Vol. 7 No.2 (2025) Page. 428-435

HealthCare Nursing Journal

available on : https://journal.umtas.ac.id/index.php/healtcare

e-ISSN : 2655-6812

Review Article

Adapting Design Thinking for Medical IoT: A Scoping Review of Iterative Frameworks in Geriatric Healthcare

Dhika Dharmansyah[1]*, Laili Rahayuwati[2], Iqbal Pramukti[2], Kuswandewi Mutyara[3], Ariani Arista Putri Pertiwi[4]

[1]Department of Nursing, Faculty of Sport Education and Health, Universitas Pendidikan Indonesia
[2]Department of Community Health Nursing, Faculty of Nursing, Universitas Padjadjaran
[3]Department of Public Health, Faculty of Medicine, Universitas Padjadjaran
[4]Department of Basic and Emergency Nursing, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada

ABSTRACT

The aging global population, projected to reach 22% by 2050, necessitates innovative healthcare technologies tailored to elderly users. While Medical Internet of Things (IoT) systems offer promising solutions for geriatric care, their development faces significant challenges including usability limitations and cybersecurity vulnerabilities. This scoping review examines how Design Thinking (DT) frameworks can be adapted to address the unique requirements of elderly-centric embedded systems development. A systematic scoping review following Joanna Briggs Institute methodology was conducted using SCOPUS database searches. Boolean operators combined keywords related to Design Thinking, elderly and Internet of Things. Inclusion criteria encompassed peer-reviewed studies (2015-2025) and grey literature addressing iterative design modifications for elderly populations, excluding non-English publications and systems without embedded sensor components. From 106 initial records, 10 studies met inclusion criteria after systematic screening. Key modifications to traditional DT phases included deeper user involvement, slower pacing, real-world validation, inclusive engagement strategies, co-design methodologies, and enhanced ethical considerations throughout development processes. Modified DT frameworks for elderly IoT development require prioritizing inclusive, context-aware, and iterative processes. Co-design approaches, real-world validation, and ongoing stakeholder support are essential for creating accessible, accepted, and effective solutions that address the complex physiological, cognitive, and socio-technical challenges faced by aging populations

Article Information

Received: 25th May 2025
Revised: 14th June 2025
Accepted: 14th July 2025
Available online: 31st July 2025

Keywords

Aged; Design Thinking; geriatric care; Medical IoT; Internet of Things

Correspondence*

Phone:
(+62) 82214105241
E-mail:
dhika.dharmansyah@upi.edu

Website

https://journal.umtas.ac.id/index.php/healtcare/index

Doi

https://doi.org/10.35568/healthcare.v7i2.6649

INTRODUCTION

The main source of nutrition received by newborns immediately after birth is breast milk (ASI) because its composition has been adjusted to the baby's physiology in the early stages of life (Azim et al., 2021). To provide the best nutritional intake during the early growth phase, newborns up to six months of age should only be given breast milk (Paramashanti et al., 2023). The World Health Organization (WHO) recommends that mothers breastfeed their babies exclusively (Irwandi et al., 2022).

The global population is undergoing an unprecedented demographic shift, with individuals aged 60 and older projected to represent 22% of the world's population by 2050 (Sahu et al., 2021). This rapid aging underscores an urgent need for healthcare innovations tailored to the physiological, cognitive, and socio-technical challenges faced by elderly populations. Embedded systems within the Medical Internet of Things (IoT) offer transformative potential for geriatric care, enabling remote health monitoring, fall detection, and chronic disease management (Dorri et al., 2023). However, the development of these technologies for vulnerable elderly users remains fraught with barriers, including heightened susceptibility to cybersecurity threats and usability limitations in existing devices (Saka & Das, 2023).

Design Thinking (DT), a human-centered framework, has demonstrated efficacy in healthcare innovation by prioritizing user needs through iterative phases of empathy, ideation, and prototyping (Schweitzer et al., 2024). Recent applications in mobile health (mHealth) illustrate its ability to enhance patient engagement and adherence through co-design methodologies (Schweitzer et al., 2024). Concurrently, advancements in sensor-based technologies have validated the feasibility of IoT systems for real-time monitoring of geriatric health parameters, such as gait stability and cognitive decline (Cammisuli et al., 2024). Despite these strides, a critical gap persists in adapting DT's core phases to address the unique requirements of elderly-centric embedded systems, particularly in balancing usability with robust data privacy protocols (Aledhari et al., 2022). This scoping review seeks to bridge this gap by synthesizing evidence on iterative design models that redefine traditional DT frameworks for geriatric IoT development.

Current literature emphasizes the technical feasibility of IoT solutions for elderly care but often overlooks the need for phase-specific modifications in design methodologies. For instance, while participatory design has been advocated to improve device acceptability, few studies operationalize empathy-building strategies that account for age-related sensory impairments (Sahu et al., 2021). Similarly, prototyping phases frequently neglect the integration of real-time biometric feedback loops, which are critical for adaptive systems in geriatric environments (Cammisuli et al., 2024). Privacy concerns, identified as a major barrier to IoT adoption among elderly users, remain inadequately addressed in existing DT-based frameworks (Saka & Das, 2023).

While previous studies have independently explored Design Thinking in healthcare innovation and IoT applications in geriatric care, no research has systematically investigated how DT's five core phases (empathize, define, ideate, prototype, test) require fundamental modifications when targeting vulnerable elderly populations with embedded sensor technologies. This study addresses this knowledge gap by providing the first comprehensive synthesis of phase-specific adaptations necessary for developing culturally sensitive, privacy-preserving, and age-appropriate Medical IoT solutions.

METHOD

This scoping review adhered to the Joanna Briggs Institute (JBI) methodological framework for evidence synthesis, which emphasizes iterative stakeholder engagement and rigorous data charting processes (Peters et al., 2020). A comprehensive search strategy was implemented SCOPUS databases using Boolean logic was applied in all title, abstract, and keyword fields: ("Design Thinking" OR "Human-Centered Design" OR "User-Centered Design") AND ("Internet of Things" OR "IoT" OR "Embedded System*") AND ("Elderly" OR "Aged" OR "Geriatric" OR "Older Adult") NOT ("Pediatric" OR "Child"). Inclusion criteria prioritized peer-reviewed studies (2015–2025) and grey literature addressing iterative design modifications for elderly populations, while excluding non-English publications and systems lacking embedded sensor components (Taylor & Pagliari, 2018). The authors conducted manual data extraction using a structured table to systematically capture study characteristics. The table included the following fields: author(s), publication year, country of origin, research design, outcome, sample size, measurement instruments, and result (Peters et al., 2020). Thematic analysis aligned with PRISMA-ScR guidelines identified recurring patterns in empathy-building techniques and ethical validation protocols (Tricco et al., 2018).

RESULTS

The PRISMA 2020 flow diagram (Figure 1) outlines the systematic identification and screening process for this scoping review. A total of 106 records were identified through a Scopus database search using tailored Boolean queries. After removing duplicates, all 106 records underwent title and abstract screening, with 86 excluded for not meeting inclusion criteria (e.g., lacking focus on geriatric IoT or Design Thinking adaptations). Twenty full-text articles were retrieved and assessed for eligibility, of which 10 were excluded due to insufficient methodological detail or irrelevant context (e.g., pediatric applications or non-embedded systems). The final synthesis included 10 studies that explicitly addressed iterative modifications to Design Thinking phases in geriatric Medical IoT development.

Table 1. PCC's Search Strategy

PCC's Framework	Search Strategy
Populations	Vulnerable elderly with sensory/cognitive impairments
Content	Design Thinking phase modifications
Context	Medical IoT ecosystems in geriatric care

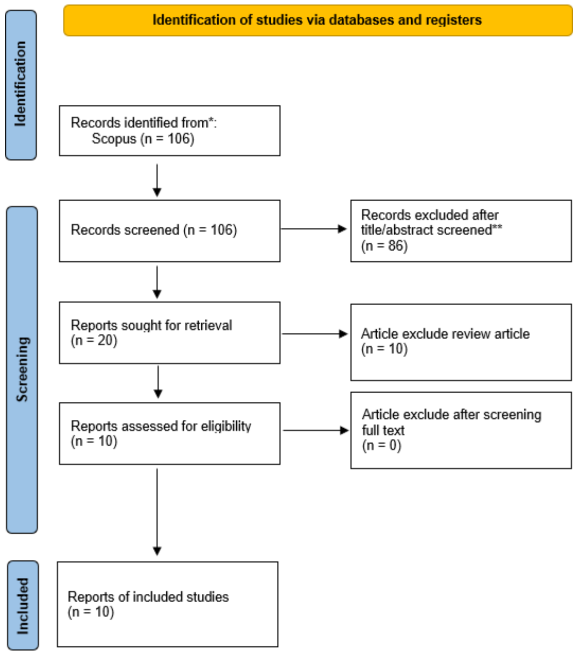

Figure 1. PRISMA Flow Diagram

DISCUSSION

Design thinking's classic phases—empathize, define, ideate, prototype, and test—can be highly effective for developing embedded systems for vulnerable elderly populations, but they require specific modifications to address the unique needs, limitations, and contexts of older adults. The most important modifications are deeper user involvement, slower pacing, and real-world validation throughout all phases.

Empathize & Define

Inclusive Engagement: Involve elderly users, caregivers, and healthcare professionals as co-designers from the start, using focus groups, interviews, and workshops to understand their lived experiences, needs, and challenges (Darley & Carroll, 2022; Moral et al., 2023; Pepping et al., 2023; Timon et al., 2024) .

Contextual Understanding: Conduct research in real-life settings (homes, care facilities) to capture environmental and social factors affecting technology use (Menghi et al., 2019; Moral et al., 2023; Pepping et al., 2023; Reis et al., 2017; Timon et al., 2024).

Digital Literacy & Accessibility: Assess and accommodate varying levels of digital literacy, providing support and education as needed (Darley & Carroll, 2022).

Ideate & Prototype

Co-Design Methods: Use participatory design activities, such as scenario-based discussions and hands-on workshops, to generate ideas and develop solutions collaboratively with elderly users and stakeholders (Darley & Carroll, 2022; Moral et al., 2023; Timon et al., 2024).

Simple, Tangible Prototypes: Create low-fidelity, easy-to-understand prototypes (e.g., paper models, simple digital demos) to facilitate feedback and ensure accessibility (Darley & Carroll, 2022; Moral et al., 2023; Timon et al., 2024).

Iterative Feedback: Incorporate frequent, iterative feedback loops, allowing users to test and refine prototypes in familiar environments (Konstantinidis et al., 2016; Moral et al., 2023; Timon et al., 2024).

Test & Iterate

Real-World Testing: Pilot solutions in the actual living environments of elderly users to assess usability, acceptability, and impact on daily life (Cristiano et al., 2022; Konstantinidis et al., 2016; Moral et al., 2023; Timon et al., 2024) .

Long-Term Evaluation: Evaluate not just immediate usability but also sustained engagement, well-being, and health outcomes over time (Cristiano et al., 2022; Konstantinidis et al., 2016; Moral et al., 2023).

Ethical Considerations: Address autonomy, informed consent, privacy, and data management throughout the process (Wangmo et al., 2019).

Comparison with Non-Geriatric Health Technology Development

In contrast to DT applications in general health technology development, where standard empathy-mapping and rapid prototyping cycles suffice, geriatric Medical IoT requires fundamentally different approaches. Non-geriatric health tech typically employs accelerated development cycles with digital-native users who can adapt quickly to interface changes and provide immediate feedback through conventional usability testing. However, elderly populations necessitate extended empathy phases with multi-stakeholder involvement (patients, caregivers, healthcare providers), slower-paced iterative cycles that accommodate cognitive processing differences, and mandatory real-world validation in authentic living environments rather than controlled laboratory settings. While general health applications can rely on self-reported outcomes and digital analytics, geriatric systems require comprehensive ethical frameworks addressing autonomy, privacy, and informed consent throughout each DT phase, alongside sustained long-term evaluation periods that extend beyond initial deployment to assess continued engagement and health outcomes. These modifications reflect the unique vulnerabilities, contextual complexities, and multi-layered support systems inherent to aging populations that are absent in standard health technology user groups.

Tabel 2. Ekstraction Data

Author & Year	Outcome	Country	Design	Sample	Result
Pepping et al. (2023)	Design thinking and end-user involvement led to a regional integrated care pathway for frail older adults with acute respiratory infections, including a hospital at home track	Netherlands	Non-RCT observational study	23 stakeholders including patient representatives, GPs, specialists, and healthcare managers	Successfully developed three patient journeys: hospital at home track, tailored ED visits, and nursing home recovery beds. Co-creation approach proved effective for regional implementation1
Timon et al. (2024)	Ambient sensors and voice-activated assistants are the most acceptable technologies for supporting independent living for older adults, with potential for automatic detection of daily activities	Ireland	Non-RCT observational study	17 stakeholders (predesign phase), 380 stakeholders (co-design phase), 7 older adults (prototype testing)	Identified key technology assistance areas: home security, falls prevention, loneliness mitigation, and family monitoring. Ambient sensors showed highest acceptability among older adults1
Moral et al. (2023)	The integrated system for managing frailty in community dwellings is easy to use, consistent, and secure, with both older adults and healthcare professionals recommending its continued use	Spain	Non-RCT experimental	10 older adults and 12 healthcare professionals in intervention group	System evaluation showed positive usability (SUS score not specified) and high user satisfaction. Both patients and professionals considered the system easy to learn and would continue using it1
Darley & Carroll (2022)	Effective co-design with older people in a digital setting requires bridging the digital divide, promoting inclusivity, and empowering them as equal collaborators in the research process	Ireland/UK	Non-RCT observational study	Older adults (specific number not disclosed)	Established methodological framework for digital co-design including engagement strategies, relationship building, digital literacy assessment, and technological support provision1
Papadopoulos et al. (2021)	Culturally competent socially assistive robots can improve psychological wellbeing for older adults in care settings, but not physical health	England and Japan	Randomized controlled trial	33 residents across care homes	Significant improvement in SF-36 Emotional Wellbeing scores ($F1 = 6.614$, $p = .019$, $\eta^2p = .258$). No significant changes in physical health subscales or loneliness scores1
Konstantinidis et al. (2016)	The FitForAll platform, designed for elderly populations, significantly improves	Greece	Non-RCT experimental	116 elderly users	Achieved 82% adherence rate over 8-week intervention. SUMI global score: 68.33±5.85%, SUS

	physical fitness and quality of life, with high user adherence and usability				score: 77.7. Significant improvements in strength, flexibility, endurance, and balance compared to control group1
Wangmo et al. (2019)	Professional stakeholders recognize ethical challenges in using intelligent assistive technology for elderly and dementia care, but differ on how to overcome these challenges and implement safe and effective solutions	Switzerland	Non-RCT observational study	Professional stakeholders including researchers and health professionals (specific number not disclosed)	Identified key ethical priorities: patient autonomy, informed consent, data management quality, distributive justice, and human contact preservation. Notable divergences in ethical challenge resolution approaches1
Cristiano et al. (2022)	A smart health platform designed for older adults meets their needs and expectations, but needs improvement in technical and privacy aspects	Italy	Non-RCT observational study	24 older adults, 118 clinicians (initial design), 6 older adults (evaluation phase)	Eight main functionalities evaluated with varying acceptance rates: cognitive/hearing training (100% across all metrics), monitoring physiological parameters (100% usefulness, 83% learnability), physical training (100% usefulness, 33% learnability)1
Reis et al. (2017)	Autonomous systems can enhance elderly well-being by maintaining social bonds with family and friends, but require effective interaction design considering the elderly's context and needs	Portugal	Non-RCT observational study	Group of elderly people in nursing homes (specific number not disclosed)	Established design principles for autonomous system interactions focusing on social bond maintenance and context-aware communication. Emphasized importance of family and friend group connections1
Menghi et al. (2019)	A user-centered platform involving older people, experts, and stakeholders can improve independence and quality of life for elderly living at home by aggregating services and optimizing local resources	Italy	Non-RCT observational study	Older people, experts, and stakeholders (specific numbers not disclosed)	Demonstrated feasibility of user-centered platform approach for home-based elderly care. Showed potential for service aggregation and local resource optimization

CONCLUSIONS AND RECOMMENDATION

Modifying Design Thinking for embedded systems targeting vulnerable elderly populations requires prioritizing inclusive, context-aware, and iterative processes. Essential elements include co-design with elderly users and caregivers, real-world validation in authentic living environments, and ongoing technical and ethical support to ensure solutions are accessible, accepted, and effective.

A key actionable recommendation for future research is the validation of modified Design Thinking frameworks through pilot implementations in low-resource settings. Such studies should assess not only usability and acceptance but also economic viability, infrastructure constraints, and scalability challenges unique to these environments. This approach aligns with recent frameworks developed for resilient medical device design in resource-limited contexts, emphasizing stakeholder engagement, capacity building, and context-specific adaptations. Additionally, investigating generational differences in IoT acceptance among elderly subgroups will help tailor interventions to diverse user needs.

By embedding these recommendations into research agendas and policy frameworks, developers and policymakers can foster Medical IoT ecosystems that balance cutting-edge innovation with the practical and ethical complexities of aging populations across varied socioeconomic settings. This will ultimately promote equitable access to technology-enabled healthcare for older adults worldwide.

FUNDING

This research received no external funding.

DATA AVAILABILITY

Not applicable

REFERENCES

Aledhari, M., Razzak, R., Qolomany, B., Al-Fuqaha, A., & Saeed, F. (2022). Biomedical IoT: Enabling Technologies, Architectural Elements, Challenges, and Future Directions. *IEEE Access*, *10*, 31306–31339. https://doi.org/10.1109/ACCESS.2022.3159235

Cammisuli, D. M., Taurisano, P., Schuller, B. W., & Qian, K. (2024). Editorial: Digital health and virtual health care for adults and older adults: innovative technological solutions for diagnosis, management, and rehabilitation. *Frontiers in Medicine*, *11*. https://doi.org/10.3389/fmed.2024.1417069

Cristiano, A., Musteata, S., De Silvestri, S., Bellandi, V., Ceravolo, P., Cesari, M., Azzolino, D., Sanna, A., & Trojaniello, D. (2022). Older Adults' and Clinicians' Perspectives on a Smart Health Platform for the Aging Population: Design and Evaluation Study. *JMIR Aging*, *5*. https://doi.org/10.2196/29623

Darley, A., & Carroll, Á. (2022). Conducting Co-Design with Older People in a Digital Setting: Methodological Reflections and Recommendations. *International Journal of Integrated Care*, *22*. https://doi.org/10.5334/ijic.6546

Dorri, S., Zabolinezhad, H., & Sattari, M. (2023). The Application of Internet of Things for the Elderly Health Safety: A Systematic Review. *Advanced Biomedical Research*, *12*(1). https://doi.org/10.4103/abr.abr_197_22

Konstantinidis, E., Billis, A., Mouzakidis, C., Zilidou, V., Antoniou, P., & Bamidis, P. (2016). Design, Implementation, and Wide Pilot Deployment of FitForAll: An Easy to use Exergaming Platform Improving Physical Fitness and Life Quality of Senior Citizens. *IEEE Journal of Biomedical and Health Informatics*, *20*, 189–200. https://doi.org/10.1109/JBHI.2014.2378814

Menghi, R., Papetti, A., & Germani, M. (2019). Product Service Platform to improve care systems for elderly living at home.

Health Policy and Technology, *8*, 393–401. https://doi.org/10.1016/j.hlpt.2019.10.004
Moral, C., Pérez-Rodríguez, R., Villalba-Mora, E., Barrio-Cortes, J., Ferré, X., & Rodríguez-Mañas, L. (2023). Integrated health system to assess and manage frailty in community dwelling: Co-design and usability evaluation. *Digital Health*, *9*. https://doi.org/10.1177/20552076231181229
Pepping, R., Van Aken, M., Vos, R., Numans, M., Van Den Berg, J., Kroon, I., & Van Nieuwkoop, C. (2023). Using Design Thinking for Co-Creating an Integrated Care Pathway Including Hospital at Home for Older Adults with an Acute Moderate-Severe Respiratory Infection in the Netherlands. *International Journal of Integrated Care*, *23*. https://doi.org/10.5334/ijic.6991
Peters, M. D. J., Marnie, C., Tricco, A. C., Pollock, D., Munn, Z., Alexander, L., McInerney, P., Godfrey, C. M., & Khalil, H. (2020). Updated methodological guidance for the conduct of scoping reviews. *JBI Evidence Synthesis*, *18*(10), 2119–2126. https://doi.org/10.11124/JBIES-20-00167
Reis, A., Barroso, I., Monteiro, M., Khanal, S., Rodrigues, V., Filipe, V., Paredes, H., & Barroso, J. (2017). *Designing Autonomous Systems Interactions with Elderly People*. 603–611. https://doi.org/10.1007/978-3-319-58700-4_49
Sahu, D., Pradhan, B., Khasnobish, A., Verma, S., Kim, D., & Pal, K. (2021). The Internet of Things in Geriatric Healthcare. *Journal of Healthcare Engineering*, *2021*, 1–16. https://doi.org/10.1155/2021/6611366
Saka, S., & Das, S. (2023). SAFEGUARDING IN THE INTERNET OF THINGS AGE: A COMPREHENSIVE REVIEW OF SECURITY AND PRIVACY RISKS FOR OLDER ADULTS. *Innovation in Aging*, *7*(Supplement_1), 819–819. https://doi.org/10.1093/geroni/igad104.2642
Schweitzer, R., Schlögl, S., & Schweitzer, M. (2024). Technology-Supported Behavior Change—Applying Design Thinking to mHealth Application Development. *European Journal of Investigation in Health, Psychology and Education*, *14*(3), 584–608. https://doi.org/10.3390/ejihpe14030039
Taylor, J., & Pagliari, C. (2018). Comprehensive scoping review of health research using social media data. *BMJ Open*, *8*(12), e022931. https://doi.org/10.1136/bmjopen-2018-022931
Timon, C., Heffernan, E., Kilcullen, S., Hopper, L., Lee, H., Gallagher, P., Smeaton, A., Moran, K., Hussey, P., & Murphy, C. (2024). Developing Independent Living Support for Older Adults Using Internet of Things and AI-Based Systems: Co-Design Study. *JMIR Aging*, *7*. https://doi.org/10.2196/54210
Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, *169*(7), 467–473. https://doi.org/10.7326/M18-0850
Wangmo, T., Lipps, M., Kressig, R., & Ienca, M. (2019). Ethical concerns with the use of intelligent assistive technology: findings from a qualitative study with professional stakeholders. *BMC Medical Ethics*, *20*. https://doi.org/10.1186/s12910-019-0437-z