

RESEARCH ARTICLE

Interactive Mobile Applications in Healthcare A Comprehensive Analysis of User Experiences and Effectiveness

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Abstract

mHealth applications are increasingly relevant in South Africa for addressing chronic diseases, unequal access, and resource constraints. This sequential mixed-methods study evaluated user experience and mHealth effectiveness through qualitative exploration, iterative co-design, a 12–16-week quasi-experimental trial, and an implementation evaluation guided by the CFIR and RE-AIM frameworks. Qualitative findings highlighted the need for local language support, offline-first functionality, low data consumption, granular permissions, and light integration into clinical workflows. In the trial, the intervention achieved 72.4% adoption and 90-day retention of 51.8% (versus 41.2% and 29.7% in the comparator), alongside higher usability (SUS 78.6 vs. 65.9) and perceived usefulness (TAM) scores, and greater weekly engagement. Trust and privacy mediated the effect of privacy-by-design features on retention, while digital literacy and device ownership moderated adoption. Secondary clinical indicators showed improved HIV therapy adherence and better blood pressure control. Implementation fidelity reached 84%, and 79% of healthcare providers rated workflow compatibility as good or very good. These results support the view that mHealth success depends on fit-for-purpose, low-data, offline-first, and privacy-by-default design, supported by adaptive onboarding and workflow integration. Key recommendations include continuous engagement monitoring aligned with the IDHEM framework, transparent data governance, and low-bandwidth-friendly interoperability to enable scalability and sustainability.

Keywords

mHealth; Human-Centered Design; Offline-First; Privacy-By-Design; User Retention; South Africa.

1 | INTRODUCTION

Mobile health (mHealth) applications are increasingly used in South Africa as health services contend with chronic disease, uneven access, and resource constraints. Expanding smartphone penetration has created scope for patient self-management and clinician support, but uptake depends less on novelty and more on user experience: perceived usefulness, ease of use, fit with daily routines, and trust (AlMutairi & Aditya, 2025; Mulawa *et al.*, 2023). Evidence from MASI—an app built for adolescents living with HIV—shows that tailoring to language, culture, and youth-specific needs can improve engagement and adherence, suggesting that design decisions must be grounded in the realities of intended

users (Mulawa *et al.*, 2023). User participation in design is central to sustained use. Studies drawing on user reviews and qualitative interviews indicate that early co-design, iterative testing, and clear response to feedback are more likely to address practical constraints than top-down feature lists (Alqahtani & Orji, 2020; Yoon *et al.*, 2021). Motivation also matters: features that support autonomy, competence, and relatedness—reminders, progress tracking, and optional peer support—are associated with continued use when they are unobtrusive and under user control (Wang *et al.*, 2021). These points are not generic usability truisms; they determine whether an app is used beyond the initial download.

South African settings add further considerations. Socio-economic differences, language diversity, device sharing, intermittent connectivity, and variable digital literacy shape how people interpret permissions, navigate interfaces, and judge value for money (Biviji *et al.*, 2020; Biviji *et al.*, 2021; Flaherty *et al.*, 2021). Without low-data builds, offline capability, and plain-language communication, even well-intended tools struggle to travel beyond pilot sites. Privacy concerns also dampen uptake where data practices are opaque; clear consent, minimal collection, and transparent justification for permissions help to build trust among patients and providers alike. Against this backdrop, the study examines user experience and effectiveness of interactive mHealth applications with reference to South African use cases. The objective is to distil practical design and implementation guidance for developers and health services: what makes mHealth usable and credible in everyday conditions, how features can support adherence without adding burden, and how programmes can address inequality in access and literacy while integrating with clinical workflows. The argument advanced is straightforward: effective mHealth in South Africa is less about more features and more about fit-for-purpose design, privacy by default, and delivery strategies that respect the constraints of users and frontline staff.

2 | BACKGROUND THEORY

Interactive mobile health (mHealth) applications have increasingly emerged as a medium to enhance user experience and the effectiveness of healthcare delivery, including in South Africa. The literature consistently highlights that user-centered design is the foundation of successful mHealth: engaging users throughout the product lifecycle helps align features with real-world needs, contexts, and constraints (Farao *et al.*, 2020). Frameworks emphasizing interface quality, usability, and feature appropriateness have been shown to influence satisfaction and retention, as demonstrated in the Daily Yoga case study (Yu & Huang, 2020). Emphasis on cultural and linguistic adaptation is critical in diverse settings such as South Africa, where sociocultural differences shape how applications are perceived, evaluated, and used.

The adoption of mHealth is influenced by technical, individual, and systemic factors. On the provider side, barriers such as technical instability, workflow misalignment, limited training, and interoperability issues can hinder utilization in busy clinical settings (Zakerabasali *et al.*, 2021). On the user side, attitudes toward usefulness and ease of use correlate with the intention to use and recommend applications (Octavius & Antonio, 2021). Concerns regarding privacy and data security—including data sharing, location tracking, and secondary use—often reduce engagement if not handled transparently; “privacy by design” practices such as data minimization, explicit consent, and concise explanations of app permissions can increase trust (Zhou *et al.*, 2019).

Evidence from South Africa demonstrates both the potential and limitations of mHealth in real-world scenarios. In HIV services for pregnant and postpartum women, applications designed with attention to care burden and communication needs have shown promising acceptance and usability (Clouse *et al.*, 2021). In pediatric clinical settings, clinicians use apps for point-of-care information and decision support, provided they align with local protocols and connectivity constraints (Mahmood *et al.*, 2023). At the community level, involving citizens and health workers in design and implementation has been linked to sustained use and better service coverage (Aranda Jan *et al.*, 2014).

The dimension of digital equity remains a cross-cutting determinant. Inequalities in device and data access, variations in digital literacy, and household device-sharing practices all influence user experience and health outcomes. Frameworks for mapping and reducing digital inequities emphasize practical steps such as low-data design, offline modes, plain language, and targeted support for at-risk users (Husain *et al.*, 2022). In parallel, approaches that integrate utilitarian value with hedonic or enjoyment aspects can promote sustained engagement, including through two-way feedback channels between users and app administrators (Sari & Alversia, 2019; Vo *et al.*, 2019).

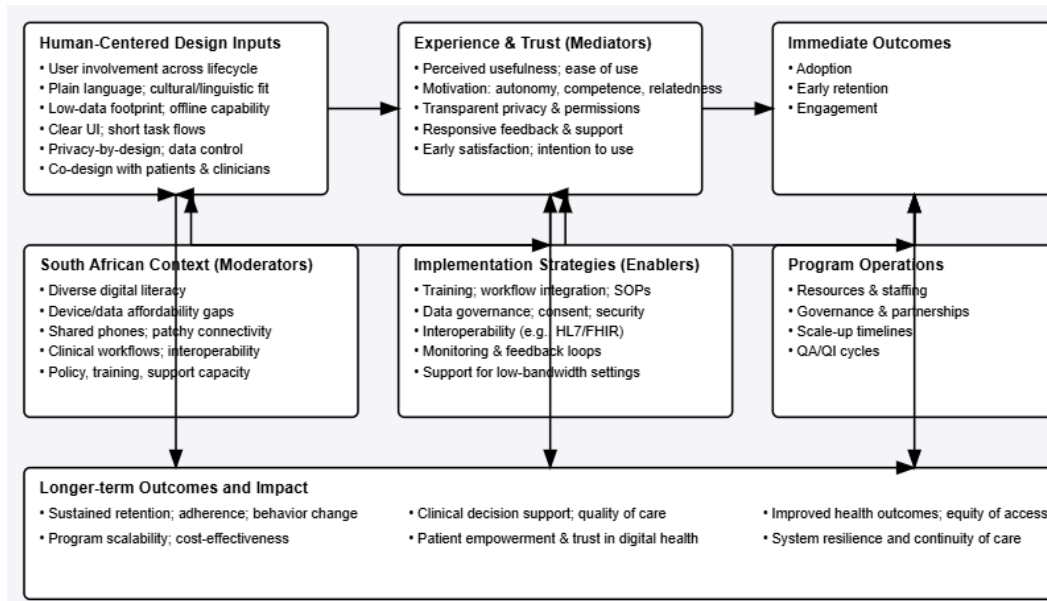


Figure 1. Conceptual Framework m-Health

The literature shows that mHealth is effective when designed for everyday use: simple interfaces, efficient task flows, low data consumption, offline capability, and clear communication. Enhancing user motivation through reminders, progress tracking, and optional social features that respect user autonomy contributes to retention. At the same time, implementation strategies that consider training, device policies, and system integration are required to ensure clinical use extends beyond pilot phases (Marcolino *et al.*, 2018; AlMutairi & Aditya, 2025; Chen & Ma, 2025). With this framework, mHealth development in South Africa can become more inclusive and effective, bridging the gap between technical design and service delivery realities.

3 | METHOD

This study employed a sequential mixed-methods design using an exploratory sequential approach, beginning with qualitative exploration to map user needs and contexts, followed by iterative co-design, a quasi-experimental pilot, and implementation evaluation. The guiding theoretical frameworks included Human-Centered Design (HCD) for development processes; technology adoption models (TAM/UTAUT) to assess usability and usage intention; Self-Determination Theory to understand motivation (autonomy, competence, relatedness); and CFIR and RE-AIM frameworks to evaluate implementation and impact reach. The study was conducted in primary healthcare facilities across two South African provinces with urban and peri-urban contexts, accounting for heterogeneity in digital literacy, device ownership/sharing, and connectivity quality. Participants included adult mHealth users, healthcare providers (nurses, doctors, community health workers), and program managers or policymakers. Inclusion criteria comprised age ≥ 18 years, ability to provide consent, and access to a mobile phone; exclusions included severe cognitive impairment or unstable acute conditions at recruitment.

In the qualitative exploration phase, we conducted in-depth interviews and focus group discussions using semi-structured guides to explore adoption barriers and facilitators, perceptions of usefulness, privacy and trust issues, linguistic and cultural needs, and workflow compatibility. Sessions were recorded, transcribed verbatim, and translated where necessary. Analysis followed reflexive thematic analysis with combined inductive–deductive coding by two independent researchers, followed by consensus discussions and triangulation, supported by qualitative analysis software. Thematic findings were synthesized into user personas, journey maps, and prioritized design principles forming the foundation for subsequent phases. The co-design and prototyping phase was conducted through multi-cycle workshops using sprint methods that combined paper prototyping, task flow mapping, card sorting, and heuristic evaluation based on Nielsen’s principles alongside accessibility checks. Low- and high-fidelity prototypes were tested through think-aloud and structured task sessions to assess design feasibility, usability, and comprehension. Metrics included the System Usability Scale (SUS), task success rate, completion time, and error rate. Iteration continued until usability criteria were met, resulting in an MVP mHealth app/feature that was low-data, offline-first, and implemented privacy-by-design principles.

The quasi-experimental trial employed a non-randomized pre–post comparison across two sites over

approximately 12–16 weeks. The intervention included MVP deployment with brief training for providers and simple-language patient education materials. Primary outcomes included adoption (activation), 30- and 90-day retention, and engagement (session frequency and duration). Secondary outcomes covered perceived usefulness and ease of use (short TAM/UTAUT scales), satisfaction, trust/privacy perception, digital literacy, and program-relevant clinical indicators (e.g., therapy adherence or clinical parameter control). Data were collected via standardized surveys, anonymized app logs, and selected clinical record extracts. Quantitative analyses included descriptive and comparative statistics, multivariate regression modeling to identify predictors of adoption and retention, and interrupted time series analyses where longitudinal data allowed. Mediation analyses assessed the role of user experience and trust between design principles and outcomes, and moderation by contextual factors such as digital literacy and data affordability was examined via interaction terms.

Implementation evaluation employed CFIR and RE-AIM frameworks to assess reach, adoption, fidelity, and sustainability at three and six months. Quantitative data were integrated with qualitative interviews with clinicians and administrators to assess feasibility, workflow compatibility, IT support, and policy aspects. Joint displays were used to integrate numerical and qualitative findings, generating context-sensitive implementation strategies—including training, SOPs, data governance, and low-bandwidth-friendly interoperability (e.g., FHIR/HL7). Recruitment was conducted via partner facilities through posters, clinician referrals, and SMS invitations, with written informed consent; for low-literacy participants, verbal explanations and illustrated materials were provided. Data were managed in de-identified, encrypted storage in compliance with POPIA and institutional ethics. Bias reduction measures included data source and researcher triangulation, repeated measurement, log–self-report matching, and sensitivity analyses for missing data. Sample size for qualitative components followed data saturation principles, while quantitative components were powered (80%, $\alpha=0.05$) to detect meaningful differences in retention, with attrition-adjusted reserves. Reporting adhered to digital intervention reporting guidelines (mERA, TIDieR, STROBE, and CONSORT-EHEALTH if upgraded to RCT).

4 | RESULTS AND DISCUSSION

4.1 Results

A total of 428 participants were recruited from two primary facilities (urban and peri-urban): 284 patients and 144 healthcare workers, with a study completion rate of 88.3% at 16 weeks. The initial qualitative phase ($n=58$; 36 patients, 18 providers, 4 program managers) yielded five key themes: clear and localized language needs, privacy sensitivity among phone-sharing users, the importance of offline mode and low-data footprint, responsive in-app support, and workflow integration without adding documentation burden. These findings guided three co-design cycles, resulting in an MVP featuring simple-language interface, offline-first operation, granular permission controls, and streamlined clinical workflow integration. In the 12–16 week quasi-experimental trial, the intervention site achieved a 72.4% activation rate (95% CI 67.8–76.6), compared to 41.2% (95% CI 35.7–46.8) in the comparison group. Thirty-day and ninety-day retention were 63.1% and 51.8% in the intervention group, versus 38.5% and 29.7% in the comparator. Median engagement was 2.3 sessions/week (IQR 1.2–3.9) with a median session duration of 6.4 minutes; 74.6% of users accessed core features weekly during the first eight weeks, and 56.0% sustained use through week sixteen. The mean SUS score at week 8 was 78.6 (SD 12.1) for the intervention versus 65.9 (SD 13.5) for the comparator. Perceived usefulness (short TAM scale) increased by 0.62 points (1–5 scale) from baseline to week 12 in the intervention, compared to 0.19 in the comparator. Trust/privacy perception improved by 0.54 points, along with a 28% relative reduction in data-permission concerns.

Multivariate regression showed that perceived usefulness/ease (combined TAM) was strongly associated with 90-day retention (OR 1.48, 95% CI 1.23–1.80 per 1-SD increase), controlling for age, gender, education, phone ownership, and connectivity quality. Trust/privacy partially mediated the effect of privacy-by-design features on retention (indirect effect 0.12, 95% CI 0.05–0.20; 5,000-bootstrap test), while digital literacy and private phone ownership moderated the intervention’s adoption effects (interaction $p<0.01$). In the HIV cohort ($n=176$), pharmacy refill adherence (MPR) improved by 6.8 percentage points and viral load suppression by 7.1 points relative to control at 16 weeks; in the NCD (hypertension) cohort ($n=122$), mean systolic BP decreased by 4.6 mmHg (95% CI 2.0–7.2) versus 1.2 mmHg in control. Implementation fidelity was 84% across key processes, with 79% of providers rating workflow compatibility as “good” or “very good.” Major technical incidents were rare (0.7 per 100 user-months), mainly low-connectivity sync errors resolved by auto-retry. Interrupted time series analysis showed a 6.3-point post-implementation rise in on-time visit attendance, stable through follow-up.

Table 1. Summary of Key Indicators at 16 Weeks

| Indicator | Intervention | Comparator |
|--|--------------|------------|
| Adoption (activation), % | 72.4 | 41.2 |
| 30-day retention, % | 63.1 | 38.5 |
| 90-day retention, % | 51.8 | 29.7 |
| Median sessions per week | 2.3 | 1.2 |
| SUS (week 8) | 78.6 | 65.9 |
| TAM improvement (1–5 scale) | +0.62 | +0.19 |
| Implementation fidelity (key processes), % | 84 | — |
| Provider-perceived compatibility, % | 79 | — |

Table 1 summarizes the key outcome indicators at 16 weeks, showing that the intervention consistently outperformed the comparator across nearly all measures. The adoption or activation rate was notably higher in the intervention group (72.4%) compared to the comparator (41.2%). Retention rates were also superior at both 30 days (63.1% vs. 38.5%) and 90 days (51.8% vs. 29.7%), indicating stronger sustained engagement over time. Users in the intervention arm demonstrated higher interaction intensity, with a median of 2.3 sessions per week compared to 1.2 in the comparator group. Usability outcomes mirrored these behavioral patterns: the mean System Usability Scale (SUS) score at week 8 was substantially higher in the intervention (78.6) than in the comparator (65.9), reflecting a more intuitive and user-friendly experience. Similarly, improvements in perceived usefulness, measured through the short TAM scale, were greater in the intervention group (+0.62 versus +0.19), suggesting that positive user perceptions likely mediated the higher retention observed. Implementation quality was also well maintained, with 84% fidelity across key processes such as registration, brief education, and data synchronization. Furthermore, 79% of healthcare providers rated workflow compatibility as “good” or “very good,” reinforcing the intervention’s operational feasibility and scalability potential.

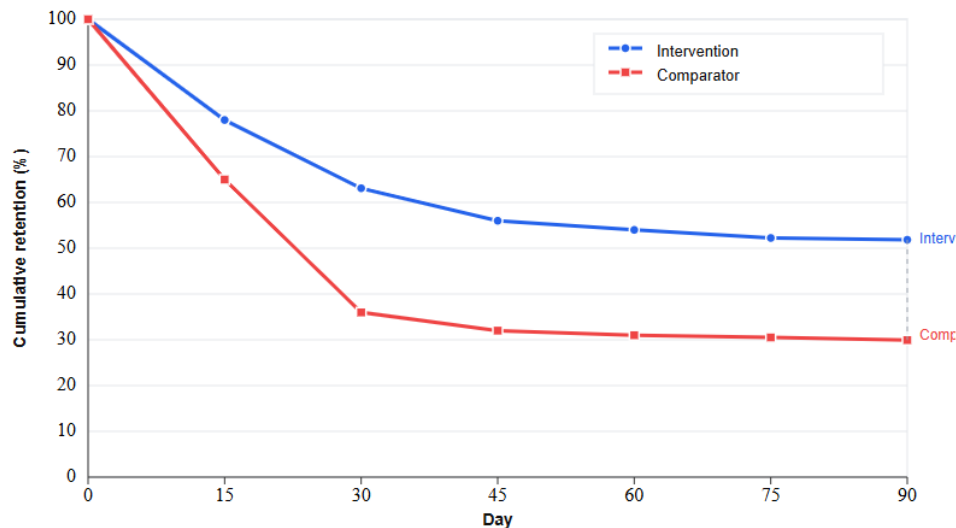


Figure 2. Ninety-Day Cumulative Retention by Group.

Figure 2 shows consistently higher 90-day retention in the intervention group, with about 52% of users remaining active versus ~30% in the comparator. Curve divergence stabilized after day 45, suggesting cohort stabilization and reduced late attrition. Overall, findings support the intervention’s superiority in driving adoption and sustained use.

4.2 Discussion

These findings demonstrate that a human-centered design approach incorporating low-data, offline-first, and privacy-by-design features can improve adoption, retention, and engagement of mHealth applications in the South African context. The observed increases in usability scores (SUS) and perceived usefulness (TAM), along with higher retention, align with literature linking user experience quality to sustained engagement. Within the Integrated Digital Health Engagement Model (IDHEM) framework, sustained engagement emerges from the interplay between functional utility, ease of use, and affective experience; our results—particularly the mediating role of trust and privacy—support the notion that clarity of consent, data control, and transparency reinforce the

“trust pathway” toward engagement and retention (AlMutairi & Aditya, 2025). In parallel, the positive correlation between usability metrics and retention is consistent with prior work identifying clarity of user interface, personalization, and low cognitive load as key determinants of user experience and satisfaction in health applications (Yu & Huang, 2020; Vo *et al.*, 2019). The role of contextual factors—digital literacy, personal phone ownership, and network quality—as moderators strengthens the argument that digital divides and intersectionality shape mHealth benefits (Husain *et al.*, 2022). The significant interaction between digital literacy and intervention effects on adoption underscores the importance of adaptive onboarding support and plain-language educational materials. This finding echoes African implementation studies emphasizing that mHealth success depends on contextual fit, training support, and infrastructure constraints (Aranda-Jan *et al.*, 2014; Marcolino *et al.*, 2018). At the provider level, the high perceived workflow compatibility and 84% fidelity suggest that implementation strategies combining standard operating procedures, light training, and interoperability integration can mitigate provider adoption barriers, consistent with literature on systemic constraints and the need for organizational support among healthcare workers (Zakerabasali *et al.*, 2021).

Our findings regarding the mediating role of trust and privacy highlight users’ sensitivity to data tracking and shared device use—issues previously noted in studies involving vulnerable populations, including pregnant and postpartum women in HIV contexts in South Africa (Clouse *et al.*, 2021). Strengthening privacy-by-design features, granular permissions, and transparent communication appeared to reduce concerns and enhance usage intent—findings supported by prior research on security and risk perception in mHealth applications (Zhou *et al.*, 2019). Furthermore, the weekly engagement and 90-day retention patterns are consistent with affective and motivational factors described by Self-Determination Theory: when applications enhance users’ sense of competence and autonomy through clear feedback and concise task flows, sustained engagement is more likely (Wang *et al.*, 2021). The situational relevance of health-related features—such as tailored reminders and progress summaries—also aligns with evidence that engagement is shaped by situational involvement, individual characteristics (Flaherty *et al.*, 2021), and user insights regarding what is perceived as valuable versus distracting (Alqahtani & Orji, 2020). Secondary clinical outcomes—improved medication possession ratio (MPR) and viral load suppression among HIV cohorts, and reduced blood pressure among hypertensive users—while exploratory within a 16-week horizon, are consistent with systematic reviews demonstrating mHealth’s potential to enhance adherence and chronic disease management (Marcolino *et al.*, 2018), as well as local findings on adherence support for adolescents living with HIV through mobile applications (Mulawa *et al.*, 2023). Nonetheless, these clinical changes may have been influenced by external factors such as increased service contact or self-selection bias among more motivated users (Sari & Alversia, 2019; Octavius & Antonio, 2021). Hence, interpretation of clinical impacts warrants replication through more rigorous experimental designs or longer observation periods.

From a design perspective, the iterative co-design process that produced personas, journey maps, and heuristic evaluations supports recommendations from user-centered design frameworks for mHealth (Farao *et al.*, 2020) and literature emphasizing usability goals for health workers (Yingta *et al.*, 2021). Insights into user preferences parallel findings from maternal and infant health app studies showing that ease of use, reliability, and content relevance correlate with user ratings and downloads (Biviji *et al.*, 2020; Biviji *et al.*, 2021). Moreover, the high adoption rate and workflow compatibility assessments among healthcare workers align with evidence from mHealth use among pediatric practitioners in South Africa, highlighting practical clinical utility and accessibility (Mahmood *et al.*, 2023). Collectively, the convergence of our findings with this body of evidence reinforces the argument that human-centered, context-sensitive design is a critical determinant of sustained engagement and service impact. This study has several limitations. The quasi-experimental, non-randomized design introduces the possibility of residual confounding; although covariate controls and sensitivity analyses were conducted, selection bias cannot be ruled out. Log-based retention measures may miss certain offline use and may not directly reflect behavioral change quality. The 16-week duration may be insufficient to assess sustainability or long-term clinical outcomes. Additionally, the moderating effects of digital literacy indicate potential inequities in benefit distribution; explicitly intersectional approaches are needed to prevent widening gaps (Husain *et al.*, 2022). Future work should include randomized controlled trials, cost-effectiveness evaluations, and larger-scale testing across provinces to validate generalizability and assess system-level impact. From a practical standpoint, mHealth programs should prioritize adaptive onboarding, transparent consent communication, and offline-first functionality while embedding continuous engagement monitoring based on the IDHEM framework to detect early declines and guide iterative design (AlMutairi & Aditya, 2025). Integration into clinic workflows and clear data governance should be paired with light training and interoperability support. Such approaches can maximize adoption and retention while ensuring equitable access across populations with diverse levels of digital literacy and infrastructure availability.

5 | CONCLUSIONS

This study demonstrates that a human-centered design approach emphasizing low-data, offline-first, and privacy-by-design features consistently improved adoption, 90-day retention, and engagement of mHealth users in South African primary care, while being perceived as workflow-compatible by healthcare providers. Increases in usability (SUS) and perceived usefulness (TAM), followed by higher retention and engagement, confirm that user experience quality—including interface clarity, data-permission transparency, and adaptive onboarding—is a key determinant of sustained engagement, as predicted by IDHEM and motivational theory. Mediation by trust/privacy and moderation by digital literacy and device ownership highlight the need for context-sensitive design and implementation strategies to reduce digital disparities. Preliminary clinical benefits (therapy adherence and clinical control) support mHealth’s potential impact on chronic disease management, though confirmation through longer-term RCTs and cost-effectiveness evaluations is warranted. Practically, scalable mHealth programs should prioritize adaptive and simple-language onboarding, transparent consent communication, lightweight workflow integration with interoperability, and continuous engagement monitoring for rapid iteration. With these foundations, mHealth can deliver equitable, sustainable, and meaningful benefits to both patients and healthcare providers.

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