

MINI-REVIEW

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Reimagining Continuous Glucose Monitors as a Tool for Primary Prevention to Combat Type 2 Diabetes and Associated Cardiometabolic Disease in Low- and Middle-Income Countries

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Abstract

Prediabetes substantially increases the risk of Type 2 diabetes mellitus (T2DM), a rapidly growing global health and economic challenge that disproportionately affects low and middle-income countries (LMICs). Conventional prevention strategies based on delayed biomarkers and generalized lifestyle advice have shown limited effectiveness. Continuous glucose monitors (CGMs), traditionally used for diabetes management, offer a promising preventive approach by providing real-time, personalized feedback that links behaviors to glycemic responses. However, evidence supporting CGM use in prediabetes remains limited, and technical, behavioral, and equity-related challenges must be addressed. Scalable implementation models for LMICs, including intermittent CGM use, digital health integration, community health worker support, and household engagement within chronic care frameworks, should be tailored to local resource constraints. Repositioning CGMs as preventive tools could provide a cost-effective strategy to reduce the growing T2DM burden if implementation overcomes barriers related to infrastructure, workforce capacity, and equitable access.

Keywords: type 2 diabetes; prediabetes; continuous glucose monitoring; lifestyle modification; prevention strategies

Introduction

The world is facing a rapidly accelerating pandemic of noncommunicable diseases (NCDs). In 2024, an estimated 12% and 9.2% of adults have impaired glucose tolerance and impaired fasting glucose, respectively, which puts individuals at a higher risk of developing T2DM. This burden is disproportionately concentrated in low- and middle-income countries (LMICs), which account for ~80% of cases, with nearly half remaining undiagnosed. Structural constraints, including limited

health spending and inadequate treatment coverage, further exacerbate the problem, with fewer than 1 in 10 individuals in LMICs receiving comprehensive care.^{1,2}

A convergence of cultural and structural factors, including diets dominated by high-carbohydrate staples, high consumption of refined sugars and sugar-sweetened beverages, and increasingly sedentary lifestyles, has created a fertile environment for metabolic disease. Persistently low consumption of fruits and vegetables, despite their relative availability in some

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countries, further highlights a disconnect between food supply and dietary habits.^{3–6}

Improving diet quality and lifestyle habits is therefore not solely a behavioral challenge but a structural one, reflecting a broader prevention paradox in which abstract risk communication and delayed biomarkers such as HbA1c fail to overcome entrenched socioeconomic and environmental constraints. These include the high relative cost of healthy diets, limited affordability, food environments saturated with inexpensive processed foods, and cultural norms favoring energy-dense staples.⁶ Together, these factors contribute to dietary inertia and health-related fatalism, limiting the effectiveness of traditional prevention strategies and underscoring the need for integrated approaches that address both structural and individual-level determinants.

Continuous glucose monitors (CGMs) have been proposed as a tool to help break this cycle by making abstract risk concrete and actionable. This article provides a narrative, LMIC-focused overview of the evidence, limitations, and implementation requirements for using CGMs as a primary prevention tool for T2DM, with particular attention to distinguishing what is established in diabetes populations from what remains provisional in prediabetes. Finally, we outline a scalable delivery model tailored for resource-constrained settings, centered on intermittent sensor wear paired with coaching led by community health workers and local champions.

The Behavioral Rationale: CGMs as Personalized Feedback Tools

A physician's recommendation to "eat less sugar" is often dismissed as an abstract and/or culturally disconnected directive. CGMs alter this dynamic by directly linking behaviors to objective metrics such as time in range (TIR), helping visualize the magnitude and duration of postprandial glucose excursions following typical local meals. This makes behavioral goals tangible, shifting the focus from distant outcomes to improvement of a daily, measurable metric.^{7–10}

Moreover, CGMs capture substantial interindividual variability in glycemic responses to identical foods, underscoring the limitations of one-size-fits-all dietary advice and reinforcing the importance of personalization for sustained behavioral change.^{11,12} Building on this, CGMs can reinforce adherence to low-burden interventions such as vegetable-first meal sequencing or postprandial walking.^{13–15} Real-time feedback enables

individuals to observe and refine behaviors, transforming general recommendations into personalized, data-driven strategies aligned with glycemic targets.

It is important, however, to note that this evidentiary support is drawn predominantly from populations with established T1DM or T2DM, where CGM is a validated, approved indication.¹⁶ The observed magnitude of effect, characterized by reduced postprandial glucose excursions, healthier dietary patterns, an approximate 0.3% reduction in HbA1c, and a roughly 7% absolute increase in TIR,^{7–10} is best interpreted as evidence of an underlying behavioral mechanism rather than direct evidence in the prevention population this review is concerned and should therefore not be read as an estimate of the clinical benefit achievable specifically for T2DM prevention. The much smaller literature specific to prediabetes is addressed separately below.

Evidence in Prediabetes: Promising but Still Immature

Evidence for CGM-guided behavior change specifically in prediabetes is more limited, more recent, and considerably less mature than the diabetes literature it is often extrapolated from. In prediabetes, CGM-informed counseling has been associated with reductions in time > 140 mg/dL from ~27.5% to ~14% and TIR increases from ~71% to ~80%, and a 2026 systematic review and meta-analysis of 14 studies (1847 participants) found CGM-guided behavioral interventions reduced progression to T2DM by approximately 42% (RR 0.58, 95% CI 0.42–0.80), with modest accompanying improvements in HbA1c, weight, and TIR.^{17,18}

At the same time, this literature carries well-documented limitations that should temper how strongly it is presented. Most prediabetes-specific trials are small (frequently under 50 participants), short in duration (weeks to a few months), and heterogeneous in device type, behavioral protocol, and comparator arm; no trial to date has been powered to detect T2DM incidence as a primary endpoint, and no study has followed participants long enough to demonstrate durable, sustained prevention after CGM use is discontinued.^{17–20} Time-in-range thresholds and other CGM-derived metrics currently in use were developed and validated in diabetic populations; whether the same thresholds meaningfully distinguish pathological from ordinary glycemic variability in normoglycemic or prediabetic individuals remains an open question.^{16,21} Some critical appraisals of this literature have gone further, describing

the use of CGM in nondiabetic populations as an area where commercial and clinical enthusiasm has outpaced the evidence and calling for caution against presenting preliminary or associative findings as established clinical benefit.^{22,23}

Device accuracy in near-normal glycemic ranges is a further, related constraint. CGM sensors were engineered and validated primarily for the wider postprandial glucose excursions typical of diabetes; several studies report reduced precision at euglycemic and near-normal ranges, including underestimation relative to reference glucose measurements during oral glucose tolerance testing, and increased error post exercise.^{24,25} These limitations do not preclude behavioral utility; an imperfectly precise CGM trace can still motivate lifestyle change. They do, however, argue against treating CGM output as a fully validated diagnostic or risk-stratification tool in this population and against overstating the interpretive clarity of the feedback provided to patients.

Since the main goal in prediabetes is building healthy habits rather than tracking exact glucose numbers, continuous wear is unnecessary. Evidence demonstrates that intermittent application of CGM technology can effectively support lifestyle adjustments.¹⁰ Consequently, a time-limited model centered on structured coaching and behavioral adaptation represents a far more feasible strategy for LMIC settings, as outlined below. During short, structured periods, individuals generate personalized data, establish cause-and-effect relationships within their dietary patterns, and develop sustainable coping strategies; where feasible, CGM and behavioral data can be integrated into digital health platforms to extend support between coaching encounters. Structured feedback and brief coaching sessions support interpretation of glucose responses and guide targeted lifestyle adjustments.^{26,27}

Counterintuitively economic: the case for prevention

From a health systems perspective, the economic rationale for prevention is clear. In Latin America and the Caribbean, *diabetes complications such as renal failure and cardiovascular disease account for nearly 40% of the region's \$66 billion in direct health care costs, outstripping routine care and medications combined, even before considering indirect costs due to premature mortality and disability.*^{28,29} With diabetes-related health expenditure already accounting for 1.3% and 0.8% of GDP in middle- and low-income countries, respectively, and the highest regional estimate reaching

2.5% of GDP in South and Central America,² preventive interventions offer a compelling economic return by curbing avoidable expenditures.

For T2DM, CGM use has already been shown to be cost-effective in multiple contexts.^{30–33} For example, in the USA, CGM use in patients with T2DM is estimated to generate annual savings of up to \$13,034 depending on treatment modality, potentially amounting to \$357 million in national Medicaid savings.³³ Feasibility data from LMICs, while encouraging, remain limited: small pilot studies from Malawi, Rwanda, and Ethiopia show CGM can be deployed and is broadly acceptable, but these studies are short-term, focus on T1DM rather than prediabetes, and often rely on donated equipment rather than sustainable supply models.^{34–36} Dedicated prediabetes-specific CGM trials in LMICs are, to date, essentially absent, and closing this evidence gap will require adequately powered studies using locally relevant behavioral and clinical endpoints, rather than continued extrapolation from high-income settings or populations with established diabetes.

While formal cost-effectiveness data for prediabetes prevention in LMICs remain scarce, we conducted a break-even analysis using local economic parameters to estimate financial viability. In the Dominican Republic, where prediabetes prevalence is approximately 22%,³⁷ local market prices indicate an average cost of 85 USD per CGM sensor (FreeStyle Libre 2) and 50 USD per specialist consultation. Applying these costs to an intermittent protocol modeled after Yoo et al.,³⁸ which combines three sensors (255 USD) and four coaching sessions (200 USD) over 3 months, yields a total intervention cost of 455 USD per patient. Dividing this intervention cost by the annual per-capita diabetes-related expenditure in the Dominican Republic (1353.9 USD) reveals that the program reaches financial break-even if at least 33.61% of treated patients successfully delay type 2 diabetes onset by 1 year. This target appears achievable given the ~42% relative risk reduction reported above, though, as already noted, that pooled estimate should be interpreted cautiously. Robust, LMIC-specific efficacy and cost-effectiveness trials remain needed before this modeling can be treated as more than illustrative.

Limitations, risks, and critical considerations

The preceding sections point to a broader conclusion: the case for CGM as a prevention tool is best characterized as promising and exploratory rather than

established, and several categories of risk and uncertainty warrant explicit acknowledgment before any implementation model is proposed.

First, as discussed above, the evidence base specific to prediabetes is thin relative to the diabetes literature it draws credibility from, with small samples, short follow-up, heterogeneous protocols, no validated prediabetes-specific glycemic thresholds, and no trial to date demonstrating durable prevention after monitoring ends.^{17–20} Device accuracy in near-normal glycemic ranges adds a technical layer of uncertainty on top of this evidence gap.^{24,25,39,40}

Second, the psychological risks associated with information overload or overinterpretation of CGM data remain largely unexplored in the existing literature. In individuals without diabetes, normal day-to-day glucose fluctuation may be misread as pathological, particularly where contextual coaching is limited. This has raised concern about induced anxiety, hypervigilance around food, and, in vulnerable individuals, the potential to reinforce disordered eating patterns; this risk has been described by several authors as substantially under-researched.^{22,23} Broader adherence and device-burden literature from diabetes populations is also informative here: commonly reported barriers to sustained CGM use include sensor detachment, skin reactions, and alarm fatigue that disrupts sleep and contributes to disengagement.^{41,42} These physical and cognitive burdens are likely to be equally pronounced, if not heightened, in a prediabetes population being asked to wear a continuous monitor for primary prevention rather than direct therapeutic management.

Third, cost and reimbursement structures raise a distinct equity concern that runs somewhat counter to the LMIC-focused rationale of this review. Because prediabetes is not a reimbursed indication in essentially any health system, CGM use in this population is overwhelmingly out-of-pocket. In high-income settings, this has produced documented disparities in access by income, geography, ethnicity, and age even where universal coverage otherwise exists.^{43,44} In LMIC contexts where affordability constraints are already severe, this dynamic risks accentuating health inequities by reaching only those already best positioned to act on general lifestyle advice.

These limitations do not undermine the rationale for exploring CGM as a prevention tool in LMICs, but they argue for framing that rationale honestly, for embedding psychological-safety monitoring into any

pilot program, and for treating long-term, sustained behavior change as an open empirical question rather than a demonstrated outcome.

Closing the implementation gap in LMICs

The general limitations described above are compounded in LMIC settings, where translating CGM into routine practice is challenged by constrained resources, limited infrastructure, and reduced health system capacity. While these barriers are substantial, they also identify clear priorities for future research and implementation design.

Cost remains the most immediate barrier. A target product profile for glucose monitoring appropriate for LMICs established an optimal end-user price of 20 USD per month, with the cost of goods sold for certain CGMs estimated at approximately 10 USD. However, the lowest price reported in an LMIC survey was 50 USD, a figure well above this established target.^{45,46} Closing this gap will require active negotiations among manufacturers, distributors, and insurers to reduce consumer pricing, supported by pooled procurement strategies or sliding-scale payment models tailored to local purchasing power.

Even where devices are physically accessible, successful implementation hinges on the capacity of both patients and health care providers to interpret and act upon continuous data streams. Lower health and digital literacy are independently associated with decreased CGM adoption, while limited numeracy correlates with poorer glycemic outcomes across populations.^{43,47,48} This barrier is well documented in clinical practice. In the first randomized trial of CGM conducted within a rural low-income setting in Malawi, limited digital literacy and low confidence in the sensor application process emerged as the primary operational challenges. Only a single participant demonstrated the ability to independently replace sensors, and the resulting average 4-day delay between sensor expiration and reapplication accounted for the vast majority of missing trial data.³⁴ This finding underscores why literacy-appropriate device design and tailored educational frameworks must be embedded into program architecture from inception, rather than relying on unexamined digital health assumptions. While structured training might mitigate these disparities, as demonstrated by an educational intervention in individuals with type 1 diabetes that achieved an 81% completion rate and a 0.5% reduction in HbA1c,⁴⁹ most LMIC health care systems

currently lack the infrastructure to deliver such comprehensive training at scale.

Cultural acceptance represents another critical yet underexplored factor. Willingness to wear a visible body-worn device, social stigma, and trust in unfamiliar medical technology are likely to vary substantially across communities.⁵⁰ These dynamics warrant formative qualitative research prior to program scaling, which can be effectively operationalized through strategies such as the community champion model described below.

In addition to patient-level considerations, successful implementation also depends on the capacity of the health system itself. Companion applications require reliable connectivity, and smartphone ownership continues to lag in parts of sub-Saharan Africa and South Asia.⁵¹ Environmental conditions, including high temperatures and humidity, may also compromise sensor adhesion, and many currently available devices are not specifically designed for tropical climates.⁵² At the same time, many LMIC clinics lack health care professionals trained in CGM initiation and interpretation, and specialist shortages leave primary care overburdened.⁵¹

Taken together, these findings highlight that while promising, implementing intermittent CGM for prediabetes in LMICs will be considerably more complex than simply making devices available. Generating prediabetes-specific evidence within LMIC populations, investing in context-appropriate devices and educational strategies, strengthening workforce capacity, and integrating intermittent CGM into existing screening and chronic disease care pathways represent the essential next steps for translating this novel approach into sustainable, large-scale diabetes prevention programs.

Community-based strategies for LMIC implementation

To address the workforce and cost constraints described above, community health workers (CHWs) can be trained in diabetes prevention with lifestyle modification strategies enhanced by CGM utilization. CHWs can support patients, previously diagnosed with prediabetes, in the use and interpretation of CGM data, facilitating supportive, nonjudgmental interactions that translate medical guidance into practical, context-specific self-management and directly helping to close the health and digital literacy gaps described above. This approach has been shown to improve diabetes prevention, self-management, and continuity of care, particularly in resource-limited settings, and reduces intervention cost relative to specialist-led consultation.^{53–55}

Community Champions—trusted individuals who help promote, support, and implement health interventions within their community—should also be identified to help build local trust and address the cultural-acceptance barrier noted above.^{56,57} Community-Based Participatory Research approaches have been shown to produce more sustainable public health outcomes, though inclusion of community champions in LMIC health interventions has to date been inconsistent.^{58,59}

Family and household members involved in food preparation and daily routines should be included as part of the intervention. Social support is consistently associated with improved adherence, and cohabiting partners often serve as the primary source of sustained assistance, particularly for dietary practices; engaging households can reduce stigma, enhance shared accountability, and support collective health-promoting behavior.^{60,61}

Finally, the Chronic Care Model (CCM) is proposed as the conceptual framework for the intervention and its associated health care services, given its emphasis on patient empowerment and coordinated care delivery.⁶² Figure 1 presents the proposed hybrid conceptual framework: the CCM forms the structural basis, providing personalized, patient-centered care delivery that facilitates engagement and adherence, while the Health Belief Model explains the mechanism by which CGM-driven feedback translates into sustained lifestyle modification. Within this framework, real-time feedback helps patients visualize their personal susceptibility to lifestyle choices while serving as an immediate cue to action. Furthermore, making tangible improvements in health metrics directly visible reinforces patient self-efficacy over time.⁶³

Given the resource constraints typical of LMIC settings, we propose a step-by-step implementation framework, summarized in Figure 2, to guide the scalability of CGM-based prevention interventions. The first step is a local pilot, integrating community screening and an intervention built around CHW delivery, designed to evaluate cost-effectiveness, generate local efficacy evidence, monitor for the psychological and adherence risks discussed above, and determine the device characteristics required for the target setting. Prespecified feasibility, safety, and cost thresholds from this pilot would then inform a formal implementation plan integrating the intervention into existing primary care or chronic disease programs. Following

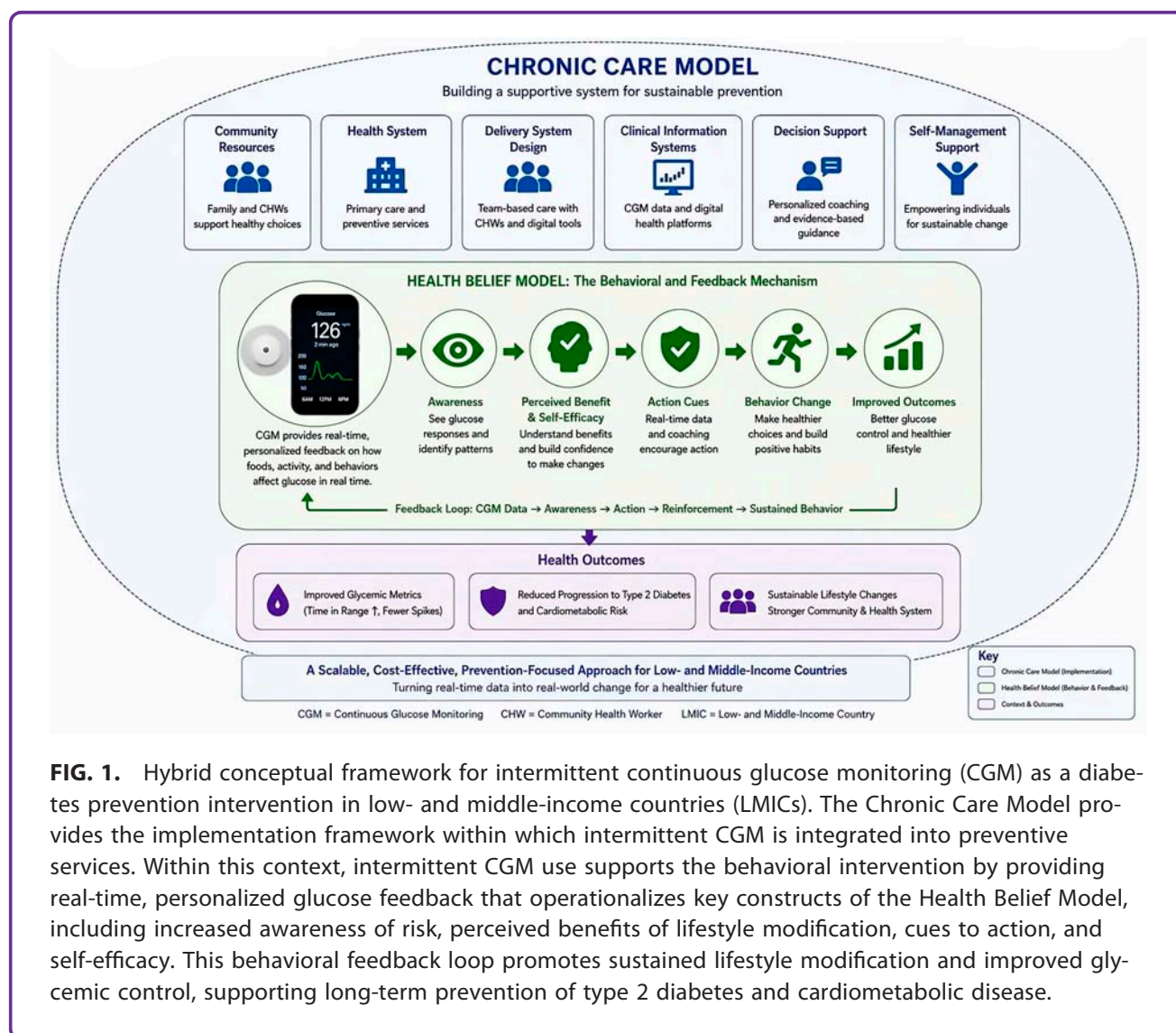


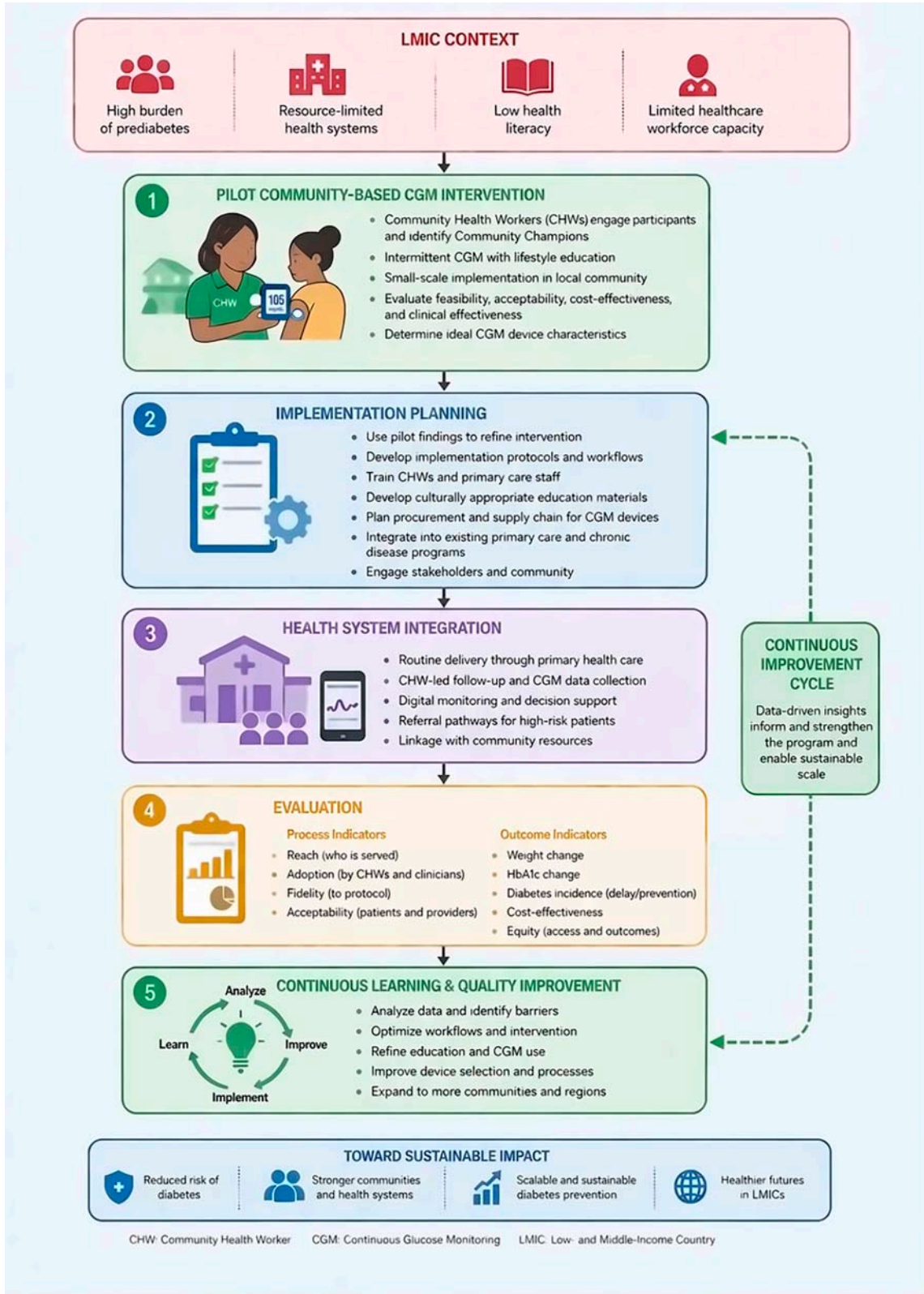
FIG. 1. Hybrid conceptual framework for intermittent continuous glucose monitoring (CGM) as a diabetes prevention intervention in low- and middle-income countries (LMICs). The Chronic Care Model provides the implementation framework within which intermittent CGM is integrated into preventive services. Within this context, intermittent CGM use supports the behavioral intervention by providing real-time, personalized glucose feedback that operationalizes key constructs of the Health Belief Model, including increased awareness of risk, perceived benefits of lifestyle modification, cues to action, and self-efficacy. This behavioral feedback loop promotes sustained lifestyle modification and improved glycemic control, supporting long-term prevention of type 2 diabetes and cardiometabolic disease.

integration, the program would enter a continuous improvement cycle in which process and outcome data are used to refine and, where thresholds are met, expand its scope.

Conclusion

CGM-guided behavioral interventions represent a promising but still preliminary strategy for diabetes prevention. Current evidence, drawn largely from

FIG. 2. Stepped Implementation Framework for Community-Based CGM Interventions for Diabetes Prevention in LMICs. Proposed framework for the phased implementation and scale-up of intermittent continuous glucose monitoring (CGM) interventions for diabetes prevention in low- and middle-income countries (LMICs). The framework begins with a pilot community-based intervention led by community health workers (CHWs). Findings from the pilot inform implementation planning, including adaptation of intervention protocols, workforce training, stakeholder engagement, and integration into existing primary care and chronic disease programs. Implementation is evaluated using process and outcome indicators, incorporating results into a continuous learning and quality improvement cycle that feeds back into implementation planning, enabling iterative refinement of the intervention and progressive scale-up within the context of LMIC health systems.



small short-term studies and from populations with established diabetes rather than prediabetes, suggests reductions in progression to type 2 diabetes and improvements in glycemic metrics but remains insufficient to confirm durable population-level benefit. Dedicated efficacy and cost effectiveness research conducted in LMIC populations is needed before intermittent CGM programs can be considered a viable public health strategy. We propose a hybrid conceptual framework combining the CCM with the Health Belief Model, paired with a stepwise implementation pathway. This pathway begins with CHW-led pilot studies and progresses toward integration into existing chronic care programs, providing a structured approach to generating this evidence while accounting for the cost, infrastructure, and equity constraints outlined above. Whether CGM can be responsibly scaled as a primary prevention tool in resource-limited settings will depend on how these barriers are addressed, not on the strength of its behavioral rationale alone.

Statements and Declarations

Generative artificial intelligence (ChatGPT, OpenAI) was used solely to assist in generating the visual layout of Figures 1 and 2 for illustrative purposes. The conceptual content, structure, and scientific interpretation of both figures were developed entirely by the authors; the AI tool was used only as a design aid to render the visual output. The authors reviewed, edited, and take full responsibility for the accuracy and content of the final figures.

Authors' Contributions

B.C.: Conceptualization, methodology, project administration, writing—original draft, writing—review & editing. T.L.: Methodology, investigation, writing—original draft, writing—review & editing. M.S.: Methodology, investigation, writing—original draft, writing—review & editing, supervision, project administration. J.C.: Conceptualization, methodology, supervision, writing—review & editing. K.P.: Methodology, investigation, writing—original draft, writing—review & editing. J.S.Y.: conceptualization, methodology, project administration, supervision, writing—review & editing.

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Abbreviations Used

- AI = Artificial Intelligence
- CCM = Chronic care model
- CI = Confidence interval
- CHW = Community health worker
- CGMs = Continuous glucose monitors
- GDP = Gross domestic product
- HbA1c = Hemoglobin A1c
- NCDs = Noncommunicable diseases
- LMICs = low- and middle- income countries
- RR = Risk ratio
- T1DM = Type 1 diabetes mellitus
- T2DM = Type 2 diabetes mellitus
- T1D = Type 1 diabetes
- TIR = Time in range
- USD = United States dollar