

# Caregiver-Centered Mobile Health Strategies for Improving Pediatric Treatment Adherence in Low-Resource Settings

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## Abstract

**Background:** Pediatric treatment adherence remains a significant challenge in low-resource settings, where families may face transportation barriers, limited healthcare access, medication shortages, financial constraints, and gaps in health literacy. For this review, low-resource settings refers to settings in which health-system constraints, household-level resource limitations, or both restrict timely access to pediatric treatment and follow-up. Mobile health (mHealth) technologies, including text messaging, telephone calls, mobile applications, and messaging platforms, offer potentially accessible approaches to support children and their caregivers between healthcare visits. **Objective:** This narrative review examines caregiver-centered mHealth strategies that may support pediatric treatment adherence in low-resource settings, distinguishes the outcomes evaluated in existing studies, and identifies practical considerations for developing equitable and sustainable digital health strategies. **Discussion:** Evidence directly evaluating caregiver-facing mHealth interventions in low-resource pediatric populations remains limited and heterogeneous. Available studies have assessed different outcomes, including medication adherence, vaccination or appointment completion, caregiver response to follow-up, caregiver knowledge, and engagement with digital systems. In Kampala, Uganda, a randomized trial of caregiver-selected SMS or automated telephone reminders increased timely receipt of needed HPV vaccination, demonstrating an effect on service completion rather than medication adherence or clinical outcomes. Other Ugandan studies have demonstrated the feasibility and challenges of mobile adherence monitoring among caregivers of children with HIV and the acceptability of

adherence-monitoring systems among adolescents and caregivers, but these studies do not establish that caregiver-centered mHealth improves long-term clinical outcomes. Broader pediatric mHealth literature also shows substantial heterogeneity and methodological limitations. These findings suggest that engagement, knowledge, appointment attendance, medication adherence, and clinical outcomes should not be treated as interchangeable measures of effectiveness. Conclusion: mHealth may strengthen pediatric treatment continuity when it addresses a specific caregiver barrier and is connected to an appropriate clinical or service pathway. The most useful interventions are likely to be accessible, caregiver-centered, bidirectional, context-adapted, clinically connected, equitable, and sustainable. These seven domains constitute an author-proposed framework informed by the reviewed literature and WHO digital-health guidance. Future studies should prioritize direct measures of pediatric adherence and clinical outcomes in low-resource settings while reporting implementation outcomes and equity.

## Keywords

Mobile Health, mHealth, Pediatric Treatment Adherence, Caregivers, Digital Health, Low-Resource Settings, Health Equity, Pediatric Care

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## 1. Introduction

Treatment adherence is an important component of successful pediatric care. For children with acute and chronic illnesses, outcomes may depend on taking medications as prescribed, attending scheduled appointments, completing investigations, following dietary or behavioral recommendations, and recognizing symptoms that require medical attention. Unlike adults, children frequently depend on parents or other caregivers to organize and deliver treatment. Consequently, pediatric adherence is influenced not only by the child's illness and behavior but also by caregiver knowledge, competing responsibilities, financial circumstances, transportation, communication with health professionals, and access to medicines and health services.

For this review, the term low-resource settings refers to environments in which limitations at the health-system level, the household level, or both constrain timely access to pediatric treatment and follow-up. Health-system constraints may include limited staffing, medication stock-outs, restricted service availability, or weak communication infrastructure. Household-level constraints may include transportation costs, loss of income, limited access to mobile data, food or accommodation costs, and competing caregiving responsibilities. The term therefore describes resource constraints relevant to care delivery rather than serving simply as a synonym for low- or middle-income country status.

These challenges can be amplified when families travel long distances to reach pediatric services, incur substantial transportation costs, encounter medication

stock-outs, or experience interruptions in care because of work and household responsibilities. Limited health literacy and language barriers may further complicate communication between families and healthcare providers. Pediatric conditions requiring prolonged treatment can therefore create a substantial burden for families and health systems.

Mobile health, commonly referred to as mHealth, describes the use of mobile and wireless technologies to support health and healthcare delivery. These technologies include short message service (SMS), telephone calls, smartphone applications, messaging platforms, and mobile-based telehealth. The World Health Organization (WHO) has identified targeted client communication, telemedicine, and other digital interventions as potential tools for strengthening health services, while emphasizing that digital technologies should complement rather than substitute for functioning health systems [1].

The potential value of mHealth in resource-constrained environments is particularly relevant because mobile phones can reach populations where more complex digital infrastructure may not be feasible. Pediatric digital health research in developing countries has described applications including SMS, mobile applications, websites, telephone calls, and teleconsultation for activities such as vaccination, breastfeeding, child growth, and healthcare delivery [2]. At the same time, the evidence base remains heterogeneous, and successful implementation depends strongly on context.

Recent evidence also highlights the importance of involving parents and caregivers. A 2025 systematic review of parent-oriented mHealth interventions identified 49 unique studies and reported improvements in selected parent and child outcomes, while noting substantial heterogeneity and a high risk of bias in more than half of the included studies [3]. These findings suggest that the relevant question is not simply whether mobile technology can be used in pediatric care, but which outcomes are improved, for whom, under what conditions, and through which mechanisms.

This narrative review focuses on caregiver-centered mHealth strategies for pediatric treatment adherence in low-resource settings. The aims are to describe common adherence barriers, summarize practical applications of mHealth, synthesize direct caregiver-facing evidence and the outcomes measured, discuss implementation challenges, and propose an author-developed framework for designing equitable and sustainable interventions.

## 2. Pediatric Treatment Adherence in Low-Resource Settings

Pediatric treatment adherence is multidimensional. A child may have access to an effective treatment but still experience poor outcomes if medication is not administered consistently, follow-up appointments are missed, or caregivers do not receive timely guidance when symptoms change. Adherence should therefore be understood as a process involving the child, caregiver, healthcare team, and health system.

## **2.1. Transportation and Geographic Barriers**

Distance from healthcare facilities can make routine follow-up difficult. Families may need to spend an entire day traveling to a hospital, lose income because of clinic visits, or rely on expensive transportation. When a child appears clinically stable, the perceived benefit of another long journey may not outweigh the immediate financial and practical burden. Mobile communication cannot eliminate these structural barriers, but it can potentially reduce unnecessary travel by supporting appointment reminders, follow-up communication, education, and triage when clinically appropriate.

## **2.2. Financial and Medication-Access Barriers**

Adherence may be affected by the direct and indirect costs of treatment. Even when medicines are provided without charge, families may have difficulty paying for transportation, food, accommodation, or other costs associated with care. Medication stock-outs or inconsistent availability can also create apparent non-adherence that is not caused by caregiver behavior. Digital interventions should therefore avoid framing every missed dose or appointment as a failure of the family. Instead, they should provide opportunities for caregivers to communicate barriers to the healthcare team.

## **2.3. Health Literacy and Communication**

Caregivers must understand what treatment is being given, how it should be administered, when it should be given, and which symptoms require urgent evaluation. Written instructions may be difficult to understand when health information is presented in technical language or in a language that is not preferred by the family. Mobile messages can reinforce education using brief, repeated, and culturally appropriate information. However, digital messages should complement, rather than replace, direct counseling for complex or sensitive clinical decisions.

## **2.4. Caregiver Burden**

Parents and caregivers may simultaneously manage employment, household responsibilities, other children, and their own health needs. A child's treatment can therefore become one responsibility among many. Parent-oriented mHealth interventions may reduce some access barriers by bringing education and support into the home. However, caregiver engagement should be considered an outcome in its own right and should not automatically be interpreted as improved adherence or improved health.

# **3. How mHealth Can Support Pediatric Adherence**

## **3.1. Medication Reminders**

SMS or app-based reminders can prompt caregivers about medication schedules. These interventions are attractive because they can be inexpensive and automated. However, reminders alone cannot solve problems such as medicine unavailability,

adverse effects, misunderstanding of instructions, or competing family priorities. Reminder interventions should therefore be interpreted specifically as strategies targeting forgetfulness or treatment organization unless evidence demonstrates effects on medication-taking behavior.

### **3.2. Appointment and Follow-Up Reminders**

Mobile communication can support attendance at clinic appointments by reminding caregivers about dates, locations, preparation instructions, and follow-up requirements. A missed appointment message can also be used as an opportunity for outreach rather than simply recording the family as non-adherent. Appointment completion is an important continuity-of-care outcome, but it should be distinguished from medication adherence and clinical improvement.

### **3.3. Caregiver Education**

Mobile platforms can deliver short educational messages regarding medication administration, nutrition, vaccination, symptom recognition, and preventive care. Education can be repeated over time and tailored to the child's condition. The language should be simple, culturally appropriate, and actionable. For families with limited literacy, voice calls or audio messages may be preferable to text-only communication. Improvement in caregiver knowledge or confidence is valuable but should not be presented as equivalent to improved treatment adherence.

### **3.4. Two-Way Communication**

One-way reminders are limited because they assume that the primary problem is forgetting. In reality, caregivers may miss treatment because of side effects, lack of medicines, financial constraints, misunderstanding, or a child's refusal to take medication. Two-way communication allows families to report these problems and allows healthcare teams to respond. WHO guidance emphasizes that digital interventions should be considered in relation to feasibility, acceptability, resource use, equity, and the functioning of the broader health system [1].

### **3.5. Telehealth and Remote Support**

Telephone or video communication can provide clinical support when in-person review is difficult. In low-resource settings, asynchronous communication may be more feasible than video-based care because it requires less bandwidth and may work with basic mobile phones. Remote support should include clear escalation pathways for children who require urgent assessment. Engagement with a remote service should be evaluated separately from downstream clinical outcomes.

## **4. The Caregiver as the Center of Pediatric mHealth**

Pediatric mHealth interventions should recognize caregivers as active participants in care. The caregiver is often the person who administers medication, transports the child, observes symptoms, communicates with clinicians, and decides whether

and when to seek additional care. Designing technology around caregiver responsibilities can therefore improve the likelihood that a digital intervention is usable in real-world settings.

Co-design is particularly important. Rather than selecting a technology based solely on what is technically available, healthcare teams should first understand how families currently communicate, what type of mobile device they use, which languages they prefer, and what barriers make treatment difficult. The 2025 review of parent-oriented mHealth interventions identified co-design and theory-informed development among features used in intervention design [2].

The caregiver-centered approach also changes the tone of digital communication. Messages should support problem-solving rather than blame. For example, instead of sending repeated reminders after a missed dose, a system could ask whether the caregiver experienced difficulty obtaining the medicine, administering it, or understanding the instructions. This transforms mHealth from a passive reminder tool into a mechanism for identifying barriers to care.

## 5. Evidence from Low-Resource Settings

Evidence from low-resource settings demonstrates that mobile technologies can support different aspects of pediatric care, although the interventions, populations, and outcomes vary considerably. A 2025 systematic review identified 16 eligible studies of digital health interventions in pediatric care in developing countries, including mobile applications, SMS, websites, and telephone calls, with common areas including breastfeeding, vaccination, and child growth [3]. This literature provides important implementation context but should not be interpreted as direct evidence that caregiver-centered mHealth improves pediatric treatment adherence.

### 5.1. Context and Health-System Evidence

Two examples previously presented as adherence evidence are better understood as implementation-context evidence. In Ghana, an mHealth clinical decision-support system was evaluated for adherence to neonatal healthcare protocols. The measured adherence was that of healthcare providers to clinical protocols, not caregiver adherence to a child's treatment [4]. Similarly, the Ugandan FamilyConnect platform used mobile communication to provide targeted maternal and child health messages to caregivers and was evaluated using selected maternal health service indicators [5]. These studies demonstrate that mobile systems can be integrated into health-service workflows and can influence provider behavior or service use, but they do not directly establish improvement in pediatric medication adherence.

### 5.2. Direct Caregiver-Facing Evidence

Direct evidence is more limited but provides useful examples of what can and cannot currently be concluded. Pediatric HIV treatment in Uganda has docu-

mented adherence challenges related to formulation and treatment fatigue, underscoring why digital interventions should address practical barriers rather than assume that missed doses reflect forgetfulness [6].

A Ugandan study involving caregivers of children receiving antiretroviral therapy used weekly SMS or interactive voice response to collect adherence information. Participant interest was high, but completion of the adherence queries was low, demonstrating both the feasibility and the practical challenges of caregiver-facing mobile adherence monitoring [7]. Importantly, the study evaluated feasibility, acceptability, and data-collection performance rather than testing whether mHealth improved the child's medication adherence or clinical outcomes.

A later Ugandan study evaluated electronic antiretroviral adherence monitors and associated reminder functions among adolescents and young adults with HIV and their caregivers. Participants generally found the system acceptable, and qualitative findings suggested improved adolescent self-efficacy and reduced caregiver burden. However, the study was primarily qualitative and did not establish a sustained improvement in clinical outcomes [8].

More direct evidence for a caregiver-facing intervention comes from the 2025 SEARCH randomized trial in Kampala. Caregivers of adolescents due for HPV vaccination received personalized SMS or automated telephone reminders according to their preferred mode. Adolescents in the intervention group were more likely to receive the needed HPV vaccine dose by 24 weeks than those receiving usual care (65.4% vs 35.5%; relative risk 1.8, 95% confidence interval 1.3 - 2.6) [9]. This is evidence of improved service completion and timeliness, rather than medication adherence. The study also illustrates the value of allowing families to choose between communication modes and incorporating educational content.

A 2025 quality-improvement study in rural Uganda used SMS and WhatsApp messages to contact caregivers seven days after a child's discharge and asked whether the child had improved. Non-responders and caregivers reporting that the child had not improved were contacted by telephone. The intervention demonstrated moderate caregiver response and a process for escalating concerning responses, supporting the feasibility of bidirectional post-discharge communication; it did not directly measure medication adherence [10].

Evidence from other pediatric populations reinforces the importance of distinguishing outcome types. For example, an adolescent and young-adult HIV trial in Uganda found no sustained effect of weekly SMS on antiretroviral adherence after one year, illustrating that message delivery or short-term engagement does not necessarily translate into durable medication adherence [11].

### 5.3. Synthesis of Outcomes

The available evidence from direct caregiver-facing interventions can be synthesized into discrete domains based on the specific metrics evaluated. These clear distinctions demonstrate that digital engagement metrics, caregiver knowledge,

service utilization, medication adherence, and downstream clinical outcomes represent separate steps along the digital health mechanism pathway (**Table 1**).

**Table 1.** Summary of outcome categories, literature examples, and clinical conclusions.

| Outcome category               | Examples in the literature                                                                                        | What can reasonably be concluded                                              |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Digital engagement/feasibility | Message delivery, response rates, completion of mobile queries [7] [8]                                            | Shows whether families can use and respond to the system                      |
| Caregiver knowledge/experience | Educational messaging, acceptability, self-efficacy, caregiver burden [3] [8] [9]                                 | Shows changes in caregiver experience or knowledge; not necessarily adherence |
| Appointment/service completion | HPV vaccination receipt and timeliness [9]                                                                        | Can demonstrate improved use of a specific service                            |
| Medication adherence           | ART adherence measures in adolescent/youth studies and caregiver-reported pediatric adherence monitoring [8] [11] | Requires direct adherence measures; effects are not consistently demonstrated |
| Clinical outcomes              | Viral suppression, hospitalization, emergency visits, symptom improvement                                         | Represents downstream health effects and requires direct clinical measurement |

This distinction is important because engagement, caregiver knowledge, appointment attendance, medication adherence, and clinical outcomes represent different steps in the pathway from a digital intervention to health improvement. A system that increases message response rates should not automatically be described as improving adherence, and improved medication adherence should not automatically be described as improving clinical outcomes unless the latter is measured.

Overall, the literature supports feasibility and selected improvements in service-related outcomes, but it does not justify assuming that every caregiver-facing digital intervention will improve medication adherence or clinical outcomes. Studies differ in population, intervention, technology, duration, and outcome measurement. Evidence specifically evaluating caregiver-centered pediatric treatment adherence in low-resource settings remains limited.

## 6. An Author-Proposed Framework for Caregiver-Centered mHealth

Based on the reviewed evidence and WHO digital-health guidance, this review proposes seven domains for designing caregiver-centered pediatric mHealth interventions: accessible, caregiver-centered, bidirectional, context-adapted, clinically connected, equitable, and sustainable [1] [3]. These domains are an author-proposed conceptual framework rather than a validated implementation framework. Each domain is linked to recurring barriers and implementation considerations identified in the literature.

### 6.1. Accessible

The intervention should work with technology that families already possess. SMS

and voice calls may be preferable to smartphone applications when smartphone ownership, data availability, or broadband connectivity is inconsistent. The goal should be to reduce technological requirements rather than create another barrier.

## **6.2. Caregiver-Centered**

Messages should address the caregiver's actual responsibilities and needs. Families should have opportunities to identify barriers, ask questions, and indicate preferred communication times and languages. Co-design should occur before implementation rather than being added after a system has been developed [3].

## **6.3. Bidirectional**

Communication should not be limited to automated reminders. Where feasible, caregivers should be able to report missed doses, medication problems, symptoms, or inability to attend an appointment. These responses should connect to an appropriate clinical or service workflow. The Ugandan post-discharge experience illustrates how caregiver responses can be linked to escalation by a health worker [10].

## **6.4. Context-Adapted**

Interventions should be developed with local healthcare workers and families. Language, cultural practices, literacy, mobile-phone ownership, connectivity, and local care pathways should influence the design. Evidence from Uganda also demonstrates that technical feasibility can be affected by seemingly small usability barriers, such as difficulty completing an identification step during an adherence query [7].

## **6.5. Clinically Connected**

A digital intervention should have a defined purpose within the health system. If a caregiver reports a concerning symptom, there must be a clear mechanism for escalation. Otherwise, the technology may create communication without providing meaningful clinical support. WHO guidance emphasizes that digital interventions cannot substitute for functioning health systems [1].

## **6.6. Equitable**

Digital health can unintentionally widen disparities if it assumes smartphone ownership, literacy, continuous connectivity, or private access to a phone. Alternative communication methods should be available for families who cannot use the preferred platform. Equity should be considered during design, implementation, and evaluation rather than only after an intervention is launched [1].

## **6.7. Sustainable**

Interventions should consider costs, staffing, training, technical maintenance, data protection, and long-term integration into routine care. A system that works

only while external funding is available may have limited value for routine pediatric services. WHO implementation guidance similarly emphasizes integration, readiness, resource requirements, and sustainability when digital interventions are introduced into health programmes [1] [12].

## 7. Privacy, Safety, and Ethical Considerations

Children's health information requires particular attention to privacy. Mobile phones may be shared among family members, and messages may be visible to people other than the intended recipient. Sensitive diagnoses should therefore not be disclosed unnecessarily in text messages. Communication systems should use appropriate consent procedures, data-protection safeguards, and clear policies regarding who can access information.

Clinical safety is equally important. Automated messages should not be interpreted as a substitute for clinical assessment. Families should receive clear instructions about which symptoms require urgent in-person evaluation. Similarly, digital systems should avoid creating false reassurance when a caregiver has reported a concerning symptom but has not received a clinical response.

## 8. Implementation Challenges and Evaluation

The success of mHealth depends on more than technical functionality. Barriers may include unreliable network coverage, electricity access, changing telephone numbers, limited digital literacy, language differences, privacy concerns, staff workload, and insufficient integration with existing medical records or communication systems.

Health-worker engagement is particularly important. If a digital system generates messages or caregiver requests without assigning responsibility for responding, it can increase rather than decrease workload. Implementation should therefore define who monitors responses, how urgent concerns are escalated, and how non-urgent questions are handled.

Technology fatigue is another potential problem. Frequent messages can become background noise, particularly when they are repetitive or poorly timed. Messages should be purposeful, concise, and appropriately spaced. Families should have the ability to modify communication preferences when feasible.

Evaluation should include both effectiveness and implementation outcomes. Useful measures include medication adherence, appointment or service completion, treatment interruptions, caregiver knowledge, patient retention, emergency visits, caregiver satisfaction, feasibility, acceptability, cost, and sustainability. Digital engagement metrics alone, such as the number of messages sent or opened, should not be interpreted as evidence of improved health.

Importantly, studies should prespecify the primary outcome and distinguish proximal from distal effects. For example, message response is a proximal engagement measure; caregiver knowledge is an intermediate outcome; medication adherence and appointment completion are behavioral or service outcomes; and vi-

ral suppression, symptom control, hospitalization, or mortality are clinical outcomes. This hierarchy can reduce overinterpretation of findings across heterogeneous studies.

## 9. Limitations

This review has several limitations. First, it is a narrative review rather than a systematic review and therefore does not provide a comprehensive or quantitatively pooled assessment of the literature. Second, the included evidence is heterogeneous with respect to pediatric age groups, clinical conditions, intervention types, delivery platforms, comparator groups, follow-up periods, and outcome definitions. Third, many studies evaluate feasibility, acceptability, engagement, caregiver knowledge, or service utilization rather than direct measures of medication adherence or clinical health outcomes. Fourth, direct evidence specifically evaluating caregiver-centered pediatric treatment adherence interventions in low-resource settings remains limited. The framework proposed here is therefore conceptual and author-developed rather than empirically validated. These limitations support cautious interpretation and highlight the need for prospective studies using standardized adherence and clinical outcome measures.

## 10. Lessons for Equitable Pediatric Care

The experience of implementing health interventions in resource-constrained settings offers broader lessons for pediatric practice. First, technology should be viewed as a tool rather than the intervention itself. The intervention is the care process that the technology supports. Second, families should be involved in designing the intervention because they understand barriers that may not be visible to clinicians or developers. Third, simple technologies can be highly valuable when they are reliable, accessible, and integrated into clinical workflows.

These principles are relevant beyond low-resource countries. Rural and underserved communities in high-income countries may also experience transportation difficulties, limited pediatric subspecialty access, fragmented care, caregiver work constraints, and digital inequities. The specific barriers differ by setting, and solutions should not be transferred uncritically. Nevertheless, the underlying implementation principle is similar: pediatric digital health should be designed around the child and family rather than around the technology.

## 11. Future Directions

Future research should move beyond measuring whether a message was delivered and determine whether digital interventions produce meaningful changes in pediatric adherence and health outcomes. Studies should use standardized adherence measures where possible and examine longer-term outcomes. Research should also include families with limited digital access so that interventions do not selectively benefit those who are already well connected to healthcare.

More implementation research is needed to determine which models can be

integrated into routine pediatric services at sustainable cost. Co-design with caregivers and healthcare workers should be incorporated early in intervention development. Research should also examine how digital tools can be linked with appointment systems, electronic medical records, pharmacy services, community health workers, and established referral pathways.

Importantly, future interventions should distinguish between different reasons for non-adherence. Forgetfulness may respond to reminders, whereas transportation, medication availability, adverse effects, or financial barriers require different solutions. A useful mHealth system should therefore help identify the reason for a missed treatment or appointment rather than simply labeling the event as non-adherence.

## 12. Conclusions

mHealth may provide a practical opportunity to strengthen pediatric treatment continuity in low-resource settings, particularly when it supports caregivers between clinical encounters. However, the direct evidence base remains limited and heterogeneous. Existing studies demonstrate improvements in selected outcomes such as service completion, engagement, caregiver experience, and feasibility, while evidence for sustained medication adherence and downstream clinical outcomes is less consistent.

The most useful pediatric mHealth interventions are unlikely to be the most technologically complex. Instead, they should be accessible, caregiver-centered, bi-directional, context-adapted, clinically connected, equitable, and sustainable. These seven domains constitute an author-proposed framework informed by the reviewed literature and WHO guidance [1] [3]. Moving from simple reminders toward communication and problem-solving may allow mHealth to address the real-world barriers that contribute to pediatric treatment interruptions. Future research should prioritize direct measures of adherence and clinical outcomes, while also reporting implementation, equity, cost, and sustainability.

## Ethics Approval and Consent to Participate

Not applicable. This manuscript is a narrative review and does not involve human participants, patient-level data, or identifiable clinical records.

## Consent for Publication

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No original datasets were generated or analyzed for this manuscript.

## Author Contributions

All authors conceived the topic, conducted the literature review, interpreted the literature, and prepared the manuscript. All authors read and approved the final manuscript.

## Conflicts of Interest

The authors declare no competing interests.

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