RESEARCH ARTICLE

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Potential of mHealth Technology for Management of Diabetes and Cardiovascular Comorbidities in Rural Bangladesh: A Narrative Review

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Abstract

Background: Diabetes is becoming a common condition in LMICs, alongside cardiovascular disease (CVD). Distance and lack of staff, referral system, diagnostics and medicines access are an extra obstacle for the rural people. Mobile health (mHealth) can offer additional extension of prevention and chronic disease management, but only as long as it is integrated with the ebb and flow of an existing primary care system.

Objective: Summarize evidence up to 31 December 2020 regarding mHealth and type 2 diabetes (T2D) and cardiovascular (CV) comorbidity in rural, resource-limited settings, and to draw implications for Bangladesh.

Methods: Evidence was identified until 31 December 2020 using targeted search strategies in PubMed/MEDLINE, Scopus, Google Scholar, WHO resources and reference lists. Sources of full text information were considered, including freely available sources which focused on randomized trials, systematic reviews and meta-analyses, major observational studies and authoritative guidance. Evidence was aligned by prevention, diabetes self-management, hypertension/CVD management, CHW decision support, and implementation barriers. This was a narrative, non-exhaustive synthesis – no new pooled estimate was made.

Results: Prior to 2021, there were some indications of minimal improvement in intermediate outcomes such as HbA1c, blood pressure, adherence, health behaviors, and treatment processes. SMS trials for diabetes prevention in India showed mixed results and meta-analyses showed modest reductions in HbA1c. Selected cardiovascular text-messaging studies showed improvement in risk factors and outcomes related to adherence. Rural CHW decision-support trials in India and Tibet/China enhanced risk assessment, referral, medication utilization, or treatment processes, with mixed outcomes for blood-pressure, and downstream care constraints reducing the clinical impact.

Conclusions: mHealth needs to be considered as an additional and supporting service within a working primary care service and not as a standalone treatment. Low bandwidth, multilingual, offline-capable tools coupled with CHWs, standardised protocols, access to medicines and effective referral mechanisms are sensible design considerations for Bangladesh and similar contexts and need to be evaluated in advance and implemented on a local basis considering both effectiveness and cost-effectiveness, as well as equity.

Keywords: Mobile health, mHealth, diabetes mellitus, cardiovascular disease, hypertension, rural health, low-resource settings, community health workers, digital health, Bangladesh.

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Introduction

Diabetes and CVD constitute overlapping cardiometabolic epidemics. In 2019, an estimated 463 million adults aged 20-79 years were living with diabetes globally, and prevalence was projected to rise substantially; although prevalence was higher in urban than rural populations, the rural burden remained substantial [1]. CVD was the leading global cause of death, with an estimated 18.6 million deaths in 2019 [2]. In LMICs, substantial losses occur at successive stages of the diabetes and hypertension care cascades, from

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diagnosis to treatment and control [3,4]. These gaps are especially consequential for people with diabetes because cardiovascular risk reduction requires simultaneous attention to glycaemia, blood pressure, lipids, smoking, weight, diet, physical activity, kidney disease, and medication adherence [5,6].

Rural and resource-constrained systems face long travel distances, clinician shortages, weak referral pathways, intermittent diagnostics, and limited medicine availability. The WHO Package of Essential Noncommunicable Disease Interventions (WHO PEN) and HEARTS therefore emphasize standardized primary-care protocols, risk-based management, team-based care, essential medicines, and longitudinal monitoring [5,7].

Mobile health, broadly referring to the use of mobile devices and communication technologies to support health care, can potentially strengthen these functions through patient messaging, self-monitoring, teleconsultation, registries, referral tracking, and clinical decision support [8,9]. However, WHO guidance emphasizes that digital interventions should complement rather than substitute for functioning health systems [8]. This review examines the potential, evidence, and implementation priorities for mHealth in diabetes and cardiovascular comorbidity in rural and resource-constrained settings, and considers implications for Bangladesh.

Review Approach

This is a narrative review rather than a systematic review or meta-analysis. Evidence was identified through targeted searches of PubMed/MEDLINE, Scopus, Google Scholar, WHO resources, and reference lists using combinations of terms related to mobile health, mHealth, text messaging, SMS, mobile application, telemonitoring, diabetes, hypertension, cardiovascular disease, rural, low-resource, LMIC, Bangladesh, South Asia, community health worker, and clinical decision support. Only sources published on or before 31 December 2020 and available as freely accessible full text were considered. Priority was given to randomized or cluster-randomized trials, systematic reviews and meta-analyses, large multicountry studies defining care gaps, implementation studies directly relevant to resource-constrained practice, and authoritative WHO or professional guidance. The selection was purposive and implementation-oriented rather than exhaustive. No de novo pooled effect estimate is presented, and the review should be interpreted as a structured narrative synthesis rather than a systematic evidence inventory.

Early reviews found modest improvements in some care processes but heterogeneous evidence and limited LMIC data [10-14]. Broader chronic-disease evidence suggested generally acceptable usability but mixed effects on adherence and clinical outcomes [15].

Why mHealth Fits Integrated Cardiometabolic Care

Diabetes and CVD share a need for repeated, low-intensity contact rather than episodic rescue care. mHealth can support this longitudinal model through five complementary functions: prevention and risk communication; medication and appointment reminders; self-monitoring of glucose, blood pressure, weight, diet, and activity; communication among patients, CHWs, and clinicians; and decision support and referral tracking for frontline workers. Labrique and colleagues described mobile technologies as health-system-strengthening tools across functions including client education, registries, decision support, provider communication, and supply-chain processes [9]. Reviews of frontline-worker programs found mobile tools feasible for data collection, clinical algorithms, referrals, work planning, and supervision when training and workflow design were adequate [16].

Technology choice is context dependent. Where smartphones, data plans, or digital literacy are limited, SMS and voice calls may be more accessible and equitable; alternatively, a CHW-held tablet can extend algorithm-supported risk assessment across many households.

Prevention of Diabetes and Cardiovascular Risk

Prevention evidence before 2021 was promising but inconsistent. A 2020 systematic review of mHealth for primary prevention of CVD and type 2 diabetes identified few eligible studies and judged the evidence limited by methodological quality and generally small effects [17]. Nevertheless, several studies demonstrated proof of concept.

In a randomized trial of 537 Indian men with impaired glucose tolerance, frequent lifestyle-support SMS reduced two-year cumulative diabetes incidence from 27% in controls to 18% in the intervention group (hazard ratio 0.64, 95% confidence interval [CI] 0.45-0.92), with a reported number needed to treat of 11 [18]. A post-trial analysis reported persistence of benefit after active messaging ended [19]. However, a later pragmatic trial of 2,062 people with prediabetes in India and the United Kingdom found no significant reduction in progression to diabetes at two years with supportive SMS (hazard ratio 0.89, 95% CI 0.74-1.07) [20]. The contrasting findings indicate that message delivery alone is insufficient; baseline risk definition, intervention intensity, behavioral tailoring, population characteristics, and linkage to other services may modify effectiveness.

At population scale, the mDiabetes program in India delivered 56 messages in 12 languages over six months and improved a composite of self-reported diabetes risk behaviors compared with controls [21]. Such models are attractive in resource-constrained settings because marginal delivery costs can be low and content can be standardized and translated. However, improvements in knowledge or

behavior should not be equated with proven reductions in myocardial infarction, stroke, or mortality.

Diabetes Self-Management and Glycaemic Control

Text messaging has the largest pre-2021 evidence base among low-complexity mHealth strategies. A 2014 meta-analysis found that educational text messaging improved glycaemic control in adults with type 2 diabetes [22]. A 2019 meta-analysis of 11 randomized trials involving 1,710 participants found that text-messaging interventions reduced HbA1c by approximately 0.38 percentage points overall [23]. These effects are clinically modest but potentially relevant when delivered at scale.

Smartphone applications add functions such as glucose logging, automated feedback, goal setting, educational content, reminders, and clinician communication. A 2016 meta-analysis of 14 randomized trials found a mean HbA1c reduction of 0.49 percentage points with diabetes applications, with greater benefit in studies incorporating health-professional feedback [24]. A 2017 meta-analysis similarly favored mobile applications for HbA1c reduction [25].

Evidence from India supports feasibility outside affluent health systems. A randomized trial in northern India used mobile messages linked to fasting blood-glucose results [26]. A multicentre trial among people with newly detected type 2 diabetes found that text messaging improved glycaemic control over two years and reported favorable changes in blood pressure and LDL cholesterol [27].

By 2020, a systematic review of app-assisted self-care for type 2 diabetes and/or hypertension included 27 randomized trials; pooled analyses supported improvements in HbA1c and blood-pressure outcomes, although evidence quality and intervention components varied [28]. A separate 2020 meta-analysis evaluating mHealth for diabetes and hypertension also concluded that mHealth could improve clinical outcomes while highlighting substantial heterogeneity [29]. These findings support mHealth as an adjunct to routine diabetes care rather than a substitute for medication supply, laboratory testing, or clinical assessment.

Hypertension and Cardiovascular Comorbidity

Because hypertension is common in diabetes and is a major determinant of stroke, coronary disease, heart failure, and kidney disease, blood-pressure management is a central target for integrated mHealth.

In the South African StAR trial, 1,372 adults with hypertension were randomized to information-only SMS, interactive SMS, or usual care. At 12 months, information-only messaging produced a small reduction in systolic blood pressure relative to usual care and increased the proportion achieving blood pressure below 140/90 mmHg; interactive messaging did not clearly provide additional benefit [30]. Reviews of telemedicine and mHealth in hypertension identified remote blood-pressure transmission, feedback, and treatment support as plausible components of improved control [31].

For established coronary disease, the TEXT ME randomized clinical trial demonstrated that four lifestyle-focused messages weekly improved several cardiovascular risk factors at six months. Compared with controls, intervention participants had lower LDL cholesterol, systolic blood pressure (difference approximately -7.6 mmHg), and body mass index, together with favorable physical-activity and smoking outcomes [32]. The Text4Heart trial also demonstrated the feasibility of an SMS-plus-web program for coronary heart-disease self-management, although effects across individual clinical outcomes were not uniformly large [33].

Systematic reviews found improvements in several cardiovascular risk factors but limited evidence for hard clinical outcomes [34]. Secondary-prevention mHealth improved medication adherence and attainment of blood-pressure targets, while effects on lipids, smoking, readmission, or mortality were less consistent [35-37]. Thus, by 2020, evidence supported mHealth mainly as an adjunct for risk-factor control and adherence, not as a proven mortality-reduction strategy.

Community Health Workers and Mobile Clinical Decision Support

For rural health systems, provider-facing mHealth may be particularly relevant because it can support task sharing and standardized assessment at the point of community care. SMARTHealth India developed a tablet-based clinical decision-support system for nonphysician health workers and primary-care physicians. Field evaluation in rural Andhra Pradesh showed that frontline workers could conduct structured cardiovascular risk assessment and generate electronic referrals, but many referred patients did not subsequently attend clinics and medication continuation remained limited [38]. The result illustrates the distinction between successful digital screening and completion of the downstream care cascade.

The SimCard cluster-randomized trial in 47 villages in rural Tibet, China, and Haryana, India enrolled 2,086 people at high cardiovascular risk. CHWs used an Android-based decision-support system during monthly visits. The intervention increased reported antihypertensive medication use and produced a modest reduction in systolic blood pressure [39]. The findings suggest that task sharing supported by relatively simple mobile algorithms can improve treatment processes in geographically difficult settings.

The larger SMARThealth India stepped-wedge trial extended this model across 54 rural villages. CHWs performed household cardiovascular-risk assessments using mobile tablets, electronically referred high-risk

Table 1: Resource-Conscious mHealth Functions for Integrated Diabetes-CVD Care

Care gap	*Potential mHealth function*	*Rural implementation priority*
Low awareness or prevention uptake	SMS/voice lifestyle education	Local language; low literacy burden
Undiagnosed diabetes or hypertension	CHW screening and digital risk assessment	Validated devices; offline data capture
Medication non-adherence	Reminders, two-way messaging, CHW calls	Link reminders to reliable medicine supply
Poor glucose/BP monitoring	Digital logging or remote transmission	Prioritize high-risk patients where devices are scarce
Variable clinical practice	Mobile decision support	National/WHO protocols; explicit escalation rules
Missed follow-up	Registry and recall alerts	Assign responsibility for active tracing
Weak referral completion	Electronic referral and tracking	Closed-loop community-facility confirmation
Limited specialist access	Teleconsultation/CHW-facilitated review	Target patients most likely to benefit

individuals, and linked information to primary-care physicians. Implementation and treatment uptake improved, but the intervention did not significantly improve the primary blood-pressure-control outcome overall [40]. Variability in blood-pressure measurements, changing risk classification, and health-system constraints complicated effectiveness.

Collectively, these studies suggest a key implementation principle: mHealth can strengthen case finding, standardization, communication, referral, and treatment initiation, but improvements in clinical outcomes remain contingent on accurate measurement, medicine availability, accessible clinicians, and sustained follow-up.

Designing mHealth for Rural and Resource-Constrained Settings

Based on the evidence and guidance summarized above, a practical rural model would integrate diabetes and cardiovascular risk rather than create separate digital programs. At community level, a CHW could use an offline-capable application to record age, smoking, diabetes status, blood pressure, previous CVD, medication use, symptoms, and locally available laboratory measures. The software could apply approved risk and treatment protocols, generate referral flags, and schedule follow-up. Patient-facing SMS or voice messages could reinforce medication use, diet, physical activity, tobacco cessation, foot care, glucose or blood-pressure monitoring, and recognition of urgent symptoms. At facility level, a simple registry could identify missed visits, uncontrolled risk factors, and incomplete referrals. This architecture is consistent with WHO PEN, HEARTS, and digital-health guidance [5,7,8], but it should be understood as a synthesis of design priorities rather than as a validated Bangladesh-specific intervention.

Several design requirements follow. Offline functionality and delayed synchronization are preferable where connectivity is intermittent. Local-language content and voice options are important where literacy is limited. Systems should minimize patient data costs and repeated manual data entry. Algorithms should support rather than replace clinical judgment, with explicit escalation pathways for acute symptoms or dangerous physiological measurements. Digital systems should also reduce, rather than duplicate, documentation workload.

Equity, Privacy, and Health-System Constraints

The assumption that mobile-phone penetration equals digital access is unsafe. Household phone sharing, unequal control of devices, disability, literacy, smartphone cost, data charges, electricity, and network coverage can selectively exclude vulnerable patients. African implementation reviews documented recurrent technical, organizational, and contextual barriers [13,14]. WHO guidance therefore recommends assessment of feasibility, acceptability, resource use, and equity - not only technical performance - before implementation at scale [8].

Privacy is also context dependent. SMS may expose sensitive information on shared devices; lost CHW devices may contain identifiable clinical information; and centralized systems require explicit data-governance arrangements. Minimum necessary data collection, authentication, role-based access, appropriate security, consent procedures, and defined retention policies should be specified prospectively [8].

Most importantly, mHealth cannot repair absent health-system inputs. WHO PEN and HEARTS explicitly pair standardized care with access to essential medicines and technologies [5,7]. A reminder to take an antihypertensive medication has little value during stock-outs; identification of uncontrolled diabetes has limited benefit without diagnostic confirmation and treatment; and electronic referral cannot improve outcomes if patients cannot access clinicians.

Rural mHealth programs should therefore be evaluated as components of complete care pathways, with indicators covering detection, treatment initiation, treatment intensification, adherence, referral completion, retention, and risk-factor control.



Interpretation and Research Priorities

The evidence available by 31 December 2020 supports three principal conclusions. First, mHealth can produce modest improvements in intermediate cardiometabolic outcomes, particularly HbA1c, blood pressure, adherence, and health behaviors [22-25,28-32]. Second, simple technologies such as SMS remain relevant and may be more scalable than smartphone-only solutions in low-resource populations [18,21,23,30,32]. Third, provider-facing technologies can extend standardized care through CHWs, but their effectiveness is bounded by the capacity of the health system to deliver medicines, confirm diagnoses, and act on referrals [38-40].

Important evidence gaps remained. Most studies were relatively short, heterogeneous, and powered for surrogate outcomes rather than myocardial infarction, stroke, renal failure, hospitalization, or mortality. Cost-effectiveness and budget impact were inadequately reported in many LMIC programs [11-15]. Rural populations, people with limited literacy, older adults, women without independent device access, and the poorest households were not consistently represented. Comparative evidence was also limited regarding whether personalized two-way communication, clinician feedback, automated algorithms, CHW mediation, or remote devices provide sufficient incremental benefit to justify their additional cost.

The review itself has important limitations. It used a narrative, purposive selection approach, included only sources with freely available full text, and did not perform a de novo meta-analysis. It should therefore be used to identify consistent themes and implementation considerations rather than to infer that every relevant pre-2021 study was captured.

No Bangladesh-specific mHealth intervention trial is represented among the intervention studies summarized here. Recommendations for Bangladesh are therefore extrapolations from trials and implementation studies in other rural or resource-constrained settings, together with WHO guidance, rather than direct estimates of effectiveness in Bangladesh.

Future evaluations should assess implementation and clinical effectiveness simultaneously. Outcomes should include medicine availability, referral completion, treatment intensification, retention, patient costs, digital exclusion, and safety. Economic evaluations should compare mHealth not only with usual care but also with alternative investments such as additional CHWs, transport support, diagnostic equipment, and reliable medicine procurement. Interoperability with routine health information systems and explicit data-governance standards should be treated as core implementation outcomes. For Bangladesh, feasibility, effectiveness, equity, and cost-effectiveness should be evaluated locally before scale-up.

Conclusion

By the end of 2020, mHealth had credible evidence of modest benefit for selected components of diabetes and cardiovascular care, but not as a stand-alone solution to cardiometabolic disease. SMS can reinforce prevention, medication adherence, and self-management; applications and connected monitoring can support more intensive feedback; and mobile clinical decision support can enable CHWs to identify and follow high-risk patients. Rural trials illustrate both the opportunity and the limitation: digital tools can bring standardized assessment and communication closer to households, but outcomes depend on whether the health system can supply medicines, confirm diagnoses, provide clinical review, and maintain follow-up.

The evidence does not establish a single highest-value mHealth technology. Instead, it supports pragmatic design priorities for rural and resource-constrained settings: low-bandwidth communication, multilingual and offline-capable tools, integration with CHW and primary-care workflows, standardized protocols, reliable medicine supply, referral pathways, accountable longitudinal care, and interoperability where feasible. In Bangladesh, these priorities should be locally tested rather than assumed to generalize from other settings. Properly integrated, mHealth may reduce geographic and organizational barriers to diabetes-CVD prevention and management while minimizing the risk of digital exclusion.

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