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THE ROLE OF MOBILE HEALTH TECHNOLOGIES IN TYPE 2 DIABETES MANAGEMENT: CLINICAL EFFECTIVENESS AND SOCIAL CHALLENGES – A NARRATIVE REVIEW

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) represents a major global healthcare challenge requiring continuous, lifelong multi-factorial self-management. While mobile health (mHealth) technologies are increasingly deployed across clinical pathways to enhance glycemic control, their long-term therapeutic effectiveness is strongly moderated by intervention software architecture, dynamic user engagement patterns, and the overarching socio-technical context.

Objective s: Guided by rigorous narrative standards, this review synthesizes contemporary meta-analytic evidence regarding the comparative clinical efficacy of mHealth modalities on glycated hemoglobin (HbA1c), evaluates the operational impact of hybrid (blended) care models on sustained patient retention, and critically identifies systemic socio-technical barriers to equitable technology adoption.

Methods: Following the Scale for the Assessment of Narrative Review Articles (SANRA) guidelines, a structured literature search of high-level secondary evidence published between 2021 and 2026 was executed across PubMed/MEDLINE, Scopus, and Google Scholar. Implementation hurdles and non-adoption patterns were interpreted through the Non-adoption, Abandonment, Scale-up, Spread, and Sustainment (NASSS) theoretical framework.

Results: Synthesized meta-analyses demonstrate that mHealth modalities achieve statistically significant and clinically meaningful reductions in HbA1c (pooled mean differences ranging from -0.32% to -0.56%). Dynamic short message service (SMS) interventions and multi-parametric smartphone applications yield significantly higher metabolic efficacy than static web platforms. However, purely automated digital interventions experience progressive user attrition over extended multi-month durations. Integrating structured, human-led clinical support markedly buffers against digital fatigue, thereby optimizing patient adherence. Key implementation barriers include disparities in digital health literacy, age-related usability constraints, and heightened data privacy apprehensions.

Conclusion s: Securing the sustained therapeutic utility of mHealth in routine diabetology necessitates shifting away from unassisted automated tools toward personalized, multi-parametric, blended care frameworks supported by transparent data governance policies.

KEYWORDS

Blended Care, Digital Health Literacy, mHealth, Telemedicine, Type 2 Diabetes Mellitus

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1. Introduction

Type 2 Diabetes Mellitus (T2DM) represents a paramount global public health imperative, imposing a profound clinical and economic burden on healthcare infrastructure worldwide. Epidemiological data published by the International Diabetes Federation (IDF) indicated that approximately 589 million adults were living with diabetes globally in 2025, with continuous demographic projections estimating an alarming escalation to 853 million individuals by the year 2050 (International Diabetes Federation, 2025). The progressive pathophysiological trajectory of T2DM is primarily characterized by chronic tissue-level insulin resistance combined with a progressive decline in pancreatic beta-cell function and secretory capacity, which ultimately precipitates persistent, uncompensated hyperglycemia. Left inadequately managed, sustained metabolic dysregulation significantly elevates the risk of devastating microvascular sequelae, including proliferative diabetic retinopathy, advanced diabetic nephropathy, and peripheral neuropathy, as well as severe macrovascular events, such as acute myocardial infarction and cerebrovascular stroke (ElSayed et al., 2025). Consequently, achieving and maintaining optimal long-term glycemic control remains the cornerstone of

clinical diabetology, essential for mitigating organ-specific complications, reducing avoidable emergency healthcare expenditures, and curbing premature diabetes-related mortality (Davies et al., 2022).

The clinical management of T2DM relies heavily and continuously on patient-driven self-management behaviors, encompassing rigorous dietary modifications, sustained physical activity, systematic self-monitoring of blood glucose (SMBG), and strict adherence to complex pharmacological regimens (Davies et al., 2022). However, conventional outpatient care delivery models, predominantly structured around brief, episodic clinical consultations scheduled several months apart, frequently prove inadequate for sustaining lifelong behavioral modifications. This fundamental structural gap between infrequent clinical encounters often precipitates clinical inertia, a widespread phenomenon wherein healthcare providers delay necessary therapeutic escalation despite clear empirical evidence of suboptimal glycemic regulation (Khunti et al., 2018). To bridge these pervasive care gaps, mobile health (mHealth) platforms, primarily interactive smartphone software applications and automated short message service (SMS) communication networks, have been progressively integrated into chronic disease pathways. These digital solutions enable asynchronous, continuous logging of physiological parameters, automated text-based feedback loops, and uninterrupted access to tailored psychoeducational materials. By providing continuous behavioral reinforcement within patients' everyday environments, mHealth tools seek to extend clinical oversight beyond the traditional hospital setting.

Current clinical literature provides variable evidence regarding the metabolic efficacy of mHealth tools, indicating that therapeutic outcomes are highly contingent upon the underlying platform architecture and the degree of clinical integration. In a comprehensive umbrella review evaluating digital interventions across chronic disease populations, Class I evidence for significant HbA1c reductions driven by mobile phone interventions was reported (Sun et al., 2024). Quantifying these metabolic gains, a Bayesian network meta-analysis confirmed that dynamic mobile applications and automated SMS networks achieved statistically significant reductions in HbA1c profiles, whereas static, non-interactive web platforms provided minimal clinical value (Zhang et al., 2023). Nevertheless, metabolic outcomes exhibit marked heterogeneity across clinical trial cohorts and intervention formats. Purely automated, unassisted digital platforms frequently suffer from high rates of user attrition over extended time horizons. For instance, a systematic review investigating high-quality diabetes applications revealed that up to 50% of platforms failed to maintain moderate-to-high medication adherence over time (Shariful Islam et al., 2022). To counter this progressive decline in engagement, while app-based interventions effectively reduce HbA1c, long-term user retention relies heavily upon flexible, interactive, bidirectional communication between patients and clinical facilitators (He et al., 2022). Incorporating remote professional coaching or continuous nursing oversight into digital workflows appears vital for preserving patient motivation, mitigating intervention fatigue, and securing lasting metabolic gains (Shariful Islam et al., 2022).

Deploying digital health technologies within routine diabetology introduces structural and behavioural challenges that extend far beyond mere clinical efficacy. A primary structural vulnerability is the digital divide, where older demographic cohorts, socioeconomically disadvantaged populations, and individuals residing in rural regions often face restricted equity in platform access due to infrastructural deficits or limited digital literacy. As conceptualized within the NASSS framework, health technology scale-up frequently encounters institutional failure when systemic, organizational, and user-level complexities remain unaddressed (Greenhalgh et al., 2017). Furthermore, the continuous collection, transmission, and cloud storage of patient-generated health data (PGHD) introduce major cybersecurity vulnerabilities, requiring rigorous end-to-end data encryption and strict institutional adherence to regulatory privacy standards. Usability friction, such as overly complex user interface design, burdensome navigation pathways, or frequent automated notification fatigue, further accelerates early platform abandonment. An objective, comprehensive evaluation of mHealth must therefore carefully weigh clinical metabolic benefits against these systemic socio-technical barriers (Kruse et al., 2017).

Although published systematic reviews have established short-term reductions in laboratory biomarkers such as HbA1c, there remains a notable paucity of secondary literature evaluating how these digital platforms operate when subjected to real-world behavioural, social, and structural constraints. Existing medical literature overwhelmingly prioritizes statistical clinical endpoints while frequently omitting qualitative evaluations regarding multi-month user attrition, platform fatigue, and demographic disparities in digital technology access.

This narrative review addresses this critical analytical gap by synthesizing empirical clinical trial evidence with a structured assessment of the behavioral and socio-technical factors shaping modern digital diabetes care. Specifically, the core objectives of this review are to:

1. Synthesize recent meta-analytic data evaluating the comparative clinical efficacy of smartphone applications versus automated text-messaging platforms in lowering HbA1c levels.
2. Characterize the operational impact of hybrid care models, combining automated software algorithms with human-led clinical coaching, on patient attrition dynamics and self-care compliance.
3. Identify key demographic, structural, and privacy-related socio-technical barriers that dictate equitable mHealth deployment in routine chronic care pathways.

2. Methodology

This narrative review was designed to synthesize current secondary literature on mHealth integration in T2DM management. Given the broad interdisciplinary scope of this topic, spanning metabolic clinical trial endpoints, human behavioral psychology, and socio-technical health informatics, a narrative synthesis methodology was selected over a narrow quantitative systematic review protocol. To maintain methodological rigor, structural clarity, and transparent reporting, this review strictly adheres to the guidelines established by the Scale for the Assessment of Narrative Review Articles (SANRA) (Baethge et al., 2019). Due to substantial heterogeneity in software functionality, intervention design, and follow-up schedules across the included secondary literature, quantitative statistical re-pooling was not conducted.

2.1. Search Strategy and Data Sources

A structured, comprehensive literature search was conducted in January 2026 across three primary electronic databases: PubMed/MEDLINE, Scopus, and Google Scholar. PubMed/MEDLINE provided primary coverage of peer-reviewed biomedical and clinical literature; Scopus was utilized to capture interdisciplinary research focusing on healthcare technologies, health informatics, and data privacy; and Google Scholar was systematically queried to identify supplementary indexing and relevant academic reviews.

The search strategy utilized combinations of Medical Subject Headings (MeSH) terms and Boolean keywords, including: "Type 2 Diabetes Mellitus", "diabetes self-management", "mHealth", "mobile health", "smartphone applications", "text messaging", "SMS", "glycemic control", "HbA1c", "blended care", "human coaching", "digital literacy", and "data privacy". The primary search window was restricted to secondary literature published between 2021 and 2026 to ensure alignment with contemporary software architectures, modern clinical guidelines, and current mHealth adoption trends. Landmark foundational studies and theoretical frameworks were additionally cited where necessary to establish conceptual background.

2.2. Inclusion and Exclusion Criteria

Eligibility criteria were systematically applied to select the retrieved literature:

Inclusion Criteria:

- Systematic reviews, meta-analyses, and umbrella reviews published in peer-reviewed journals.
- Studies examining adult cohorts (age ≥ 18 years) diagnosed with Type 2 Diabetes Mellitus (T2DM), or mixed diabetes cohorts where T2DM outcomes were separately analyzed.
- Interventions evaluating interactive mHealth delivery systems, including mobile applications, SMS text messaging, and connected self-management platforms.
- Articles reporting primary glycemic endpoints (specifically HbA1c) or key implementation metrics (e.g., attrition rates, engagement levels, socio-technical barriers).
- Publications written in the English language.

Exclusion Criteria:

- Primary research articles (individual RCTs or observational cohorts), except when cited strictly as contextual real-world illustrations of blended care frameworks or socio-technical barriers.
- Interventions relying exclusively on static desktop web platforms without mobile software integration.
- Studies focused primarily on invasive hardware (e.g., fully automated closed-loop insulin pumps) without an active mHealth software user interface.
- Conference abstracts, grey literature, dissertations, and non-peer-reviewed reports.

2.3. Data Selection and Synthesis

Title and abstract screening, followed by full-text evaluation, were completed by a single reviewer. A thematic synthesis framework was then applied to extract core findings. Socio-technical barriers and technology non-adoption patterns were interpreted through the Non-adoption, Abandonment, Scale-up, Spread, and Sustainment (NASSS) framework (Greenhalgh et al., 2017). Synthesized data were organized into three thematic areas:

- Clinical Outcomes: Synthesizing meta-analytic evidence on the comparative efficacy of mobile apps versus automated SMS platforms for HbA1c reduction.
- Human-Technology Interplay: Evaluating how hybrid models, combining automated algorithms with human-led coaching, influence patient retention and adherence.
- Socio-Technical Challenges: Identifying structural, demographic, and ethical barriers, with emphasis on the digital divide, digital literacy, and data security.

3. Results

3.1. Effectiveness of E-Health-Based Interventions on Glycemic Control in Patients with Type 2 Diabetes

Synthesized meta-analytic evidence indicates that e-health interventions are effective tools for improving glycemic control in T2DM. Integrating digital health modalities leads to statistically significant reductions in HbA1c levels across diverse trial populations. The magnitude of glycemic reduction varies according to communication format and platform architecture. A Bayesian network meta-analysis demonstrated distinct outcome profiles across digital modalities (Zhang et al., 2023). Short message service (SMS) interventions achieved the highest relative efficacy in lowering HbA1c, yielding a mean difference (MD) of -0.56% (95% CI: -0.82 to -0.31) compared with usual care. Dedicated smartphone applications (SA) and multicomponent platforms (CM) combining several digital tools also produced significant reductions, with mean differences of -0.45% (95% CI: -0.61 to -0.30) and -0.41% (95% CI: -0.57 to -0.25), respectively. Conversely, static web platforms and routine phone calls produced smaller improvements. The strong performance of SMS interventions likely stems from their widespread accessibility, minimal technical requirements, and low user burden, which facilitate consistent integration into daily routines (Zhang et al., 2023).

These observations align with broader meta-analytic syntheses. In a comprehensive review of 118 randomized controlled trials ($n = 21,662$), digital health interventions produced overall HbA1c reductions ranging between -0.32% and -0.54% (Xue et al., 2025). Their analyses confirmed that dynamic, mobile delivery channels outperform static digital formats. Furthermore, software functionality directly shapes therapeutic impact, with smartphone applications featuring two-way communication between patients and facilitators yielding larger effect sizes, particularly among individuals with higher baseline HbA1c levels ($\geq 9\%$) (He et al., 2022).

Trial duration plays a key role in moderating these clinical gains. Across multiple reviews, pooled effect sizes tend to diminish over extended trial periods, reflecting declining patient engagement and software disuse over time. However, interpreting these aggregated outcomes requires caution due to substantial heterogeneity in software design, baseline metabolic risk, and follow-up schedules across individual trials.

3.2. Hybrid Care Models and the Human-Technology Interface: Patient Retention and Adherence

Although standalone mHealth platforms demonstrate clear short-term metabolic efficacy, their long-term clinical value is often limited by progressive user disengagement, frequently described as digital fatigue or intervention attrition. Automated reminders and static notifications tend to lose behavioural potency over time. Consequently, blended care frameworks that pair digital self-monitoring with human clinical support have become a primary focus in digital diabetes management.

High-level secondary evidence indicates that fully automated interventions yield more modest sustained clinical benefits when implemented without human oversight or structured feedback. Interactive systems that

incorporate bidirectional communication between patients and clinical facilitators consistently achieve larger effect sizes in reducing HbA1c and sustaining user involvement (He et al., 2022).

Real-world pilot data illustrate how human-led coaching can be operationalized within digital workflows. For example, a pilot study evaluated an mHealth platform pairing automated tracking features (blood glucose, physical activity, and weight) with structured coaching delivered by community pharmacists (Sze et al., 2023). Over a 12-week period, participants demonstrated marked increases in daily physical activity alongside significant reductions in HbA1c (from $8.58 \pm 1.02\%$ to $7.79 \pm 1.11\%$, $p = 0.0001$), while maintaining a high study retention rate (97.0%, $n = 33$). Although single-arm implementation studies cannot isolate the causal impact of human coaching from potential Hawthorne effects or novelty bias, they provide practical context showing how human support can enhance participant accountability and buffer against the attrition typical of purely automated software tools (Sze et al., 2023).

Taken together, synthesized reviews indicate that while automated mHealth platforms efficiently handle routine parameter logging and basic psychoeducation, embedding structured human coaching, delivered by nurses, pharmacists, or diabetes educators, is essential for sustaining long-term user engagement and treatment adherence in T2DM.

3.3. Socio-Technical Barriers: Digital Divide, Age Factors, and Data Privacy Concerns

Despite clinical benefits, real-world mHealth adoption remains constrained by structural and social challenges. Key barriers include disparities in digital health literacy, age-related usability friction, and persistent concerns regarding patient data privacy and security. Digital health literacy (DHL) is a critical determinant of user engagement. In a systematic review and meta-analysis of 8 studies ($n = 2,527$) across chronic disease populations, a pooled mean eHealth Literacy Scale (eHEALS) score of 27.03 (95% CI: 25.08–28.98) was reported, with diabetes cohorts averaging 27.79 (Zaghloul et al., 2025). While these scores suggest moderate baseline digital literacy, the study highlighted that uneven digital skills remain a key structural barrier to equitable access. DHL was heavily moderated by socio-demographic factors, including age, formal education level, employment status, and personal familiarity with online health resources (Zaghloul et al., 2025).

Age-related disparities pose a distinct challenge given the high prevalence of T2DM among older adults. Addressing this demographic, a meta-analysis of 7 RCTs ($n = 490$) demonstrated that mHealth applications yield meaningful glycemic improvements in older populations (Hedges' $g = -0.40$, 95% CI: -0.75 to -0.06) (Azevedo et al., 2025). However, the analysis also revealed that intervention efficacy declined as trial duration extended, highlighting distinct usability and engagement decay challenges among older demographics over multi-month horizons (Azevedo et al., 2025).

Finally, patient perceptions of data confidentiality, cybersecurity, and server integrity present major psychological barriers to technology adoption. Synthesizing qualitative and quantitative data across 33 studies, widespread user apprehension regarding potential health data breaches was observed (Alhammad et al., 2024). Privacy concerns were most pronounced among older individuals, patients with past experiences of security breaches, and users in higher income brackets. Conversely, concerns decreased when patients understood how their data was protected or when using platforms that allowed anonymized tracking. Key facilitators to user trust included strong data encryption, transparent data governance policies, and options to suppress explicit medical terms from push notifications (Alhammad et al., 2024). Equitable mHealth deployment requires bridging socio-demographic gaps in digital literacy, mitigating engagement decay, and establishing transparent, patient-centered data privacy safeguards.

4. Discussion

4.1. Principal Findings and Key Determinants of mHealth Success

This narrative review indicates that while mHealth technologies are effective adjuncts to T2DM care, their clinical utility depends heavily on platform architecture, user engagement patterns, and broader socio-technical contexts. Rather than functioning as a uniform intervention, mHealth tools display varying effectiveness based on specific software design features and their integration within established clinical workflows.

A central finding of this synthesis is the limited long-term durability of fully automated digital tools. Purely automated platforms, providing standalone educational content or basic tracking, achieve modest short-

term HbA1c reductions and encourage early self-monitoring behaviors. However, their efficacy frequently wanes over extended periods. As observed across demographic subgroup analyses, intervention attrition and software disuse represent major operational bottlenecks in continuous digital care (Azevedo et al., 2025). Static reminders and generic alerts rapidly lose behavioural potency without dynamic personalization.

The substantial heterogeneity observed across meta-analytic outcomes likely reflects differences in baseline HbA1c levels, follow-up timelines, software usability, and the degree of human oversight. Interpreting these findings highlights several core characteristics of successful mHealth interventions. First, personalizing platform features through behavioral frameworks, such as Social Cognitive Theory, improves retention by tailoring feedback to individual patient capabilities (Sze et al., 2023). Second, combining digital tools with structured clinical support, such as pharmacist- or nurse-led coaching, provides the interpersonal accountability required to maintain multi-month adherence (Sze et al., 2023). Finally, multi-parametric tracking systems capable of concurrently monitoring blood glucose, physical activity, weight, and blood pressure offer broader metabolic benefits than single-function applications.

4.2. Clinical, Practical, and Policy Implications

These findings point to a necessary shift in how digital therapeutics are integrated into clinical practice. mHealth tools should not be viewed as standalone replacements for professional care, but rather as supportive infrastructure designed to extend clinical oversight into patients' daily lives. Healthcare providers should select and prescribe validated mHealth platforms tailored to individual digital readiness. Moreover, clinical workflows must evolve to capture and review continuous patient-generated health data during routine consultations, enabling timely medication adjustments and lifestyle recommendations.

At policy and structural levels, overcoming socio-technical barriers is essential to prevent digital therapeutics from worsening existing health disparities. Because low digital health literacy and usability challenges remain major obstacles, particularly among older adults, software developers and health system leaders must prioritize gerontechnology-informed design. This requires intuitive interfaces, customizable visual displays, and simplified data entry. Addressing privacy concerns also requires transparent data governance. Policies must ensure health data encryption and allow users control over notification content to avoid unintended medical disclosures. Health systems should also consider incorporating digital literacy training into standard diabetes self-management education (DSME) programs.

4.3. Resource Allocation, Workload, and Cost-Effectiveness of Hybrid Models

While blended care models demonstrate superior patient retention and clinical engagement compared to standalone software, their real-world implementation introduces important resource and operational considerations. Incorporating human clinicians, such as clinical pharmacists, specialized nurses, or diabetes educators, into digital communication loops requires dedicated personnel time, structured administrative workflows, and ongoing funding.

In resource-constrained healthcare systems, continuous human monitoring risks exacerbating clinician burnout and increasing overall operational expenditures. As highlighted by global digital health frameworks, scaling hybrid care requires rigorous evaluation of cost-effectiveness and workforce allocation (World Health Organization, 2021). Health systems must determine optimal staffing ratios and identify which patient subgroups benefit most from intensive human coaching versus automated support. For instance, risk-stratified care protocols could route high-risk individuals, such as those with baseline HbA1c $\geq 9\%$ or frequent severe hypoglycemia, to intensive blended care, while lower-risk patients use automated, algorithmically personalized tools. Without clear economic evaluation and strategic resource allocation, the operational demands of blended care models may hinder their long-term sustainability and widespread adoption in routine clinical practice.

4.4. Artificial Intelligence and Machine Learning: The Next Frontier in Personalised mHealth

As digital health transitions from static tracking tools to dynamic behavioral engines, the integration of Artificial Intelligence (AI) and Machine Learning (ML) represents a pivotal evolutionary step in diabetology. Conventional mHealth tools often suffer from static alert fatigue and rigid algorithmic rules, which contribute to progressive user disengagement (He et al., 2022). AI methods, specifically machine learning algorithms combined with mobile computing and sensor technologies, overcome these constraints by evaluating multi-parametric streams of patient-generated health data (PGHD) to support blood glucose prediction, adverse event prevention, and clinical decision support (Contreras & Vehi, 2018).

Furthermore, the key applications of AI in healthcare revolve around clinical decision support, diagnostic assistance, and enhancing patient engagement and adherence (Davenport & Kalakota, 2019). By shifting from generic text messaging to adaptive, context-aware interactions, AI-driven mHealth platforms can simulate personalized coaching presence, mitigating intervention attrition without overburdening human clinical workflows (Davenport & Kalakota, 2019). However, implementing AI in routine diabetes self-management introduces complex non-technical and systemic challenges. As highlighted in literature reviews, ethical concerns regarding automated decision-making, data privacy vulnerabilities, and implementation barriers will likely prevent full automation, reinforcing the necessity of human-in-the-loop hybrid models within clinical governance frameworks (Contreras & Vehi, 2018; Davenport & Kalakota, 2019).

5. Limitations

Several methodological limitations of this narrative review must be noted. First, as a narrative synthesis rather than a quantitative systematic review or meta-analysis, this study did not perform independent pooling of primary data. The conclusions rely on the aggregated statistical reporting of the included meta-analyses and systematic reviews.

Second, substantial methodological heterogeneity existed across the synthesized secondary literature. Included trials displayed wide variations in software features, follow-up durations, baseline HbA1c levels, background pharmacological treatments, and co-intervention strategies. High statistical heterogeneity across pooled meta-analytic models indicates that mHealth efficacy is context-dependent, limiting the direct generalizability of pooled effect sizes across all clinical settings.

Third, several included meta-analyses contained mixed populations of Type 1 and Type 2 diabetes patients, presenting T2DM outcomes primarily within subgroup analyses. This structural overlap limits the precision of estimates presented as specific to T2DM. Additionally, because the included meta-analyses shared search windows and thematic scopes, individual primary RCTs were likely included in multiple meta-analytic pools. Without a formal citation overlap analysis, such as calculating the Corrected Covered Area, convergent meta-analytic findings should be interpreted as consistent, reinforcing evidence rather than fully independent replications.

Fourth, implementation evidence illustrating blended care workflows relied partly on small-scale, single-arm pilot studies (Sze et al., 2023). Because these observational illustrations lacked unexposed control groups, observed engagement metrics cannot be causally isolated from potential Hawthorne effects or temporary enthusiasm for novel software tools.

Finally, the secondary literature regarding socio-technical barriers, specifically digital health literacy and data privacy perceptions, is predominantly observational or cross-sectional. Long-term longitudinal studies evaluating how digital literacy interventions or privacy enhancements directly impact hard metabolic outcomes over multi-year periods remain sparse.

6. Conclusions

This narrative review demonstrates that mHealth applications are effective adjuncts to standard Type 2 Diabetes Mellitus management. Across synthesized meta-analyses, mobile interventions consistently achieve clinically meaningful reductions in HbA1c alongside improvements in patient self-monitoring. However, overall therapeutic utility depends heavily on platform architecture, long-term user engagement, and structural integration into routine clinical care. Fully automated platforms often suffer from user attrition over time, limiting their long-term efficacy when deployed without ongoing clinical support.

To achieve sustained clinical benefits, future mHealth strategies should emphasize adaptive personalization, multi-parametric parameter tracking, and blended care models that pair automated tools with structured human coaching. Addressing socio-technical barriers, including digital health literacy gaps, age-related usability friction, and data privacy concerns, remains critical to ensure equitable and sustainable technology adoption.

Future Research Directions

To advance digital therapeutics in T2DM care, future research should focus on:

- **Evaluating Two-Way Communication:** Conducting randomized controlled trials comparing the clinical and behavioral impacts of real-time bidirectional messaging versus automated unidirectional feedback.
- **Validating Blended Care Scale and Economics:** Running large-scale, multi-center trials to assess the causal impact, long-term cost-effectiveness, and staffing efficiency of human-in-the-loop coaching models relative to fully automated systems.
- **Assessing Socio-Technical Interventions:** Executing longitudinal studies to quantify how gerontechnology-informed design, digital literacy training, and transparent data safeguards influence multi-year technology retention and glycemic control.
- **Optimizing Multi-Parametric Features:** Identifying specific feature combinations, such as concurrent tracking of glucose, physical activity, weight, and blood pressure, that maximize metabolic benefits while minimizing patient burden.

REFERENCES

1. Alhammad, N., Alajlani, M., Abd-Alrazaq, A., Epiphaniou, G., & Arvanitis, T. (2024). Patients' perspectives on the data confidentiality, privacy, and security of mHealth apps: Systematic review. *Journal of Medical Internet Research*, 26, 1–20. <https://doi.org/10.2196/50715>
2. Azevedo, R. F. L., Varzino, M., Steinman, E., & Rogers, W. A. (2025). Evaluating effectiveness of mHealth apps for older adults with diabetes: Meta-Analysis of randomized controlled trials. *Journal of Medical Internet Research*, 27, 1–17. <https://doi.org/10.2196/65855>
3. Baethge, C., Goldbeck-Wood, S., & Mertens, S. (2019). SANRA—a scale for the quality assessment of narrative review articles. *Research Integrity and Peer Review*, 4(1), 5. <https://doi.org/10.1186/s41073-019-0064-8>
4. Contreras, I., & Vehi, J. (2018). Artificial intelligence for diabetes management and decision support: Literature review. *Journal of Medical Internet Research*, 20(5), 1–21. <https://doi.org/10.2196/10775>
5. Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. *Future Healthcare Journal*, 6(2), 94–98. <https://doi.org/10.7861/futurehosp.6-2-94>
6. Davies, M. J., Aroda, V. R., Collins, B. S., Gabbay, R. A., Green, J., Maruthur, N. M., Rosas, S. E., Del Prato, S., Mathieu, C., Mingrone, G., Rossing, P., Tankova, T., Tsapas, A., & Buse, J. B. (2022). Management of hyperglycemia in type 2 diabetes, 2022. *A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD)*. *Diabetes Care*, 45(11), 2753–2786. <https://doi.org/10.2337/dci22-0034>
7. ElSayed, N. A., McCoy, R. G., Aleppo, G., Balapattabi, K., Beverly, E. A., Briggs Early, K., Bruemmer, D., Ebekozien, O., Echouffo-Tcheugui, J. B., Ekhlaspour, L., Gaglia, J. L., Garg, R., Khunti, K., Lal, R., Lingvay, I., Matfin, G., Pandya, N., Pekas, E. J., Pilla, S. J., ... Bannuru, R. R. (2025). 2. *Diagnosis and Classification of Diabetes: Standards of Care in Diabetes—2025*. *Diabetes Care*, 48(Supplement_1), S27–S49. <https://doi.org/10.2337/dc25-S002>
8. Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., A'Court, C., Hinder, S., Fahy, N., Procter, R., & Shaw, S. (2017). 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*, 19(11). <https://doi.org/10.2196/jmir.8775>

9. He, Q., Zhao, X., Wang, Y., Xie, Q., & Cheng, L. (2022). Effectiveness of smartphone application-based self-management interventions in patients with type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials. *Journal of Advanced Nursing*, 78(2), 348–362. <https://doi.org/10.1111/jan.14993>
10. International Diabetes Federation. (2025). IdF diabetes atlas (11th ed.). <https://diabetesatlas.org/>
11. Khunti, K., Gomes, M. B., Pocock, S., Shestakova, M. V., Pintat, S., Fenici, P., Hammar, N., & Medina, J. (2018). Therapeutic inertia in the treatment of hyperglycaemia in patients with type 2 diabetes: A systematic review. *Diabetes, Obesity and Metabolism*, 20(2), 427–437. <https://doi.org/10.1111/dom.13088>
12. Kruse, C. S., Frederick, B., Jacobson, T., & Monticone, D. K. (2017). Cybersecurity in healthcare: A systematic review of modern threats and trends. *Technology and Health Care*, 25(1), 1–10. <https://doi.org/10.3233/THC-161263>
13. Shariful Islam, S. M., Mishra, V., Siddiqui, M. U., Moses, J. C., Adibi, S., Nguyen, L., & Wickramasinghe, N. (2022). Smartphone apps for diabetes medication adherence: Systematic review. *JMIR Diabetes*, 7(2), 1–14. <https://doi.org/10.2196/33264>
14. Sun, S., Simonsson, O., McGarvey, S., Torous, J., & Goldberg, S. B. (2024). Mobile phone interventions to improve health outcomes among patients with chronic diseases: An umbrella review and evidence synthesis from 34 meta-analyses. *The Lancet Digital Health*, 6(11), e857–e870. [https://doi.org/10.1016/S2589-7500\(24\)00119-5](https://doi.org/10.1016/S2589-7500(24)00119-5)
15. Sze, W. T., Waki, K., Enomoto, S., Nagata, Y., Nangaku, M., Yamauchi, T., & Ohe, K. (2023). StepAdd: A personalized mHealth intervention based on social cognitive theory to increase physical activity among type 2 diabetes patients. *Journal of Biomedical Informatics*, 145(February), 104481. <https://doi.org/10.1016/j.jbi.2023.104481>
16. World Health Organization. (2021). Global strategy on digital health 2020–2025. <https://www.who.int/publications/i/item/9789240020924>
17. Xue, H., Zhang, L., Shi, Y., Zhang, H., Zhang, C., Liu, Y., Tan, W., & Liu, Y. (2025). The effectiveness of digital health intervention on glycemic control and physical activity in patients with type 2 diabetes: A systematic review and meta-analysis. *Frontiers in Digital Health*, 7(July), 1–13. <https://doi.org/10.3389/fdgth.2025.1630588>
18. Zaghloul, H., Fanous, K., Ahmed, L., Arabi, M., Varghese, S., Omar, S., Al-Najjar, Y., El-Khoury, R., Gray, J., Rakab, A., & Arayssi, T. (2025). Digital health literacy in patients with common chronic diseases: Systematic review and Meta-Analysis. *Journal of Medical Internet Research*, 27, 1–12. <https://doi.org/10.2196/56231>
19. Zhang, X., Zhang, L., Lin, Y., Liu, Y., Yang, X., Cao, W., Ji, Y., & Chang, C. (2023). Effects of e-health-based interventions on glycemic control for patients with type 2 diabetes: A bayesian network meta-analysis. *Frontiers in Endocrinology*, 14(May), 1–11. <https://doi.org/10.3389/fendo.2023.1068254>