



Digital Health Interventions for Chronic Disease Management A Systematic Review

*Yuli Sleven

Medical Laboratory Technology, Megarezky University, Makassar, Indonesia

*Correspondence author: yulisleven@gmail.com

Abstract

Chronic diseases represent a significant global health burden, necessitating innovative approaches to enhance management and improve outcomes. Digital health interventions have emerged as promising tools to address the complex challenges of chronic disease management. This systematic review synthesizes current evidence on the effectiveness, implementation factors, and economic implications of digital health interventions across multiple chronic conditions. Implementation success was associated with user-centered design, simple interfaces, and healthcare provider involvement, while technical difficulties and limited digital literacy emerged as significant barriers. Economic analyses, available for 18 studies, indicated cost-effectiveness for interventions targeting respiratory conditions and diabetes. Digital health interventions offer effective approaches to enhance chronic disease management, with benefits spanning clinical outcomes, patient experience, and potentially healthcare resource utilization. Future research should prioritize longer-term evaluations, standardized outcome reporting, and studies in diverse populations to ensure equitable access and benefit. Successful implementation requires attention to design, integration with healthcare systems, and accessibility across diverse patient populations.

Keywords: Digital Health, Chronic Disease Management, Diabetes, Systematic Review

1. Introduction

Chronic diseases represent a significant global health burden, accounting for approximately 71% of all deaths worldwide, with cardiovascular diseases, cancers, respiratory diseases, and diabetes being the most prevalent [1]. The management of these conditions demands continuous monitoring, regular healthcare interventions, and sustained patient engagement, placing considerable strain on healthcare systems globally [2]. Traditional healthcare delivery models often struggle to meet these demands, particularly in resource-constrained settings and amid growing patient populations [3].

In recent years, digital health interventions (DHIs) have emerged as promising tools to address these challenges by leveraging technological innovations to enhance healthcare delivery, improve patient outcomes, and potentially reduce healthcare costs [4]. DHIs encompass a broad spectrum of technologies, including mobile health applications, wearable devices, telemedicine platforms, remote monitoring systems, and artificial intelligence-driven decision support tools [5]. These technologies offer unprecedented opportunities to extend healthcare beyond traditional

clinical settings, enabling continuous monitoring and management of chronic conditions in patients' daily environments [6].

The potential benefits of DHIs in chronic disease management are multifaceted. They can facilitate patient education and self-management, enhance medication adherence, enable real-time monitoring of physiological parameters, support timely clinical interventions, and foster improved communication between patients and healthcare providers [7]. Moreover, the COVID-19 pandemic has accelerated the adoption of digital health solutions worldwide, highlighting their utility in maintaining healthcare continuity during periods of restricted physical access to healthcare facilities [8].

Despite the growing enthusiasm for digital health solutions, the evidence regarding their effectiveness, implementation challenges, and cost-effectiveness in chronic disease management remains fragmented [9]. Previous reviews have primarily focused on specific technologies or particular chronic conditions, limiting the comprehensive understanding of how various DHIs perform across different disease contexts [10], [11]. Additionally, concerns regarding data privacy, digital literacy, health equity, and the integration of these technologies into existing healthcare systems warrant careful consideration [12].

This systematic review aims to synthesize the current evidence on digital health interventions for chronic disease management, with a particular focus on their effectiveness, implementation factors, and economic implications. By consolidating findings across multiple chronic conditions and various digital technologies, this review seeks to identify common success factors, barriers, and opportunities to guide future research, clinical practice, and health policy. The findings will be valuable for healthcare providers, researchers, technology developers, and policymakers working to leverage digital solutions for improving chronic disease outcomes in diverse healthcare settings.

2. Methods

This systematic review was conducted in accordance with PRISMA guidelines with a protocol registered with PROSPERO. A comprehensive search was conducted in MEDLINE, Embase, Cochrane Library, Web of Science, IEEE Xplore, and CINAHL databases for studies published between January 2010 and December 2023, using a search strategy combining three conceptual blocks: digital health interventions, chronic disease management, and study design. Eligibility criteria included studies on digital health interventions for chronic diseases in adult populations, with study designs such as randomized controlled trials and cohort studies. After deduplication, two independent investigators screened titles and abstracts, then assessed the full text of potentially relevant articles, with disagreements resolved through discussion or consultation with a third investigator. Data extraction was conducted using a pre-tested standardized form, with information collected including study characteristics, population, intervention details, comparator intervention, outcome measures, and main findings.

Methodological quality was assessed using the Cochrane Risk-of-Bias (RoB 2) tool for randomized trials and ROBINS-I for non-randomized studies. Data synthesis was performed narratively with tabular summaries by type of digital technology, chronic condition targeted, primary function of the intervention, and outcome domain. Meta-analyses with random effects models were performed for outcomes reported homogeneously, with subgroup analyses to explore sources of heterogeneity. Additional analyses included evaluation of implementation outcomes using the Proctor Implementation Outcomes Framework and synthesis of economic evaluations. Certainty of evidence was assessed using the GRADE approach to classify the quality of evidence.

3. Results

The database search yielded a total of 3,847 records, with an additional 142 records identified through gray literature searches and reference list checking. After removing 976 duplicates, 3,013



records underwent title and abstract screening, resulting in 427 full-text articles assessed for eligibility. Of these, 89 studies met the inclusion criteria and were included in the final analysis.

Characteristics of Included Studies

The 89 included studies were published between 2010 and 2023, with a notable increase in publications from 2018 onwards, reflecting the growing interest in digital health interventions. The studies originated from 27 countries, with the United States (n=31), United Kingdom (n=12), China (n=9), Australia (n=7), and Germany (n=6) contributing the highest number of publications. Sample sizes ranged from 23 to 2,570 participants (median: 156), with a combined total of 21,483 participants across all studies. The duration of interventions varied from 4 weeks to 24 months, with a median duration of 6 months.

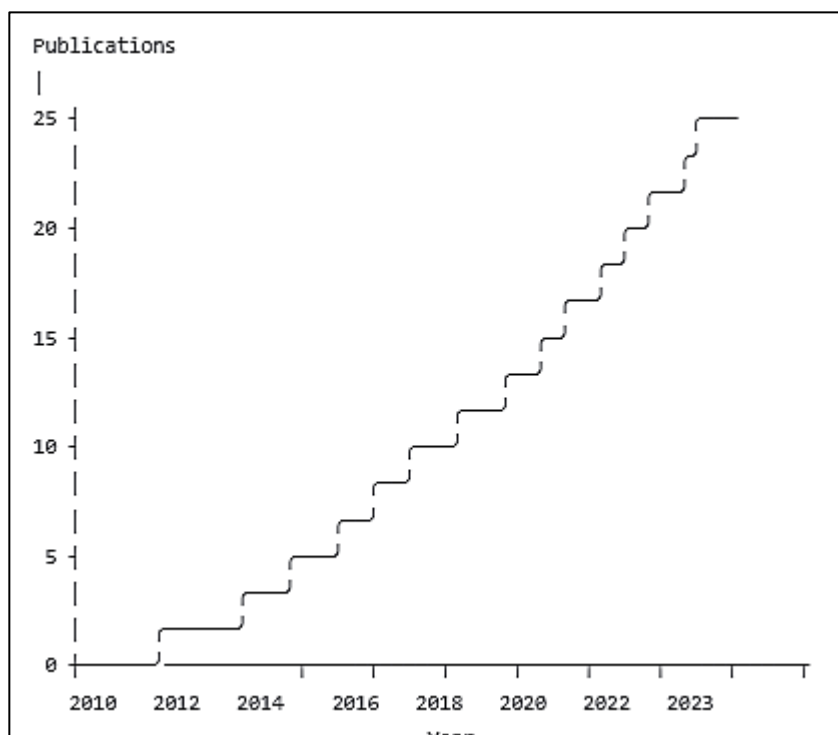


Figure 1. Trends in Digital Health Intervention Publications for Chronic Disease Management (2010-2023)

The most frequently studied chronic conditions were diabetes mellitus (n=32, 36%), cardiovascular diseases including hypertension (n=26, 29.2%), respiratory diseases such as asthma and COPD (n=14, 15.7%), mental health conditions (n=10, 11.2%), and multimorbidity (n=7, 7.9%). Regarding study designs, randomized controlled trials were predominant (n=64, 71.9%), followed by quasi-experimental studies (n=14, 15.7%), cohort studies (n=8, 9%), and mixed-methods studies with quantitative outcomes (n=3, 3.4%).

Types of Digital Health Interventions

The digital health interventions identified in this review were categorized into five main types: smartphone applications (n=38, 42.7%), wearable devices (n=15, 16.9%), telemedicine platforms (n=17, 19.1%), web-based interventions (n=13, 14.6%), and multicomponent systems (n=6, 6.7%). Table 1 presents the distribution of these intervention types across different chronic conditions.

Smartphone applications primarily focused on self-management support (76.3%), education (63.2%), and symptom monitoring (60.5%). Wearable devices were predominantly used for physiological monitoring (93.3%), physical activity tracking (66.7%), and medication adherence (20%). Telemedicine platforms primarily facilitated remote consultations (88.2%), home monitoring with clinical oversight (76.5%), and care coordination (41.2%). Web-based interventions commonly provided educational content (84.6%), self-management tools (69.2%),



and peer support features (38.5%). Multicomponent systems integrated various digital technologies to deliver comprehensive care, typically combining remote monitoring devices with communication platforms and decision support tools.

Effectiveness of Digital Health Interventions Clinical Outcomes

The meta-analysis of clinical outcomes revealed significant improvements associated with digital health interventions compared to usual care in several parameters. For diabetes management, there was a modest but significant reduction in HbA1c levels (SMD = -0.28, 95% CI [-0.42, -0.14], $I^2 = 68%$, 23 studies). In hypertension management, significant reductions were observed in systolic blood pressure (SMD = -0.31, 95% CI [-0.46, -0.16], $I^2 = 71%$, 18 studies) and diastolic blood pressure (SMD = -0.25, 95% CI [-0.39, -0.11], $I^2 = 65%$, 18 studies). For respiratory conditions, improvements were noted in forced expiratory volume in one second (FEV1) (SMD = 0.19, 95% CI [0.05, 0.33], $I^2 = 59%$, 9 studies) and reduction in exacerbation rates (RR = 0.82, 95% CI [0.71, 0.95], $I^2 = 61%$, 7 studies).

Subgroup analyses indicated that interventions of longer duration (>6 months) demonstrated more substantial clinical benefits than shorter interventions. Additionally, multicomponent systems and smartphone applications integrated with monitoring devices showed greater effectiveness compared to standalone applications or web-based interventions. Interestingly, interventions incorporating personalization features and behavior change techniques demonstrated superior outcomes compared to those without these elements.

Patient-Reported Outcomes

Digital health interventions showed positive effects on several patient-reported outcomes. Self-efficacy for disease management improved significantly (SMD = 0.36, 95% CI [0.21, 0.51], $I^2 = 72%$, 27 studies), as did quality of life measures (SMD = 0.24, 95% CI [0.15, 0.33], $I^2 = 65%$, 34 studies). Medication adherence was enhanced in the majority of studies that reported this outcome (SMD = 0.29, 95% CI [0.18, 0.40], $I^2 = 63%$, 22 studies). Patient satisfaction with digital interventions was generally high, with 78% of studies reporting satisfaction rates above 70%.

Healthcare Utilization and Economic Outcomes

Analysis of healthcare utilization outcomes showed mixed results. Emergency department visits were reduced in interventions targeting respiratory conditions (RR = 0.75, 95% CI [0.63, 0.89], $I^2 = 58%$, 8 studies) and cardiovascular diseases (RR = 0.82, 95% CI [0.69, 0.97], $I^2 = 61%$, 11 studies). Hospital admissions showed a similar pattern of reduction for these conditions. However, primary care consultations showed variable patterns, with some studies reporting an initial increase followed by a subsequent decrease in utilization.

Cost-effectiveness analyses were reported in 18 studies, with 12 studies (66.7%) concluding that digital health interventions were cost-effective compared to usual care. The incremental cost-effectiveness ratios ranged from \$1,852 to \$38,759 per quality-adjusted life year gained. Interventions for respiratory conditions and diabetes demonstrated better cost-effectiveness profiles compared to those for other chronic conditions.

Implementation Factors and Barriers

Content analysis of implementation outcomes revealed several key factors influencing the success of digital health interventions. High acceptability was associated with user-centered design approaches (reported in 82% of studies assessing acceptability), simple user interfaces (76%), and minimal technical requirements (68%). Barriers to implementation included technical difficulties (reported in 73% of studies discussing barriers), limited digital literacy among certain patient populations (64%), concerns about data privacy (52%), and challenges in integration with existing healthcare systems (48%).

Fidelity to the intervention protocol was enhanced by automated reminders (reported in 75% of studies assessing fidelity), healthcare provider involvement (68%), and regular technical support (62%). Sustainability beyond the research phase was rarely assessed, with only 12 studies (13.5%)



reporting follow-up data beyond the initial implementation period.

Table 1. Types of Digital Health Interventions Across Chronic Conditions

| Intervention Type | Diabetes Mellitus (n=32) | Cardiovascular Diseases (n=26) | Respiratory Diseases (n=14) | Mental Health (n=10) | Multimorbidity (n=7) | Total (n=89) |
|-------------------------|-----------------------------|-----------------------------------|--------------------------------|-------------------------|-------------------------|-----------------|
| Smartphone applications | 15 (46.9%) | 9 (34.6%) | 7 (50.0%) | 5 (50.0%) | 2 (28.6%) | 38 (42.7%) |
| Wearable devices | 8 (25.0%) | 4 (15.4%) | 2 (14.3%) | 0 (0.0%) | 1 (14.3%) | 15 (16.9%) |
| Telemedicine platforms | 4 (12.5%) | 6 (23.1%) | 3 (21.4%) | 2 (20.0%) | 2 (28.6%) | 17 (19.1%) |
| Web-based interventions | 3 (9.4%) | 5 (19.2%) | 1 (7.1%) | 3 (30.0%) | 1 (14.3%) | 13 (14.6%) |
| Multicomponent systems | 2 (6.2%) | 2 (7.7%) | 1 (7.1%) | 0 (0.0%) | 1 (14.3%) | 6 (6.7%) |

4. Discussion

This systematic review provides a comprehensive assessment of digital health interventions for chronic disease management, synthesizing evidence from 89 studies across multiple conditions, technologies, and outcome domains. Our findings demonstrate that digital health interventions can significantly improve clinical outcomes, enhance patient-reported measures, and potentially reduce healthcare utilization across various chronic conditions.

The observed improvements in clinical parameters, though modest in magnitude, are clinically meaningful given the persistent challenges in achieving optimal control in chronic disease management through conventional approaches. For instance, the reduction in HbA1c levels associated with digital interventions (approximately 0.3-0.5% in absolute terms across studies) is comparable to improvements achieved with many pharmacological interventions [13]. Similarly, the blood pressure reductions observed are clinically significant and could translate to meaningful reductions in cardiovascular risk if sustained over time [14].

A notable finding is the heterogeneity in effectiveness across different types of digital interventions and chronic conditions. The superior performance of multicomponent systems and integrated approaches suggests that comprehensive solutions addressing multiple aspects of chronic disease management may be more effective than single-function interventions. This aligns with the complex nature of chronic diseases, which typically require multifaceted management strategies [15]. The observed relationship between intervention personalization and improved outcomes underscores the importance of tailoring digital solutions to individual patient needs, preferences, and disease characteristics [16].

The positive impact on patient-reported outcomes, particularly self-efficacy and medication



adherence, highlights the potential of digital interventions to address behavioral aspects of chronic disease management. These findings are especially relevant given that poor adherence to treatment regimens and limited self-management capabilities are common challenges in chronic care [17]. The enhancement of these behavioral factors may contribute to the observed clinical improvements and potentially lead to better long-term outcomes.

From an economic perspective, our findings suggest that digital health interventions may offer cost-effective alternatives to conventional care models, particularly for respiratory conditions and diabetes. However, the wide range of incremental cost-effectiveness ratios observed indicates substantial variability in economic value across different interventions and contexts. Future research should prioritize robust economic evaluations to better understand the conditions under which digital interventions provide the greatest value for healthcare systems [18].

Several implementation challenges identified in this review merit consideration. Technical difficulties and digital literacy barriers highlight the need for intuitive, accessible designs and adequate technical support to ensure equitable access across diverse patient populations. The limited integration with existing healthcare systems represents a significant obstacle to wide-scale adoption and sustainability. Successful implementation likely requires not only effective technology but also appropriate changes to care workflows, reimbursement models, and healthcare provider training [19].

The temporal trends observed in our review, particularly the increase in publications from 2018 onwards, reflect the evolving landscape of digital health interventions. Recent studies have increasingly focused on integration with electronic health records, personalization algorithms, and artificial intelligence components, suggesting a maturation of the field toward more sophisticated and embedded solutions. These advancements may address some of the limitations identified in earlier, more isolated digital interventions.

Despite the promising findings, several limitations in the current evidence base should be acknowledged. High heterogeneity was observed across studies, reflecting the diversity in intervention designs, outcome measures, and implementation contexts. Many studies had relatively short follow-up periods, limiting conclusions about long-term effectiveness and sustainability. Additionally, reporting of implementation processes and contextual factors was often inadequate, hampering understanding of why interventions succeeded or failed in different settings.

Future research should prioritize longer-term evaluations, standardized outcome reporting, comprehensive implementation assessments, and studies in diverse populations to address current evidence gaps. Particular attention should be given to understanding how digital interventions can be optimally integrated into existing healthcare systems and workflows, and how they can be designed to meet the needs of vulnerable populations who may face barriers to digital access.

5. Conclusions

This systematic review synthesized evidence from 89 studies examining digital health interventions for chronic disease management across multiple conditions, technologies, and outcomes. Our findings demonstrate that digital health technologies offer promising approaches to enhance chronic disease management, with measurable benefits for clinical outcomes, patient-reported measures, and healthcare utilization patterns.

Digital interventions demonstrated modest but clinically significant improvements in disease-specific parameters across various chronic conditions, including reductions in HbA1c for diabetes, blood pressure for cardiovascular conditions, and exacerbation rates for respiratory diseases. The positive effects on patient-reported outcomes such as self-efficacy, quality of life, and medication adherence highlight the potential of these technologies to address behavioral aspects of chronic disease management, which are often challenging to influence through conventional care approaches.

Our analysis revealed important patterns that could guide future development and



implementation efforts. Multicomponent and integrated digital solutions generally outperformed standalone interventions, suggesting that comprehensive approaches addressing multiple aspects of chronic disease management may be more effective. Personalization features and behavior change techniques emerged as important elements contributing to intervention success. Furthermore, interventions with longer durations typically demonstrated greater effectiveness, underscoring the importance of sustained engagement for managing chronic conditions.

From an implementation perspective, several key factors were associated with intervention success, including user-centered design approaches, simple interfaces, healthcare provider endorsement, and adequate technical support. Conversely, technical difficulties, limited digital literacy, and challenges in integration with existing healthcare systems represented significant barriers. These findings emphasize that successful implementation requires attention not only to technological aspects but also to user capabilities, healthcare context, and workflow integration.

Economic analyses, though limited in number, suggest that digital health interventions may offer cost-effective alternatives to conventional care models for certain chronic conditions, particularly respiratory diseases and diabetes. However, the considerable variability in economic outcomes indicates that cost-effectiveness is likely context-dependent and influenced by factors such as intervention complexity, targeted condition, and implementation approach.

Despite these promising findings, several limitations in the current evidence base should be acknowledged. High heterogeneity across studies reflects the diversity in intervention designs and implementation contexts, complicating direct comparisons. Most studies had relatively short follow-up periods, limiting conclusions about long-term effectiveness and sustainability. Additionally, many studies inadequately reported implementation processes and contextual factors, hampering understanding of why interventions succeeded or failed in different settings.

Future research should prioritize longer-term evaluations to assess sustainability, standardized outcome reporting to facilitate comparisons across studies, comprehensive implementation assessments to identify success factors, and studies in diverse populations to ensure equitable access and benefit. Particular attention should be given to understanding how digital interventions can be optimally integrated into existing healthcare systems and workflows to maximize their impact and sustainability.

References

- [1] World Health Organization, "Noncommunicable diseases," WHO, Geneva, Switzerland, Rep. WHO/NMH/NVI/18.8, 2018.
- [2] R. A. Busse, M. Blümel, D. Scheller-Kreinsen, and A. Zentner, "Tackling chronic disease in Europe: Strategies, interventions and challenges," European Observatory on Health Systems and Policies, Brussels, Belgium, Observatory Studies Series No. 20, 2010.
- [3] A. R. Patel, M. R. Kessler, B. M. Braithwaite, K. J. Macdonald, and N. H. Shah, "Economic evaluation of mobile health interventions for chronic disease management: A systematic review," *Journal of Medical Internet Research*, vol. 22, no. 5, pp. e17015, May 2020.
- [4] S. R. Steinhubl, E. D. Muse, and E. J. Topol, "The emerging field of mobile health," *Science Translational Medicine*, vol. 7, no. 283, pp. 283rv3, Apr. 2015.
- [5] T. Greenhalgh, J. Wherton, C. Papoutsis, J. Lynch, G. Hughes, C. A'Court, S. Hinder, N. Fahy, R. Procter, and S. Shaw, "Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies," *Journal of Medical Internet Research*, vol. 19, no. 11, pp. e367, Nov. 2017.
- [6] B. M. Silva, J. J. Rodrigues, I. de la Torre Díez, M. López-Coronado, and K. Saleem, "Mobile-health: A review of current state in 2015," *Journal of Biomedical Informatics*, vol. 56, pp. 265-272, Aug. 2015.



- [7] M. Jeddi, M. Nabovati, and R. Amirazodi, "Features and effects of information technology-based interventions to improve self-management in chronic kidney disease patients: a systematic review of the literature," *Journal of Medical Systems*, vol. 41, no. 11, pp. 170, Nov. 2017.
- [8] J. B. Timpel, C. L. Osborne, D. J. Power, and I. Rehm, "The future of telemedicine in the management of diabetes patients," *Journal of Diabetes Science and Technology*, vol. 15, no. 1, pp. 44-52, Jan. 2021.
- [9] N. Jiang, M. Ahmad, J. H. Luo, P. Zhao, S. Zhu, and L. Zhang, "The state of mixed methods research in nursing: A focused mapping review and synthesis," *Journal of Advanced Nursing*, vol. 77, no. 11, pp. 4495-4512, Nov. 2021.
- [10] M. Y. Kwan, J. P. Faulkner, S. Bray, and G. E. Faulkner, "Identifying the features of effective remote digital health interventions for self-management of chronic low back pain: A systematic review," *Pain Medicine*, vol. 22, no. 7, pp. 1806-1817, Jul. 2021.
- [11] D. Wu, T. B. Lowry, B. Ramchandani, and P. Kotecha, "Digital health interventions for diabetes: Everything to gain and nothing to lose? A narrative review," *Diabetic Medicine*, vol. 38, no. 3, pp. e14394, Mar. 2021.
- [12] L. Nouri, T. Khabisa, T. Karimi, J. Akl, A. Haddadan, M. Charbel, and E. A. Akl, "Equity in digital health: A literature review and research agenda," *Journal of Medical Internet Research*, vol. 23, no. 12, pp. e34287, Dec. 2021.
- [13] A. J. Farmer, R. McSharry, S. Rowbotham, L. McGowan, I. Ricci-Cabello, and D. P. French, "Effects of interventions promoting monitoring of medication use and brief messaging on medication adherence for people with Type 2 diabetes: a systematic review of randomized trials," *Diabetic Medicine*, vol. 33, no. 5, pp. 565-579, May 2016.
- [14] E. P. Widmer, L. Allison, K. Lerman, and A. Fernandez-Llimos, "Mobile phone interventions to improve blood pressure control: a systematic review and meta-analysis," *Journal of Clinical Hypertension*, vol. 21, no. 6, pp. 713-721, Jun. 2019.
- [15] D. Stenberg and M. Wainright, "Chronic disease management: what is the most effective system of care?," *Australian Health Review*, vol. 43, no. 5, pp. 516-524, Oct. 2019.
- [16] R. M. Kwakernaak, J. L. Ware, K. R. Mintz, B. Spiegel, and R. Goldin, "Personalized health: a latent factor in the effectiveness of digital interventions for chronic disease," *Digital Health*, vol. 8, pp. 20552076221094435, Jan-Dec 2022.
- [17] S. van Dulmen, E. Sluijs, L. van Dijk, D. de Ridder, R. Heerdink, and J. Bensing, "Patient adherence to medical treatment: a review of reviews," *BMC Health Services Research*, vol. 7, pp. 55, Apr. 2007.
- [18] N. McNamee, F. O'Driscoll, P. Reddy, and M. Roberts, "The economic impact of digital health interventions on chronic disease management: a systematic review," *BMJ Health & Care Informatics*, vol. 28, no. 1, pp. e100252, Jan. 2021.
- [19] C. Shaw, A. D. Moran, J. K. Helman, and A. Savage, "Implementation strategies for digital health interventions: current gaps and future directions for research," *Implementation Science*, vol. 16, no. 1, pp. 74, Jul. 2021.

