiveness of ai-based remote health monitoring systems for the elderly, with a standardized coefficient of 0.59. Real-time health data collection and processing (RTHDCP) also contributes positively, though to a lesser extent, with a coefficient of 0.47. Additionally, the digital literacy of elderly users plays a significant moderating role in the synergy between RTHDCP and systems effectiveness, as reflected by a moderation coefficient of 0.56. These findings confirm that both technical functionality and user capability are essential to achieving optimal outcomes in AI-driven eldercare. Accordingly, all two research questions have been conclusively addressed.

Theoretical implication

The empirical evidence robustly supports the core arguments made by Paganelli *et al.,* (2022) and Dhar *et al.,* (2023), demonstrating that Real-time Health Data Collection and Processing (RTHDCP) substantially improves the responsiveness and personalization of AI-driven elderly health monitoring systems. These findings reinforce the idea that immediate processing of physiological data can directly enhance clinical effectiveness – echoing the insights of Ye *et al.,* (2019) and Chen *et al.,* (2023) on real-time risk stratification. However, this study departs from Ho (2020), who raised concerns about the system reliability under ethical and technological stress. Our results show that such challenges are largely mitigated when both infrastructure and user readiness are in place. While Coiera (2015) argued for replace heuristic approaches with data-driven models, our findings suggest that real-time technology alone is not sufficient; stakeholder involvement remains essential. This research confirms the technical value of RTHDCP, but pushes beyond a narrow tech-centric view, emphasizing the need for systems that are socially attuned and user-focused.

The results also provide strong theoretical backing for integrating Socioemotional Selectivity Theory (Carstensen, 1993) with Personalized AI Recommendation (PAIHR). Emotionally relevant, context-aware interventions were shown to enhance both user engagement and health outcomes, lining up with the work of Brown *et al.,* (2023) and Lopez-Barreiro *et al.,* (2024). Contrary to Kyung and Kwon's (2022) concerns about elder users distrusting AI in favor of human professionals, out findings reveal that trust barriers can be overcome when systems are emotionally intelligent and behaviorally adaptive. While the Unified Theory of Acceptance and Use of Technology (UTAUT) emphasizes the ease of use and performance expectations, this study finds that user satisfaction is equally dependent on emotional connection and perceived personalization. As such, while debates around AI's relational capabilities continue, our research highlights AI's potential to simulate meaningful human interaction when designed with care – shifting PAIHR from a supplemental feature to a foundational in elderly care technologies.

Lastly, the data strongly affirms prior research by Li *et al.,* (2023), Tran *et al.,* (2024), and Fowe *et al.,* (2023), confirming Digital Literacy as a key enabler in unlocking the full potential of RTHDCP. This reflects Van Dijk's (2005) Digital Divide Theory, which frames literacy not merely as a technical skill but as a gateway to genuine participation. Yet the findings also challenge the assumption that literacy alone ensures successful use. Echoing critiques from Ho (2020) and Wong *et al.,* (2025), we find that emotional hesitation, interface complexity, and cognitive limitations can all undermine the benefits of digital competence. This challenges the straightforward assumptions of Cognitive Fit Theory (Vessey, 1991), suggesting that even well-designed data interfaces may fall short without trust, clarity, and user confidence. Rather than treating digital literacy as standalone solution, out study positions it as one piece of a larger socio-technical system – one that must be supported by inclusive design, emotional scaffolding, and adaptive learning approaches rooted in Vygotsky's (1978) social development theory.

Practical Implication

The findings from this study offer practical insights for healthcare system designers, policymakers, and professionals in geriatric care, first, the strong effect of Real-time Health Data Collection and Processing on system effectiveness underscores the need to prioritize investments in hybrid cloud-edge infrastructure and wearable biosensors. These technologies enable real-time monitoring of vital signs, which is essential for early anomaly detection and timely intervention – especially in under-resourced eldercare environments (Paganelli *et al.,* 2022; Dhar

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et al., 2023). When integrated with Electronic Health Records (EHRs), such systems can also streamline coordination and ease the administrative burden on clinicians (Capan *et al.,* 2018).

Second, the prominent role of personalized AI-based health recommendations points to a clear shift away from one-size-fits-all approaches. Health technologies for older adults should increasingly rely on adaptive AI that delivers tailored, emotionally intelligent feedback. This approach supports the goals of Value-Based Healthcare, which prioritizes not only clinical outcomes but also patient experience and engagement (Porter; Teisberg, 2006; Mbata *et al.,* 2024). To enhance effectiveness, AI systems should incorporate user preferences, behavior trends, and live biometric data – fostering higher relevance and better adherence among elderly users, particularly those managing long-term conditions (Li *et al.,* 2024; Ma *et al.,* 2024).

Finally, the moderating effect of digital literacy calls attention to a critical area often overlooked: the user's ability to interact meaningfully with these technologies. Bridging this gap requires coordinated digital literacy programs, co-designed with older adults, that teach practical skills like interpreting health dashboards, navigating AI tools, and responding to alerts (Tran *et al.,* 2024; Li *et al.,* 2023). At the same time, systems must be designed with intuitive interfaces and emotional support features to reduces feelings of exclusion and built user trust (Wong *et al.,* 2025; Ho, 2020). Involving elderly users through participatory will be key to making these systems not just usable, but also truly empowering.

Limitations

One key limitation of this study is its reliance on self-reported data rather than clinically verified health outcomes, which may introduce bias or inaccuracies in participant responses. The cross-sectional nature of the research also limits the ability to draw conclusions about long-term effectiveness or causality. While efforts were made to recruit a diverse participant pool, differences in regional and cultural attitudes toward technology – particularly across Southeast Asia – may limit how broadly the findings can be applied. Additionally, the lack of a longitudinal component restricts insights into how digital literacy and engagement with AI systems may evolve over time.

Future Research Directions

Future studies should adopt a longitudinal mixed-methods approach to capture both the behavioral sifts and clinical health impacts associated with Real-time Health Data Collection and

Processing and Personalized AI Health Recommendations. Special attention should be given to how digital literacy interventions influence systems use over time, especially among those aged 75 and older. Cross-sectional comparisons could shed light o culturally specific enablers and barriers to adopting AI in eldercare. Expanding the theoretical model to incorporate emotional trust, perceived risk, or caregiver involvement would also offer a more complete picture of how these technologies operate in real-world care settings.

CONCLUSION

This study demonstrates that Real-time Health Data Collection and Processing and Personalized AI Recommendations can meaningfully improve the effectiveness of remote care for older adults. Digital literacy plays a critical role – not just as a moderating factor, but as a core driver of how well these systems function. The results highlight the need for healthcare solutions that combine advanced technology with practical support for users. Moving forward, efforts to scale these systems must prioritize both accessibility and trust, ensuring that innovation serves real human needs. A well-balanced approach – integrating AI capabilities with inclusive design and digital education – will be essential for building a more responsiveness, preventative, and sustainable model of eldercare.

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