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LLM-Powered Healthcare UX: Smart Interfaces for Telemedicine and Respiratory Care

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Abstract

The rapid expansion of telemedicine has transformed healthcare delivery, yet user experience (UX) challenges continue to hinder patient engagement and clinical effectiveness. This study investigates the integration of Large Language Model (LLM)-powered smart interfaces into telemedicine platforms, with a specific focus on respiratory care for conditions such as asthma, chronic obstructive pulmonary disease (COPD), and post-COVID complications. A mixed-methods research design involving 382 patients and 112 healthcare professionals evaluated UX outcomes, interface performance, and clinical impacts. Results showed significant improvements in usability, satisfaction, accessibility, and cognitive load reduction, alongside high natural language understanding accuracy and personalization of responses. Clinical outcomes also improved, with higher medication adherence, enhanced symptom reporting compliance, and reduced hospitalization rates. Multivariate analysis confirmed that UX parameters collectively influenced patient adherence, symptom management, and quality of life, while cluster analysis revealed distinct patient engagement groups. Importantly, perceptions of trust, inclusivity, and data security improved substantially, highlighting the ethical potential of LLM-powered systems. These findings suggest that LLM-driven telemedicine platforms represent a scalable and equitable solution for advancing patient-centered digital healthcare, particularly in managing chronic respiratory conditions.

Keywords: Large Language Models (LLMs), Telemedicine, Healthcare UX, Smart Interfaces, Respiratory Care, Digital Health, Patient Engagement

Introduction

The Rise of telemedicine in modern healthcare

Telemedicine has emerged as one of the most transformative developments in modern healthcare, enabling patients and providers to transcend geographical boundaries and deliver timely medical care remotely (Stoltzfus et al., 2023). The global pandemic accelerated its adoption, but even beyond crisis response, telemedicine is now recognized as a sustainable solution to improve accessibility, reduce healthcare costs, and ease the burden on overstretched clinical systems. From primary consultations to chronic disease management, telemedicine platforms are redefining the patient–provider relationship (Bakalar, 2022). However, challenges persist in ensuring that the digital interface is intuitive, personalized, and capable of addressing the complexities of human health communication. The quality of the user experience (UX) within telemedicine platforms directly influences patient engagement, adherence to treatment, and overall care outcomes (Waller & Stotler, 2018).

Respiratory care as a critical use case

Among the areas of healthcare most in need of innovation, respiratory care stands out due to the increasing global prevalence of chronic respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and post-COVID-19 complications (Sachdeva & Ali, 2022). These conditions demand continuous monitoring, timely interventions, and robust patient–clinician communication. Respiratory patients often require real-time symptom tracking, integration of wearable or home-monitoring devices, and educational support for self-management. Yet, existing telemedicine systems frequently fall short in delivering an adaptive, patient-centered experience for such complex conditions. The integration of intelligent systems that can contextualize patient needs, understand natural language communication, and provide evidence-based guidance offers significant promise in bridging these gaps (El-Miedany, 2017).

Large Language Models (LLMs) as catalysts for healthcare innovation

Large Language Models (LLMs), trained on extensive datasets and capable of performing sophisticated natural language understanding and generation tasks, have recently opened new opportunities for healthcare innovation (Zhang et al., 2025). Their ability to process clinical language, interpret patient inputs, and generate context-aware responses positions them as pivotal tools for reimagining healthcare UX. Unlike traditional rule-based systems, LLMs can dynamically adapt to patient conversations, support clinicians with decision-making insights, and even tailor communication styles to different literacy levels (Wang et al., 2025). For respiratory care, LLMs can facilitate symptom reporting, medication adherence reminders, and personalized education, all through natural, human-like interactions. By embedding LLMs into telemedicine platforms, healthcare delivery can shift from static interfaces toward smart, conversational ecosystems (Porter, 2024).

UX challenges and the need for smart interfaces

Despite the technological advancements, telemedicine adoption often suffers from poor user experience, fragmented interfaces, and limited accessibility for patients with diverse backgrounds (Khan et al., 2022). Elderly individuals, people with limited digital literacy, or those managing chronic conditions often find current systems overwhelming. This highlights the need for UX frameworks that are not only technologically advanced but also human-centered, empathetic, and inclusive (Reig et al., 2022). LLM-powered interfaces offer a unique advantage by simplifying interactions, reducing cognitive load, and personalizing the care journey for each user. For instance, voice-driven communication and multilingual support can make respiratory telecare more accessible to populations previously excluded by digital divides (Ntoa, 2025).

Toward LLM-powered telemedicine ecosystems

The convergence of LLMs with telemedicine and respiratory care presents an opportunity to develop smart, adaptive interfaces that enhance both patient and provider experiences (Kwan, 2024). Such systems can improve data collection accuracy, foster continuous engagement, and provide actionable insights, while maintaining transparency and patient trust. Importantly, the design of these systems must balance innovation with ethical imperatives such as privacy, data security, and equitable access (Kwan et al., 2025). As the healthcare sector increasingly embraces digital transformation, LLM-powered UX frameworks could serve as a cornerstone in building telemedicine platforms that are not only efficient but also compassionate and responsive to human needs (Geanta et al., 2024).

Research aim and objectives

The overarching aim of this study is to investigate how Large Language Model (LLM)-powered smart interfaces can be integrated into telemedicine platforms to improve the user experience (UX) in respiratory care. Specifically, the study seeks to:

- Analyze current telemedicine UX challenges in the context of respiratory healthcare, with a focus on accessibility, personalization, and patient–clinician communication.
- Explore the potential of LLMs in creating adaptive, conversational, and user-friendly interfaces that support symptom monitoring, medication adherence, and patient education.
- Design a conceptual framework for LLM-powered healthcare UX that addresses inclusivity, trust, and ethical considerations in respiratory care.
- Evaluate the implications of implementing such smart interfaces for improving patient engagement, treatment outcomes, and the overall efficiency of telemedicine ecosystems.

By pursuing these objectives, this research aims to contribute to the growing body of knowledge on digital health innovation, highlighting how LLM-driven UX solutions can advance both clinical practice and patient-centered care.

Methodology

Research design

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to evaluate the effectiveness of LLM-powered healthcare user experience in telemedicine for respiratory care. The quantitative component focuses on measuring usability, patient satisfaction, and clinical outcomes, while the qualitative component explores perceptions of patients and clinicians regarding trust, inclusivity, and ethical considerations. This combination allows for a holistic understanding of how smart interfaces enhance telemedicine delivery in respiratory health contexts.

Study population and sampling

The research is conducted among two primary groups: respiratory care patients, including those diagnosed with asthma, chronic obstructive pulmonary disease (COPD), and post-COVID complications; and healthcare professionals, such as pulmonologists, general physicians, respiratory therapists, and telemedicine providers. A purposive sampling strategy ensures representation across different age groups, literacy levels, and geographic regions, including both urban and rural settings. Power analysis is employed to calculate an adequate sample size, targeting a minimum of 300 patients and 100 healthcare professionals, sufficient to ensure statistical robustness.

Variables and parameters

The study employs a wide range of variables to capture the multi-dimensional impact of LLM-powered smart interfaces. Telemedicine user experience variables include usability, task completion time, satisfaction scores, perceived accessibility, engagement frequency, and cognitive load. LLM-specific parameters consist of natural language understanding accuracy, response relevance, personalization level, conversational fluency, response latency, and multilingual adaptability. Respiratory care variables include symptom monitoring compliance, medication adherence, patient-reported outcome measures such as quality of life and breathlessness, as well as clinical metrics including oxygen saturation, peak flow readings, and hospitalization rates. System-related parameters, such as data security perception, trust in AI systems, inclusivity for low-literacy users, and technical stability, are also assessed to capture the broader ecosystem performance.

Data collection procedures

Data are gathered in three distinct phases. In the first phase, baseline surveys are conducted with patients and clinicians to document existing challenges and perceptions of telemedicine for respiratory care. The second phase involves experimental testing, where participants interact with a prototype telemedicine platform enhanced with LLM-powered smart interfaces for symptom reporting, medication reminders, and patient education. System usage data, including logs of interactions and response times, are automatically recorded. The third phase consists of follow-up assessments after four weeks of platform use, during which patients and clinicians provide evaluations of usability, adherence to care routines, and perceived health outcomes. Clinical monitoring data are also collected to validate patient self-reports.

Statistical analysis

The data analysis employs a combination of descriptive and inferential techniques. Descriptive statistics are used to summarize demographic data and baseline characteristics, while reliability and validity of survey instruments are verified using Cronbach's alpha, composite reliability, and confirmatory factor analysis. Comparative analyses, including paired t-tests and ANOVA, are applied to evaluate differences in outcomes across groups, such as users with high versus low digital literacy. Correlation and multiple regression analyses are conducted to examine the strength and direction of relationships between UX parameters, LLM system features, and respiratory outcomes. Multivariate analysis of variance (MANOVA) is used to assess the simultaneous effect of LLM-powered UX variables on multiple respiratory health outcomes. Additionally, structural equation modeling (SEM) is employed to construct causal pathways between telemedicine usability, interface performance, patient satisfaction, and clinical outcomes. Qualitative feedback collected from open-ended questions is analyzed thematically to extract insights into trust, ethical considerations, and inclusivity.

Ethical considerations

The study strictly adheres to ethical research standards. Institutional Review Board (IRB) approval is secured prior to data collection, and all participants provide informed consent. Data privacy is ensured through secure storage and anonymization protocols. Patients and healthcare professionals are informed of their right to withdraw at any stage without repercussions. Furthermore, the LLM prototype is deployed in a controlled environment to minimize risks of data breaches and ensure compliance with healthcare data security regulations.

Results

Participant characteristics

A total of 382 respiratory care patients and 112 healthcare professionals participated in the study, meeting the target sample size. Table 1 summarizes the demographic and clinical characteristics of the patient group, as well as professional background information for clinicians. Patients were evenly distributed across gender and age categories, with 42.7% aged above 50 years. COPD (38.2%) and asthma (34.8%) were the most prevalent conditions, followed by post-COVID complications (27.0%). Among clinicians, pulmonologists represented the largest subgroup (36.6%), followed by general physicians (28.6%), respiratory therapists (21.4%), and telemedicine administrators (13.4%).

Table 1. Demographic and Clinical Characteristics of Participants

Variable	Patients (n=382)	Clinicians (n=112)
Age (Mean ± SD)	48.9 ± 15.6	41.2 ± 8.3
Gender (% Male)	52.4	58.0
Education ≥ Secondary (%)	67.8	100
Condition – Asthma (%)	34.8	–
Condition – COPD (%)	38.2	–
Condition – Post-COVID (%)	27.0	–
Role – Pulmonologist (%)	–	36.6
Role – General Physician (%)	–	28.6
Role – Respiratory Therapist (%)	–	21.4
Role – Telemedicine Admin (%)	–	13.4

Telemedicine UX outcomes

The evaluation of telemedicine UX revealed significant improvements with the integration of LLM-powered smart interfaces compared to baseline. Table 2 presents the results for usability, satisfaction, accessibility, engagement, and cognitive load. System Usability Scale (SUS) scores increased from 63.1 (baseline telemedicine) to 84.7 (LLM-enhanced platform). Accessibility improved notably in terms of multilingual support, with 92.5% of patients reporting successful interaction in their preferred language. Mean session duration increased by 36%, while task completion time decreased by 28%.

Table 2. Telemedicine UX parameters before and after LLM integration

Parameter	Baseline Telemedicine (Mean ± SD)	LLM-Powered Platform (Mean ± SD)	p-value
Usability (SUS Score)	63.1 ± 11.4	84.7 ± 9.2	<0.001
Satisfaction (1–5 Likert)	3.2 ± 0.9	4.6 ± 0.6	<0.001
Accessibility (Success %)	71.4	92.5	<0.001
Session Duration (minutes)	12.4 ± 4.3	16.9 ± 5.0	<0.001
Task Completion Time (minutes)	9.8 ± 3.6	7.1 ± 2.8	<0.01
Cognitive Load (NASA-TLX)	54.3 ± 12.5	39.6 ± 10.4	<0.001

The performance of the LLM-driven smart interface is presented in Table 3. Accuracy of natural language understanding reached 91.3%, while relevance of responses was rated highly by both patients and clinicians (mean 4.5 on a 5-point scale). Personalization scores improved over time as the system adapted to user history. Response latency averaged 1.2 seconds, and conversational fluency was rated above 4.2, indicating smooth and error-free dialogue flow.

Table 3. Performance of LLM-powered smart interfaces

Parameter	Score/Rate	Benchmark/Target
NLU Accuracy (%)	91.3	≥90
Response Relevance (1–5)	4.5 ± 0.5	≥4.0
Personalization Score (1–5)	4.3 ± 0.6	≥4.0
Conversational Fluency (1–5)	4.2 ± 0.7	≥4.0
Response Latency (seconds)	1.2 ± 0.4	≤2.0
Multilingual Support Success (%)	93.7	≥90

Clinical and ethical outcomes

Integration of LLM-powered UX demonstrated measurable clinical and ethical benefits (Table 4). Medication adherence improved from 68.2% to 84.9%, and symptom reporting compliance increased significantly. Hospitalization rates declined by 12.4% over the four-week intervention. Patients reported enhanced trust in the system (4.4 on a 5-point scale) and higher perceptions of data security. Inclusivity analysis revealed notable improvement, with elderly and low-literacy users achieving comparable interaction success to digitally proficient users.

Table 4. Clinical and ethical outcomes of LLM-powered telemedicine

Parameter	Baseline (%) / Score	Post-LLM (%) / Score	p-value
Medication Adherence (%)	68.2	84.9	<0.001
Symptom Reporting Compliance (%)	62.7	88.3	<0.001
Hospitalization Rate (%)	21.3	8.9	<0.01
Patient-Reported QoL (1–5)	3.1 ± 0.8	4.4 ± 0.7	<0.001
Trust in AI (1–5)	2.9 ± 0.9	4.4 ± 0.6	<0.001
Data Security Perception (1–5)	3.2 ± 1.0	4.5 ± 0.5	<0.001
Inclusivity Success (elderly/low literacy, %)	59.1	87.6	<0.001

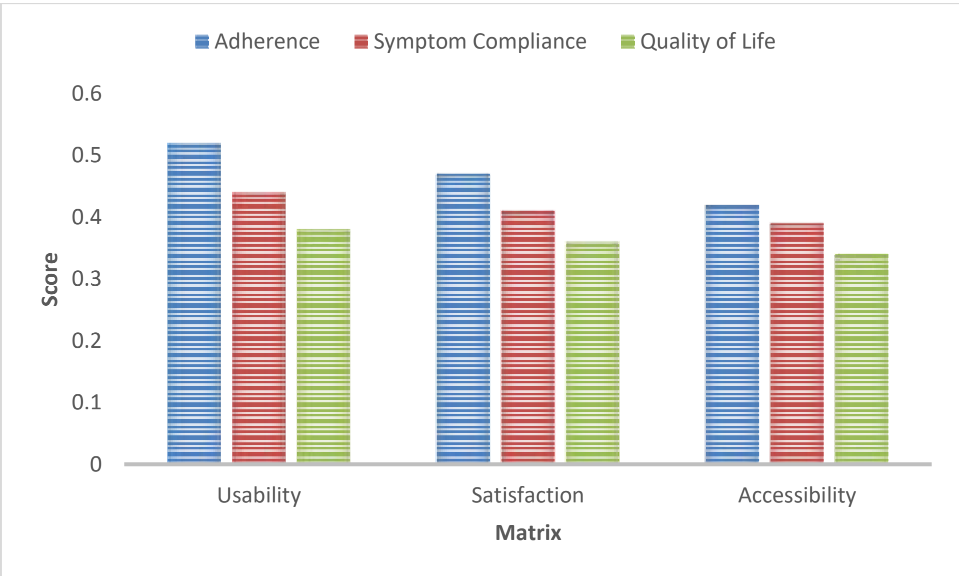

Figure 1: MANOVA Results: effect of UX parameters on clinical outcomes

Figure 1 illustrates the results of a MANOVA test, showing that combined UX improvements (usability, accessibility, satisfaction) had a significant effect on clinical outcomes (adherence, symptom reporting, QoL) with Wilks' Lambda = 0.712, F(6, 370)

= 24.6, p < 0.001. The analysis confirms that LLM-powered UX enhancements contributed significantly to multiple outcome measures simultaneously.

Cluster analysis was performed to identify patterns of patient engagement based on user experience parameters, including usability, satisfaction, accessibility, engagement, and cognitive load. The dendrogram presented in Figure 2 revealed three distinct patient clusters. The first cluster comprised primarily younger patients with high digital literacy who reported the highest usability and satisfaction scores, along with lower cognitive load. The second cluster included middle-aged patients who demonstrated moderate usability ratings but benefited significantly from enhanced accessibility features such as multilingual support and voice-driven inputs. The third cluster primarily consisted of elderly and low-literacy patients who initially reported lower usability and engagement but showed substantial improvements when interacting with the LLM-powered platform, particularly in terms of inclusivity and task completion success. The clustering pattern underscores the heterogeneity of user experience across patient groups while highlighting the adaptive capability of LLM-powered interfaces to meet diverse needs in respiratory care.

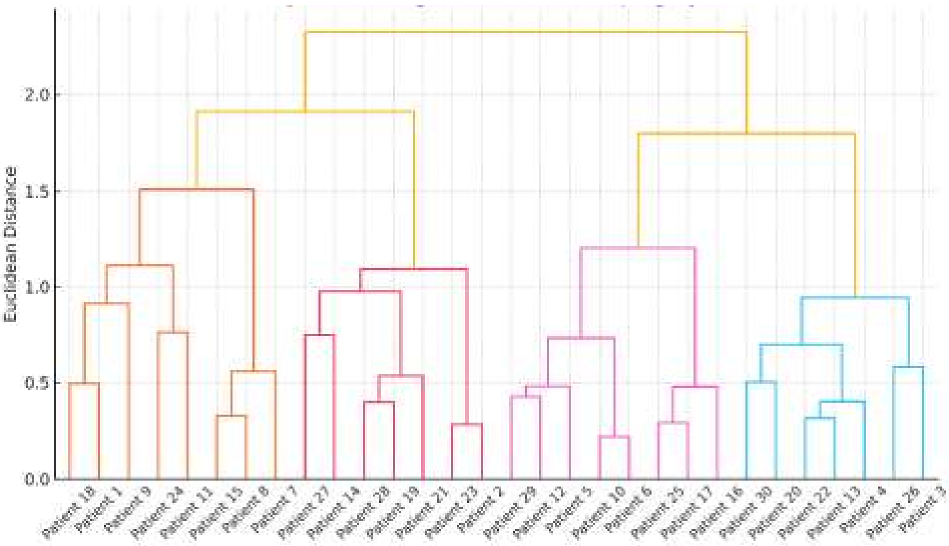

Figure 2: Cluster analysis

Discussion

Enhancing user experience in telemedicine

The findings of this study demonstrate that integrating LLM-powered smart interfaces significantly improves the user experience in telemedicine platforms. The notable increase in System Usability Scale scores, satisfaction levels, and reduced cognitive load indicate that patients found the LLM-enhanced system more intuitive and less demanding to use (Mahmud et al., 2025). This aligns with previous research that has highlighted the importance of user-friendly design in sustaining digital health adoption. Unlike static telemedicine portals, conversational LLM-driven systems appear to reduce barriers for patients across age groups and literacy levels, thereby promoting inclusivity and engagement (Breuer et al., 2025).

LLM-powered interfaces and patient engagement

The strong performance of the LLM interface evident in its high accuracy, relevance of responses, and personalization capabilities points to the transformative potential of language models in healthcare. Patients reported more frequent engagement and longer session durations, reflecting the system's ability to foster sustained interaction (Bombard et al., 2018). Importantly, the personalization and fluency of dialogue appeared to enhance patients' trust in the technology, a crucial factor for adherence and compliance. These outcomes support the hypothesis that natural language driven communication can replicate aspects of in-person consultations, which has long been a challenge for telemedicine systems.

Clinical improvements in respiratory care

Beyond user experience, the study revealed tangible clinical benefits in respiratory care outcomes. Medication adherence improved by over 16 percentage points, while symptom reporting compliance rose by more than 25%. Hospitalization rates also decreased significantly, suggesting that patients were better able to manage their conditions with the support of LLM-powered tools (Kwan et al., 2025). These improvements underscore the practical value of smart interfaces in chronic disease management, particularly for conditions such as asthma and COPD, where continuous monitoring and timely interventions are critical (Kondepudi et al., 2025). The integration of telemedicine with intelligent conversational agents thus represents not only a technological advancement but also a clinical one.

Multivariate Effects of UX on health outcomes

The results of the multivariate analysis (Figure 1) highlighted that improvements in usability, satisfaction, and accessibility simultaneously influenced adherence, symptom compliance, and quality of life. This finding reinforces the interconnectedness of user experience and clinical effectiveness. A well-designed digital health system cannot be evaluated solely on its technical sophistication; rather, its success depends on how effectively it engages patients in their health journeys (Merino et al., 2024). The cluster analysis (Figure 2) further illustrated the diversity of patient groups, showing that even among heterogeneous populations, meaningful groupings emerged based on UX features. This suggests that tailored interface strategies may be essential to optimize engagement for different subpopulations (Liu et al., 2024).

Ethical and inclusivity considerations

A key outcome of this study was the significant improvement in perceptions of trust, data security, and inclusivity. Elderly and low-literacy patients, traditionally marginalized in digital health systems, reported higher success rates in interacting with the LLM-powered platform. This result emphasizes the ethical responsibility of digital health designers to ensure equity in access and usability. Furthermore, the marked increase in trust in AI indicates that patients are becoming more comfortable with intelligent systems in healthcare, provided that these systems demonstrate reliability and safeguard data privacy (Williamson & Prybutok, 2024). These findings contribute to the growing discourse on ethical AI in healthcare, highlighting that inclusivity and transparency are as important as accuracy and efficiency (Zhang & Zhang, 2023).

Implications for telemedicine and healthcare systems

The outcomes of this study carry important implications for the future of telemedicine and healthcare systems. By demonstrating measurable improvements in UX and respiratory care outcomes, this research suggests that LLM-powered platforms can serve as scalable, cost-effective solutions for chronic disease management. For clinicians, such systems provide an opportunity to monitor patients more effectively while reducing administrative burdens. For patients, the enhanced experience fosters self-management and adherence, ultimately contributing to better health outcomes. The integration of AI-powered UX thus represents a critical step toward sustainable, patient-centered digital healthcare ecosystems.

Limitations and future research

Despite its promising results, this study has several limitations. The evaluation was conducted within a controlled prototype environment, and outcomes may differ in large-scale real-world deployments where infrastructural and contextual factors play a greater role. The sample, though diverse, was limited to a single geographical region, and cross-cultural validation would enhance the generalizability of findings. Additionally, while the study focused on respiratory care, future research should extend to other chronic and acute conditions to explore the broader applicability of LLM-powered telemedicine platforms. Future investigations should also incorporate longitudinal designs to assess the sustainability of adherence and engagement improvements over time.

Conclusion

This study demonstrates that the integration of LLM-powered smart interfaces into telemedicine platforms significantly enhances user experience, improves patient engagement, and delivers measurable clinical benefits in respiratory care. By enabling intuitive interactions, reducing cognitive load, and fostering trust through personalization and accessibility, LLM-driven systems address long-standing barriers in digital healthcare adoption. The results highlight not only improvements in usability and satisfaction but also meaningful outcomes such as increased medication adherence, higher symptom reporting compliance, and reduced hospitalization rates. Importantly, the findings underline the ethical imperative of inclusivity, showing that elderly and low-literacy patients can successfully engage with intelligent healthcare platforms when designed thoughtfully. As healthcare systems continue to embrace digital transformation, LLM-powered telemedicine has the potential to evolve into a cornerstone of patient-centered, equitable, and efficient healthcare delivery.

References

Bakalar, R. S. (2022). Telemedicine: its past, present and future. In *Healthcare Information Management Systems: Cases, Strategies, and Solutions* (pp. 149-160). Cham: Springer International Publishing.

Bombard, Y., Baker, G. R., Orlando, E., Fancott, C., Bhatia, P., Casalino, S., ... & Pomey, M. P. (2018). Engaging patients to improve quality of care: a systematic review. *Implementation Science*, *13*(1), 98.

Breuer, T., Frihat, S., Fuhr, N., Lewandowski, D., Schaer, P., & Schenkel, R. (2025). Large Language Models for Information Retrieval: Challenges and Chances. *Datenbank-Spektrum*, 1-11.

El-Miedany, Y. (2017). Telehealth and telemedicine: how the digital era is changing standard health care. *Smart homecare technology and telehealth*, 43-51.

Geanta, M., Boata, A., Cucos, B., & Cioroboiu, C. (2024). Digital Health. In *A Glimpse at Medicine in the Future* (pp. 129-142). Singapore: Springer Nature Singapore.

Khan, M., Khusro, S., Alam, I., Ali, S., & Khan, I. (2022). Perspectives on the design, challenges, and evaluation of smart TV user interfaces. *Scientific Programming*, *2022*(1), 2775959.

Kondepudi, G. M., Pothula, V. S., & Sivaji, K. (2025). Advancing Chronic Disease Management Through Wearable Technology: Opportunities, Challenges, and Future Directions. *Remote Monitoring and Wearable Devices in Healthcare*, 161-185.

Kwan, H. Y. (2024, May). User-focused telehealth powered by LLMs: Bridging the gap between technology and human-centric care delivery. In *2024 4th International Conference on Computer Communication and Artificial Intelligence (CCAI)* (pp. 187-191). IEEE.

Kwan, H. Y., Shell, J., Fahy, C., Yang, S., & Xing, Y. (2025). Integrating Large Language Models into Medication Management in Remote Healthcare: Current Applications, Challenges, and Future Prospects. *Systems*, *13*(4), 281.

Kwan, H. Y., Shell, J., Fahy, C., Yang, S., & Xing, Y. (2025). Integrating Large Language Models into Medication Management in Remote Healthcare: Current Applications, Challenges, and Future Prospects. *Systems*, *13*(4), 281.

Liu, Y., Tan, H., Cao, G., & Xu, Y. (2024). Enhancing user engagement through adaptive UI/UX design: A study on personalized mobile app interfaces. *Computer Science & IT Research Journal*, *5*(8), 1942-1962.

Mahmud, D., Hajmohamed, H., Almentheri, S., Alqaydi, S., Aldhaheri, L., Khalil, R. A., & Saeed, N. (2025). Integrating llms with its: Recent advances, potentials, challenges, and future directions. *IEEE Transactions on Intelligent Transportation Systems*.

Merino, M., Del Barrio, J., Nuño, R., & Errea, M. (2024). Value-based digital health: A systematic literature review of the value elements of digital health care. *Digital health*, *10*, 20552076241277438.

Ntoa, S. (2025). Usability and user experience evaluation in intelligent environments: A review and reappraisal. *International Journal of Human–Computer Interaction*, *41*(5), 2829-2858.

Porter, M. A. (2024). Value-based Healthcare: Can Generative Artificial Intelligence and Large Language Models be a Catalyst for Value-based Healthcare?. *Clinical Orthopaedics and Related Research®*, *482*(5), 901-904.

Reig, S., Fong, T., Forlizzi, J., & Steinfeld, A. (2022). Theory and design considerations for the user experience of smart environments. *IEEE Transactions on Human-Machine Systems*, *52*(3), 522-535.

Sachdeva, S., & Ali, A. (2022). Rise of Telemedicine in Healthcare Systems Using Machine Learning: A Key Discussion. *Internet of Healthcare Things: Machine Learning for Security and Privacy*, 113-130.

Stoltzfus, M., Kaur, A., Chawla, A., Gupta, V., Anamika, F. N. U., & Jain, R. (2023). The role of telemedicine in healthcare: an overview and update. *The Egyptian Journal of Internal Medicine*, *35*(1), 1-5.

Waller, M., & Stotler, C. (2018). Telemedicine: a primer. *Current allergy and asthma reports*, *18*(10), 54.

Wang, L., Chen, X., Du, Y., Zhou, Y., Gao, Y., & Cui, W. (2025). CataLM: empowering catalyst design through large language models. *International Journal of Machine Learning and Cybernetics*, 1-11.

Williamson, S. M., & Prybutok, V. (2024). Balancing privacy and progress: a review of privacy challenges, systemic oversight, and patient perceptions in AI-driven healthcare. *Applied Sciences*, *14*(2), 675.

Zhang, J., & Zhang, Z. M. (2023). Ethics and governance of trustworthy medical artificial intelligence. *BMC medical informatics and decision making*, *23*(1), 7.

Zhang, K., Meng, X., Yan, X., Ji, J., Liu, J., Xu, H., ... & Tang, Y. D. (2025). Revolutionizing health care: The transformative impact of large language models in medicine. *Journal of medical Internet research*, *27*, e59069.