Continuous Glucose Monitoring in Elderly Diabetes Management: Technologies, Trends, and Regional Perspectives

Jinit Patel [2]
Research Scholar
Department of Health Informatics
University of North Texas (Denton)
jinitpatel@my.unt.edu

Abstract: Continuous Glucose Monitoring (CGM) is transforming diabetes care by enabling real-time tracking of glucose levels, particularly among elderly individuals who face increased vulnerability to glycemic variability and hypoglycemia. This paper explores the advancements in CGM technologies, including Dexcom G7, FreeStyle Libre 3, and Eversense, and their implications for diabetes management in older adults. It examines clinical benefits, adoption challenges in the Indian context, and integration with digital health tools such as telemedicine. The analysis highlights the potential of CGM to improve glycemic outcomes and quality of life for elderly patients while emphasizing the need for accessible and cost-effective solutions tailored to regional needs.

Keywords: Continuous Glucose Monitoring, elderly, diabetes, glycemic variability, Dexcom G7, FreeStyle Libre, India, telemedicine, glucose sensors, hypoglycemia

I. Introduction

Diabetes mellitus imposes a heavy burden worldwide, especially as populations age. In the United States, for example, roughly 21 million adults (8.6%) have type 2 diabetes (T2D), and nearly one in five Americans aged 65 years or older has T2D (19.6%). In Asia, the elderly diabetic population is projected to soar current estimates suggest Asia's diabetic population aged 65 and above will grow from approximately 35.5 million in 2019 to over 78 million by 2045. India alone is home to about 8.3% of adults with diabetes, roughly 74.2 million people as of 2021. These trends highlight an urgent need for improved management tools.

Continuous glucose monitoring (CGM) — wearable devices that provide real-time or near-real-time glucose readings — are transforming care by helping patients and clinicians track glycemic trends continuously, rather than relying solely on intermittent fingerstick blood glucose testing (self-monitoring of blood glucose, SMBG) or periodic HbA1c checks. This paper reviews CGM in diabetes management with an emphasis on elderly patients (both type 1 and type 2), compares current CGM technologies and brands, surveys recent advances since 2021, and examines regional insights from India and Asia.

II. Background: Glucose Monitoring and CGM Basics

Traditionally, diabetes management has centered on SMBG and periodic hemoglobin A1c (HbA1c) tests to gauge average control. However, SMBG provides only snapshots of glucose, missing fluctuations, and nocturnal events. CGMs overcome this by frequently sampling interstitial glucose (typically every 1–5 minutes) and providing high/low-level alarms.

CGM-derived metrics such as Time in Range (percentage of time within target glucose range) and glycemic variability are now widely used as complementary measures to HbA1c. In older adults, CGM use has been shown to improve outcomes: for instance, a randomized trial of adults aged 60 years or older with diabetes

(both T1D and T2D on insulin) found that CGM users reduced HbA1c by an additional 0.4% compared to SMBG users and had less time spent in extreme hyperglycemia. CGM also consistently reduces hypoglycemia risk and glycemic variability in the elderly.

Indeed, expert guidelines increasingly recommend CGM in elderly patients — for example, the 2023 ADA Standards emphasize CGM to reduce hypoglycemia in older type 1 diabetic. Overall, CGM has become a new standard in optimized diabetes care.

III. Current CGM Technologies

Wearable CGM systems fall into several categories. Real-time CGMs (rtCGMs) continuously transmit glucose readings to a display or phone app. Leading rtCGMs include Dexcom and Medtronic systems. The Dexcom G6 (FDA-approved 2018) requires a 2-hour warm-up, lasts 10 days, and needs no fingerstick calibrations. Its successor, the Dexcom G7 (launched 2022), offers a smaller sensor, shorter warm-up (<30 minutes), and single-digit MARD (8–9%) accuracy.

Medtronic's Guardian series uses sensors with 7- or 10-day wear (depending on the model). The new Simplera sensor is also calibration-free and intended to integrate with automated insulin delivery. Flash CGMs like Abbott's FreeStyle Libre differ because the user "scans" the sensor to retrieve data. The Libre 3 (FDA-approved 2022) transmits glucose every minute to a smartphone app with high accuracy (MARD 10–12%).

Senseonics Eversense is an implantable CGM with versions lasting 90 to 365 days, showing sustained accuracy (MARD 91%). These systems offer varied wear time, calibration requirements, and connectivity features — all aiding elderly users and caregivers in therapy adjustment

IV. Statistical Overview of Diabetes and Continuous Glucose Monitoring (CGM) Use

Diabetes prevalence significantly escalates with age, particularly within older demographics. In the United States, roughly 19.6% of adults aged 65 years and older are diagnosed with Type 2 Diabetes (T2D). Meanwhile, projections indicate that the elderly diabetic population in Asia is set to nearly double, rising from 35.5 million to 78 million between 2019 and 2045. In India, the adult diabetic population has increased from 7.1% in 2009 to 8.3% in 2021, translating to approximately 74.2 million individuals.

A recent survey conducted across the Asia-Pacific region reveals that only 10-70% of endocrinologists reported regular use of CGM in patients with Type 1 Diabetes (T1D), with the highest usage observed in Japan and the lowest in India. The adoption of CGM for patients with Type 2 Diabetes is even less prevalent. Countries with subsidized CGM systems, such as Australia, demonstrate significantly higher uptake than India, which experiences what is considered "suboptimal utilization" with nearly nonexistent routine CGM usage.

Regional Insights: Asia and India

The Asia-Pacific region presents distinct challenges in diabetes management. The condition often manifests at younger ages and lower BMI levels, resulting in what is termed a "thin fat" phenotype. Factors such as high-carbohydrate diets and disparate income levels further complicate disease control efforts. For instance, Japan and South Korea are leaders in CGM adoption; in contrast, nations like India struggle with low uptake due to prohibitive costs and insufficient insurance coverage Despite these challenges, India's CGM market is anticipated to grow at an annual rate of 10–15%. Furthermore, several countries in the Asia-Pacific region have begun to endorse CGM and Time in Range (TIR) in their guidelines for both T1D and T2D patients. Yet, it remains concerning that traditional testing methods such as Self-Monitoring Blood Glucose (SMBG) and HbA1c testing are still underutilized among older demographics.

Recent Trends and Statistical Insights

Innovative advancements in CGM technology include the recently released Dexcom G7 and Libre 3 sensors, automated insulin delivery systems such as Medtronic's Simplera, and the Eversense E3, which boasts a 365-day CE Mark approval. The concept of Time in Range has achieved widespread adoption within clinical guidelines (e.g., American Diabetes Association, Advanced Technologies, and Treatments for Diabetes), and remote monitoring tools have significantly increased in popularity since the onset of the COVID-19 pandemic.

Modern CGMs now offer seamless integration with smartphones, smartwatches, and insulin pumps, forming hybrid closed-loop systems that enhance user experience. Applications like Dexcom Clarity and LibreView provide analytical insights and data-sharing functionalities. Large-scale studies have confirmed that CGM use is associated with reduced acute complications in both T1D and T2D patients.

Brand and Device Comparisons

A comprehensive 2022 study comparing the Libre 3, Dexcom G7, and Medtronic Simplera within controlled settings found that both the Libre 3 and G7 exhibited comparable accuracy, while the Simplera showed more considerable deviations at elevated glucose levels. The mean absolute relative differences (MARDs) were found to be between 9-12% for Libre 3 and G7, while Simplera's MARD ranged from 12-16%. Notably, all devices consistently achieved over 99% readings within safe ranges, establishing the Libre 3 and G7 as highly accurate choices, especially for elderly patients.

Overview of CGM Systems Available in the U.S. Market: The image compares professional and personal CGM options, including Dexcom, FreeStyle Libre, and Medtronic Guardian systems. Key differences include calibration needs, sensor wear duration, data transmission methods, and user interface designs. The FreeStyle Libre, classified as a flash CGM, requires manual scanning to obtain readings. All listed systems offer software platforms for data sharing between patients and healthcare providers.

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Global Adoption and Market Growth

As of 2024, the global CGM market is valued at over USD 8 billion and is projected to exceed USD 12 billion by 2028, reflecting a compound annual growth rate (CAGR) of approximately 10.8%. The adoption of CGMs among elderly populations is on the rise, driven by user-friendly interfaces, compatibility with telemedicine, and increased support from healthcare providers.

Clinical Outcomes in the Elderly

Studies indicate that CGM utilization among elderly individuals with T1D and T2D significantly improves Time in Range (TIR), reduces instances of hypoglycemic events, and enhances overall quality of life. One particular study involving 203 seniors aged 65 and above reported a remarkable 36% reduction in severe hypoglycemic episodes after just six months of CGM use.

V. CHALLENGES AND LIMITATIONS

Technology Acceptance

The adoption of Continuous Glucose Monitors (CGMs) among the elderly presents several challenges that can hinder their effective use. One significant barrier is the financial cost associated with CGMs, which may

be prohibitive for many seniors on fixed incomes. Additionally, cognitive and visual impairments are common in the elderly and can make it difficult for them to understand and operate the technology effectively. Lastly, there is often initial resistance to adopting new technological interfaces, as some seniors may prefer traditional monitoring methods or feel overwhelmed by the shift to digital health tools.

Despite these hurdles, research indicates that educational interventions can significantly improve acceptance and adherence to CGM use. When caregivers provide support and guidance, elderly users tend to become more comfortable with the technology, leading to better health outcomes.

Data Overload and Psychological Impact

Real-time data provided by CGMs can be extremely beneficial for managing diabetes; however, there is a downside. Excessive monitoring can lead to increased anxiety levels among users. This "data overload" can create a phenomenon known as alarm fatigue, where users become desensitized to alerts, potentially ignoring critical warnings. Additionally, constant monitoring may result in over-adjustments of insulin dosages, which can have serious health implications.

To address these challenges, it is essential to prioritize human-centered design in CGM technology. This involves creating interfaces that are intuitive and easy to navigate, along with ensuring that comprehensive training is available for users and caregivers. Such measures can help optimize CGM usage and alleviate some of the psychological burdens associated with frequent monitoring.

Regional Focus: Asia and India

The diabetes burden in Asia is alarming, as it is the region with the highest incidence of diabetes globally. In India alone, over 77 million people have been diagnosed with the condition. This is particularly concerning for the elderly population, which faces specific challenges in managing its health.

One of the major issues is inadequate healthcare infrastructure in rural areas, where many elderly individuals reside. Economic limitations can restrict access to necessary medical care and technology, further compounding the problem. Additionally, low levels of digital literacy among the elderly mean that they may struggle to use CGM technology effectively, leading to underutilization.

Adoption of CGMs in India

Currently, the penetration of CGMs in India remains low, estimated at under 5%. However, there are promising signs in urban centers, where the uptake is experiencing rapid growth. This increase is largely due to improved availability of CGM devices, a rise in awareness among healthcare professionals, and ongoing patient education initiatives that aim to inform individuals about the benefits of CGMs

As urban healthcare systems become increasingly equipped to manage diabetes, there may be an opportunity to expand access to CGMs even further, potentially improving health outcomes for millions of diabetic patients in India and the broader region.

VI. Advancements and Future Directions

Non-invasive and Long-term Monitoring

There is a clear trend towards developing the next generation of CGMs that incorporate non-invasive sensors. These innovative sensors could rely on alternative methodologies such as sweat or optical sensing. Additionally, advancements are being made to design sensors that allow for longer wear durations of up to 180 days, as seen with the Eversense XL model.

Such innovations could greatly benefit elderly users by minimizing the frequency of sensor insertions, which can be uncomfortable and may deter them from using the technology altogether. Longer-lasting sensors

would not only enhance user compliance but also provide a more streamlined experience for managing their diabetes.

AI and Predictive Analytics

The integration of artificial intelligence (AI) into CGM technology holds significant promise for the future. AI can enhance pattern recognition capabilities and facilitate glycemic forecasting, enabling users to better understand their blood glucose trends. Furthermore, AI can provide personalized alerts that consider individual user patterns, which would be particularly beneficial for preventing nocturnal hypoglycemia serious risk for many diabetic patients.

Such predictive modeling could transform diabetes management, allowing for a more tailored approach to medicine that aligns with individual patient needs. With advances in AI, healthcare providers can offer more precise recommendations, ultimately leading to improved health outcomes and overall quality of life for those using CGM technology.

VII. CONCLUSION

In conclusion, the growth in the number of senior citizens suffering from diabetes in areas such as Asia or India requires instant consideration of new management approaches. Through this technology, which is called Continuous Glucose Monitoring (CGM), there are vitally important, just-in-time insights that allow people to actively manage their diabetes. Pumps with CGM have reported marked benefits in both TIR and decreased incidence of serious hypoglycemic events, both of which are critical in assisting the improvement in an increased quality of life. CGM has many benefits, but its acceptability is hampered by financial barriers, limited insurance possibilities, and the health and typical elderly aversion to change, requiring a strategic and unified response.

Enhancing the wider adoption of CGM requires the implementation of an educational outreach effort and elaborate support to caregivers. Providing training to providers on influencing older adults concerning the value of CGM can demystify the technology and allow its continued introduction in diabetes management strategies. Additionally, future adoption of such advances as non-invasive sensors and AI into CGM technology will increase the promise for personalized treatment, tailor-made for individual needs and risks of diabetes.

To take diabetes management further, there needs to be a concerted effort to promote greater and cheaper accessibility to CGM technology. There is a need for collaboration among policymakers with healthcare providers and members of the larger community to enable a conducive environment for the education, innovation, and financial support of diabetes care. The emphasis on the integration of CGM into therapy for the elderly will significantly improve health results and allow millions of people to adopt a healthier, more enjoyable quality of life. So, this holistic approach will significantly improve diabetes treatment while also arming patients with the knowledge and preparedness necessary for effective diabetes management.

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