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TELEMEDICINE AND MOBILE HEALTH IN TYPE 2 DIABETES SELF-MANAGEMENT: EFFECTIVENESS, SAFETY, AND THE CASE FOR HYBRID CARE

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ABSTRACT

Background: Type 2 diabetes mellitus requires sustained self-management and regular clinical assessment. Telemedicine and mobile health may improve continuity of care, although their value varies with service design, patient capability, and professional oversight.
Aim: To critically evaluate the effectiveness, safety, equity, and appropriate clinical use of telemedicine and mobile health in adults with type 2 diabetes mellitus.
Material and Methods: Peer-reviewed literature was identified in PubMed, with Google Scholar used for supplementary citation searching. Current clinical standards, systematic reviews, meta-analyses, randomized trials, safety assessments, and qualitative studies were included in a narrative synthesis.
Results: Digital interventions produced modest average reductions in glycated hemoglobin, but results varied substantially between studies and were neutral in a primary-care meta-analysis. Benefit was more evident in patients with higher baseline HbA1c and in services combining monitoring with medication adjustment or responsive professional feedback. Relevant risks included digital exclusion, unvalidated dosing advice, unclear clinical responsibility, additional professional workload, and omission of necessary physical examination.
Conclusions: Telemedicine should complement rather than replace direct care. A hybrid model integrating remote monitoring with defined escalation procedures, accountable professional review, and periodic or clinically indicated face-to-face assessment is the most defensible approach.

KEYWORDS

Type 2 Diabetes Mellitus, Telemedicine, Mobile Health, Digital Health, Glycated Hemoglobin, Hybrid Care

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Introduction

Type 2 diabetes mellitus (T2DM) requires continuing decisions about medication, nutrition, physical activity, glucose monitoring, and complication prevention. Because most self-management occurs outside the clinic, telemedicine and mobile health may improve continuity and shorten the time between a clinical problem and professional response (American Diabetes Association Professional Practice Committee for Diabetes [ADA PPC], 2026a; Franc et al., 2011).

Digital care is not a single intervention. Text messages, self-guided applications, video consultations, clinician-led monitoring, and algorithms that recommend insulin doses differ in purpose, intensity, and risk. Their effects therefore cannot be attributed to technology alone; many interventions also include coaching, medication review, or personalized feedback (Faruque et al., 2017; Kerr et al., 2024; Moschonis et al., 2023).

The evidence is encouraging but inconsistent. Meta-analyses generally report modest HbA1c reductions, whereas some comparisons with usual care are neutral and benefits may decline after active support ends. Remote care can also miss findings that require examination and may introduce risk when dose recommendations are unvalidated or responsibility for follow-up is unclear (Alfarwan et al., 2024; Eberle & Stichling, 2021; Fleming et al., 2020; Sitter et al., 2022).

This critical narrative review examines which service models are associated with benefit, how technology can be matched to patient and clinical needs, and how medication safety, professional workload, equity, and direct assessment should shape implementation. The central question is not whether telemedicine works in the abstract, but when it adds value to a clinically accountable pathway.

Clinical Context: Diagnosis of Diabetes and Interpretation of HbA1c

Diagnostic criteria for diabetes

In nonpregnant adults, diabetes may be diagnosed by an HbA1c value of at least 6.5% (48 mmol/mol), fasting plasma glucose of at least 126 mg/dL (7.0 mmol/L) after at least eight hours without caloric intake, a 2-hour plasma glucose of at least 200 mg/dL (11.1 mmol/L) during a 75-g oral glucose tolerance test, or a random plasma glucose of at least 200 mg/dL in a person with classic hyperglycemic symptoms or a hyperglycemic crisis. The HbA1c assay used for diagnosis should be laboratory based, NGSP certified, and standardized to the Diabetes Control and Complications Trial assay (ADA PPC, 2026b; Sacks et al., 2023).

Unless hyperglycemia is unequivocal and accompanied by classic symptoms or crisis, diagnosis requires two abnormal results from the same or different tests. Discordant results should prompt repetition of the test above the threshold and assessment of factors that may distort glucose or HbA1c. Adults with weight loss, ketosis, rapid deterioration, or atypical features may also require evaluation for another type of diabetes. Data displayed by an application cannot replace diagnostic laboratory testing or clinical classification (ADA PPC, 2026b; Sacks et al., 2023).

The diagnostic tests are not fully interchangeable. Fasting plasma glucose, the oral glucose tolerance test, and HbA1c identify overlapping but not identical groups because they measure different aspects of glucose metabolism. In a remote pathway, an abnormal home glucose value should prompt appropriate clinical and laboratory assessment rather than automatic labelling or treatment intensification. The same caution applies when an algorithm receives incomplete information about symptoms, acute illness, medication, or pregnancy (ADA PPC, 2026b; Sacks et al., 2023).

Clinical assessment and interpretation of HbA1c

Diagnosis is only the beginning of assessment. Blood pressure, lipids, kidney function and albuminuria, cardiovascular risk, neuropathy, eye and foot disease, hypoglycemia, mental health, treatment burden, and the patient's ability to manage therapy can alter both prognosis and treatment choice. HbA1c targets must therefore be individualized rather than applied independently of comorbidity and risk (ADA PPC, 2026a).

HbA1c is formed by nonenzymatic glycation of hemoglobin and provides a weighted estimate of glycemic exposure over approximately the preceding 2-3 months, with more recent glucose contributing more strongly. It is convenient because fasting is unnecessary and it links monitoring to long-term complication risk. These properties explain why HbA1c is the dominant primary outcome in trials of digital diabetes care (ADA PPC, 2026b; Sacks et al., 2023).

HbA1c remains an indirect measure. Altered erythrocyte turnover, anemia, recent blood loss or transfusion, hemolysis, erythropoietin treatment, kidney failure, pregnancy, HIV treatment, and some hemoglobin variants can change its relation to prevailing glucose. Unexpected discordance between HbA1c,

capillary readings, and continuous glucose monitoring should therefore be investigated (ADA PPC, 2026b; Sacks et al., 2023).

Remote glucose data can reveal patterns between visits, but they complement rather than replace laboratory testing, examination, and clinical interpretation. HbA1c outcomes should likewise be considered with hypoglycemia, treatment burden, quality of life, persistence of benefit, and access to care (Alfarwan et al., 2024; Faruque et al., 2017; Hamasaki, 2022).

This distinction is important when evaluating digital interventions. A small mean HbA1c reduction may be valuable at population level, yet it does not show whether individual targets were reached or whether benefit was offset by hypoglycemia or treatment burden. Conversely, equivalence to face-to-face care may still be useful when remote delivery preserves access or reduces travel. Clinical importance therefore depends on baseline risk, the comparator, safety, and the purpose of the service, not on statistical significance alone (Alfarwan et al., 2024; Faruque et al., 2017).

Materials and Methods

A structured literature search was updated on July 2, 2026. PubMed was the primary database, while Google Scholar was used for supplementary citation searching. Search terms combined type 2 diabetes with telemedicine, telehealth, mobile health, remote monitoring, smartphone applications, artificial intelligence, insulin titration, safety, and cost-effectiveness.

Publications were eligible when they addressed adults with T2DM or a directly relevant component of digital diabetes care and reported clinical, behavioral, patient-centered, safety, equity, professional, implementation, or economic outcomes. Reports limited to type 1 or gestational diabetes, purely technical descriptions without a clinical or implementation outcome, duplicate reports, and publications without sufficient information to evaluate the relevant claim were not used as primary evidence.

Priority was given to current clinical standards, systematic reviews, meta-analyses, and randomized trials in adults with T2DM. Current ADA standards and laboratory guidance informed diagnostic and HbA1c statements. Diabetes-specific syntheses and trials informed effectiveness, while directly relevant safety assessments and qualitative studies were used only for questions such as dose-calculator safety, acceptability, digital capability, professional workload, and the need for physical examination.

Thirty-three peer-reviewed publications were included. For each source, the population, intervention, comparator, duration, principal outcomes, professional involvement, authority to adjust treatment, and author-reported limitations were considered. Findings were grouped by service model and interpreted according to study design, directness to T2DM, consistency with higher-level evidence, and clinical relevance. The review was a narrative synthesis; screening and extraction were not duplicated, no independent statistical pooling was performed, and no new formal certainty grade was assigned.

Results: What the Evidence Shows

Three service models rather than a list of devices

The interventions fall into three broad service models. Communication and self-management support uses SMS, telephone calls, websites, applications, or video to provide education, reminders, or discussion. Clinician-led remote management adds review by a nurse, pharmacist, physician, educator, or coach, sometimes with medication adjustment under a protocol (Cao et al., 2022; Crowley et al., 2022; Faruque et al., 2017; Jiang et al., 2022).

Data-intensive and algorithm-supported care links continuous or connected measurements to tailored behavioral or medication advice. CGM-supported education, integrated platforms, and conversational AI may increase responsiveness, but they require stronger validation, interoperability, alarm management, and clinical governance, particularly when insulin dosing is affected (Fleming et al., 2020; Lau et al., 2024; Lee et al., 2023; Nayak et al., 2023).

This classification avoids treating devices as competing therapies. A simple channel with timely professional review may be more intensive than a sophisticated self-guided application. The relevant variables are the response loop, staffing, and authority to act, not the screen through which care is delivered (Faruque et al., 2017; Kerr et al., 2024; Moschonis et al., 2023).

Mode of delivery still influences reach and feasibility. In the review by Moschonis et al. (2023), 56 randomized trials included 20 SMS, 25 smartphone-app, and 11 website interventions. The pooled HbA1c difference was significant for smartphone apps and SMS but not websites; however, reach, uptake, and intervention intensity also differed. These findings do not establish an intrinsic therapeutic hierarchy between channels, because content, participants, and professional support were not equivalent across groups.

HbA1c effects are real on average but inconsistent

High-level evidence supports a modest average effect, not a universal benefit. Hangaard et al. (2023) included 246 reports and calculated HbA1c effects for 168; telemedicine reduced HbA1c by 0.415 percentage points, but heterogeneity was very high ($I^2 = 93.05\%$). Moschonis et al. (2023) found a 0.30-point reduction across 56 randomized trials, and Kerr et al. (2024) estimated a 0.31-point advantage. In the latter review, only 12 of 23 comparative randomized trials reported a statistically significant HbA1c result.

Faruque et al. (2017) included 111 randomized trials with 23,648 adults. Mean differences were -0.57 percentage points at up to 3 months, -0.28 at 4-12 months, and -0.26 beyond 12 months. Effects were larger with higher baseline HbA1c and when medication adjustment was possible, whereas quality of life, mortality, and hypoglycemia did not show convincing improvement.

A 2024 primary-care meta-analysis was neutral. Across 21 randomized trials and 10,732 participants, telemedicine was not significantly superior to usual care for HbA1c or other reported cardiometabolic outcomes; the pooled HbA1c difference was -0.08 percentage points (95% CI -0.18 to 0.02). Telemedicine was therefore comparable to usual care in that setting, rather than demonstrably better (Alfarwan et al., 2024).

Comparator intensity helps explain these differences. Adding professional contact to limited usual care may improve control, whereas replacing an effective consultation may preserve rather than improve outcomes. Benefits also appear greater when baseline HbA1c is high, but available studies do not establish a single threshold for selecting patients (Crowley et al., 2022; Lim et al., 2021; Moschonis et al., 2023).

Two trials illustrate targeted benefit without proving universal effectiveness. In 200 patients with HbA1c at least 8.5% for one year or longer, comprehensive nurse-delivered telehealth produced a 12-month between-group HbA1c difference of -0.61 percentage points compared with simpler telemonitoring and care coordination. In 221 African American or Latinx adults with baseline HbA1c at least 8%, a pharmacist- and health-coach-led mobile intervention produced an adjusted 12-month effect of -0.62 points compared with usual care (Crowley et al., 2022; Gerber et al., 2023). Both interventions were intensive, staffed services in selected populations.

Durability and patient-centered outcomes remain uncertain. Some app and coaching trials showed early improvements that were not maintained after personalized support ended, while satisfaction was generally comparable to face-to-face care in six heterogeneous randomized trials (Hamasaki, 2022; Kim et al., 2024; Lee et al., 2022; Young et al., 2020). HbA1c should therefore be reported with hypoglycemia, treatment burden, quality of life, discontinuation, and follow-up after support is reduced.

Outcomes beyond HbA1c

HbA1c is clinically important, but it does not describe how an intervention affects day-to-day safety or the work required from the patient. Two services can produce a similar mean HbA1c while differing in hypoglycemia, treatment complexity, distress, medication burden, technical effort, or access to professional help. Evaluation should therefore include adverse events, severe and recurrent hypoglycemia, treatment changes, retention, quality of life, diabetes distress, and the proportion of participants who can continue using the service, rather than treating HbA1c as a complete measure of benefit (ADA PPC, 2026a; Faruque et al., 2017; Gerber et al., 2023).

The available evidence is less decisive for these outcomes than for glycemia. Faruque et al. (2017) did not find convincing improvement in quality of life, mortality, or hypoglycemia, and the satisfaction review by Hamasaki (2022) included only six heterogeneous randomized trials. Comparable satisfaction is useful when remote care improves access, but it does not establish clinical superiority. Patient-reported convenience should also be interpreted alongside technical failure, privacy, continuity with a known clinician, and the ability to obtain direct assessment when needed (Donaghy et al., 2019; Hamasaki, 2022).

Medication adherence illustrates the difficulty of selecting outcomes. Prescription-based measures such as medication possession ratio and proportion of days covered indicate that medicine was available, not that it was taken correctly or that dose changes were understood. In the review by Bingham et al. (2021), eHealth and telehealth interventions were associated with improvement in these measures, whereas the mHealth subgroup was not. Because populations, technologies, and adherence measures differed, the result supports careful measurement of the specific adherence barrier rather than a general claim that digital reminders improve adherence.

Safety evidence also requires scale and duration. In the eight-week trial of voice-based basal insulin support, no severe hypoglycemia or hyperglycemia occurred, but only 32 adults participated and the algorithm implemented a predefined, physician-approved titration protocol. This is reassuring for the tested pathway, not

proof of long-term safety or evidence that unrelated applications can recommend doses independently. Larger studies with longer follow-up and explicit adverse-event reporting are needed before automated medication support can be generalized (Fleming et al., 2020; Nayak et al., 2023).

Human support, medication adjustment, and durability

Responsive feedback appears more important than the communication channel. Higher coaching intensity and the ability to adjust medication were associated with larger HbA1c effects, while app reviews also identified interactivity and feedback as relevant components (Faruque et al., 2017; He et al., 2022; Kerr et al., 2024). These are associations across heterogeneous interventions and should not be interpreted as proof that one component is independently effective.

Medication-related services illustrate the distinction between access and superiority. Telepharmacy improved HbA1c from baseline, but did not significantly outperform face-to-face pharmacy care for HbA1c. Similarly, a nurse-led smartphone program was broadly comparable to an established nurse-led service rather than superior to it (Cao et al., 2022; Jiang et al., 2022). The professional service remained an active component in both formats.

Evidence for medication adherence is similarly mixed. A systematic review identified 13 studies reporting medication possession ratio or proportion of days covered. eHealth and telehealth interventions were associated with improved adherence measures, whereas the mHealth subgroup was not. Differences in populations, modalities, and adherence measurement limit direct comparison, but the review supports matching the intervention to the specific adherence barrier rather than assuming that reminders alone will change medication use (Bingham et al., 2021).

Where benefit depends on frequent coaching or messages, a maintenance plan is necessary. Programs should define when contact can be reduced, how deterioration will be detected, and how patients can re-enter more intensive support. Outcomes measured only during the active phase do not establish long-term effectiveness (Kim et al., 2024; Lee et al., 2022; Young et al., 2020).

Matching technology to the patient and the clinical task

Chronological age alone is an inadequate selection rule. A digitally experienced older adult may need less assistance than a younger person with limited literacy, unstable connectivity, disability, or work conditions that impede synchronous visits. Assessment should address vision, hearing, dexterity, cognition, language, health and digital literacy, device access, preference, caregiver support, and the complexity of the clinical task (Lam et al., 2020; Mayberry et al., 2019; Oh et al., 2021).

Telephone or simple messaging may suit limited bandwidth or digital experience; asynchronous applications may suit flexible follow-up; and clinician-led monitoring may be appropriate for insulin titration or persistently poor control. Training, accessible interfaces, and a non-digital alternative should remain available. Video may improve convenience and visual communication, but technical difficulties and the need to examine complex problems limit its use (Donaghy et al., 2019; Sitter et al., 2022).

Digital capability should be assessed for the intended task, not inferred from smartphone ownership. A patient may be able to receive messages but unable to upload data, distinguish urgent alerts, or judge the reliability of automated advice. Instruments used with older adults often measure only part of digital literacy, and safety and problem-solving are assessed less consistently than basic access. A brief practical demonstration may therefore be more informative than age or self-reported confidence alone (Oh et al., 2021).

A practical framework for matching digital support to patient and clinical context Is presented In Table 1.

Table 1. Matching digital support to patient and clinical context

Patient or clinical context	Potentially suitable model	Conditions for safe use and evidence base
Limited digital experience; visual, hearing, dexterity, or cognitive barriers; unreliable broadband	Telephone contact, simple SMS, or a low-complexity connected device	Assess capability rather than age alone; provide training, caregiver support when desired, accessible design, and a non-digital alternative (Lam et al., 2020; Oh et al., 2021).
Digitally confident adult seeking flexible follow-up around work, caring duties, or travel	Asynchronous messaging, app-based logging, or remote data review with scheduled video contact	Confirm reliable connectivity, ability to exchange data, and a route for urgent clinical contact; convenience does not remove the need for periodic clinical assessment (Donaghy et al., 2019; Sitter et al., 2022).
Persistently elevated HbA1c, insulin use, polypharmacy, recurrent hypoglycemia, or treatment intensification	Clinician-led telemonitoring with nurse, pharmacist, educator, or physician review	Use named clinical responsibility, documented titration rules, alarm thresholds, and rapid escalation; unsupervised dose calculators should not substitute for a validated pathway (Crowley et al., 2022; Huckvale et al., 2015; Nayak et al., 2023).
Low health literacy, language discordance, socioeconomic disadvantage, or low-bandwidth setting	Culturally and linguistically adapted, low-bandwidth support with a human contact component	Measure reach and dropout, avoid smartphone-only enrollment, test comprehension, and retain telephone or community-based support (Mayberry et al., 2019; Mokaya et al., 2022; Moschonis et al., 2023).

The match should be reviewed when clinical status changes. Recurrent hypoglycemia, treatment intensification, a new foot lesion, hospitalization, cognitive decline, or unreliable measurements may require more direct or intensive care, while stable control may permit less frequent contact (ADA PPC, 2026a; Sitter et al., 2022).

Safety risks and the limits of remote-only management

Medication advice is the highest-risk function. In a 2015 assessment of 46 rapid- or short-acting insulin calculator apps, 67% carried a risk of inappropriate dose output and only one was free of the predefined problems. These historical findings cannot be generalized to every current product, but they establish the need for validation, input checks, transparent calculations, and clinical oversight (Huckvale et al., 2015).

An EASD-ADA consensus report similarly identified limited evidence for many stand-alone apps and concerns about clinical validity, interoperability, training, regulation, and data security. Remote titration can be appropriate when a validated protocol defines eligibility, monitoring, dose authority, safety checks, and access to professional review. The randomized trial of conversational AI for basal insulin management used such a structured pathway and should not be interpreted as support for unsupervised dose changes (Fleming et al., 2020; Nayak et al., 2023).

The AI trial was small and short: 32 adults were followed for eight weeks. Participants using the voice system reached an optimal basal insulin dose sooner and had higher adherence and glycemic-control rates than standard care, but the sample and follow-up do not establish long-term safety, effectiveness, or generalizability. The result supports further evaluation of protocol-based titration; it does not validate generative advice or unrelated commercial applications (Nayak et al., 2023).

Platform activity is not equivalent to adherence. Missing data may reflect technical or access barriers, while frequent uploads do not establish that medication was taken or advice understood. Services should distinguish technical engagement, self-management behavior, medication adherence, and clinical outcome, and should define when nonresponse prompts direct contact (Bingham et al., 2021; He et al., 2022; Mayberry et al., 2019).

The reviewed studies do not demonstrate that telemedicine generally causes patients to alter insulin or discontinue medical visits without advice. The concern is more specific: poorly governed systems can make the source and authority of a recommendation unclear, and remote convenience can become unsafe if access

to clinical review is restricted. Patients should receive explicit instructions about which changes they may make under protocol, which require professional confirmation, and which symptoms require urgent or in-person assessment (Fleming et al., 2020; Huckvale et al., 2015; Sitter et al., 2022).

Remote-only care can also omit clinically necessary observation. Follow-up may require blood pressure measurement, inspection of injection sites, foot and vascular assessment, evaluation of neuropathy, or investigation of symptoms that cannot be resolved from a glucose trace. Clinical standards and qualitative studies support remote contact when examination is not required, while favoring face-to-face assessment for complex, uncertain, or examination-dependent problems (ADA PPC, 2026a; Donaghy et al., 2019; Sitter et al., 2022).

At service level, alert fatigue, fragmented records, delayed review, unclear liability, privacy concerns, and unequal access may offset convenience. Responsibility, review frequency, escalation thresholds, documentation, and interoperability must therefore be specified before routine implementation (Fleming et al., 2020; Kerr et al., 2024; Sitter et al., 2022).

Privacy, data governance, and accountability

Diabetes platforms may combine glucose readings, medication records, messages, dietary information, activity data, and identifiers. The clinical usefulness of this information does not remove the need for proportionate access control and clear governance. Patients should be told what data are collected, who can view them, whether information is transferred to another system, how long it is retained, and how a technical or privacy incident will be managed. Consent to use a device should not be treated as consent to every secondary use of the data (Fleming et al., 2020).

Accountability must also follow the clinical function of the platform. A tool used only for education carries a different risk from one that prioritizes alerts or recommends a medication change. Services should document which outputs are informational, which are reviewed by a professional, and which can trigger action under a protocol. Software updates that alter calculations, thresholds, or data flow require renewed evaluation rather than an assumption that evidence for an earlier version remains applicable. These safeguards are especially important when systems exchange data with records used by several professionals (Fleming et al., 2020; Huckvale et al., 2015).

Privacy and usability can also conflict. Repeated authentication may burden patients with limited digital skills, while shared devices or caregiver access can expose sensitive information. Implementation should therefore consider both security and the patient's practical ability to use the service, with explicit permission for caregiver involvement and a non-digital alternative when secure independent use is not feasible. Excluding such patients without offering another pathway would convert a security requirement into an access barrier (Lam et al., 2020; Mayberry et al., 2019; Oh et al., 2021).

The physician and nurse perspective: why hybrid care is the stronger model

Professional evidence supports selective rather than universal use. In interviews with 26 endocrinologists, appropriateness depended on clinical complexity, patient capability and preference, visit purpose, timing, and the perceived need for examination. Wide variation between clinicians suggested a need for explicit local criteria (Sitter et al., 2022). Primary-care participants likewise valued the convenience and visual communication of video but preferred direct assessment for some complex or sensitive problems (Donaghy et al., 2019).

For nurses, pharmacists, and educators, remote data can support earlier intervention but may also increase the volume of measurements and messages requiring review. Safe delivery requires allocated time, a defined scope of practice, documentation standards, and access to a prescriber when treatment must change. Trials of comprehensive and nurse-led programs evaluated staffed services rather than autonomous software (Cao et al., 2022; Crowley et al., 2022; Gerber et al., 2023; Jiang et al., 2022).

Patient experience does not clearly favor either format. A systematic review found satisfaction with telemedicine broadly comparable to conventional care, but included only six heterogeneous randomized trials. Acceptability should therefore be evaluated locally and should not be used as a substitute for clinical outcomes. Convenience, technical reliability, privacy, continuity with a known clinician, and the ability to obtain direct assessment may all influence preference (Donaghy et al., 2019; Hamasaki, 2022).

These findings support a hybrid pathway. Direct assessment can establish diagnosis, complication status, treatment goals, examination findings, and digital capability; remote intervals can then support data review, education, adherence, and protocol-based titration. New symptoms, discordant data, recurrent hypoglycemia, treatment failure, or suspected complications should prompt in-person review (ADA PPC, 2026a; Donaghy et al., 2019; Sitter et al., 2022).

From trial efficacy to routine service effectiveness

A digital intervention that works in a selected trial population may perform differently in routine care. Enrollment can require a compatible device, internet access, sufficient literacy, willingness to upload data, and time to respond to messages. Patients unable to meet these conditions may be excluded before outcomes are measured. This can overestimate reach and may conceal the support required by people with sensory impairment, cognitive difficulty, limited language proficiency, unstable housing, or low income (Kim et al., 2024; Lam et al., 2020; Mayberry et al., 2019; Oh et al., 2021).

The active ingredient is also difficult to isolate. Several successful programs combined technology with repeated contact, medication reconciliation, education, coaching, and authority to intensify therapy. Their results cannot be attributed to an application or messaging platform alone. A fair implementation assessment must describe staff roles, contact frequency, response time, treatment authority, and the usual-care comparator. Otherwise, a digital service with additional professional resources may be compared with a less intensive control and the difference incorrectly presented as a technology effect (Crowley et al., 2022; Faruque et al., 2017; Gerber et al., 2023).

Routine delivery also changes professional work. Connected devices can make deterioration visible earlier, but they can generate incomplete uploads, duplicate messages, false alarms, and data that require interpretation outside scheduled visits. A service therefore needs protected review time, thresholds that distinguish routine from urgent findings, a named professional responsible for action, and a documented route to a prescriber. Without these elements, additional data may increase workload without improving decisions (Fleming et al., 2020; Sitter et al., 2022).

Integration with the existing record is equally important. Advice given through a separate platform should be visible to the wider clinical team, and patients should know whether a message is monitored continuously or reviewed only at stated intervals. Hybrid care is strongest when remote contacts preserve relational continuity and lead directly to examination or laboratory testing when the question cannot be resolved online. The objective is not to maximize remote activity, but to place each contact in an accountable pathway (Donaghy et al., 2019; Fleming et al., 2020; Sitter et al., 2022).

Discussion

Interpreting benefit without overselling it

Digital diabetes care has a small average HbA1c benefit in several syntheses, but the estimate is heterogeneous and does not apply equally to every patient or service. Higher baseline HbA1c, responsive monitoring, medication adjustment, and professional feedback are associated with greater effects, while long-term and patient-reported outcomes are less certain (Faruque et al., 2017; Hangaard et al., 2023; Kerr et al., 2024).

Positive and neutral studies can coexist because they compare different service designs. Additional professional contact may improve limited care, whereas a remote visit may simply preserve the outcomes of an effective direct visit. Trials should therefore report staffing, response rules, treatment authority, comparator intensity, and maintenance strategy rather than relying on a broad technology label (Alfarwan et al., 2024; Faruque et al., 2017; Moschonis et al., 2023).

No modality is optimal for every patient. SMS can provide low-bandwidth support, asynchronous applications can accommodate work or travel, and connected platforms can organize complex longitudinal data. Patients with persistently poor control or insulin titration may require clinician-led monitoring, while stable patients may need only periodic remote contact. Choice should follow the clinical task, patient capability, and available staffing rather than technological novelty (Lam et al., 2020; Mayberry et al., 2019; Oh et al., 2021).

A practical hybrid-care pathway

A hybrid pathway should begin with a verified diagnosis, assessment of complications and hypoglycemia risk, individualized goals, and any required examination. The team should then assess digital access and competence and agree which data will be collected, who will review them, and within what interval (ADA PPC, 2026a, 2026b; Sacks et al., 2023).

The remote component should have a defined purpose. Stable patients may need education and periodic review; persistently high HbA1c may justify more frequent contact and treatment adjustment. Insulin pathways require explicit dose authority, alarm thresholds, hypoglycemia procedures, and circumstances in which automated advice is withheld (Fleming et al., 2020; Huckvale et al., 2015; Nayak et al., 2023).

In-person assessment should occur periodically and when clinically indicated, including new symptoms, recurrent or severe hypoglycemia, major treatment change, discordant HbA1c and glucose data, suspected foot or vascular disease, hospitalization, cognitive decline, or unreliable measurements. Patients need a named contact and urgent-care instructions, while professionals need clear responsibility, escalation routes, review time, and interoperable documentation (ADA PPC, 2026a; Crowley et al., 2022; Fleming et al., 2020; Sitter et al., 2022).

The frequency of remote and direct review should not be fixed solely by the platform. It should reflect glycemic stability, treatment complexity, hypoglycemia risk, complications, recent medication changes, ability to generate reliable data, and patient preference. The pathway should be reconsidered after hospitalization, repeated nonresponse, a major change in self-management capacity, or failure to improve despite apparently frequent digital contact. These events may indicate that the current mode of care is inadequate rather than that the patient is simply nonadherent (ADA PPC, 2026a; Sitter et al., 2022).

Cost, equity, and implementation

Economic claims remain uncertain. In the 2024 primary-care review, only one included study reported intervention-related costs, precluding a pooled cost-effectiveness conclusion. Digital care may reduce travel or substitute for some visits, but may add devices, platform fees, technical support, and professional review. Results from one staffed program cannot be generalized across health systems (Alfarwan et al., 2024; Crowley et al., 2022; Zhai et al., 2014).

Access also affects effectiveness. Device ownership, data cost, broadband, language, literacy, disability, privacy, and trust influence enrolment and continued use. Reviews in disadvantaged populations and low- and middle-income countries report promising but uneven evidence, so results among program completers should not be assumed to represent all eligible patients (Mayberry et al., 2019; Mokaya et al., 2022).

Onboarding should be treated as part of clinical delivery rather than a one-time technical instruction. Before remote follow-up begins, the patient should demonstrate the tasks required for the selected service, such as joining a consultation, uploading a measurement, recognizing an alert, and requesting help. The team should confirm language and accessibility needs, caregiver involvement when desired, monitoring hours, response expectations, and an alternative route when the platform or connection fails. Capability should be reassessed when treatment becomes more complex or health status changes (Lam et al., 2020; Oh et al., 2021; Sitter et al., 2022).

Data quality is a separate implementation requirement. Missing values may indicate nonuse, technical failure, loss of connectivity, or a device that is difficult to operate; they should not automatically be interpreted as intentional nonadherence. Unexpected measurements require confirmation and clinical context, particularly when an automated recommendation could alter medication. Remote glucose patterns should be reconciled with symptoms, laboratory HbA1c, treatment changes, and conditions that can distort HbA1c. A safe service therefore needs procedures for implausible values, incomplete uploads, device replacement, and escalation when the data cannot support a reliable decision (ADA PPC, 2026b; Fleming et al., 2020; Sacks et al., 2023).

Implementation studies should report uptake, technical failure, nonresponse, dropout, staff time, maintenance costs, and outcomes across relevant demographic groups. Lower-bandwidth alternatives and human assistance are part of service design, not optional additions (Mayberry et al., 2019; Mokaya et al., 2022; Moschonis et al., 2023).

The evidence from low- and middle-income countries illustrates the reporting problem. Mokaya et al. (2022) included 30 studies from 14 countries, with SMS used in 19. Feasibility was reported in all studies, but acceptability, appropriateness, and cost were reported much less often, and standardized mHealth reporting guidance was not used. Clinical outcomes without reach, dropout, and implementation data cannot show whether a service is scalable or equitable.

Priorities for future research

Future trials should distinguish the effect of the delivery channel from the effect of additional clinical care. Intervention reports need to specify who reviews data, how quickly a response is expected, whether medication can be changed, how many contacts occur, and what usual care contains. Factorial or component-based designs may help determine whether benefit comes from monitoring, education, coaching, treatment adjustment, or their combination. Without this detail, heterogeneity remains difficult to interpret and pooled estimates remain only broad averages (Faruque et al., 2017; Hangaard et al., 2023; Kerr et al., 2024; Moschonis et al., 2023).

Longer follow-up is a second priority. Short trials can capture early engagement and rapid treatment adjustment but cannot establish whether use persists after reminders, coaching, or study support is reduced. Outcomes should be measured during the active phase and after intensity decreases. Reports should include severe and nonsevere hypoglycemia, treatment burden, quality of life, distress, withdrawal, technical failure, and reasons for nonuse, together with HbA1c and other cardiometabolic outcomes (Eberle & Stichling, 2021; Faruque et al., 2017; Kim et al., 2024; Young et al., 2020).

Equity should be evaluated from invitation to completion. Studies should report how many eligible patients lacked a device, connectivity, language support, digital skills, or confidence; how many required caregiver or staff assistance; and whether outcomes differed by age, disability, literacy, socioeconomic position, and place of residence. Offering a telephone or face-to-face alternative should be treated as part of the intervention design. Results among participants who successfully enrolled cannot by themselves demonstrate equitable access (Mayberry et al., 2019; Mokaya et al., 2022; Oh et al., 2021).

Economic evaluation should use the same whole-service perspective. Devices and software are only part of cost; staff review, training, technical support, integration, replacement equipment, additional testing, avoided travel, and substituted visits also matter. Current evidence is too limited and context-dependent to support a universal cost claim. Future studies should report resource use and outcomes over a sufficient period and explain whose costs are counted: the health service, the professional team, the patient, or society (Alfarwan et al., 2024; Crowley et al., 2022; Zhai et al., 2014).

Limitations

This is a structured narrative review rather than a registered systematic review. PubMed was the principal database and Google Scholar was used for supplementary citation searching; selection and extraction were not duplicated, and no new formal risk-of-bias or certainty grade was assigned to every study. Selection and interpretation bias therefore remain possible.

The evidence is heterogeneous in baseline HbA1c, duration, comparator intensity, professional involvement, and authority to adjust treatment. Meta-analytic averages cannot identify a universally optimal model, and subgroup findings may be exploratory (Faruque et al., 2017; Hangaard et al., 2023; Kerr et al., 2024).

Some evidence was indirect: the insulin-calculator assessment was not limited to T2DM and the video-consultation study was conducted in primary care. Rapid product and regulatory change also limits generalization from older applications to current systems. The review therefore draws broader conclusions about service design and governance rather than endorsing specific products (Donaghy et al., 2019; Fleming et al., 2020; Huckvale et al., 2015).

The search was updated to a defined date, but newer versions of applications and unpublished evaluations may not be represented. Publication bias and selective reporting may favor positive clinical outcomes, while harms, workload, and implementation failure are less consistently measured. These limitations strengthen the case for cautious, service-specific conclusions rather than a single estimate of whether digital care works (Fleming et al., 2020; Mokaya et al., 2022; Sitter et al., 2022).

Conclusions

Telemedicine and mobile health can support T2DM management, but their average HbA1c benefit is modest and heterogeneous. Effects are more credible when the service provides responsive monitoring, professional feedback, and safe medication adjustment. Technology should be selected according to clinical risk, digital capability, access, and patient preference, with validated tools and explicit responsibility for high-risk decisions (Faruque et al., 2017; Fleming et al., 2020; Hangaard et al., 2023; Kerr et al., 2024).

The most defensible approach is hybrid care. Remote contact can improve continuity, while periodic or clinically triggered face-to-face assessment preserves examination and diagnostic review. Digital care should extend an accountable clinical team rather than replace it (ADA PPC, 2026a; Donaghy et al., 2019; Sitter et al., 2022).

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