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Review Article

A Review on Digital Adherence Technologies for Chronic Disease Management: Global Evidence, Implementation Gaps, and Future Directions

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ABSTRACT

Sticking to long-term medication plans is hard for people with chronic diseases. Missing doses, stopping treatment, or quitting early can cause more sickness, longer hospital stays, and higher healthcare costs. Digital tools like SMS reminders, wearables, smart pillboxes, apps, and AI tools are now popular for helping people remember to take their medicine. This review looks at global studies on how well these digital tools work, how people use them, and the problems faced when using them. It also points out what needs to improve to make these tools a regular part of healthcare. We searched PubMed, Scopus, and Web of Science for studies from 2015 to 2025. We used terms like "digital health," "medication adherence," and "chronic disease." We included studies like trials, observational studies, and reviews that looked at digital tools for any chronic condition. Digital tools have improved medication adherence by 10–34% in over 100 studies on conditions like HIV, asthma, diabetes, hypertension, and post-transplant care. The best tools combine support with reminders. AI messaging, alerts, and smart dispensers help keep people engaged. SMS and app-based systems work well, especially in places with fewer resources. But challenges like lack of digital skills, privacy worries, user fatigue, and not fitting into healthcare systems are still big issues. Digital tools can greatly improve medication adherence. But for them to succeed widely, they need inclusive design, better system integration, strong privacy protection, and to work for all patient groups.

INTRODUCTION

Chronic non-communicable diseases (NCDs), such as diabetes, heart disease, long-term lung conditions, and cancer, account for approximately

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74% of deaths worldwide. According to the World Health Organization, over 41 million people die from NCDs every year.¹ It is worth noting that this is not evenly distributed. The heavier blow lands on low- and middle-income countries, where regular care can be patchy and sometimes unpredictable.¹

Managing these illnesses almost always means staying on medication in the long term. However, adherence to prescribed regimens remains suboptimal. Even in wealthier nations, as many as half of patients do not follow their prescriptions properly—and the figure is probably worse where resources are scarce.² And this isn't just a minor lapse. This translates to worse health, more hospital visits, and, in the US alone, avoidable costs that hover around \$290 billion a year.³ Over the last decade, digital health tools have started to slip into everyday chronic care, including mobile apps, wearables, text message nudges, and web dashboards. They first gained attention in diabetes care, showing early promise in helping people manage their own conditions and stay engaged.⁴ More recent research has pointed to gains in adherence, better blood sugar control, and, importantly, a sense of empowerment for patients.⁵ The idea is simple enough: send reminders, track habits in real time, and provide a bit of personal feedback.⁵ Then came the pandemic, which—despite everything—pushed these technologies into the spotlight. Remote care became a necessity, and these tools were suddenly tested at scale.⁶ Remote patient monitoring (RPM) and tele-homecare (THC) are at the heart of this shift. RPM uses connected devices, such as Bluetooth glucometers, blood pressure cuffs, and smart weighing scales, to send data directly to clinicians, flagging problems before they worsen and often saving a hospital trip.^{7,8} THC takes it further: medication coaching, scheduled video check-ins, and a bit more hands-on support from afar. For

older adults juggling multiple prescriptions, this can be a lifeline. Reviews so far suggest that these setups can help lower blood pressure and blood glucose and may even keep people out of the hospital more often.

The cost benefits? The evidence supports this^{7,8}

However, it is not all wins and breakthroughs. These digital adherence tools are a mixed bag of advantages and disadvantages. Some deliver real and measurable benefits. Others—barely a ripple. This gap indicates that we need sharper evaluations and more targeted rollouts, not just blanket adoption.^{5,9} Therefore, in my view, a close, critical look at what is actually working—and why—feels overdue.

This review goes beyond summarizing the efficacy of digital adherence technologies (DATs). These interventions were situated within the broader context of health policy, regulatory preparedness, and equity-focused implementation. By integrating the most recent clinical evidence with considerations of AI-enhanced personalization, interoperability standards, and behavioural design, this review provides a multi-layered perspective. This approach is intended to support researchers, clinicians, and policymakers in translating evidence into practice in the future. Despite the increasing data on adherence improvements, guidance that is simultaneously evidence-based and implementation-ready remains limited. Accordingly, this synthesis seeks to address this gap, offering insights that may facilitate the wider, more effective, and equitable deployment of DATs.

Conceptualization of digital adherence technologies (DATs) for managing chronic illnesses. Key categories are depicted in the graphic, such as telehealth services, smartphone apps, smart pill dispensers, AI-driven



customisation, and SMS reminders sent to mobile phones. These technologies support medication adherence and patient engagement.

2. OVERVIEW OF MEDICATION ADHERENCE

The World Health Organization simply states that medication adherence is about how well someone follows the treatment plan they have agreed on with their clinician. It is not just taking the right pill at the right time; it is about starting the treatment, maintaining it day after day, and sticking with it over the long haul.² When people do not, the reasons usually fall into two broad categories. One is intentional—skipping doses on purpose because of worries, doubts, or side effects. The other is unintentional—forgetting, getting confused, or running into practical snags.^{10,11} And here's the twist: a huge survey—over 24,000 people living with chronic diseases—found that those “unintentional” mistakes, like missing a dose (62%), running out of pills (37%), or just being a bit careless (23%), often had intentional roots. In other words, what they believed about their medication was quietly shaping these slips.¹⁰ The cost of all this? Not just in money. Conditions worsen, hospital trips increase, and life expectancy decreases. In the US, poor adherence is estimated to cost \$100 to \$300 billion each year in avoidable healthcare spending. Globally, it is one of the major drivers of rising illness and mortality rates.^{12,13} This is not a localized problem. Reviews show the same pattern—wherever you look, weaker adherence drags down chronic disease outcomes and strains the health systems.¹⁴

Traditional fixes—pillboxes, marked calendars, simpler regimens, and face-to-face counselling—can help, especially for unintentional lapses.^{14,5} However, they rarely get to the root of the intentional side. Digital approaches have started to step in. These include SMS reminders, app

notifications, smart caps on pill bottles, video-based check-ins, and packaging that logs every opening. They do not just nudge; they can tell if a dose was actually taken. Across different conditions—hypertension, diabetes, HIV, and asthma—reviews suggest that these tools can make a moderate but real difference.^{5,7}

What seems to work best, however, is when the strategy does not pick sides. Stronger interventions tackle both practical barriers—memory and routines—and mental barriers, such as beliefs and motivation.^{11,5} This combination tends to outperform single-focus methods. It feels like we are moving away from one-dimensional fixes toward multi-layered, tech-backed approaches that try to capture the full messiness of why people take—or do not take—their medications.

3. TYPES OF DIGITAL TOOLS FOR MEDICATION ADHERENCE

3.1. Comparison of Medisafe and MyTherapy Applications

Mobile health (mHealth) applications are increasingly used for medication adherence, with Medisafe and MyTherapy being among the most widely adopted. Both apps provide reminder alerts and adherence tracking; however, their scope and design differ. Systematic evaluations of medication adherence apps have emphasized that usability, personalization, and clinically relevant features are critical determinants of sustained engagement and effectiveness.^{15,16} Medisafe is particularly noted for its medication-specific adherence support, such as drug interaction warnings and intuitive reminder systems, whereas MyTherapy offers additional functionalities, including symptom logging and health parameter monitoring, which may be advantageous for patients with multiple chronic conditions.¹⁶ Evidence from meta-analyses of mobile-based



adherence interventions suggests that such digital tools can significantly improve adherence and clinical outcomes in chronic disease management, reinforcing the clinical value of platforms such as Medisafe and MyTherapy.¹⁷

Next, we have the hardware: smart pillboxes and electronic dispensers. These have shifted the game slightly. They combine sound or visual alerts, real-

time monitoring, and application-based feedback. In short, they do not just say, “take your medicine”; they can tell if you actually did.

Key elements including reminders, refill notifications, caregiver support, monitoring capabilities, motivational tools, privacy and security standards, and evidence of clinical impact are listed in the table along with citations for each.

Table 1: Comparison Of Medication Adherence Apps

Feature/APP	Medisafe	MyTherapy	Notes	Reference
Medication Reminders	offers customizable, structured reminders with an intuitive user interface	offers reminders in addition to integrating activity and symptom logging	Personalization and app usability are important adherence aspects.	¹⁶
Refill Alerts	supports reminders and refill notifications to avoid missing doses.	Includes refill management but focuses more broadly on health logging.	Helps maintain continuity and avoid treatment gaps.	¹⁶
Caregiver support	characteristics for social support (such as family/caregiver monitoring)	The importance of caregiver connectedness is diminished. ¹⁶	Involving caregivers increases adherence, especially for elderly or high-risk patients.	^{15,16}
Tracking and reporting	Monitor adherence and offer data and trends in health parameters.	Monitor adherence together with health, mood, and symptom indicators.	Medisafe is primarily concerned with pharmaceutical safety, whereas MyTherapy highlights comprehensive disease management.	¹⁶
Motivational features	Participation through incentives, trend tracking, and progress visualization	Makes progress feedback easier to understand.	Innovative design components encourage continued use.	¹⁶
Privacy and Security	Designed to ensure regulatory compliance	Also adheres to privacy standards.	Both apps align with best practices in data protection and security	¹⁶
Clinical impact evidence	demonstrated to increase adherence in mHealth app systematic reviews ^{15,16}	Improved adherence in mHealth app systematic reviews ^{15,16}	Evidence from meta-analyses supports the idea that digital reminders increase adherence in chronic illnesses.	¹⁷

3.2. Devices such as MedMinder, AdhereTech, and Spencer push the idea of medication support further by mixing dose tracking, telehealth links, and automatic alerts. They are especially useful for older adults and individuals managing long-term

conditions. For example, in one pilot trial, a multi-compartment dispenser in older adults maintained adherence above 98% over six months. Patients maintained their independence while still

benefiting from timed reminders and regular pharmacist contact.¹⁸

In another study, this time with an Automated Home Medication Dispenser, adherence in caregiver–patient pairs increased from 49% to nearly 97%. This is a significant shift that occurred in the home setting.¹⁹ In Canada, work on the Spencer system—essentially a touchscreen smart pillbox tied into pharmacists and mobile devices—showed similarly high adherence, aided by real-time support.²⁰

Reviews generally align with these results. Electronic adherence tools tend to improve results,

particularly when feedback and reminders are included. One large review of 37 clinical trials found adherence gains of up to 34% with the use of electronic packaging.²¹ And there’s a twist—reminders that fit into a person’s routine (context-aware) can work even better than fixed-time prompts. Some hit adherence rates were as high as 92%.²²

The table details commonly used smart pill dispensers and telehealth tools. It outlines their main features, target populations, adherence results, and supporting references.

Table 2: Smart Devices And Telehealth Interventions For Medication Adherence

Device	Key Features	Target Users	Adherence Outcomes	Reference
MedMinder	Audio-visual alerts, telehealth connectivity	Older adults, chronic illness patients	Improved adherence; tracked via app	¹⁸
AdhereTech	Automated dispensing, SMS alerts, and remote monitoring	Chronic illness patients	Adherence improved from 49% to 97% in caregiver-patient pairs	¹⁹
Spencer	Touchscreen smart pillbox, pharmacist linkage, app integration	Community-dwelling older adults	High adherence with real-time support	²⁰
Multi-compartment dispensers	Timed alerts, pharmacist contact	Older adults	≥98% adherence for 6 months	^{18, 20}

In people managing chronic diseases or living with a transplant, smart pillboxes have done more than just keep the schedule. They have nudged lab results in the right direction and pushed adherence up, particularly when they are part of a larger digital health setup.^{22,18} But it’s not all straightforward. Holding user engagement over the long haul is tricky, and a one-size-fits-all approach rarely works. Different patient groups require different approaches. Therefore, the next step probably is not just “more devices,” but more human-centred designs and studies built for specific diseases.²³

3.3 Text Messaging (SMS) and IVR Systems

3.3.1 SMS-Based Interventions in Low- and Middle-Income Settings

In many low- and middle-income countries, SMS-based mHealth programs—sometimes nudged forward by the WHO, sometimes run with national health ministries—have shown that simple text messages can shift both patient and provider engagement. And yes, adherence too. Kenya offers a few telling snapshots. One well-known cluster-randomized trial examined malaria care for health workers. Over six months, SMS reminders improved the correct use of artemether–lumefantrine by approximately 23–24 percentage points. The twist? This effect did not fade when

the messages stopped; it was still measurable six months later.²⁴

Another Kenyan initiative, the SMS RES MAL project, went for a slightly different target: caregivers of children with malaria. Automated texts reminded them of their medication schedule and follow-up visits. Adherence to the drugs was already high (70% to 97 %), but the texts noticeably improved clinic returns on days 3 and 28. This indicates how SMS can shape care-seeking habits, not just pill-taking.^{25,26}

The bigger picture? Well-organized text messaging, especially when linked to national treatment guidelines and included in current health systems, can do two things at once. It can support the work of providers and keep caregivers involved in a way that feels relevant to their daily lives.

3.3.2 Blended Messaging Approaches: SMS Plus Voice and Two-Way Systems

However, SMS is not the only card in the deck. Adding interactive voice response calls (IVR) has shown some extra lift, especially in HIV care and maternal health programs. In South India, one group of HIV-positive adults received weekly

automated IVR calls plus SMS reminders for six months. Adherence increased from 85% to 91%, and people generally liked it. Interestingly, these gains did not evaporate when the calls and texts stopped.²⁷

In Kenya, a study compared one-way SMS with two-way SMS for new mothers living with HIV. Viral suppression did not differ significantly between the groups; however, two-way messages led to a faster uptake of postpartum contraception. This is not a minor behavioural shift.²⁸

Then, there is South Africa's Mom Connect. Although not directly related to medication adherence, it is difficult to exclude. This national maternal health SMS platform has reached more than 2.7 million users. It is feasible, scalable, and built to last.²⁹

Taken together, these blended approaches—IVR plus SMS, two-way messaging, and even a bit of human touch—tend to lift behaviours linked to adherence, contraception uptake, and broader engagement with healthcare. Of course, the results still hinge on the setting, program design, and, quite honestly, how well it is executed in the real world.

Table 3A: Digital Communication And Telehealth Interventions For Medication Adherence

Intervention Type	Key study/region	Target population	Effect on Adherence	Reference
SMS reminders	Kenya, Malaria case management	Health workers	Correct artemether lumefantrine use ↑ by 23-24%	²⁴
SMS RES MAL	Kenya	Caregivers of paediatric malaria patients	Day 3 clinic visits ↑; adherence 70-97%	²⁶
IVR + SMS	South India, HIV care	Adults with HIV	Medication adherence ↑ 85%-91%	²⁷
Two-way SMS	Kenya, postpartum mothers with HIV	New mothers	Faster initiation of contraception; engagement ↑	²⁸
MomConnect	South Africa, maternal health	Pregnant women	Nationwide reach; feasible for larger populations	²⁹
Telemedicine follow-up/e-prescriptions	Type-2 diabetes mellitus	Chronic disease patients	Adherence SMD = 0.50; improved glycaemic control	^{34,35,36}



Messaging and Accountability	Chronic conditions, HIV	Patients on long-term therapy	ART adherence ↑ ~ 18%; better refill rates	37,38,39
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This table summarizes non-AI-based digital tools, including SMS reminders, mobile apps, telemonitoring, and smart pill devices. It shows their target populations, effects on medication adherence, and supporting references.

Table 3B: Ai-Driven And Digital Therapeutics Interventions

Intervention Type	Key study/ region	Target population	Effect on Adherence	Reference
AI chatbots (NLP-driven)	Global / 2021-2023	Patient with chronic conditions	Improved adherence; personalized behaviour nudges	40,41,43
Voice assistants / context-based reminders	2024-2025	Chronic disease patients	Increased engagement, satisfaction ↑, and reduced user burnout	42
Prescription digital therapeutics (reSET-O)	USA	Patients with opioid use disorder	Improved treatment retention; abstinence ↑	44
Digital behaviour changes program (Laddr™, Kaia Health)	2024-2025	Chronic disease, & musculoskeletal pain	Improved adherence; better self-regulation; pain/stress reduction	45,46,47

The table gives examples of chatbot and voice assistant-based adherence support, digital therapeutics prescriptions, and digital behavior change programs. It emphasizes their target populations, clinical effects, and supporting references.

3.4 Wearables and Smartwatches

3.4.1 Syncing Medication Reminders to Wearables

Smartwatches, such as the Apple Watch and Fitbit, are being used in medication reminder systems. The appeal is obvious. Vibrations, alarms, and visual prompts are delivered straight to the wrist. No phone required. For some, that is a big deal—less fiddling with devices and more immediate nudges.

One randomized controlled trial examined older adults using a medication-reminder wristwatch. The results? Patients exhibited noticeably better

adherence over 12 weeks and felt more confident in handling their medicines. Moreover, their average systolic blood pressure dropped to approximately 120 mm Hg compared to approximately 142 mm Hg in those without the device ($p < 0.001$).³⁰ Scoping reviews back this general trend—wearables do seem to help across various conditions by sending those small but persistent prompts—vibrations, beeps, flashes—right where people cannot easily ignore them.³¹

3.4.2 Biofeedback and Adherence Tracking

Then, there is the more advanced side of things—wearables that do not just remind but also detect. Passive tracking of biofeedback to determine when a dose is actually taken. Cochran and colleagues, in *NPJ Digital Medicine*, reported that patterns in daily activity and heart rate variability could predict medication-taking behaviour in people with serious mental illness. Not just loosely statistically significant ($p = 0.004$).³²



Another example is Odhiambo et al. (2023) in the JMIR Human Factors. Using accelerometer data from everyday consumer smartwatches run through a neural network, they identified medication-taking gestures with approximately 96.5% accuracy. Even in new real-world contexts.³³ That's impressive.

These data streams are not just for the sake of collecting numbers. They can feed into dashboards for doctors and patients—shared visibility, early flags, and a chance to step in before adherence slides too far. Of course, the technology works best when paired with actual human follow-up.

3.5 Telemedicine Platforms

3.5.1 Virtual Follow-Ups & e-Prescription Renewals

Some of the most consistent wins in digital adherence work have come from plain old structured telemedicine—virtual follow-ups, plus the ability to get a prescription renewed without travelling to a clinic. The numbers are not bad either. One 2024 meta-analysis pooling data from 18 RCTs in type 2 diabetes showed a moderate but real lift in adherence when telehealth was built in automated check-ins and e-prescribing (SMD = 0.50; 95% CI 0.23–0.77; $p < 0.001$).³⁴ And there's more. Systematic reviews have consistently highlighted that telemonitoring does not merely nudge adherence; it can actually trim HbA1c, with some trials finding larger drops for patients in more intensive telehealth setups than for those on simpler remote-monitoring plans. The interesting bit? In some cases, the self-management boost persisted for a year.³⁵

It is not only a diabetes story. In hypertension care, pharmacist-led video consultations combined with e-prescriptions have been linked to steady falls in systolic BP, along with better adherence.³⁶ That's

worth noting. Because it is a reminder that these virtual visits are not only about convenience. They can grease the wheels for medication renewals and keep people moving along in their treatment without so many speed bumps.

3.5.2 Patient–Provider Messaging & Accountability

The patient–provider messaging is the quieter, less flashy side of telehealth. Secure platforms, sometimes paired with calls, have been surprisingly effective in keeping people accountable for actually taking (and refilling) their medications. A 2021 systematic review observed consistent improvements in medication possession and refill rates for chronic conditions, such as diabetes, hypertension, and hyperlipidaemia, when these tools were used.³⁷

Let us now focus on HIV care. A 2023 meta-analysis of five RCTs found that messaging and calls together increased ART adherence by approximately 18% (RR = 1.18; 95% CI 1.03–1.35; $p < 0.05$).³⁸ That's not trivial. Qualitative work suggests that it is not only the reminders; it is the chance to report side effects, get quick feedback, and feel like the provider is still there in between appointments.³⁹ When these tools are stacked on top of regular virtual check-ins, a sturdier telemedicine loop is created—one that keeps the patient engaged, spots trouble before it snowballs, and helps treatment stick.

3.6 AI Chatbots and Digital Assistants

3.6.1 Reminders, Check-Ins, and Voice-Based Interactions

AI-driven chatbots and voice assistants have been getting a fair bit of attention lately. Not just hype—there is actually some substance. Aggarwal et al. in 2023, for example, pulled together evidence



showing that these tools—whether embedded in messaging platforms or sitting on mobile apps—can give a genuine lift to adherence. They have been used to nudge people into more movement, cut down on smoking, and keep medications on schedule, all by firing off reminders, helping set goals, and logging symptoms.⁴⁰ The pattern? They work better when the nudges feel personal and not canned, and when responses come quickly.

Voice assistants are also entering this space. Barreda's 2025 review noted their growing role in chronic disease care—dropping short verbal prompts about medications, follow-ups, and routine health checks. The kicker is that they sound less like machines than their predecessors. This softer tone matters; it helps people stick with it without feeling worn out.⁴¹ Bérubé et al. (2024) pulled from different studies and described voice systems that timed their check-ins according to a person's habits or the time of day. That small tweak? This seems to boost satisfaction and keeps the engagement curve from dipping too soon.⁴²

3.6.2 NLP-Driven Behaviour Prompts (2021–Present)

Now, once natural language processing started to hit its stride around 2021, the chatbots themselves shifted. Less scripted. More conversational. And a bit more... human. Oh et al. reported that these NLP-powered bots could nudge healthier habits and, in some cases, give medication adherence a push in the right direction.⁴³ The same Aggarwal review pointed out that they outperformed older rule-based bots, mostly because they could shape language on the fly, respond with empathy, and keep people from tuning out.⁴⁰

Bérubé's 2024 findings round it out: voice assistants using both NLP and contextual cues—such as altering reminder timing based on earlier responses—end up feeling more personal and

trustworthy. Not perfect, but in the long game of habit building, that trust seems to make the difference.⁴²

3.7 Digital Therapeutics (DTx)

3.7.1 FDA-Approved Examples (e.g., reSET-O, Kaia Health)

Some of the clearest signs that prescription digital therapeutics (PDTs) have moved beyond theory come from products like reSET® and reSET-O®. Both were developed by Pear.

Therapeutics, and reSET-O®—which made it through the FDA's De Novo pathway—sits alongside buprenorphine in treating opioid use disorder (OUD). It is not just another app; trials have shown that it can improve treatment retention and help patients stay abstinent in outpatient settings.⁴⁴ The program leans heavily on cognitive behavioural therapy (CBT) modules, delivered over the phone, and keeps people engaged with structured lessons and personal feedback. Then there is Kaia Health—technically not FDA-approved but still operating under enforcement discretion. It is aimed at musculoskeletal pain using app-based multimodal therapy that blends physical exercises with bite-sized education. Results? Notable decreases in pain, stress, and depression symptoms.⁴⁵ Taken together, these cases suggest that when digital therapeutics receive regulatory recognition—or even a green light to operate—they can deliver evidence-based care, make it easier for patients to get help, and relieve some of the burden on already stretched health systems.

3.7.2 Adherence-Focused Digital Behaviour Change Programs

Another space where these tools are starting to show real value is in fixing one of healthcare's



most stubborn problems— adhering to the treatment plan. A recent (2025) systematic review pointed out that for chronic conditions such as heart disease, diabetes, and COPD, weaving in motivational nudges—reminders, feedback loops, even light gamification, or social encouragement—can move the needle on adherence.⁴⁶ One interesting study followed people using Laddr™, a digital therapeutic that builds in small prompts for self-regulation. Those moments of reflection, triggered at the right time, predicted next-day adherence and were associated with improvements in step counts and fewer cigarettes smoked.⁴⁷ A broader meta-analysis in oncology found that users of digital interventions had approximately a 40% lower risk of poor adherence than non-users (OR 0.60; 95% CI 0.47–0.77). However, the trial results were not perfectly aligned, and heterogeneity was high ($I^2 = 73.1\%$).⁴⁸ Even so, the takeaway feels consistent enough: when these programs are designed with behaviour change in mind—real-time feedback, habit reinforcement, and prompts that actually make sense in the moment—they can give adherence a solid boost.

4. EVIDENCE FROM STUDIES

A good chunk of solid meta-analyses and RCTs now leave little doubt that digital tools built for adherence can push the needle on both sticking to medications and improving the numbers that matter. We are discussing hypertension, diabetes, asthma, and HIV. In low- and middle-income countries, Boima et al. (2024) noted that simple channels—SMS, smartphone apps, and phone calls—produced a standardized mean bump in

adherence of 1.59 (95% CI 0.51–2.67). This is not bad, especially with parallel drops in systolic BP (–5.75 mmHg) and some lifestyle gains that, while harder to quantify, seem worth noting.⁴⁹

Zoom in on diabetes and hypertension: A systematic review of 17 RCTs found that mobile apps were not just a novelty. They trimmed HbA1c by roughly –0.39% and nudged blood pressure lower, while getting people more engaged with self-management.⁵⁰ In asthma and COPD, the 2022 Cochrane review observed a similar pattern. Tools such as electronic monitoring devices and SMS increased adherence by approximately 14.7 percentage points (95% CI 7.7–21.6). Better asthma control (SMD 0.31, 95% CI 0.17–0.44) and a modest drop in exacerbations (RR 0.53, 95% CI 0.32–0.91) were also observed.⁵¹

HIV care has its own unique story. Several meta-analyses pooling 21 RCTs with approximately 3,937 participants showed a small but real boost in ART adherence (Cohen’s $d = 0.25$, 95% CI 0.05–0.46). The biochemical markers edged in the right direction too—steady gains, nothing headline-worthy, but they cannot be ignored.⁵² As for hypertension, digital therapeutics aimed squarely at it have some numbers to show: Liu et al. (2025) saw systolic fall by –3.75 mmHg (95% CI –5.74 to –1.77) and diastolic by –1.79 mmHg (95% CI –2.81 to –0.77).⁵³ Taken together, this presents a varied but converging picture. Reminders, feedback, and monitoring seem to work across different diseases. Not perfectly, and not always by the same margin, but enough to argue that digital adherence interventions deserve a permanent place in chronic care settings.

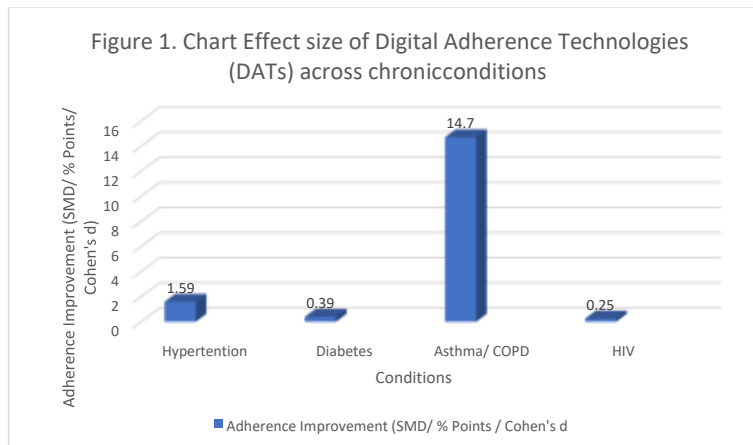


Figure 1. The chart shows adherence improvement (expressed as standardized mean difference [SMD], percentage points, or Cohen’s d) for various chronic conditions, including Hypertention (1.59), diabetes (0.39), asthma/COPD (14.7), and HIV (0.25).

Table 4: Efficacy Of Digital Adherence Tools Across Key Chronic Conditions

Chronic Condition	Intervention Type	Key study/ region	Effect on Adherence	Reference
Hypertension	Mobile apps, SMS, Telemonitoring	Bioma et.al.,2024	Standardised mean adherence ↑ 1.59; systolic BP ↓ 5.75 mmHg	49
Diabetes Mellitus	Mobile apps, telehealth follow-up	Systematic review of 17 RCTs	HbA1C ↓ ~0.39%; improved self-management	50
Asthma/COPD	Electronic monitoring device, SMS	Cochrane Review, 2022	Adherence ↑ 14.7 pp; asthma control SMD 0.31; exacerbations RR 0.53	51
HIV	SMS, IVR, telehealth messaging	Meta-analyses of 21 RCTs	ART adherence ↑ Cohen’s d = 0.25; improved biochemical outcomes	52
Hypertension (Digital Therapeutics)	FDA-approved DTx, reminder programs	Liu et.al.,2025	Systolic BP ↓ 3.75mmHg; diastolic BP ↓ 1.79mmHg	53

The table summarizes important interventions, representative studies, and their effects on medication adherence and clinical outcomes in hypertension, diabetes, asthma/COPD, HIV, and digital treatments for hypertension.

5. BENEFITS AND LIMITATIONS OF DIGITAL ADHERENCE TOOLS

Digital adherence tools—or DATs if we’re going to shorten it—cover a wide mix: smart pillboxes, phone apps, wearables, even remote monitoring setups. They tend to pull their weight in a few key

areas of the company. First, they can boost patient engagement through targeted reminders, personal feedback, educational snippets, and occasional gamified nudges.

Chronic conditions, such as diabetes and cardiovascular disease, are the obvious beneficiaries.^{50,53} They also allow clinicians to monitor things from a distance, such as real-time adherence patterns and key physiological signals, which opens the door to timely interventions and can give patients a stronger sense that they can manage their own care.⁵⁴

The economics are not bad either. Several systematic reviews have examined cost-effectiveness, and the results are fairly consistent. Video-observed therapy (VOT) and mobile-based systems for TB treatment are often cost-effective, sometimes even cost-saving, especially in middle- and high-income settings.^{55,56} True, the studies are not all equally tight in methodology, and the way they report economic outcomes can vary. However, once the basic infrastructure is in place, scalability is difficult to argue. The marginal cost per extra user is small, which makes the case for long-term value fairly strong.⁵⁷

However, adoption is not frictionless. Access to devices and the Internet is not universal—older adults and underserved groups are often left behind. Even when technology is available, usability and digital literacy issues can nudge people toward disengagement, sometimes resulting in complete dropout.⁵⁴ Then, there is the matter of privacy and data security, which regularly raises eyebrows. People worry about breaches and sensitive health information going to places it should not. Clinicians, meanwhile, face their own headaches: extra alerts, data overload, and the ongoing mess of integrating these tools with electronic health records when interoperability standards are missing.⁵⁴

Therefore, DATs can do a lot: keep patients engaged, allow remote follow-up, and make economic sense over the long haul. But, and it's a big but, those gains won't hold in practice unless the digital gaps are narrowed, the data is safeguarded properly, and the tools are slotted into workflows without adding more chaos.

6. CHALLENGES IN IMPLEMENTATION

The rollout of digital adherence tools (DATs) is rarely a straight shot. These hurdles tend to overlap.

First, there is a digital divide. Rural areas still lag behind cities in terms of EHR adoption and broadband reach. The gap isn't small. Older adults also engage far less with digital platforms, which means that outreach is uneven before it even begins. Broader reviews keep pointing to the same bottlenecks—underserved communities lack infrastructure, affordable Internet, and sometimes the basic digital skills to make use of these tools. Without these, DATs cannot be deployed effectively.^{57,58}

Concerns exist over cybersecurity and data privacy as well. GDPR and HIPAA set clear rules on consent, encryption, breach alerts, and keeping data collection to a minimum. On paper, everything is there. In practice? Enforcement can be minimal. Many consumer-grade tools skirt the legal definitions entirely. Regulations have not caught up with third-party trackers or the movement of health data outside clinical settings. McGraw and Mandl suggested a more layered fix—baking privacy in from the start, adding governance at multiple levels, and still leaving room for innovation.^{59,60}

Integration with clinical workflows is another challenge. Even where EHRs are common, real interoperability is inconsistent. Rural providers with lower “meaningful use” uptake feel this more sharply. Clinicians face messy, fragmented workflows, in addition to the constant drip of alerts; alert fatigue is real. The absence of standard protocols makes it more difficult. Without addressing these barriers, embedding DATs into day-to-day care will remain an uphill climb.⁶¹

What does it take to move past these limitations? Infrastructure investment to close the rural–urban gap. Digital literacy programs that meet users where they are. Tougher and smarter enforcement of data protection rules. For the clinical side, stronger interoperability and standardized



workflows are required. Without these pieces in place, adoption may occur, but it is unlikely to be successful.

7. GLOBAL POLICIES AND REGULATORY ASPECTS

Regulation of digital adherence technologies (DATs) has been gaining speed globally and nationally. The idea is simple: if these tools are going to be part of real healthcare systems, they

need clear rules, standards, and a shared vision for how they fit in. Globally, the WHO's Global Strategy on Digital Health 2020–2025 attempts to set this direction. Endorsed at the 73rd World Health Assembly, it promotes secure, interoperable systems and equitable access to health data worldwide. The language is big-picture—harmonizing governance, pushing for equity, and building national capacity through shared global standards and pooled investments.⁶² The Global Initiative on Digital Health (GIDH) was then established to turn that blueprint into action. It relies on ethical governance, cross-border interoperability, and the development of digital public goods as core priorities.⁶³ India's path has been quick by comparison. The Ayushman Bharat Digital Mission (ABDM), launched in 2021, is creating a federated, consent-based health ecosystem. These include unique health IDs (ABHA), national registries of healthcare professionals and facilities, and a unified Health Information Exchange (HIE). The aim is to let patient data follow the patient across

states, sectors, and providers. With over 400 million citizens already linked, it is a sizable leap toward a national-scale digital health infrastructure.⁶⁴ Elsewhere, regulations and reimbursements have taken different forms. The U.S. The FDA uses a risk-based model for Software as a Medical Device (SaMD), housed under its Digital Health Innovation Action Plan. Oversight runs through the Digital Health Centre of Excellence, which manages precertification programs and helps move digital therapeutics toward approval, ideally backed by both clinical trial results and real-world evidence.⁶⁵ Germany offers a contrasting model to the United States. Under its DiGA pathway, certain physician-prescribed apps receive statutory reimbursement once vetted by the Federal Institute for Drugs and Medical Devices.

(BfArM). In contrast, the United States still has a fractured picture—private insurers, some Medicare pilots, and new billing codes slowly making their way into practice. Despite its infrastructure progress, India is still figuring out how to fund this space. Early pilots linked to Ayushman Bharat-PNJAY and the talk of value-based assessment from expert committees hint at where it might go.⁶⁶

Taken together, these efforts point to the same conclusion: coordinated policy—whether global or national—is not just helpful; it is essential if DATs are going to be deployed in a way that is safe, effective, and built to last.

Table 5: Policy Landscape For Digital Adherence Technologies

Region/Entity (Light Blue Header)	Policy/Program (Light Green cells)	Core Features (Light yellow Cells)	Current Implementation Status (Light Grey Cells)	Reference
World Health Organisation (WHO)	Global Strategy on Digital Health 2020-2025	Secure, interoperable systems; equitable access; governance harmonisation;	Endorsed at 73 rd WHA; guiding member states	62

		national capacity building		
World Health Organisation (WHO)	Global initiative on Digital Health (GIDH)	Ethical governance; Cross-border interoperability; creation of digital public goods	Active; roadmap released; partnerships forming	63
India	Ayushman Bharath Digital Mission (ABDM)	Federated, consent-based ecosystem; unique IDs (ABHA); provider/facility registries; unified HIE	Launched 2021;>400M citizens linked	64
United States (FDA)	Digital Health Innovation Action Plan & digital Health Centre of Excellence	Risk-based regulation of SaMD; precertification; real-world evidence integration	Operational; supports DTx approvals	65
Germany	DiGA Pathway	Physician-prescribed digital apps are reimbursable under statutory insurance; vetted by BfArM	Active; multiple apps approved & reimbursed	66

This section summarizes key initiatives from major organizations like the World Health Organization, India, the United States, and Germany. It highlights their main features, implementation status, and reference sources.

8. FUTURE TRENDS IN DIGITAL ADHERENCE TECHNOLOGIES

The next wave of digital adherence technologies (DATs) is being pushed forward by a mix of forces—AI, interoperability standards, behavioural economics, and a sharper look at multimorbidity. These trends are not isolated; they feed into each other.

First, artificial intelligence is used. Machine learning has already made it possible to send hyper-personalized “nudges” that shift in real time with a person’s behaviour. Scoping reviews note that AI-driven digital behaviour changes interventions—using reinforcement learning, conversational bots, and recommendation

systems—can offer custom-tailored support and, in many cases, modest but measurable improvements in health behaviours. However, the long-term effects of this approach remain uncertain.⁶⁷ On the design side, there is experimentation with generative AI for crafting adherence messages for diabetes. Early work shows that it can produce huge volumes of varied, evidence-aligned content—enough to keep messaging fresh at scale.⁶⁸

Second, interoperability is required. Getting DATs to talk to electronic health records is not a nice-to-have; it is a backbone requirement. The FHIR standard, with its modular RESTful architecture, is emerging as the go-to standard for smooth data exchange and API-based integration. Reviews emphasize that semantic interoperability and systematic FHIR adoption—especially for telemonitoring and adherence apps—are already making deployment easier and more scalable.^{69,70}



Third, the blend of gamification with behavioural economics is explored. This is not just badges and points. Studies have shown that AI-enhanced “choice architecture” can make nudges more persuasive—enough to shift adherence patterns and pull patients into deeper clinical engagement. Reward systems, goal-setting, and feedback loops, all grounded in behavioural economics, have become standard in managing complex chronic care ⁷¹

Finally, tool design is being stretched to handle multimorbidity and polypharmacy. This means

that systems can adjust messaging when patients juggle multiple regimens—simplifying when needed, highlighting the essentials, and reducing cognitive overload. AI has already demonstrated how this can work in practice, although the evidence base is still in its early days.^{67,68}

Together, these trends hint at where DATs are heading—AI making them more personal, interoperability making them more connected, behavioural science making them more engaging, and multimorbidity support making them more relevant to the patients who need them most.

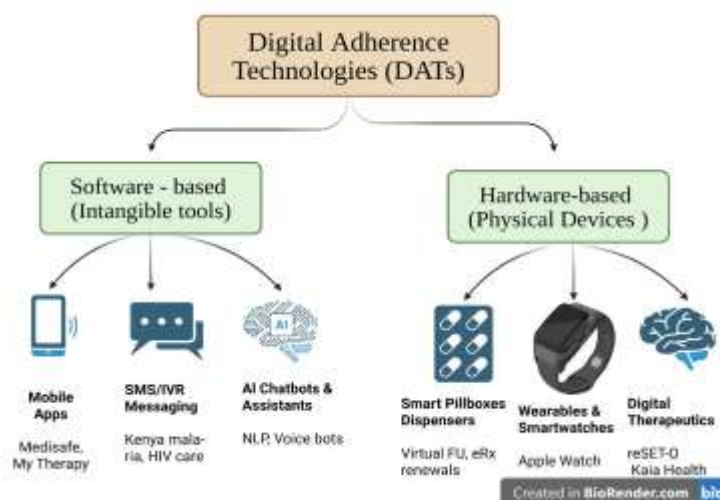


Figure 2.

The goal of this review is to evaluate how well digital adherence technologies work in managing chronic diseases. It will identify gaps in current use and point out future directions for research, clinical practice, and policy.

CONCLUSION:

Digital adherence technologies (DATs) are no longer on the fringes; they have become a core part of chronic disease management. The evidence is steady across the board: diabetes, hypertension, asthma, and HIV—adherence improves, and so do clinical outcomes. The newer wave—AI-driven personalization, standards-based interoperability,

and behavioral design—pushes the ceiling higher. Large-scale efforts, such as the WHO Global Strategy on Digital Health and India’s Ayushman Bharat Digital Mission, are laying the policy scaffolding needed to expand this further.

However, cracks were still visible. Digital inequality has not disappeared, privacy concerns continue to surface, and clinical workflows are not always ready to absorb another layer of technology. Reimbursement models? Many are still taking shape, and some hardly exist. For DATs to make a lasting impact, the basics must be shored up: better infrastructure, stronger digital literacy, tighter data governance, and seamless

clinical integration that adds value without adding noise.

Looking ahead, the conversation is likely to shift. The question is not whether these tools work, but how fairly, sustainably, and widely they can be deployed. The opening is there—pair strong governance with inclusive access and well-designed clinical integration, and DATs could help close one of the most stubborn gaps in chronic care worldwide.

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REFERENCES

1. World Health Organization: Noncommunicable diseases. WHO Fact Sheet. 2023. Available at: <https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases>
2. Sabaté E: Adherence to Long-Term Therapies: Evidence for Action. World Health Organization, 2003.
3. Cutler RL, Fernandez-Llimos F, Frommer M, Benrimoj C, and Garcia-Cardenas V: Economic impact of medication nonadherence by disease groups: a systematic review. *BMJ Open* 2018; 8: e016982.
4. Iyengar V, Wolf A, Brown A and Close K: Challenges in diabetes care: can digital health help address them? *Clin Diabetes* 2016; 34:133-141.
5. Nieuwlaat R, Wilczynski N, Navarro T, et al: Interventions for enhancing medication adherence. *Cochrane Database Syst Rev* 2014; (11): CD000011.
6. Omboni S, McManus RJ, Bosworth HB, et al: Evidence and recommendations on the use of telemedicine for the management of arterial hypertension: an international expert position paper. *Hypertension* 2020; 76:1368-1383.
7. Kruse CS, Soma M, Pulluri D, Nemali NT and Brooks M: The effectiveness of telemedicine in the management of chronic heart disease: a systematic review. *JRSM Open* 2017; 8:2054270416681747.
8. Bashi N, Karunanithi M, Fatehi F, Ding H and Walters D: Remote monitoring of patients with heart failure: an overview of systematic reviews. *J Med Internet Res* 2017; 19:e18.
9. Armitage LC, Kassavou A and Sutton S: Do mobile device apps designed to support medication adherence demonstrate efficacy? A systematic review of randomized controlled trials with meta-analysis. *BMJ Open* 2020; 10:e032045.
10. Gadkari AS and McHorney CA: Unintentional non-adherence to chronic prescription medications: how unintentional

- is it really? *BMC Health Serv Res* 2012; 12:98.
11. Lam WY and Fresco P: Medication adherence measures: an overview. *Biomed Res Int* 2015; 2015:217047.
 12. Neiman AB, Ruppert T, Ho M, et al: CDC grand rounds: improving medication adherence for chronic disease management—innovations and opportunities. *MMWR Morb Mortal Wkly Rep* 2017; 66:1248-1251.
 13. Stewart SJ, Moon Z and Horne R: Medication nonadherence: health impact, prevalence, correlates and interventions. *Psychol Health* 2022; 38:726-765.
 14. Gast A and Mathes T: Medication adherence influencing factors—an (updated) overview of systematic reviews. *Syst Rev* 2019; 8:112.
 15. Santo K, Richtering SS, Chalmers J, Thiagalingam A, Chow CK and Redfern J: Mobile phone apps to improve medication adherence: a systematic stepwise process to identify high-quality apps. *JMIR Mhealth Uhealth* 2016; 4:e132.
 16. Tabi K, Randhawa AS, Choi F, et al: Mobile apps for medication management: review and analysis. *JMIR Mhealth Uhealth* 2019; 7:e13608.
 17. Thakkar J, Kurup R, Laba TL, et al: Mobile telephone text messaging for medication adherence in chronic disease: a meta-analysis. *JAMA Intern Med* 2016; 176:340-349.
 18. Faisal S, Samoth D, Aslam Y, et al: Key features of smart medication adherence products: updated scoping review. *JMIR Aging* 2023; 6:e50990.
 19. Patel T, Ivo J, Pitre T, Faisal S, Antunes K and Oda K: An in-home medication dispensing system to support medication adherence for patients with chronic conditions in the community setting: prospective observational pilot study. *JMIR Form Res* 2022; 6:e34906.
 20. Faisal S, Samoth D, Aslam Y, et al: Key features of smart medication adherence products: updated scoping review. *JMIR Aging* 2023; 6:e50990.
 21. Paterson M, Kinnear M, Bond C and McKinstry B: A systematic review of electronic multicompartiment medication devices with reminder systems for improving adherence to self-administered medications. *Int J Pharm Pract* 2017; 25:185-194.
 22. Zhou L, Cheng K, Chen L, Hou X and Wan J: Effectiveness of eHealth for medication adherence in renal transplant recipients: systematic review and meta-analysis. *J Med Internet Res* 2025; 27:e73520.
 23. Rajagopalan A, Loiseau S and Yaraghi N: A human-centred evaluation of smart medication dispensers: barriers and facilitators to usability. *Health Inform J* 2024; 30:1460458324124921.
 24. Zurovac D, Sudoi RK, Akhwale WS, et al: The effect of mobile phone text-message reminders on Kenyan health workers' adherence to malaria treatment guidelines: a cluster randomised trial. *Lancet* 2011; 378:795-803.
 25. Talisuna AO, Zurovac D, Githinji S, Oburu A, Malinga J, Nyandigisi A, et al: Efficacy of mobile phone short message service (SMS) reminders on malaria treatment adherence and day 3 post-treatment reviews (SMS-RES-MAL) in Kenya: a study protocol. *J Clin Trials* 2015; 5:217.
 26. Talisuna AO, Zurovac D, Githinji S, Oburu A, Malinga J, Nyandigisi A, et al: Efficacy of text-message reminders on paediatric malaria treatment adherence and their post-treatment return to health facilities in Kenya: a randomized controlled trial. *Malar J* 2017; 16:185.
 27. Rodrigues R, Shet A, Antony J, Sidney K, Arumugam K, Krishnamurthy S, et al:

- Supporting adherence to antiretroviral therapy with mobile phone reminders: results from a cohort in South India. *PLoS One* 2012; 7:e40723.
28. Finocchiaro-Kessler S, Puffer S, et al: A randomized clinical trial of 1-way vs 2-way SMS messaging for postpartum HIV care in Kenya. *PLoS One* 2021; 16:e0248443.
 29. Praekelt Foundation and South African NDoH: MomConnect maternal health SMS platform in South Africa—over 2.7 million users across 11 official languages.
 30. Solmaz T and Altay B: The role of training and medication reminder wristwatch in adherence to treatment in geriatric patients diagnosed with hypertension: a randomized controlled trial. *Geriatr Gerontol Int* 2024; 24:1189-1195.
 31. Iino H, Kizaki H and Imai S: Medication management initiatives using wearable devices: scoping review. *JMIR Hum Factors* 2024; 11:e57652.
 32. Cochran JM, Heidary Z and Knights J: Characterization of activity behaviour using a digital medicine system and comparison to medication ingestion in patients with serious mental illness. *NPJ Digit Med* 2021; 4:63.
 33. Odhiambo CO, Ablonczy L, Wright PJ, Corbett CF, Reichardt S and Valafar H: Detecting medication-taking gestures using machine learning and accelerometer data collected via smartwatch technology: instrument validation study. *JMIR Hum Factors* 2023; 10:e42714.
 34. Gürçay B, Yılmaz FT and Bilgin A: The effectiveness of telehealth interventions on medication adherence among patients with type 2 diabetes: a meta-analysis. *Telemed J E Health* 2024; 30:3-20.
 35. Emonena H and Ojo O: The efficacy of tele-monitoring in maintaining glycated haemoglobin levels in patients with type 2 diabetes mellitus: a systematic review. *Int J Environ Res Public Health* 2022; 19:16722.
 36. Omboni S, McManus RJ, Bosworth HB, et al: Evidence and recommendations on the use of telemedicine for the management of arterial hypertension. *Hypertension* 2020; 76:1368-1383.
 37. Bingham JM, Black M, Anderson EJ, et al: Impact of telehealth interventions on medication adherence for patients with type 2 diabetes, hypertension and/or dyslipidemia: a systematic review. *Ann Pharmacother* 2021; 55:637-649.
 38. Esmaeili ED, Azizi H, Dastgiri S and Kalankesh LR: Does telehealth affect adherence to ART among patients with HIV? A systematic review and meta-analysis. *BMC Infect Dis* 2023; 23:169.
 39. MacPherson MM and Kapadia S: Barriers and facilitators to patient-to-provider messaging using the COM-B model and theoretical domains framework: a rapid umbrella review. *BMC Digit Health* 2023; 1:33.
 40. Aggarwal A, Tam CC, Wu D and Li X: Artificial intelligence-based chatbots for promoting health behavioural changes: systematic review. *J Med Internet Res* 2023; 25:e40789.
 41. Barreda M, Cantarero-Prieto D, Coca D, et al: Transforming healthcare with chatbots: uses and applications—a scoping review. *Digit Health* 2025; 11:20552076251319174.
 42. Bérubé C, Nißen M, Vinay R, et al: Proactive behaviour in voice assistants: a systematic review and conceptual model. *Comput Hum Behav Rep* 2024; 14:100411.
 43. Oh YJ, Zhang J and Fang ML, et al: A systematic review of artificial intelligence chatbots for promoting physical activity, healthy diet, and weight loss. *Int J Behav Nutr Phys Act* 2021; 18:160.

44. U.S. Food and Drug Administration: De Novo Summary (DEN160018): reSET-O for opioid use disorder. Centre for Devices and Radiological Health, 2017.
45. Rohaj A and Bulaj G: Digital therapeutics (DTx) expand multimodal treatment options for chronic low back pain: the nexus of precision medicine, patient education, and public health. *Healthcare (Basel)* 2023; 11:1469.
46. Lu T, Lin Q and Yu B, et al: A systematic review of strategies in digital technologies for motivating adherence to chronic illness self-care. *NPJ Health Syst* 2025; 2:13.
47. Plaitano EG, McNeish D, Bartels SM, et al: Adherence to a digital therapeutic mediates the relationship between momentary self-regulation and health risk behaviours. *Front Digit Health* 2025; 7:1467772.
48. Liao WC, Angus F, Conley J and Chen LC: The efficacy of digital interventions on adherence to oral systemic anticancer therapy among patients with cancer: systematic review and meta-analysis. *JMIR Cancer* 2025; 11:e64208.
49. Boima V, Doku A, Agyekum F, Tuglo LS and Agyemang C: Effectiveness of digital health interventions on blood pressure control, lifestyle behaviours and adherence to medication in patients with hypertension in low- and middle-income countries: a systematic review and meta-analysis of randomised controlled trials. *EClinicalMedicine* 2024; 69:102432.
50. de Souza Ferreira E, de Aguiar Franco F and dos Santos Lara MM, et al: The effectiveness of mobile application for monitoring diabetes mellitus and hypertension in the adult and elderly population: systematic review and meta-analysis. *BMC Health Serv Res* 2023; 23:855.
51. Chan A, De Simoni A, Wileman V, et al: Digital interventions to improve adherence to maintenance medication in asthma. *Cochrane Database Syst Rev* 2022; 6:CD013030.
52. Wang Z, Zhu Y, Cui L and Qu B: Electronic health interventions to improve adherence to antiretroviral therapy in people living with HIV: systematic review and meta-analysis. *JMIR Mhealth Uhealth* 2019; 7:e14404.
53. Liu L, Guo J, Jiao X and You L: The effect of digital therapeutics intervention on improving hypertension management in adults: a meta-analysis of randomized controlled trials. *Hypertens Res* 2025; 48:456-469.
54. Rodrigues DA, Roque M, Mateos-Campos R, Figueiras A, Herdeiro MT and Roque F: Barriers and facilitators of health professionals in adopting digital health-related tools for medication appropriateness: a systematic review. *Digit Health* 2024; 10:20552076231225133.
55. Kafie C, Mohamed MS, Zary M, Chilala CI, Bahukudumbi S, Gore G, Foster N, Fielding KL, Subbaraman R and Schwartzman K: Cost and cost-effectiveness of digital technologies for support of tuberculosis treatment adherence: a systematic review. *BMJ Glob Health* 2024; 9:e015654.
56. Gentili A, Failla G, Melnyk A, et al: The cost-effectiveness of digital health interventions: a systematic review of the literature. *Front Public Health* 2022; 10:787135.
57. AJ, Geary CR, Dai R, et al: Lower electronic health record adoption and interoperability in rural versus urban physician participants: a cross-sectional analysis from the CMS quality payment program. *BMC Health Serv Res* 2025; 25:128.
58. Western MJ, Smit ES, Gültzow T, et al: Bridging the digital health divide: a narrative review of the causes, implications, and

- solutions for digital health inequalities. *Health Psychol Behav Med* 2025; 13:2493139.
59. Conduah AK, Ofoe S and Siaw-Marfo D: Data privacy in healthcare: global challenges and solutions. *Digit Health* 2025; 11:20552076251343959.
60. McGraw D and Mandl KD: Privacy protections to encourage use of health-relevant digital data in a learning health system. *NPJ Digit Med* 2021; 4:2.
61. Tsai CH, Eghdam A, Davoody N, Wright G, Flowerday S and Koch S: Effects of electronic health record implementation and barriers to adoption and use: a scoping review and qualitative analysis of the content. *Life (Basel)* 2020; 10:327.
62. World Health Organization: Global strategy on digital health 2020–2025. Geneva: WHO; 2021.
63. World Health Organization: Global initiative on digital health (GIDH): policy recommendations and roadmap. Geneva: WHO; 2023.
64. Sharma RS, Rohatgi A, Jain S, et al: The Ayushman Bharat Digital Mission (ABDM): making of India's digital health story. *CSIT* 2023; 11:3–9.
65. U.S. Food and Drug Administration: Digital health innovation action plan & digital health center of excellence. U.S. FDA; 2023.
66. Mantovani A, Leopaldi C, Nighswander CM and Di Bidino R: Access and reimbursement pathways for digital health solutions and in vitro diagnostic devices: current scenario and challenges. *Front Med Technol* 2023; 5:1101476.
67. Bucher A, Blazek ES and Symons CT: How are machine learning and artificial intelligence used in digital behaviour change interventions? A scoping review. *Mayo Clin Proc Digit Health* 2024; 2:375-404.
68. Harrison R, Lapteva E and Bibin A: Behavioural nudging with generative AI for content development in SMS health care interventions: case study. *JMIR AI* 2024; 3:e52974.
69. Lehne M, Sass J, Essenwanger A, et al: Why digital medicine depends on interoperability. *NPJ Digit Med* 2019; 2:79.
70. Bossenko I, Randmaa R, Piho G and Ross P: Interoperability of health data using FHIR mapping language: transforming HL7 CDA to FHIR with reusable visual components. *Front Digit Health* 2024; 6:1480600.
71. Horne BD, Muhlestein JB, Lappé DL, et al: Behavioural nudges as patient decision support for medication adherence: the ENCOURAGE randomized controlled trial. *Am Heart J* 2022; 244:125-134.

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