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Managing Diabetes One Step at a Time in Low- and Middle-Income Countries: The Promise of Wearable Devices

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ABSTRACT

The global burden of diabetes mellitus disproportionately affects low- and middle-income countries (LMICs), where limited healthcare infrastructure hampers timely and effective disease management. Wearable technologies, such as continuous glucose monitors (CGMs), insulin pumps, and fitness trackers, offer a transformative opportunity to bridge care gaps by enabling real-time monitoring, personalized feedback, and improved glycemic control. Evidence shows how wearables enhance patient engagement, support clinical decision-making, and reduce complications. However, significant barriers such as cost, digital illiteracy, poor system integration, and data privacy concerns impede widespread adoption in LMICs. Case studies from Ghana, China, and Ethiopia illustrate these devices' potential and challenges in resource-limited settings. Policy interventions, such as public-private partnerships, subsidies, simplified interfaces, and digital literacy programs, are essential to overcome these obstacles. Furthermore, integrating wearable data into national health systems and leveraging artificial intelligence can improve individualized care and long-term outcomes. As mobile phone use increases in LMICs, coupling wearables with mHealth platforms could further empower self-management. With targeted investments and regulatory support, wearable technologies can be pivotal in advancing equitable, proactive, and data-driven diabetes care across underserved populations.

1 | Introduction

Diabetes mellitus is now one of the significant chronic disease challenges worldwide. According to the International Diabetes Federation, around 537 million individuals aged 20–79 years were living with diabetes globally in 2021. This increase is linked to urbanization, dietary changes, and low levels of physical activity [1]. Of these cases, four-fifths were among adults living in low- and middle-income countries (LMICs) [2]. By 2045, this number is projected to rise to 783 million [1, 2].

Traditional diabetes care relies on patient self-reporting, infrequent blood glucose readings, and regular clinic visits. These methods generally do not provide real-time feedback or assist in proactive self-management. Wearable devices, for example, Diabetes Cam, on the other hand, are defined as electronic devices that are worn on the body to collect and transmit

Summary

- Wearable technologies including continuous glucose monitors, insulin pumps, and fitness trackers offer transformative potential for diabetes management in low- and middle-income countries (LMICs) by enabling real-time monitoring, personalized feedback, and enhanced glycemic control, thereby empowering patients and supporting clinical decision-making.
- Despite their benefits, adoption of wearables in LMICs faces critical barriers, such as cost, digital illiteracy, infrastructure deficits, and data privacy concerns, which can be addressed through targeted policy interventions, public-private partnerships, simplified interfaces, and integration with national health systems.

health data, and have the potential to usher in a new era of continuous monitoring, immediate feedback, and individualized feedback [3, 4]. This study aims to explore the potential and barriers of the application of wearable technology in enhancing the quality of diabetes care, particularly in LMICs where the burden is high.

2 | The Current Landscape of Wearables in Diabetes Care

Wearable technology has rapidly evolved in the past few years, providing a new horizon for diabetes management. The most revolutionary of these devices are continuous glucose monitors (CGMs) that constantly measure interstitial glucose levels around the clock. Technologies like the Dexcom G7 and FreeStyle Libre 3 enable patients to monitor their glucose trend line without frequent finger pricks, making it easier to understand the impact of things like diet, activity, and medication on blood sugar levels [5]. Besides CGMs, insulin pump delivery systems similar to the Tandem t: slim X2 have appeared and, when combined with CGM, can create hybrid closed-loop systems that automatically regulate insulin according to glucose values, minimizing the risk for hypoglycemia and hyperglycemia [6]. Wearables such as fitness tracking devices and smartwatches, like those by Fitbit and Apple, also support diabetes self-management by monitoring physical activity, heart rate, and sleep (which are factors that affect glycemic control), and integrating support into mHealth apps to help maintain a complete log [7]. The more these tools are integrated, intuitive, and easy-to-use, the more they offer a stream of data and behavior-driving nudges and warnings that enable patients to self-manage the condition and providers to make care more personal.

3 | Benefits and Transformative Potential

Wearable technology has the potential to significantly enhance diabetes management by addressing both clinical and behavioral facets of the disease. One of the main advantages of wearables, especially CGMs, is to improve glycemic control. Research has demonstrated that CGMs can cause significant HbA1c reductions compared to self-monitoring of blood glucose techniques [8]. They give patients instant readings of their glucose levels, which they can use to track how diet, exercise, stress, and other factors can affect their blood sugar. This quick feedback allows people to make timely adjustments in their lifestyle and medication to achieve better glycemic control. Another significant advantage that wearables bring is the empowerment that they give patients. Unremitting access to information about health elicits a sense of power and responsibility in individuals, which will motivate them to be healthier and more compliant with therapies [9]. Previous investigations have demonstrated that wearables increase patient engagement by providing instant feedback, fostering enhanced self-management and compliance [10]. Furthermore, the wearables contribute to clinical decision-making, as they produce vast amounts of data that clinicians can use to personalize treatments and identify complications at an early stage. Wearables interoperating with electronic health records (EHRs) will enrich clinical decision support, resulting in better risk stratification and proactive interventions [11]. By limiting glucose variability and catching dangerous trends before the onset, wearables have the potential to prevent acute and chronic complications of diabetes, including diabetic ketoacidosis, neuropathy, and cardiovascular events [12]. It aids patients in better managing their condition and facilitates a more personalized and timely response to diabetes.

4 | Barriers to Adoption

Notwithstanding the potential, several impediments challenge the adoption of wearable technology in the management of diabetes.

4.1 | Cost and Affordability

The high cost of wearable devices, such as CGMs and smart insulin pens, is a significant barrier in LMICs [9]. These devices are rarely covered by state health insurance, making them expensive out-of-pocket expenses for patients, with limited or no access to subsidies or reimbursement [9, 13].

4.2 | Digital and Health Literacy

Many patients in LMICs have limited experience with digital technologies and low health literacy, which hinders the effective use and interpretation of data from wearable devices [13, 14]. Successful use of these technologies requires digital skills and the ability to analyze and act on health information, which may be especially lacking among older individuals. Usability challenges, such as complex interfaces and poor user-friendly design, further reduce adoption and sustained use [13–15].

4.3 | Data Privacy and Security

The ethics and legal issues involve collecting, storing, and sharing sensitive health data [16]. It is suggested that in the absence of regulations, there is potential for patient information to be abused or misappropriated.

4.4 | Interoperation and Infrastructure

Many LMICs face inadequate healthcare infrastructure, with limited availability of digital health technologies and poor integration of wearable devices into existing systems [13]. In most cases, wearable data are not linked to the EHRs or clinical workflows, reducing their usefulness for care coordination [17]. Additionally, limited access to healthcare professionals and diabetes specialists further undermines the effectiveness of wearables that require professional oversight and data interpretation [13, 17].

5 | Opportunities and Considerations for LMICs

In resource-constrained LMICs, the increasing burden of diabetes offers a tremendous opportunity to integrate wearable technologies into diabetes care. In these areas, urbanization, change in dietary pattern, and decreased physical activity have led to the emergence of diabetes as a major health problem. However, LMICs often experience significant limitations in terms of the availability of healthcare resources and access to timely medical interventions [18]. Wearables, such as CGMs and smart insulin pumps, may help to narrow this gap by providing continuous monitoring that is frequently unavailable at conventional healthcare in these countries [17]. For instance, in Ghana, CGM devices have demonstrated potential in improving diabetes care among young people with Type 1 diabetes. Despite their high cost and limited availability, participants reported improved blood sugar control and increased awareness of lifestyle impacts. However, technical difficulties, discomfort, and social stigma were noted. These findings suggest that with targeted policy interventions, such as cost reduction strategies, usability improvements, and enhanced education on CGM use, these devices could significantly advance diabetes care for young patients [19].

Similarly, digitally monitored exercise in China has led to greater physiological improvements in patients with Type 2 Diabetes Mellitus than self-reported exercise, even when the recorded exercise duration was shorter [20]. This highlights the accuracy and effectiveness of digital monitoring in diabetes management. In Ethiopia, only 47% of 883 diabetes patients were willing to adopt wearable health devices, citing complex designs, low awareness, lack of training, and high costs [21]. Adoption could improve through simplified interfaces, education, support programs, and subsidies, highlighting the need for multifaceted strategies in resource-limited settings. With the rising use of mobile phones in LMICs, these devices can be coupled with mobile Health (mHealth) platforms to give patients feedback on their glucose levels, treatment adherence, and lifestyle in near real time. This kind of integration might allow patients to self-manage their condition more effectively (e.g., to reduce visits to the clinic and provide immediate intervention when required) [22].

Again, wearables in LMICs may play a game-changing role in accessibility and cost if adequately subsidized. Public-private partnerships between government departments, tech companies, and nongovernment organizations (NGOs) should ensure that the cost of these devices will decrease and not remain a luxury which only a few can afford. Public–private partnerships could also help in the dissemination of wearables to underserved populations, especially in rural locations, where access to care is often restricted [10]. Furthermore, integrating wearable data into community-based care programs may contribute to developing the capacity of local healthcare professionals, enabling them to make more informed decisions in diabetes management by reviewing real-time data. Such an approach would also improve health literacy, so that people in LMICs can leverage evidence from wearable device data to manage their condition better and mitigate diabetes complications [17].

6 | Policy and Practice Implications

Coordinated action is needed in several areas for wearable technology to care for individuals with diabetes fully. First, governments must craft solid regulatory environments for wearable device certification, data management, and quality assurance. Such regulations are required to protect patient, to ensure the correctness of a device, and to keep privacy-sensitive health-related data safe [16]. This should also prioritize policies that support public funding, insurance coverage, and incentives to accelerate the adoption and usage of this innovation to make it more readily accessible to all segments of the population. Without a firm policy, that would not necessarily be achievable, and the full clinical potential of wearables may not be realized, at the cost of patient safety.

Apart from regulation, another necessity is the integration of wearable technologies into the health system, such as the national diabetes program. This includes developing standard protocols for integrating this innovation into the clinical workflows and generating data from the wearable, which must be interoperable with EHRs and public health registries. This integration can enhance decision-making, support personalized care, and improve long-term diabetes outcomes. That way, healthcare professionals can tap into a rich data pool that helps drive personalized care while enhancing patient outcomes. A second set of solutions includes the incorporation of wearables into the new health systems, to guarantee that the technology works with, rather than against, current health care routines [11]. Capacity development is also essential to successfully using wearable technology in diabetes control. Healthcare services should educate doctors, other healthcare personnel, and patients to help everybody who adopts wearable devices interpret the data. This allows clinicians to make data-informed choices and deliver patient-centered care through real-time information collected from their patients [10]. Training can help providers incorporate wearable data into their sessions and treatment plans, enhancing overall care.

Similarly, patient acceptance is crucial to maximizing the benefits and usage of wearable health devices. Studies from various countries on patients' intention to use such devices have shown promising results. Notably, reasonable acceptance rates of mHealth devices have been reported in China, Ethiopia, Malaysia, and other LMICs [23–26]. However, patients must be further sensitized and educated on device usage, data interpretation, and protection. In addition, digital and community health literacy initiatives are essential to ensure that all patients, especially older adults and marginalized populations, can effectively engage with these technologies. Indeed, subsidies and incentives need to be added to enhance affordability and acceptance. Others propose giving financial support or tax incentives to patients to obtain wearable devices, so as to help ensure greater equity in diabetes care, especially among those with low incomes. These strategies potentially lower the cost of these devices, which can be beneficial in making these devices accessible and affordable to more patients, especially in countries with scarce healthcare resources [17]. These policy responses will be critical to the scaling of wearables in diabetes and the assurance of their sustainability.

From a research perspective, wearable devices provide a valuable channel for collecting large volumes of continuous, real-world data. This enables researchers to study long-term patterns, individual variability, and the impact of lifestyle on glycemic control with greater accuracy and efficiency [27]. While wearable technologies are promising, rigorous clinical trials remain essential to validate their effectiveness and long-term impact on diabetes management. For instance, CGMs have transformed care by providing real-time blood glucose data [28, 29]. However, challenges remain in ensuring sensor accuracy across diverse physiological conditions. Enhancing precision and reducing the need for frequent calibration will further improve their reliability and clinical utility.

In addition, advanced artificial intelligence (AI) and predictive analytics offer great potential [14]. Integrating AI into wearables can support personalized, predictive models to anticipate blood sugar fluctuations, optimize insulin dosing, and deliver tailored health recommendations [14, 28]. Moreover, combining wearable data with multi-omics approaches such as genomics and proteomics could enable individualized diabetes management [28].

7 | Conclusion

Wearable technologies hold immense promise in transforming diabetes management, particularly in LMICs with the highest burden. Continuous monitoring, real-time feedback, and personalized care enabled by devices such as CGMs can bridge existing healthcare gaps. However, barriers like cost, digital literacy, and infrastructure must be addressed through targeted policies, public-private partnerships, and user-centered design. With proper integration into healthcare systems, continuous support, rigorous research, and AI innovation, wearables can empower individuals and healthcare providers alike, paving the way for more equitable, effective, and proactive diabetes care in resource-constrained settings.

Author Contributions

Safayet Jamil: conceptualization, project administration, writing – original draft, writing – review and editing, **Masoud Mohammadnezhad:** conceptualization, writing – original draft, supervision, writing – review and editing, **Abdulrakib Abdulrahim:** writing – original draft, writing – review and editing, **Faisal Muhammad:** writing – original draft, writing – review and editing. **Hafiz T. A. Khan:** supervision, project administration, writing – review and editing. All authors have read and approved the final version of the manuscript.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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