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PERCEPTIONS AND IMPACT OF WEARABLE GLUCOSE MONITORS IN URBAN AND RURAL DIABETES MANAGEMENT IN KERALA AND IRELAND

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MSc in Medical Device Technology & Business

Innopharma labs and faculty of science

Griffith College Dublin

Dissertation Supervisor: Celine Coffey

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August 2025

CANDIDATE DECLARATION

I hereby declare that the dissertation entitled: **“PERCEPTIONS AND IMPACT OF WEARABLE GLUCOSE MONITORS IN URBAN AND RURAL DIABETES MANAGEMENT IN KERALA AND IRELAND”**

submitted in partial fulfilment of MSc in Medical Device Technology & Business is the result of my own work and due acknowledgment is given. I also assure that I have not plagiarised anyone else’s work.

Candidate name: Anjaly Joy Date
24/08/2025

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ANJALY JOY

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Full Form
CGM	Continuous Glucose Monitoring
HbA1c	Hemoglobin A1c (Glycated Hemoglobin)
HCP	Healthcare Professional
CME	Continuing Medical Education
AGP	Ambulatory Glucose Profile
TIR	Time in Range
GP	General Practitioner
T2D	Type 2 Diabetes
RtCGM	Real-time Continuous Glucose Monitoring
HIQA	Health Information and Quality Authority (Ireland)

Abstract

Perceptions and Impact of Wearable Glucose Monitors in Urban And Rural Diabetes Management in Kerala and Ireland

Anjaly Joy

Diabetes mellitus is a growing global health challenge, with marked differences in prevalence, management, and access to technology across countries. Continuous glucose monitoring (CGM) devices have transformed diabetes care by enabling real-time monitoring, improved glycaemic control, and patient self-management. This study compares the perceptions, adoption, and impacts of wearable glucose monitors of two locations. The first location is Kerala, India. In India diabetes prevalence is among the highest worldwide but CGM adoption remains limited. The second location is Ireland, where national strategies and reimbursement policies have facilitated wider uptake. Using a mixed-methods approach, surveys and interviews were conducted with healthcare professionals across urban and rural settings to identify barriers, enablers, and perceived patient outcomes.

Findings indicate that CGM use is substantially higher in Ireland, supported by structured care pathways, reimbursement schemes, and integration into clinical workflows. In contrast, Kerala demonstrates sporadic adoption, constrained by high out-of-pocket costs, limited availability, and gaps in provider education. Despite these disparities, both contexts reported high clinician confidence in device efficacy, with over 80% perceiving improvements in glycaemic control, reduced hypoglycaemic episodes, and increased patient engagement. Barriers were context-specific: economic and infrastructural in Kerala, and workforce capacity and workflow integration in Ireland. Notably, non-internet CGMs emerged as a partial solution to connectivity challenges in Kerala, though supply and interpretation gaps persist.

The study concludes that equitable CGM diffusion requires bundled strategies, including financing, workforce training, and reliable supply chains, tailored to local contexts. These findings provide actionable evidence for policymakers and clinicians seeking to scale wearable glucose monitoring in diverse healthcare environments.

1. Introduction

1.1 Purpose of the Study

With the increasing incidence of diabetes across the world, there has been an increased need to know how digital health technologies, in this case, CGMs, have been incorporated in the clinical practice setting, hence their potential to change patient outcomes due to the real-time monitoring, better glycaemic control, and self-management.

The research study was well-placed, as it aims to make comparisons and contrasts between two different healthcare settings: Kerala (India), and Ireland. Kerala is a district with an extremely high prevalence of diabetes in the world. Still inspite of this prevelence there is not enough adoption of CGM due to numerous infrastructural, economic, and educational limitations. In comparison, however, Ireland presents an environment in which the national healthcare strategies have encouraged the adoption of CGMs, with increasing adoption and utilisation by both providers and patients. Comparing these two zones, the study aims to shed light on the contextual barriers and facilitators related to the implementation and long-term use of wearable glucose monitors in urban and rural environments.

With the help of this twofold approach, the aim is not only to provide novel knowledge on the subject of CGM integration into the real world but also to produce evidence-based guidelines that enhance diabetes management in a wide variety of healthcare settings. Evaluating or critically assessing these key areas will help close the technology gaps and optimise the benefits of digital innovations on people living with diabetes, marking the relevance of the research.

1.2 Overall Context of the Study

Diabetes mellitus is a major global public health concern, with prevalence rates rising significantly in both developed and developing countries (Hossain *et al.*, 2024). India, which has one of the largest populations of diabetics in the world, has experienced an almost doubling of national prevalence from 5.5 per cent in 1990 to 9.6 per cent in 2021, and there is an estimate that the count may reach 10.9 per cent by the year 2045 (Kumar *et al.*, 2023). In India, the state of Kerala has effectively shown detrimental figures, with the recent nationwide survey of Kerala carried out by the Indian Council of Medical Research showing that around 25.5 per cent of adults in Kerala have diabetes, more than twice the national average (11.4%). This ranks Kerala second, behind only Goa (26.4%) and Puducherry (25.3%), among states that record a high burden of diabetes (Anjana *et al.*, 2023). This is exacerbated by the lifestyle and diet in Kerala, which include diets high in refined and sugary carbohydrates, sedentary habits, and increased stress resulting from demographic shifts (Daivadanam *et al.*, 2013). The difference between the diabetes levels in urban and rural areas still exist, with obesity and sedentary life being the causative factors in urban population while rural rates are rising due to lifestyle changes too. Socioeconomic differences also contribute to the difficulty, as there is less awareness of disease and poorer access to care in rural and impoverished sectors (Ranasinghe *et al.*, 2021).

In contrast, Ireland has a relatively stable prevalence of diabetes of about 6%, which places Ireland among the lower-prevalence countries in Europe. This stabilisation has been largely credited to the existence of proactive national prevention initiatives, improved care infrastructure, and strong policy projects undertaken by the government in the area of public health (Valentelyte *et al.*, 2025). Nevertheless, it remains true that an urban-rural divide exists in healthcare, not only in Europe, but urban dwellers typically enjoy superior access to quality healthcare and educational messages about disease prevention and management. In contrast, rural areas often face challenges in initial detection and continued care (Saeedi *et al.*, 2019).

Blood glucose monitoring is a crucial part of managing diabetes effectively. Self-monitoring has primarily relied on finger-prick devices for decades, and although this approach is effective, it is not ideal because it is intrusive, painful, and provides data intermittently. These were the late 1990s, when continuous glucose monitors (CGMs) were introduced, providing real-time, continuous monitoring of glucose levels (Olczuk and Priefer, 2018). The use of CGM in Ireland, particularly with type 1 diabetic patients, has shown a surge due to the healthcare policies and engagements with clinicians and insurance coverage. The study by Courtney *et al.* (2023) in an Irish tertiary healthcare centre noted that 96.9% of the study population used CGM and observed a decrease in mean HbA1c by 6.7mmol/L compared to their previous quantification. In the meantime, CGM focuses on a limited number of urban speciality centres in Kerala and most of India, primarily due to high rates, low awareness levels, and a lack of training among providers.

Against this backdrop of contrasting landscapes, the present study attempts to compare and interpret the determinants surrounding CGM perceptions, adoption, and effects in urban and rural healthcare contexts in Kerala and Ireland.

1.3 Significance of the Study

Diabetes mellitus has a huge clinical, social, and economic impact on people, families, and health care worldwide. Inadequate glycaemic control not only leads to a high risk of developing severe complications, including retinopathy, nephropathy, cardiovascular disease and stroke, but also significantly impairs the quality of life and life expectancy of the affected individuals (Alzaid *et al.*, 2020). Research provides strong evidence that a small change in glycaemic control, such as a decrease in HbA1c of one percentage point, significantly increases quality-adjusted life years and also reduces the number of diabetes-related complications (Boye *et al.*, 2022).

The social and economic implications are also enormous. Diabetes is associated with low productivity rates, high rates of absences, premature retirement, and high informal care requirements, especially among predisposed individuals like the aged and the low-income groups (Bain *et al.*, 2019). Poor glycaemic control results in a steep increase in direct medical costs, and population-level analysis shows that as much as hundreds of millions of dollars in healthcare expenditures and lost productivity could be saved by improving glycaemic management in a year (Rodriguez-Sanchez *et al.*, 2021).

Continuous glucose monitors (CGMs) that can be worn are a game-changer in terms of managing diabetes. These CGMs help users understand trends and act quickly when glucose levels change, as they provide a constant and real-time reading of glucose levels. These tools enable users to make informed choices about what and how they eat, exercise, and use medication. It has also been demonstrated that this technology can diminish the level of diabetes-related distress, increase patient satisfaction, and promote self-management involvement. Notably, strong evidence, supported by clinical trials and real-world experiences, indicates the meaningful results of using CGM in reducing HbA1c, time spent in target glucose ranges, and preserving quality of life (Gilbert *et al.*, 2021).

Although all these benefits have been proven, the adoption of CGM in India and Kerala is strikingly low due to the high cost of devices, inadequate insurance coverage, lack of awareness, insufficient provider education, and infrastructural limitations (Kesavadev *et al.*, 2021). On the contrary, there is a drastic increase in adoption in other countries, such as Ireland, where adoption policies are supportive and reimbursement acts have been established (Courtney *et al.*, 2023).

Comparative, context-specific studies are urgently needed to identify the factors that hinder and support the use of CGM in various healthcare settings. This research paper fills the gap by looking at perceptions, patterns, and other practical challenges in Kerala and Ireland. The results will be useful and can be referenced to guide and inform clinical practice, policy formulation, and resource allocation towards enhancing diabetes care provision by maximising the use of available wearable glucose monitoring technologies.

1.4 Aim and Objectives

The purpose of this research is to investigate and compare the perceptions, adoption rates, and perceived impacts of wearable glucose monitors (continuous glucose monitoring devices, or CGMs) among healthcare professionals in urban and rural diabetes management settings in both Kerala and Ireland. The study aims to identify the key barriers and facilitators to the implementation and sustained use of CGMs in these diverse healthcare environments. By understanding the factors influencing the uptake and effectiveness of wearable glucose monitors, the research seeks to results and recommendations that can improve diabetes management strategies and promote better health outcomes for people with diabetes in Kerala and Ireland.

The research question is: How do perceptions, adoption rates, and perceived impacts of wearable glucose monitors differ between healthcare professionals in urban and rural diabetes management settings in Kerala, and what are the key barriers and facilitators to their implementation?

The research hypothesis is: There are significant differences between urban and rural healthcare professionals in Kerala in terms of their perceptions, adoption rates, and perceived impact of wearable glucose monitors in diabetes management, with infrastructural, economic, and educational factors acting as key barriers or facilitators to implementation.

The objectives of the research are as follows:

- To assess perceptions of the effectiveness and usability of wearable glucose monitors in diabetes management across urban and rural healthcare settings in Kerala and Ireland.

- To evaluate the observed impact of wearable glucose monitors on patient glycaemic control and self-management, as reported by healthcare providers in Kerala and Ireland.
- To compare the adoption rates, usage patterns, and perceived barriers to wearable glucose monitor use among healthcare professionals in urban versus rural diabetes care environments in Kerala and Ireland
- To identify infrastructural, economic, and educational factors influencing the implementation and sustained use of wearable glucose monitoring devices from the perspective of clinicians and diabetes educators in Kerala and Ireland
- To gather recommendations for improving the integration and accessibility of wearable glucose monitors in diabetes management programmes throughout Kerala and Ireland.

1.5 Structure of the Study

This dissertation consists of 5 chapters.

The Introduction sets the scene by noting the significance of diabetes as a global health issue, with a particular focus on the contrasting landscapes of Kerala and Ireland. It presents the rationale for the study, outlines the research aims and objectives, and identifies the knowledge gap addressed by the research.

The Literature Review synthesises and critically evaluates existing research on diabetes epidemiology, wearable glucose monitoring technology, and adoption trends in both regions. It draws on peer-reviewed articles, authoritative reports, and key policy documents to provide context for the primary research and to notes areas where evidence is lacking or inconclusive.

The Research Methodology chapter details the mixed-methods approach employed, including survey and interview design, participant selection, data collection, and analysis strategies. It also addresses the ethical considerations underpinning the research and explains the conceptual framework guiding the investigation.

Findings and Analysis present and interprets the primary data, using statistical and thematic methods. It compares the study's results with information from the literature, providing a nuanced understanding of adoption patterns and contextual challenges.

Conclusions and Recommendations summarise key findings, discusses their implications, offers practical and academic recommendations, and suggests avenues for future research and reflection.

2. Literature Review

2.1 Introduction

The prevalence of diabetes is indeed one of the significant global health concerns: in 2021, approximately 537 million adults represented the global number of diabetes, and this number is expected to increase to 643 million by the year 2030 (Alhaddad *et al.,* 2023). Kerala ranks among the highest in prevalence of diabetes in India, i.e. hundreds of thousands of Indian adults suspected to have diabetes, and it is estimated that more than 20 per cent of the aged or adults have diabetes in Kerala. This is alarming because such a high concentration of cases puts immense pressure on healthcare infrastructure and highlights the urgent need for advanced prevention and management strategies. Even though only about 6% of the population in Ireland have a diagnosis, the real rate of the disease is likely higher due to unknown cases, particularly in rural areas. The general trend is concerningly increasing. This epidemiological situation requires advanced glycaemic control tools, especially since the current self-monitoring approaches, including finger-prick blood glucose measurement, have encountered challenges in the form of discomfort, low adoption rates, and lack of immediate feedback (Baker *et al*., 2021).

The transformative potential in wearable continuous glucose monitors (CGMs) is the ability to answer the real-time question of interstitial glucose minimally invasively using the device. These tools have evolved, including those based in hospital settings and those more consumer-friendly and incorporated into mobile health platforms with opportunities likely to exist in both high- and low-resource environments (Bent *et al*., 2021). This literature review looks at the perceptions, the diffusion and effects of CGMs in Kerala and Ireland and compares the two contexts of urban and rural diabetes management. It is formatted with the core themes such as epidemiology, technology adoption, patient-provider perceptions, clinical outcomes, implementation challenges, and policy frameworks. The conclusion is with the synthesis of research gaps and recommendations.

2.2 Epidemiology and Current Management of Diabetes in Kerala and Ireland

2.2.1 Comparative Diabetes Prevalence and Trends

The world is experiencing a growing trend of diabetics, and there are enormous regional variations. Recent sources believe that the number of people with the problem (adults) exceeds 537 million globally, and they estimate that the figure will increase even more (Bent *et al.*, 2021). Kerala is also noted to be the diabetes capital of India, with an observed high level of prevalence in the urban region, indicating more than 20 per cent against the national average. On the contrary, the adult diabetes prevalence has been estimated to be about 6 per cent in Ireland. The trend is however drifting upwards secondary to the ageing population and lifestyle changes.

Kerala and Ireland share similar demographic and lifestyle factors that lead to the burden of diabetes. The high rates in Kerala are associated with sedentary lifestyles, a rise in refined carbohydrate consumption, and the ageing process. In Ireland, likewise, urbanisation and obesity are the major factors that contribute positively to this obesity epidemic. The study by Chaudhry *et al*. (2024) indicated that significant fluctuations in the level of glucose were observed even in the setting of pre-diabetic and non-diabetic Indian populations, which reflects the existing risk of metabolic problems.

The predicted prevalence of diabetes in the two regions highlights the need to deploy preventive measures. In India, ICMR and WHO projections show that it will keep increasing in the coming years, owing to galloping urbanisation and changing diet patterns (Bent *et al*., 2021). The National Diabetes Strategy in Ireland predicts a 30% rise in prevalence by 2030, and this, the strategy suggests, points toward the need to implement more efficient and less disparate care delivery models (Chang *et al*., 2023).

2.2.2 Urban-Rural Disparities in Diabetes Care

The presence and coverage of diagnosis, health literacy, and access to specialist care are higher in the urban areas in both Kerala and Ireland. In rural communities, however, there is a lag in diagnosis, irregular follow-up services, and fewer trained health practitioners. Such differences in access lead to an even greater rate of complications in rural patients, particularly in Kerala, where logistical and financial barriers limit such outreach methods.

The healthcare infrastructure assumes starring roles in determining the progression of diabetes. In rural Kerala, there is a lack of sophisticated diagnostic equipment or even knowledgeable diabetes educators in the primary health centres. Rural general practices are more separated, and patients in Ireland could be forced to travel long distances to meet endocrinology experts. The loss of data in the remote health population monitoring systems is more common in under-resourced regions and contributes to health disparities (Braem *et al*., 2024).

Lesser disease awareness and the ability to self-manage are related to lower incomes and education levels of rural populations. The inequalities come across with digital exclusion too and make the technology-based interventions possible in these fields. Based on this disparity, it is evidenced that there is a requirement for context-specific approaches to reduce the urban-rural divide in care.

2.2.3 Current Practices in Diabetes Monitoring

Self-monitoring of blood glucose (SMBG) by finger-prick testing is the most common method in Kerala and Ireland. Although this is available extensively, SMBG suffers in that it is only intermittent, uncomfortable to use, and not well complied with, especially in the elderly and low-income groups.

Kerala's issues include out-of-pocket expenditure on test strips, poor compliance because of the associated culture of shame and irregularities in patient education. In Ireland, the use of test strips can be subsidised in some schemes, but it is dependent on age, insurance cover, and digital literacy. According to Bisio *et al*., patients often experience fatigue or become fatigued by the repeated demands of traditional glucose monitoring, and this lasting sense of burden reduces their long-term commitment to maintaining glucose control (2021).

The idea of moving to continuous glucose monitoring (CGM) systems is gaining increasing evidence. CGMs are easy to implement and have actionable, real-time data; they also do not burden the patient. Bent *et al*. (2021) also focus on the non-invasive capabilities of the emerging CGM technologies; thus, they are more appealing to be used long-term. Besides, Chang *et al*. (2023) indicated how CGM information could be used to assist individual lifestyle interventions, such as exercise frequency.

In combination the epidemic spread of the disease, the high levels of underrepresentation of urban to rural areas, as well as the constraints on traditional monitoring functions, in Kerala state of India and Ireland, highlight the importance of scalable, attainable measures of glucose monitoring. This is a powerful argument to investigate the role of CGMs in different socio-geographic situations, which shall be discussed later in the following sections.

2.3 Technology Adoption and Diffusion in Diabetes Care

2.3.1 Evolution of Glucose Monitoring Technologies

The methods of glucose monitoring have progressed through self-monitoring blood glucose (SMBG) using a finger-prick to flash glucose monitors and, lately, continuous glucose monitors (CGMs). Whereas SMBG only provided periodical information, CGMs provided real-time information, trend analysis, and compatibility with smartphones, which can greatly enhance the self-management of diabetes.

The new form of CGMs integrates AI-based analytics and wireless biosensors. Cisuelo *et al*. (2023) emphasised their combination with AI based on ECG to detect hypoglycaemia, and Dave *et al*. (2022) showed the possibility of accelerometery to trace glycaemic variations noninvasively. The study by Chu *et al*. (2024) revealed that CGMs are superior in glycaemic fluctuations in patients in the ICU. In contrast, Craig *et al*. (2021) linked the use of long-term CGM with the potential of reduced variability and improved HbA1c after discharge in an outpatient setting.

2.3.2 Factors Influencing CGM Adoption

There is differentiation in adoption worldwide, which is dependent on price, policy, online services, and provider attitude. In Ireland, type 1 diabetes patients, through government schemes, support CGM in Ireland, particularly through their diabetes clinics. Conversely, there is disparity in the adoption of Kerala because there is high out-of-pocket expenditure and small levels of incorporation in public health.

Clinicians must be engaged. Where professionals are the driving force of use in Irish endocrinology centres, general practitioners in Ireland and Kerala are generally not trained in CGM use. Diffusion is further inhibited by the low digital literacy and provider awareness levels amongst people residing in rural Kerala.

The centralised system, digital health, and the support of the Ministry of Health of Ireland form an attractive setting for CGMs. In Kerala, the scattered delivery system between the PHC and the privately owned hospitals poses infrastructural and logistical issues, mostly in rural areas.

2.3.3 Challenges and Opportunities in Diffusion

The major obstacles are affordability, device availability, patient education, and data-sharing apprehensions. According to Dave *et al*. (2022), uneven smartphone access in rural India kills tech utilisation. Access to new CGM models is also restricted in India due to delays in general regulations.

Nevertheless, when facing difficulties, there are positive signs. The implementation of CGMs in paediatric and gestational diabetes in Ireland has shown solid results. In Kerala, access among urban, technology-savvy patients to private digital health services, such as those offered by Ultrahuman, has been enhanced (Cui *et al*., 2025). The rate of rural penetration is low.

An initiative of the Health Service Executive (HSE) in Ireland has embraced the use of CGM. Kerala has no coherent public health coordination in the market-driven approach, which is in contrast with policy-led and market-led diffusion models.

The effective diffusion requires affordability, cultural appropriateness, provider training, and the ability to fit into the local care systems. Craig *et al*. (2021) emphasised that CGMs should be integrated into patient-centred paths to care with real-time interpretation and clinician involvement.

The CGM environment represents the fast digitalisation of diabetes phenomena. Nevertheless, the variations in Kerala and Ireland's individual adoption speak to the essentiality of readiness block, healthcare structure, and socioeconomic circumstance. Overcoming them will play the critical role of achieving equitable and successful diffusion of wearable glucose technologies.

2.3.4 Prevalence of CGM Use in India and Ireland

In India, CGM is not widely used, and national data on its use is limited. Worldwide statistics show that only 5 out of 1000 individuals with diabetes avail themselves of the CGM technology, and India is no exception in this not-so-encouraging coverage (Cronin *et al.,* 2023). Of the estimated 74-101 million Indians with diabetes, CGM is generally restricted to a small group of patients, mainly patients with type 1 diabetes in specialist care. The surveys conducted in the Asia-Pacific region indicate that 10 percent of eligible individuals in India (and a range of neighbouring countries) use CGM continuously (Twigg *et al.,* 2023). Clinician assessments report the utilisation of glucose monitoring technologies as suboptimal across India. i.e., even self-monitoring using finger sticks is not very high, and continuous monitoring is even less common. As a case in point, a single rural study found that only 9.2 percent of the people regularly checked their blood glucose, highlighting the lack of glucose checks, much less advanced CGMs, in a large population segment. Overall, despite the growing recognition of CGM among urban endocrinology clinics, its adoption in primary care or general clinical practice in India remains in its infancy (Singh *et al.,* 2024).

Even though the prevalence is low, there has been increased interest in CGM over the past few years among Indian clinicians and patients as newer CGM devices have become available. Notably, India was the first nation to authorise Abbott FreeStyle Libre Flash Glucose Monitoring (a type of intermittently scanned, disposable glucose monitoring) in 2015, provided it was initially used in a professional clinical setting (Abbott, 2025). In 2020, the personal FreeStyle Libre was released into the Indian market and quickly gained acceptance, even amid pandemic-related disruptions. This suggests that there may be a hidden need for CGM technology in areas of availability (Kesavadev *et al.,* 2021). Still, CGM-using patients are a very minor minority in the overall framework of the 77+ million diabetic patients in India. According to expert reports published, CGM usage in India is not optimal. Still, it remains in a nascent phase of diffusion, although CGM holds potential to enhance glycaemic control (Twigg et al., 2023). In brief, the adoption of CGM in daily practice in India remains limited to a few tertiary centres and select patient groups. Its widespread adoption is hindered by numerous obstacles described below.

Unlike the situation in India, Ireland has reached an impressive level of CGM incorporation, at least among type 1 diabetic patients. According to a 2023 health technology assessment, the prevalence of Irish adults with type 1 diabetes who are using CGM devices in the management is an estimated 50.5 percent (HIQA, 2023). This number indicates that, in recent years, with the successful integration of CGM into both specialist diabetes clinics and reimbursement systems, the number of research patients in the Ireland as increased. Most of these CGM users in Ireland are real-time users who have continuous information and triggers, or users of flash monitoring appliances who use a program of intensive insulin therapy. In comparison, the number of type 2 diabetics who are given CGM is small, particularly the patients under primary-based care settings, a trend that reflects the international trend in which regular usage of CGM on patients with diabetes who are not undergoing insulin therapy is still rare (Shields *et al.,* 2024). Irish clinical practice continues to have CGM as a priority regarding people on aggressive regimens or with substantial glycaemic fluctuations.

This uptake in Ireland is comparable to that of other high-income nations that have prioritized diabetes technology. Most European healthcare systems currently facilitate

CGM to low and middle-income earners; neighbouring countries show that in their systems, the adoption rate of CGM by those with diabetes type 1 is about 5080 percent through universal health coverage plans. This European norm is mirrored in Ireland, where approximatelly50% of type 1s use CGM (Conway *et al.,* 2024). It is a significant leap from the mid-2010s, when CGM was a specialised device accessible to only a small percentage of patients.

2.3.5 Offline CGM Technologies and Adoption Without Internet

One of the main trends in the field of glucose monitoring is the emergence of CGM systems that do not require an around-the-clock internet connection to function correctly. This will be the most notable example, the Free Style Libre intermittently scanned CGM or the so-called flash monitoring. The glucose measurements are stored in one of these gadgets on a sensor throughout 8 hours and can be downloaded by the patient/clinician by scanning the sensor with their reader or cell phone (Kesavadev *et al.,* 2021). The glucose data from such systems is read in real-time, and trend reports are coupled with scanning; however, the data is not continuously broadcast to the cloud. This would make them especially helpful in environments where connectivity is low or in those where simplicity and reduced cost are the primary concerns. The Libre and flash systems have become the most popular CGM devices in the world, with more than 5.5 million consumers in over 60 countries enjoying this technology. They are famous due to their user-friendliness, the factory calibration (eliminating the need for fingerstick calibration), and their relative affordability compared to conventional real-time CGMs (Molfetta *et al.,* 2025). These devices provide an easy option for patients and healthcare professionals to achieve glucose profiles, especially those unable to receive round-the-clock internet or remote supervision services.

An offline CGM has been observed to have considerable usage in clinical practice in resource-limited settings, such as in India. The FreeStyle Libre Pro (professional flash CGM) became available in India in 2015 as a clinic technology; patients use a blinded sensor without data (Abbott, 2025). After 14 days, they bring the sensor back to the clinic, and the data are downloaded. This model enabled endocrinologists to periodically monitor CGM information to adjust therapies without requiring patients to use complicated technology or access the internet. A retrospective CGM follow-up has been shown to improve glycaemic control by identifying trends and directing interventions, as seen in Indian studies (e.g., the GLITTER study in Mumbai) (Kesavadev *et al.,* 2021).

With this, the personal Libre (14-day isCGM) release in 2020 enabled people in India to scan their sensors and obtain real-time values without relying on a continuous transmission platform. In India, adoption of the Libre pre-pandemic was "well received by patients and providers alike", meaning that they were eager to use a product that can bypass infrastructure challenges. It is also important to note that, since not every Indian person with diabetes has access to the internet and smartphones, the offline operation of CGM (storing data on the reader itself) is a highly beneficial feature. Flash CGM sensors can be worn by patients living in rural or tribal communities, and data can be interpreted during routine clinic visits, allowing all CGM insights to be gained without the need for continuous connection. This form of adoption is gradually growing, although the figures are still relatively low due to limitations in cost and availability (Kesavadev *et al.,* 2021).

Irish jurisdiction has also introduced intermittently scanned CGM into its healthcare system, albeit placing certain peculiar policy limitations. The Libre isCGM is reimbursed in Ireland and has gone through the approval process, but in the past access to the device was restricted by age and clinical requirements. Indeed, within modern Irish reimbursement (as of the early 2020s), Libre became unavailable to adults (over the age of 21) being initiated on CGM, whereas the real-time CGMs were to be fully reimbursed to the individuals that met the medical conditions. As a result of this policy quirk, uptake of real-time CGMs (rtCGM) such as the Dexcom was increased in the adult population with 90% of CGM expenditure being on the rtCGM devices by 2022 in the health service spending. However, many patients (particularly younger persons and those who feel comfortable with a simpler device) use flash monitors, and they do not need the internet to use them daily. Libre sensors can be scanned by Irish patients using a reader or phone, but most do enter their records into clouds so they can be reviewed at the clinic, although it is not required to gain the primary benefit of the system. Therefore, the aspects of the availability of offline supported CGMs such as Libre has been a critical aspect of CGM adoption, if a patient is not permanently connected, he or she can still enjoy the advantage of continuous monitoring of glucose functioning (HIQA, 2023). More generally, in Europe flash CGM has been the point of CGM growth but because it is cheaper the UK and other EU nations have experienced mass roll-out of Libre which has established a path to greater use of CGM. To conclude, non-continuous CGM technologies (including intermittently scanned or professional CGM solutions) have extended the number of people exposed to glucose monitoring. They are also especially useful in filling in the digital infrastructure gaps: they can be deployed even in rural clinics in India, or in patients lacking the smartphone, and they provide a much less expensive alternative that has expanded the use of CGM worldwide (Molfetta *et al.,* 2025). These real-time CGM cum off-line capable systems are complementary to the use of real-time CGMs and help in the increasing use of CGMs across the healthcare facilities.

2.4 Healthcare Professional and Patient Perceptions of CGMs

2.4.1 Clinician Knowledge, Attitudes, and Acceptance

The medical workers play the leading role in the adoption of continuous glucose monitors (CGMs). In Ireland and Kerala, endocrinologists and specialist diabetes practitioners working in cities and small groups in Kerala hospitals are more exposed to CGMs and prescribe them more frequently as compared to in rural areas amongst general practitioners. According to Garg *et al*. (2022), increased clinical confidence was observed in other devices, such as the Dexcom G7, in their accuracy and care plan adherence. Nevertheless, Di Filippo *et al*. (2022) also observed its poor adoption in obstetricians unless protocols facilitate it.

Training is essential in the uptake of CGM. According to Lind *et al*. (2024), healthcare providers with formal training had a much greater chance of using CGMs on Type 2 diabetes with insulin treatment. In Kerala, clinicians in the public sector have limited access to ongoing Continuing Medical Education (CME) on IT tools, which impedes confidence and uptake.

2.4.2 Patient Perspectives: Usability, Acceptability, and Adherence

Acceptance of CGMs by patients is determined by their comfort, aesthetic, and convenience. Research cases such as Jensen *et al*. (2020) show a high rate of satisfaction among Type 1 diabetes users, especially younger, urban, and tech-savvy people in both Ireland and Kerala. But there are cultural attitudes which influence usage. Other rural Kerala users are unwilling to express discomfort with claims of machine dependency or social stigma because the device is in view. The elderly patients or those in rural settings might no longer trust the technology or even that it is invasive.

Age and education have a powerful impact on CGM adherence. The digitally literate youths in both countries would be expected to adopt it better (Garg *et al*., 2022). In Ireland, older people receive scheduled training and have improved long-term usage. In Kerala, differences exist between the rural and urban levels in patient education, mainly in the public primary healthcare centres, which lead to adherence or early discontinuation.

The use of fixed-dose combinations every other day or more frequently should never lead to poor glycaemic control; hence, Lind *et al*. (2024) stressed that the active maintenance of use should enhance glycaemic maintenance, yet this would depend on the perceived benefit and trust using the device.

2.4.3 Communication and Decision-Making

Communication between the provider and the patient enhances CGM success. Patient satisfaction and the outcome of CGM use improve when clinicians help patients select and interpret the device. According to Di Filippo *et al*. (2022), a more collaborative approach to introducing CGMs in prenatal care resulted in improved compliance.

Digital literacy is needed to interpret CGM data. Garg *et al*. (2022) emphasised that patient education was required so that the sensor-derived readings could be translated into decision-making. This is hampered in the rural parts of Kerala due to low health literacy. In Ireland, education programs regarding diabetes do some justice, but there is still inequality related to marginalised groups.

CGMs are only empowering when supported, not just with data. According to Lind *et al*. (2024), the tangible benefits of coaching patients to identify trends and actions to take when they g*et al*erts are that patients benefit the most.

Clinicians' and patients' perceptions influence CGM uptake and adherence. Training and specialisation affect clinical acceptance, whereas usability, trust, and education can affect patient use. The educational, cultural, and geographic divide between the two countries should be overcome in the interests of prolonged, fair access to wearable glucose monitors and therefore resultant improved outcomes as stated here below

2.5 Impact of CGMs on Patient Outcomes and Self-Management

2.5.1 Clinical Outcomes: Glycaemic Control and Complications

Continuous Glucose Monitors (CGMs) have been of great help in the management of diabetes since they give real-time glucose information. As illustrated by the randomised controlled trials like Migdal *et al*. (2020), CGMs lower HbA1c, time-in-range (TIR), and decrease the hypoglycaemic events, especially in type 1 and insulin-treated type 2 diabetes. In the setting of the COVID-19 disease, flash glucose monitoring (FGM) enhanced inpatient results (Robbins *et al*., 2022). Ireland has reported wider improvement as a result of the detection of early glucose patterns and planned care routes.

Nonetheless, follow-up and system preparedness are low in rural Kerala, which limits the outcomes. In real-world studies (Rodriguez-Rodriquez *et al.*, 2024), it has been acknowledged that performance depends on patients' characteristics, digital access, and training. Although there are clinical benefits, there have been concerns about precision in situations of severe glucose events and cost-effectiveness in settings with lower incomes. The gain can also last in a plateau in well-managed patients.

2.5.2 Self-Management, Empowerment, and Behavioural Change

CGMs promote self-management, where patients learn to read glucose patterns and respond as changes occur. Unlike conventional SMBGs, CGMs allow real-time monitoring and other trend advances. According to Rodriguez *et al.*, CGM-associated predictive models inspired proactive behaviour, namely, changing diet, insulin, or activity levels (2022). CGM-led mobile apps enhance dietary adherence through the visualisation of the glucose response to certain kinds of food (Roux de BZieux *et al.*, 2021).

The behavioural advantages involve general confidence, enhanced interaction with the health professionals, and improved adoption of lifestyle change. CGMs also lower anxiety, especially that about nocturnal or exercise-related hypoglycaemia. There are, however, some drawbacks such as data fatigue, alarm burden, as well as the need to educate its users on how to interpret the complex information (Migdal *et al.*, 2020). With wrong support, users can not take any action on what CGMs teach them.

2.5.3 Disparities: Urban vs Rural Impact in Kerala and Ireland

The effect of CGM is uneven in different geographies. The advantage of urban Kerala is the availability of specialist clinics and more awareness compared to the rural side, which has challenges like affordability, inadequate training facilities, and infrastructure. By comparison, the national policies, reimbursement models, and standardised format of education of providers in Ireland result in the wider spreading of CGM (Rodriguez-Rodriguez *et al.*, 2024).

Socioeconomic factors, digital access, and the state of health systems determine the influence of CGMs on behavioural change. There is a potential to use the Kerala e-health registry to enable CGM in the context of chronic care, although interoperability and privacy raise issues. Also, digital illiteracy and poor internet availability in rural areas restrict the use of devices (Migdal *et al.*, 2020).

Poor CGM performance in the low health literacy population or individuals unfamiliar with self-monitoring has also been reported. Nonetheless, results of pilot studies of mobile coaching and peer-support models in India have demonstrated positive outcomes under conditions of cultural adaptation of the use of CGM (Rodríguez *et al*., 2022).

These CGMs have great potential in upgrading clinical and behavioural outcomes, although they need supportive systems to optimise their effects. The domestic, rural-urban, and international inequalities indicate infrastructure, policy, and literacy inequalities. These barriers must be met to achieve long-term success on an equal basis.

2.6 Barriers and Facilitators to CGM Implementation

2.6.1 Economic and Infrastructural Barriers

Cost-effectiveness is one of the underlying obstacles to CGM implementation in Kerala and Ireland. Kerala has an out-of-pocket scheme that renders the CGMs unaffordable to the low- and middle-income earners. According to Sathish *et al*. (2020), the low-cost interventions had adoption barriers because of the limited funds. In the meantime, the Long-Term Illness scheme in its full extent does not cover many adults with Type 2 diabetes in Ireland and offers partial reimbursement instead, so CGMs become a pricey prospect in the country (Shields *et al*., 2024).

There are also infrastructure problems that contribute to the reluctance to take it up. In rural Kerala, no electricity, refrigeration or digital space compromises the sustainability of data collection and analysis of CGM. In comparison to Ireland, Ruissen *et al*. (2023) point out that integration challenges between CGMs and e-health systems in general persist. The two regions are also affected by the supply chain barriers.The scarcity of sensor availability, delays in distribution and a lack of maintenance services, particularly where long distances are involved to name a few

2.6.2 Educational, Cultural, and Behavioural Barriers

Despite the availability of devices, acceptance of CGMs is hindered by gaps in patient education and by diminishing adherence behaviours. Health workers in Kerala are not generally trained to use CGMs, and patients in rural areas might feel that the devices are too complicated or culturally strange. Most people, particularly seniors, do not have a well-defined experience with sensors, their calibration, and data visualisation in an app, so they avoid using it.

Shields *et al*. (2024) identify limited provider training as a restriction to the use of CGM in Ireland with few of the GPs having the capacity to interpret the data in CGM beyond the glucose trends. Also, it is usual that privacy issues need to be addressed. Occasionally, the Irish patients do not want to share their data with the clinicians or insurers because they may be judged. Due to the stigma on diabetes and that it is a sign of personal failure, there can be secrecy in the use of the device in Kerala, which decreases social reinforcement and family support.

2.6.3 Key Facilitators and Enablers

Nevertheless, various facilitators boost the use of CGM. In Ireland, the initiative at the policy level, including structured diabetes care, integration of eHealth, and insurance, improves uptake. To give an example, CGMs are gaining popularity in antenatal care of gestational diabetes, where national guidelines are adopted (Scott *et al*., 2020).

NGOs and community-based pilot programs have proven important in Kerala. Demonstration projects indicate an increase in patient confidence and self-monitoring with the combination of education and wearable tech. Government and nonprofit contributions have led to the development of culturally sensitive training modules, which have empowered frontline workers.

Ruissen *et al*. (2023) note that structured education and decision-support systems are useful over a long period. Van den Brink *et al*. (2022) mention the possibilities of non-invasive CGMs and digital biomarkers in rural applications as a solution that diminishes the reliance on advanced infrastructure.

When local idols, community leaders, or religious figures advocate the use of a device, it becomes more acceptable in the culture. The method has contributed to de-stigmatisation in Kerala. In Ireland, diabetes educators and pharmacists have contributed to the improvement of primary care integration, leading to uniform follow-up and individualised use.

2.7 Policy, Programmatic, and System-Level Strategies

2.7.1 Policy Initiatives and National Programmes

The role of CGMs as an element of integrated care in diabetes is becoming more apparent in national health policies and diabetes structures. In Ireland, access to CGM has been broadened on a Long-Term Illness Scheme and by supplying paediatric endocrinology services, but access to adults with type 2 diabetes is very restricted. The priority at the government level is mostly given to type 1 diabetes, and CGMs are largely reimbursed in younger patients or those with a lot of hypoglycaemic events (Weiner *et al*., 2022).

Absence of universal reimbursement schemes and prioritisation of wearable diabetes technology in the hands of the government and low priority in the government sector means that such technology cannot be implemented at the national level in India. Nevertheless, there are opportunities like the National Programme to Prevent and Control Cancer, Diabetes, Cardiovascular diseases and Stroke (NPCDCS), which encourages early detection with the integration of digital health support, but CGMs are not extensively covered in such programs. The subnational experience of Kerala with digital platforms in Kerala Diabetes Prevention Programme provides a possible way forward in terms of CGM scale-up in contexts of community-wide health system interventions (Zahedani *et al*., 2023).

Relatively, lowand middle-income countries (LMICs) face issues with incorporating the CGM into essential health benefits because of costs and infrastructure limitations. Use is more evident in high-income countries (HICs) such as Ireland, but policy-level fragmentations and differences in access to technology occur, especially in non-urban areas.

2.7.2 Stakeholder Roles and Collaborative Models

Inclusion of multiple stakeholders, including governments, healthcare providers, device manufacturers, insurers, and advocacy groups, is essential in defining effective CGM integration. Policy-makers should also get involved in supporting devices and include CGM data in the national electronic health records, which will boost continuity of care and distant monitoring (Sia *et al*., 2021).

The influence of device companies (e.g. Abbott, Dexcom) comes in the form of market expansion strategy, and the companies may aim at the urban private-sector hospitals. In the meantime, collaboration examples defined by the public-private relationship, such as the pilot program of digital health in Ireland or the campaign of health education by the nongovernmental organisations in India, demonstrate scalable models of collaboration. An example is the two-fold collaboration of Abbott in rural Maharashtra on community education and point-of-care screening is creating a flexible formula that can be extended to more areas.

The role of patient advocacy groups should also be mentioned here, as raising awareness, lobbying for CGM subsidies, and decreasing the stigma around wearable devices are the major points of focus. Sustained implementation, however, requires continuously training providers and preparing them to achieve readiness in terms of infrastructure and interoperability standards across both rural and urban contexts (Zhu *et al*., 2022).

2.7.3 Recommendations for Practice and Future Research

The solution against equitable implementation of continuous glucose monitoring (CGM) systems can only be formulated on a multi-pronged approach based on pragmatic frameworks of policy and clinical reasoning. Some recommendations will be to expand insurance coverage and government-sponsored CGM programs to help make them more accessible to the underserved population, and more so those with type 2 diabetes mellitus (T2DM). The education of nurses and general practitioners in integrating CGM use in primary care should be incorporated into national diabetes programs, and frontline health staff should be prepared to assist individuals who use CGM to manage diabetes. Telehealth services have been found to play an essential role in supporting CGM implementation in rural settings, offering remote glucose monitoring and timely response in case of problems (Villard *et al*., 2022). Despite these efforts, a research gap still exists. As an example, the evidence regarding the efficacy of CGM in rural populations without insulin treatment, especially older people and marginal populations, is scarce, given that they may be less attracted to digital technologies (Weiner *et al*., 2022). Future research needs to be conducted on behavioural incentives and implementation science models and community-based solutions, including the role of Accredited Social Health Activists (ASHAs) in Kerala, to enhance uptake in low-literate or resource-limited environments.

2.8 Gap Analysis

Although there has been an improvement in the use of wearable glucose monitoring (WGM), there exist significant gaps in comprehension of its use within rural and low-resource settings. Research is conducted mainly on patients treated with insulin in urban settings, with little information available on the characteristics of non-insulin-treated type 2 diabetes in a rural community, such as in Kerala in India or an underserved area of Ireland (Weiner *et al*., 2022). The barrier of behaviour, culture and infrastructural factors of rural users is hardly studied. Cross-nation research on medical care systems and health insurance platforms, and even digital literacy is few and far between.

Furthermore, the voices of the primary healthcare givers, caregivers, and community healthcare workers are also lacking, which restricts knowledge of the implementation issues on the ground. Long-term compliance, psychosocial effects and effects beyond short-term trials are yet to be researched thoroughly. There is usually a lack of depth in policy research regarding the mechanisms carried out using public-private partnerships or national programs that guarantee equitable access to WGM.

These gaps are congruent with the review's aim, which involves assessing user perceptions and system enablers in Kerala and Ireland. The comparative context-aware approach is essential to supporting liberal, fair WGM strategies in different healthcare ecosystems.

2.9 Conclusion

The present review examined how wearable glucose monitors (WGM) can be used to care for diabetes in urban and rural groups of Kerala and Ireland. Results across six themes indicate that CGMs enhance self-management and glycaemic control, but there remain affordability disparities, digital literacy disparities, and access disparities, particularly in rural settings.

The city residents enjoy improved infrastructure, and the country folk cannot easily adapt. Optimism was cautious but prominent as the provider representatives expressed their views and training, and policy support as the most significant enablers. The uptake of CGM is greatly affected by national policies and individual insurance coverage, and the importance of coordination strategies.

Research gaps are minimal rural data, insufficient analysis from provider perspectives and missing long-term outcome studies. The present review further adds to this work by setting up a user- and system-level conceptualisation of CGM integration in contrasted contexts. These results can be used to formulate specific policies, educational policy, and future studies to address the digital health disparities in diabetes care management in diverse healthcare settings.

3. Methodology and Research Design

3.1 Overview

This section outlines the methodological framework used in the research. A mixed-methods approach was employed, integrating quantitative survey data with qualitative interviews to capture both breadth and depth of perspectives. Details are provided regarding research design, participant selection, data collection instruments, ethical considerations, and the strategies used for both quantitative and qualitative data analysis.

3.2 Research Philosophy and Approach

In this study, pragmatism is used as the research philosophy, which is adopted because the research on healthcare technology was an intricate and contextually diverse one, especially when proposing an equivalence in adoption and impact of the same technology in different regions like Kerala and Ireland. Pragmatism is more focused on the practical result and solving problems. It emphasises approaches and philosophies that are best suited to reaching the research goals as opposed to a stricter following of one tradition. This flexibility is significant in the case of medical device adoption assessment, where measured results coexist with more contextual and difficult-to-measure factors affecting the success in the real world (Kaushik and Walsh, 2019).

On the ontological and epistemological framework, both the positivist and the interpretivist perceptions are incorporated in this research. The quantitative component is based on the positivist approach: a structured survey that aims at obtaining objective, generalisable information about the perceptions, experiences, and adoption patterns of the healthcare professionals considering continuous glucose monitors (CGMs). It indicates the assumption that particular phenomena that can be observed and measured, e.g., reported adoption rates or perceived barriers, can be measured and compared systematically across domains (Pratt, 2016).

At the same time, the qualitative aspect will be informed by the interpretivist perspective, employing in-depth interviews to examine the subjective, contextual meanings, experiences, and realities that CGM use as clinicians working in Kerala and Ireland under the element of clinician-patient relationship variables. This concept relies more on the subjective nature of the research topic by obtaining perceptions of professionals associated with the domain (Junjie and Yingxin, 2022).

The pragmatic decision is mainly appropriate in a study that wishes to offer valid knowledge that can be formulated into strong recommendations. It allows the study to fill the gap between objective measurement and contextual understanding, on which development of practical recommendations rests, but with adherence to contextual diversity at the regional and individual levels. Pragmatism is not only concerned with what works in the domain but focuses more on what is the best fit for the research, which makes the findings based not only on empirical evidence but also on daily practice.

To operationalise this philosophy, a mixed-methods approach is utilised to conduct the study. It is a research design that can take advantage of the aspects of both quantitative data (breadth, representativeness, statistical validity) and qualitative data (depth, context, meaning). The method is also widely known to yield subtle and policy-relevant evidence on health technology research.

3.2 Research Strategy

In this study, a mixed-methods sequential explanatory design is utilised as this method combines the best aspects of quantitative and qualitative research methods to create a complete picture of the practices of CGM use in the management of diabetes in Kerala and Ireland. In such a design, the researcher starts collecting data with a quantitative stage, a cross-sectional survey of a structured nature, and then moves to qualitative semi-structured interviews. This way of sequencing makes the first survey data inform and ground the focus of the second interviews with the qualitative information focused on the research objectives by suggesting anomalies, trends, or gaps (Creswell and Clark, 2025).

The quantitative element will apply a cross-sectional survey that will be sent to the healthcare professionals who work in the field of diabetes care, such as endocrinologists, diabetologists, general practitioners, and the diabetes nurse educators. The survey includes structured, closed-ended questions which will contain measurable data regarding the perceptions, adoption rates, usage patterns, obstacles and suggestions to CGMs. Through surveying a broad sample, this method makes it possible to make statistical comparisons across the significant demographic variables included in the study, country (Kerala vs. Ireland) and practice setting (urban vs. rural). The survey approach helps to provide generalisability and measures the prevalence and distribution of essential phenomena quantitatively (Regmi *et al.*, 2016).

The qualitative portion entails using semi-structured interviews in a specific sample of healthcare providers in both regions. These interviews intend to delve more deeply into the themes and issues outlined in the survey, by putting them into context, giving them shades and understanding the why and how in terms of quantitative trends. The open question format of the interviews will enable the research participants to share their experiences, misperceptions, and situational circumstances regarding the use of CGM and its impact on patient outcomes. This method is beneficial because it helps to discover the local contexts, institutional processes, as well as cultural factors that can hardly be ascertained with the help of a survey (Pyo *et al.*, 2023).

The combination of methods takes place on the level of both analysis and its meaning. The quantitative findings clarify trends and any variation across regions and settings, whereas the qualitative findings describe and expound on the identified trends. The article employs joint displays, the thematic synthesis and triangulation in relating the quantitative and qualitative results to come up with recommendations that are more meaningful and can be acted upon by health policy and practice.

It is possible to illustrate that by selecting the groups of participants in two different national backgrounds and comparing urban and rural areas, the research will encompass a wide range of individual experiences and obstacles. The given comparative design promotes the external validity of the study. It ensures that the findings and suggestions can be applied in various health system settings that could be used in the local and global approaches to the implementation of CGM.

3.4 Primary Data Collection

3.4.1 Sources

This research utilises a mixed-methods approach. The quantitative data is collected through a structured cross-sectional survey that targets registered medical professionals such as endocrinologists, diabetologists, general practitioners, and diabetes nurse educators. All participants must be currently practicing in diabetes care settings within Kerala or Ireland, have at least one year of experience managing patients with diabetes, and possess direct experience in recommending or managing glucose monitoring, either with finger-prick testing or CGMs. The survey instrument, hosted on Google Forms for broad accessibility, comprises 39 close-ended questions designed to elicit detailed responses on demographics, professional role, patterns of CGM use, perceived effectiveness, usability, barriers, infrastructural constraints, access to training, and recommendations for improved integration. The question set has been carefully adapted to account for contextual factors unique to each region, such as device availability and internet connectivity, ensuring that local realities are fully considered.

To complement the survey, the qualitative phase consists of semi-structured interviews conducted via Zoom. Two participants are purposively selected to represent both practice environments: one clinician in Kerala who predominantly manages patients using traditional finger-prick testing, and one healthcare provider in Ireland with significant experience in the clinical use of CGMs. Each interview lasts approximately 35 to 40 minutes and follows a 15-question guide that probes perceptions, barriers, benefits, infrastructural issues, and potential solutions in detail. Both phases are designed to ensure rich, meaningful insights that reflect the lived realities of diabetes care in urban and rural settings.

Recruitment for both surveys and interviews leverages purposive sampling, identifying relevant professionals through platforms like LinkedIn, and is further extended via snowball sampling, whereby initial respondents refer colleagues who meet the inclusion criteria, in line with established qualitative research practice.

The interview questions were deliberately crafted to map directly to each research objective. Early questions investigate current blood glucose monitoring practices and individual experience with CGMs, setting a foundation for exploring perceptions of effectiveness and usability as outlined in Objective 1. Subsequent questions shift focus to clinical outcomes and behavioural changes, addressing Objective 2 by examining the real-world impact of CGM use on patient glycaemic control and self-management. Midway through the interview, the guide shifts to adoption trends, prevalence, and the specific role of non-internet-enabled CGMs, thereby supporting Objective 3, which seeks to compare patterns and barriers to CGM adoption across regions and practice settings. Further questions investigate infrastructural, economic, and educational influences on the implementation and sustained use of CGMs, directly informing Objective 4. The interview concludes by soliciting the participant’s recommendations for improving access and integration of CGMs, thus capturing data pertinent to Objective 5.

The sample size for this study was calculated using standard statistical formulas for finite populations. The calculation assumed a 95% confidence interval ($z = 1.96$), a proportion estimate (p) of 0.5 for maximum variability, and a margin of error (E) of 5%.

The finite population correction (FPC) was applied since the population of healthcare professionals in both Kerala and Ireland is known.

Step 1: Initial Sample Size (Infinite Population)

The formula for the initial sample size is given by:

$$n_0 = (z^2 * p * (1 - p)) / E^2$$

Substituting the values:
$n_0 = (1.96^2 * 0.5 * 0.5) / (0.05^2) \approx 384.16$

Step 2: Finite Population Correction (FPC)

The corrected sample size for a finite population is calculated as:

$$n = n_0 / (1 + (n_0 - 1) / N)$$

Where N is the population size of healthcare professionals in the given region.

Kerala (N = 6,328)

$n = 384.16 / (1 + (383.16 / 6328))$
$n \approx 362.23 \Rightarrow$ Rounded to 363

Ireland (N = 3,884)

$n = 384.16 / (1 + (383.16 / 3884))$
$n \approx 349.67 \Rightarrow$ Rounded to 350

Recommended Sample Sizes

Kerala: 363
Ireland: 350
Total: 713

Although the recommended sample size was 713 (363 from Kerala and 350 from Ireland), a recalculated conservative estimate with 8% margin of error gave a minimum requirement of 292 samples (147 from Kerala and 145 from Ireland). However, due to practical constraints, only 203 responses were collected across both regions.

3.4.2 Ethical Issues

The integrity and credibility of this study are affirmed based on their compliance with stringent ethical guidelines. Before any data collection is initiated, ethical approval will be obtained from the Griffith College process to ensure that the procedures to be undertaken meet the established ethical standards and the compliance requirements. Transparency and the voluntary nature of the study form the fundamental pillars of its ethical considerations. Survey members will be provided with a comprehensive Participant Information Leaflet (PIL), which will describe the goals of the research, what participating in it entails, the right to withdraw at any point, and how their data will be secured and utilised. Interview participants will also be given an informed consent form next to the PIL, which they are specific regarding participation and audio-recording.

In the research, confidentiality of data and anonymity of participants are highly emphasised. The survey will not contain any personally identifiable information like names or contact details, and any identifying information will be removed. All electronic research data will be stored on a password-protected OneDrive folder with access to the principal investigator and supervisor only. The data will be retained for two years after completion of research, after which it will be destroyed. This safe data practice is compliant with the demands of the data protection laws and with best practices on managing confidential data according to guidelines put forth by GCEC and GDPR.

A second ethical priority is participant wellbeing. Medical professionals have highly demanding schedules, so the survey has been strategically developed as brief, mobile, and streamable with low-speed internet, especially when seeking the contribution of scientists working in rural and resource-limited regions. Thus, the survey is designed through Google Forms. The interview will also be conducted virtually through video conferencing platforms such as Zoom. It is also acknowledged by the study that some questions can address issues that are likely to be quite sensitive, including the sense of failing local healthcare systems or impediments to the use of technology. To minimise the discomfort, all survey and interview questions are well-formulated, avoiding judgment, and it will be made clear to participants that they can skip any questions they are not comfortable with.

3.5 Data Analysis

The quantitative data for this study will be collected using a structured, closed-ended questionnaire distributed to healthcare professionals in Kerala and Ireland. Data will be exported from Google Forms into Microsoft Excel and subsequently imported into SPSS (or equivalent statistical software) for analysis.

The first step will be to check for completeness and consistency of responses. Incomplete or duplicate entries will be excluded. All categorical responses will be numerically coded for analysis. For questions with multiple-choice or 'select all that apply' options, each option will be treated as a separate binary variable.

Descriptive analysis will summarise the demographic and professional profiles of respondents (gender, country, professional role, years of experience with CGM, primary practice setting, etc.). Frequencies and percentages will be calculated for all categorical variables (e.g., familiarity with CGMs, current use, perceived effectiveness, barriers). Means and standard deviations will be reported for Likert scale items and composite perception scores, where relevant.

To address the study objectives, different statistical tests will be applied.

Chi-square tests will be used to examine associations between categorical variables, such as country/region (Kerala vs. Ireland), practice setting (urban vs. rural), and key outcomes (e.g., CGM adoption, perceived barriers, engagement in education programmes). For example, the relationship between primary practice setting and reported CGM usage will be tested using chi-square analysis.

Independent samples t-tests will be conducted for variables measured on interval or ordinal scales, such as perception scores (e.g., confidence in using/explaining CGMs) or mean years of CGM experience, comparing across subgroups (urban vs. rural, Kerala vs. Ireland).

Cross-tabulation will be performed to present the distribution of key responses by subgroups, such as country and practice setting, allowing for direct visual comparison.

Subgroup Analysis may include comparisons across different professional roles, experience levels, or those who have/ have not attended education programmes (Guetterman, 2019).

For survey items with multiple response options (e.g., barriers to CGM use), frequencies of each barrier will be reported, and further stratified by region or practice setting. Although the primary focus is on close-ended responses, any open-ended feedback (e.g., for unclear questions or elaborations on barriers) will be categorised using content analysis to identify common themes or additional barriers not covered by the options.

For all inferential analyses, a p-value < 0.05 will be considered statistically significant. Key findings will be presented in tables and figures (bar charts, pie charts, cross-tabulation tables), providing both overall results and stratified results by country and practice setting (Guetterman, 2019).

The qualitative data in this study will be derived from semi-structured interviews with healthcare professionals in Kerala and Ireland. The analysis will be conducted using Braun and Clarke's six-phase approach to thematic analysis, which is well-suited for healthcare research and allows for rich, flexible interpretation of qualitative data.

Interview recordings will be transcribed verbatim. The researcher will read and re-read the transcripts to become thoroughly familiar with the content, noting initial ideas and patterns that emerge from participants' accounts. The transcripts will be systematically coded line-by-line. Coding will be both deductive (informed by research objectives and interview questions, such as barriers, perceived benefits, training, and context differences) and inductive (allowing new, unanticipated insights to emerge). Codes may be assigned to short phrases, sentences, or passages representing meaningful units of data.

Codes will be collated into potential themes by looking for patterns across the dataset. For example, codes relating to cost, training, and infrastructure may be grouped under a broader theme such as "Barriers to CGM Uptake." Themes will be mapped against the research objectives to ensure comprehensive coverage (e.g., perceptions, adoption factors, cross-cultural differences).
Candidate themes will be reviewed in relation to the coded extracts and the entire dataset to ensure they accurately reflect the data and are distinct from each other. Themes may be refined, split, merged, or discarded as needed.

Once final themes are established, each theme will be clearly defined and named, capturing the essence of the data it represents. Subthemes may also be identified to provide more nuanced insight into specific aspects of the theme. The final step will involve weaving together a compelling narrative based on the themes, supported by illustrative quotes from the interviews. The analysis will be directly linked to the research objectives and discussed in relation to relevant literature (Braun and Clarke, 2006).

3.6 Conclusion

The methodology uses both quantitative and qualitative techniques to obtain results. The use of a pragmatic mixed-methods design ensures that the study not only quantifies key trends and barriers but also explores the lived experiences of clinicians in detail. Rigorous attention to sampling, ethical safeguards, and strong data analysis strategies strengthens the reliability and relevance of the findings.

Chapter 4: Findings and Analysis

4.1 Introduction

This study was aimed to explore the concepts and effects of wearable glucose monitors (WGMs) on diabetes management in two different settings Kerala (India) and Ireland with an instance comparison between the urban and rural areas. The research took both quantitative and qualitative methods, where a survey was used, and the qualitative information was achieved using interviews with the help of interviews.

This survey was conducted amongst 203 healthcare professionals and practitioners dealing with diabetes care. Participants in either region represented various roles involved with diabetes: physicians, nurses, pharmacists, and diabetes educators. This heterogeneity made it possible to scope the experiences and careers of diverse people.

Recording of the information through the interviewing process further contextualised these survey results by pointing out personal and system characteristic that affects the adoption of WGMs. The cross-cultural comparative approach between Kerala and Ireland as well as urban and rural helped gain insights on what cultural, infrastructural, and system level differences drive the adoption and integration of digital health technologies.

The findings are organised into two groups: first, the demographics and background of the survey participants (Q1-Q6), followed by the analysis of perceptions and impact, organised according to the themes elicited through quantitative and qualitative data.

4.2 Findings and Analysis

4.2.1 Participant Demographics and Background (Survey: Q1–Q6)

Q1. What is your gender?

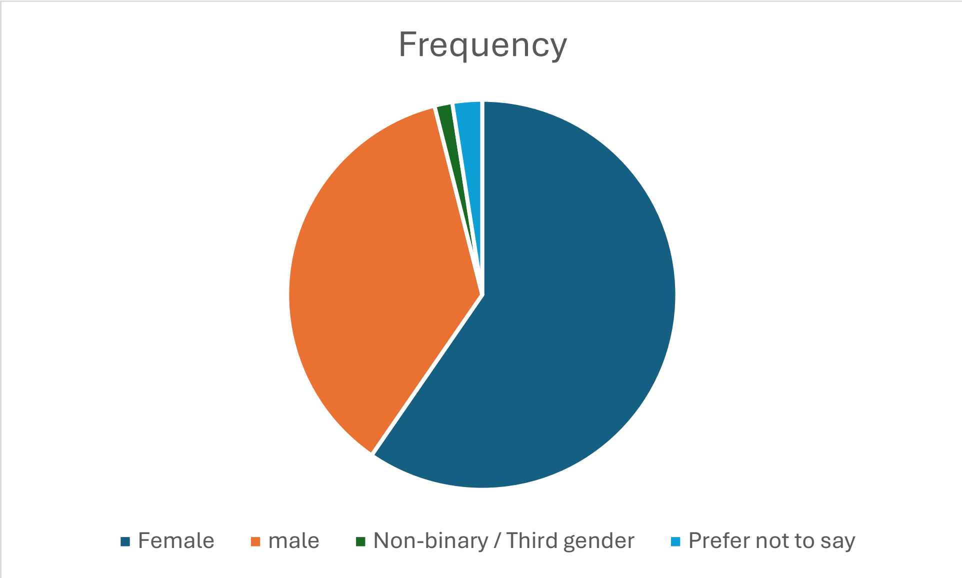

Figure 1: Distribution of Participants by Gender (Q1).

Table 1: Descriptive Statistics of Frequency by Gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	121	59.6	59.6	59.6
Male	74	36.5	36.5	96.1
Non-binary / Third gender	3	1.5	1.5	97.5
Prefer not to say	5	2.5	2.5	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

Q2. Which country do you primarily practice in?

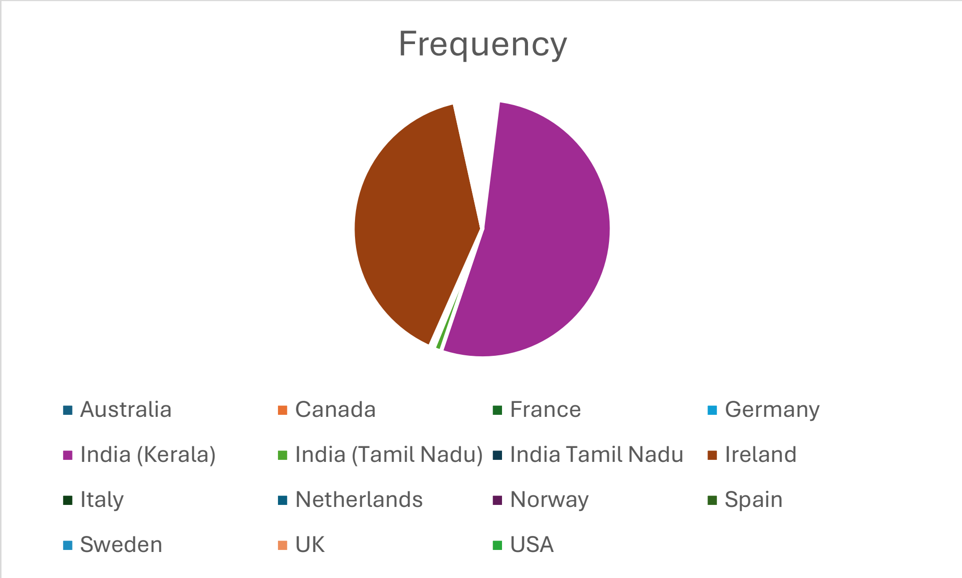

Figure 2: Distribution of Participants by Country of Practice (Q2)

Table 2: Distribution of Participants by Country of Practice

Country	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
India (Kerala)	108	53.2	53.2	55.2
Ireland	81	39.9	39.9	96.6
Others (Australia, Canada, France, Germany, etc.)	14	6.9	6.9	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

Q3. Is English your first language?

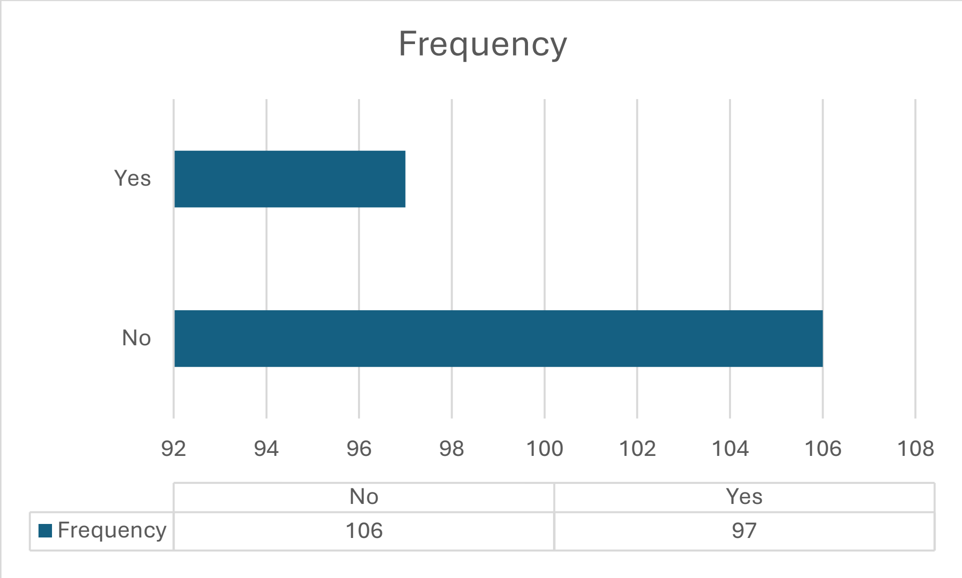

Figure 3: English as First Language among Participants (Q3).

Table 3: English as First Language Among Respondents

Response	Frequency	Percent	Valid Percent	Cumulative Percent
No	106	52.2	52.2	52.2
Yes	97	47.8	47.8	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

Q4. Are you fluent in English?

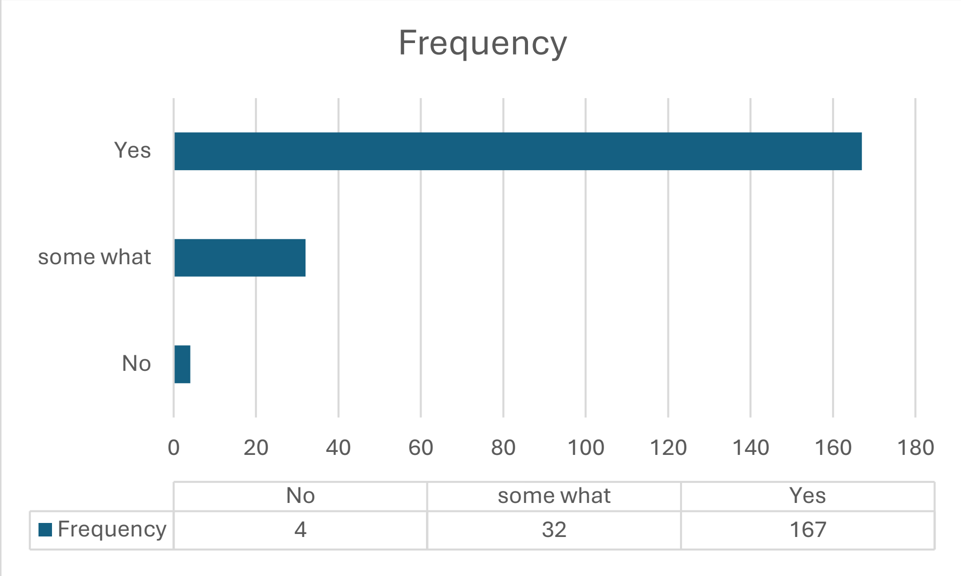

Figure 4: English Fluency among Participants (Q4).

Q5. What is your primary practice setting?

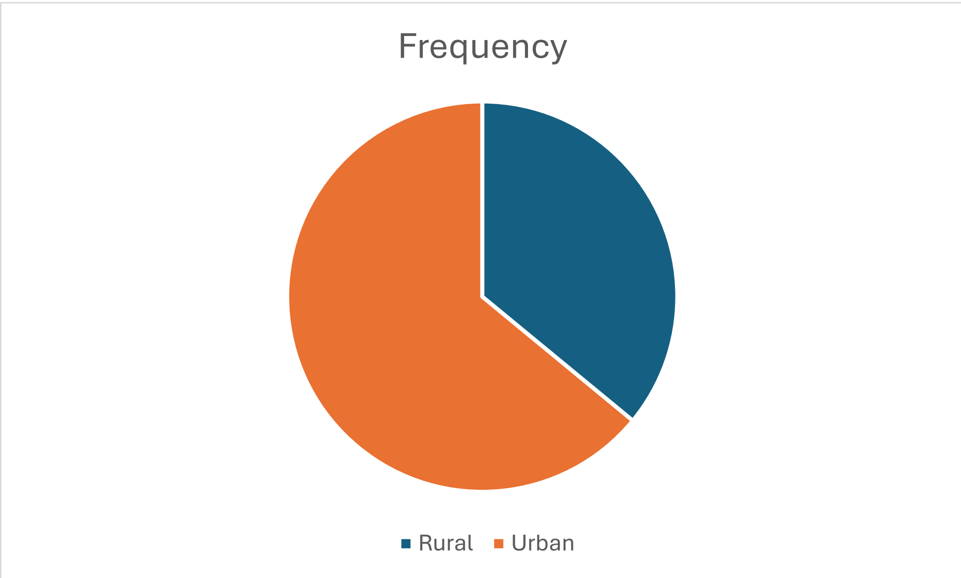

Figure 5: Distribution of Participants by Practice Setting (Q5).

Table 4: Distribution of Participants by Practice Setting

Setting	Frequency	Percent	Valid Percent	Cumulative Percent
Rural	73	36.0	36.0	36.0
Urban	130	64.0	64.0	100.0

Total	**203**	**100.0**	**100.0**	**100.0**

Q6. What is your professional role?

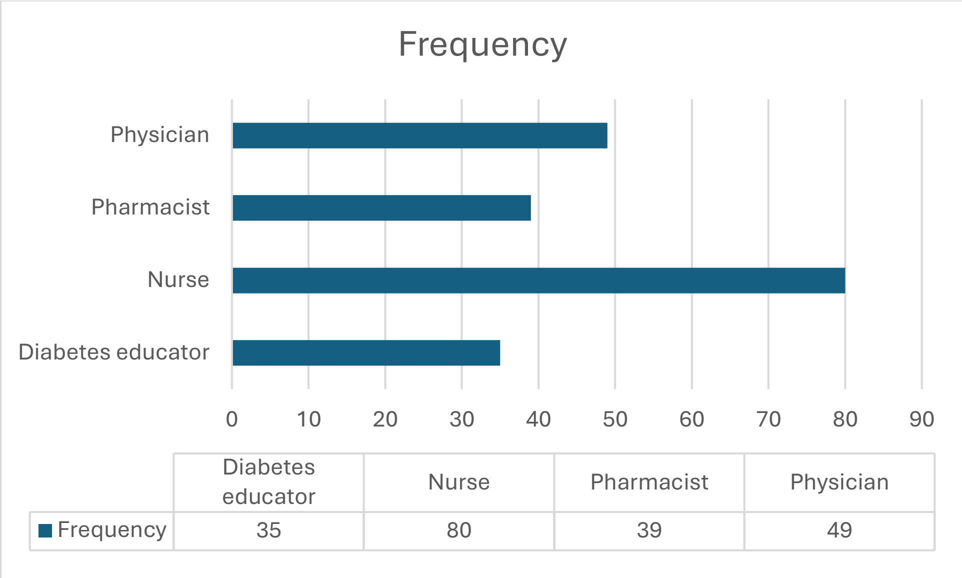

Figure 6: Professional Roles of Participants (Q6).

Table 5: Professional Roles of Participants

Role	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Diabetes Educator	35	17.2	17.2	17.2
Nurse	80	39.4	39.4	56.7
Pharmacist	39	19.2	19.2	75.9
Physician	49	24.1	24.1	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

The quantitative survey data were analysed through a series of descriptive and inferential statistical techniques to understand the demographic distribution of respondents and test associations between categorical variables.

First, frequency distributions were generated for participants' gender, country of practice, language proficiency, practice setting, and professional role. This provided a clear overview of the composition of the sample: the majority were female (59.6%), based in

India (Kerala) (53.2%) and Ireland (39.9%), with 64% working in urban practice settings. Professional roles were well distributed across physicians, nurses, pharmacists, and diabetes educators.

Next, cross-tabulations were used to explore the relationship between country of practice (Kerala vs. Ireland, with international respondents retained for completeness) and practice setting (urban vs. rural). Results (Table X) showed that within Kerala, 42 participants worked in rural and 66 in urban settings, while in Ireland, 27 were rural and 54 urban. This indicates that both regions had stronger urban representation. The chi-square test ($\chi^2 = 13.384$, df = 14, p = .497) confirmed that country and practice setting were not significantly associated, suggesting the urban–rural distribution was relatively consistent across locations.

A second cross-tabulation examined the relationship between professional role and country of practice. Kerala had a higher concentration of nurses (48) and physicians (25), while Ireland had proportionally more diabetes educators (19) alongside physicians (16). The chi-square test ($\chi^2 = 53.291$, df = 42, p = .114) indicated no statistically significant difference in professional role distribution across countries, though some clustering patterns were visible.

Overall, the analysis plan combined descriptive and inferential methods to map participant demographics, explore cross-national differences, and establish whether professional role or practice setting varied significantly between Kerala and Ireland. These findings laid the foundation for interpreting perceptions and impacts of wearable glucose monitors in the subsequent sections.

4.2.2 Perceptions of CGM Effectiveness and Usability (Objective 1)

4.2.2.1 Quantitative analysis

51.2% very familiar and 25.1% somewhat familiar with CGMs (Q7). A majority use CGMs in their current role (57.6%) (Q8), and 63.5% report centre-level availability (Q9). Personal use/recommendation is also widespread (64.5%) (Q10). Among those who have never used/recommended, perceptions skew positive/neutral (Q9a): 20.7% very positive, 19.2% somewhat positive, 20.7% neutral, with small negative shares.

Perceived effectiveness. Respondents view CGMs as superior to finger-prick: 53.2% "much more effective" and 30.0% "somewhat more effective" (combined 83.2% "more effective") (Q11).

Usability. Most rate CGMs as easy for patients: 38.9% straightforward and 36.5% somewhat easy (Q12). Confidence to counsel is strong: 47.3% very confident, 32.0% somewhat (Q15).

Workload & implementation. Resource demands are acknowledged (Q13): 32.0% “somewhat” and 18.2% “significant” staff time/resources. Implementation effort (Q14) is typically not very or somewhat time-consuming (36.5% and 28.6%, respectively), with 9.9% calling it very time-consuming.

Perceived advantages (multi-select, Q16). Selections cluster around five benefits: real-time glucose data, fewer finger-pricks, alerts for highs/lows, better glycaemic control, and data-sharing with providers. The single most frequent pattern was the bundle ("real-time + fewer pricks + better control + alerts + data-sharing": n=39). Other high counts included real-time only (n=28) and real-time + fewer pricks + better control + alerts (n=24). "Unsure" remained modest (n=17), and "none of the above" was rare (n=6).

Country contrasts on low-connectivity CGMs. For “Would increased access to non-internet CGMs improve uptake/adherence?” support was broad in both settings:

- Kerala (n=108): Yes 50.0% (54), Not sure 44.4% (48), No 5.6% (6).
- Ireland (n=81): Yes 55.6% (45), Not sure 28.4% (23), No 16.0% (13).
- The association between country and response was insignificant (χ^2=19.731, df=28, p=.874), indicating similar directional attitudes across locations despite system differences.

Bottom line. Quantitatively, stakeholders report high familiarity, strong perceived effectiveness and usability, solid confidence to educate, and recognize non-trivial but manageable workload—while valuing real-time, actionable data and fewer finger-pricks above all.

4.2.2.2 Qualitative Analysis

In Kerala, CGMs are considered restricted to non-routine care due to cost (4,000-5,000/- per month), supply side challenges and infrastructure/ digital literacy shortcomings; finger-prick has become the default option since it is nearly free, accessible in pharmacies, does not require electricity or phone connection and can be taught within minutes. The few users, such as the adhesive reactions, sensor failure during humid climate, alarm-associated anxiety, and the data overload without directions, have reported usability concerns regarding text messages. The limited clinician exposure also mitigates perceived effectiveness, as the Kerala clinician has had ~1520 CGM users over the past 12 years, which also required learning demands (AGP, TIR, variability) and additional time to interpret the data.

In Ireland, CGMs have had their position redefined as one of progression toward standard of care and intensive insulin therapy, enabled by HSE reimbursement and guideline inclusion- a shift in position and towards perceptions of greater efficacy and use in comparison to finger pricks due to visibility of nocturnal hypos, post-prandial excursions, dawn phenomenon and richer more decision-ready data. Self-reported feelings of liberation of finger-prick routines are common, with smartphone literacy making usage easy. Yet, older individuals may experience information and alarm fatigue, prompting a relapse to finger-prick-underscoring, again underscoring the necessity of selection and preparative concern.

The synthesis (Objective 1). The survey has a high perceived effectiveness and ease, but workflow cost is recognised. Structural barriers and minimal hands-on experience explain why perceived increases in usability fail to translate to routine use absent both financing and training and supply, at least in Kerala (structural barriers and minimal hands-on experience explain of perceived increases in usability fail to translate to routine use absent both financing and training and supply at least in Kerala). The Ireland transcript demonstrates how system enablers (coverage, training) can turn around good perceptions and convert to adoption and lived usability. Yet, no one will be surprised that human-factor frictions (alarms, data anxiety) are still there and must be addressed. In general, the perceptions are aligned with the potential of CGMs (real-time, reduced pricking, actionable information), but context dictates whether that potential is realised at scale.

4.2.3 Observed Impact of CGMs on Glycaemic Control and Self-Management (Objective 2)

4.2.3.1 Quantitative results

Quantitative results (survey). Across Q17–Q21, respondents consistently linked CGM use with better control, fewer hypos, and higher engagement. Most reported better glycaemic control among CGM users (Q17: 61.1% Yes), and rated CGMs as positively impacting self-management (Q18: 69.5% positive; 18.7% N/A). Most observed fewer hypoglycaemic events (Q19: 67.5% slight/significant reduction) and said patients often discuss CGMs/data in visits (Q20: 24.1% Always, 23.2% Often, 19.7% Sometimes). Engagement perceptions were strong (Q21: 66.5% agree/strongly agree; 19.7% N/A).

A role-based cross-tab (Q19) shows all professions reported reductions, with physicians and diabetes educators most often endorsing "significant reduction." The association between professional role and observed hypo reduction was statistically significant (Pearson $\chi^2=38.463$, df=12, $p<.001$).

Table 6: Top-line Survey Results on Observed Impact (Q17–Q21)

Question	**Key positive indicator**	**n**	**%**	**Not applicable (n, %)**
Q17 Better control vs finger-prick	Yes	124	61.1	41 (20.2)
Q18 Impact on self-management	Positive (Very/Somewhat)	141	69.5	38 (18.7)
Q19 Reduction in hypoglycaemia	Yes (Slight/Significant)	137	67.5	44 (21.7)
Q20 Patient CGM discussion frequency	≥Sometimes (Sometimes/Often/Always)	136	67.0	42 (20.7)
Q21 CGMs increase engagement	Agree/Strongly agree	135	66.5	40 (19.7)

Interpretation (Table 7, short). A clear majority signals clinical benefit and engagement, but notable N/A shares indicate that observed impact depends on exposure/access in each setting.

Table 7: Reduction in Hypoglycaemic Events by Professional Role (Q19 Cross-tabulation)

	Diabetes educator	**Nurse**	**Pharmacist**	**Physician**	**Total**
No change	1	5	0	0	6

Not applicable (no CGM seen)	4	24	14	2	44
Not sure	1	6	5	4	16
Yes, significant reduction	22	26	11	35	94
Yes, slight reduction	7	19	9	8	43
Total	**35**	**80**	**39**	**49**	**203**

Interpretation (Table 8, short). Reductions reported across all roles; physicians and educators most frequently note significant reductions—likely reflecting greater CGM data exposure and follow-up intensity.

Table 8: Chi-Square Tests for Role × Hypoglycaemia Reduction (Q19)

Test	**Value**	**df**	**Sig. (2-sided)**
Pearson Chi-Square	38.463a	12	.000
Likelihood Ratio	43.262	12	.000
N of Valid Cases	203		

a: 7 cells (35.0%) have expected count <5; minimum expected count = 1.03.

Interpretation (Table 9, short). Significant association between role and reported hypo reduction (p<.001); interpret with caution due to small expected counts in some cells.

Overall interpretation. Quantitatively, respondents view CGMs as translating into measurable clinical gains (better control, fewer hypos) and behavioural benefits (more discussion, higher engagement). The N/A fractions underscore that impact remains contingent on access and implementation across sites and roles.

4.2.3.2 Qualitative evidence

Kerala. Clinicians report anecdotal and modest CGM ROI: in patients where it is available, CGMs aid in identifying patterns (post-meal spikes, nocturnal lows) and adjusting mealtimes, insulin, and activities earlier than doing so through finger-prick alone. Reported advantages include reduced symptomatic hypoglycemia, increased confidence in self-adjustment, and increased routine compliance. Still, gains are mixed, limited by expense, sensor availability, adhesive/humidity issues, and alarm anxiety that can disengage sensor use without coaching.

Ireland. As CGM expands, practitioners can see more evident improvement in glycaemia and a decreased number of hypoglycaemic incidents, with more focused discussions in the clinic and patients bringing specific data to deal with the issues. Patients usually express being more in control (ownership, motivation), although elderly patients may be overwhelmed with information or alarm fatigue, which has to be addressed with individual adjustments and education.

Synthesis. Transcripts confirm survey: CGMs offer the benefit of better control and fewer hypos when utilized and greater engagement with actionable feedback loops. The potential of these gains at scale requires access, device reliability/amenity and scaffolded support (training, alarm calibration and directable guidance of interpretation) in such a way that self-management confidence is developed, not crushed by, their volumes.

4.2.4 Adoption Rates, Usage Patterns, and Barriers (Objective 3) Quantitative

4.2.4.1 Quantitative Analysis

Q22. Recommendation activity

Interpretation. Professional endorsement is high: 70.0% have recommended CGMs, indicating strong frontline support for adoption.

Table 9. Recommendation of CGMs to Patients (Q22)

Response	Frequency	Percent	Valid Percent	Cumulative Percent
No	61	30.0	30.0	30.0
Yes	142	70.0	70.0	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

Q23. Patient usage levels

Interpretation. Usage is heterogeneous: the most common categories are <10% (22.2%) and 26–50% (20.2%), while >50% is reported by 13.8%.

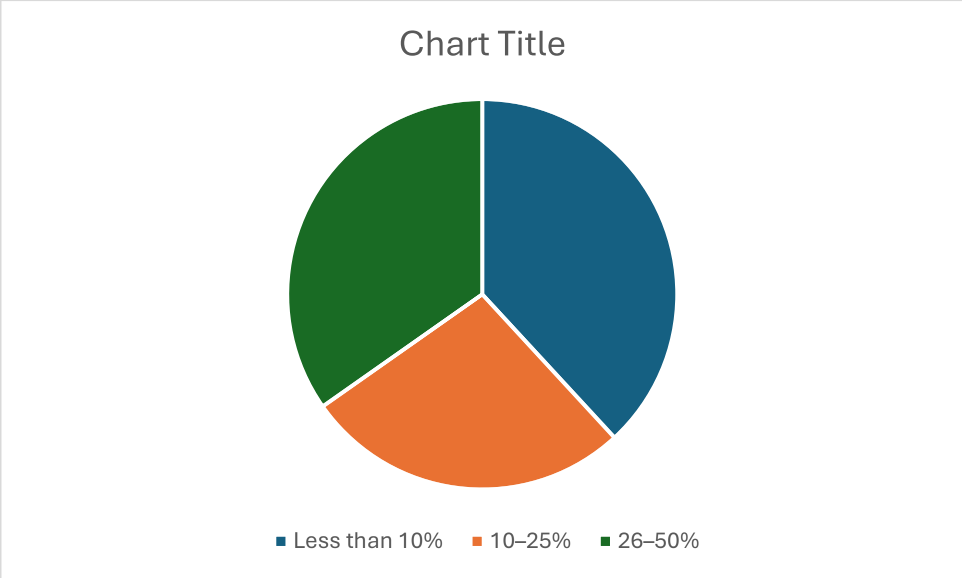

Figure 7: Estimated Percentage of Patients Using CGMs (Q23)

Table 9: Estimated Percentage of Patients Using CGMs (Q23)

Category	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Less than 10%	45	22.2	22.2	58.1
10–25%	32	15.8	15.8	15.8
26–50%	41	20.2	20.2	36.0
More than 50%	28	13.8	13.8	71.9
None	30	14.8	14.8	86.7
Not sure	27	13.3	13.3	100.0
Total	**203**	**100.0**	**100.0**	**100.0**

Interpretation (setting differences). Urban clinics report more **>50%** users (23 vs 5 rural) and fewer **none** (11 vs 19 rural). The association is **significant**.

Table 10: CGM Patient Use × Practice Setting (Q23 Cross-tab)

CGM Use %	**Rural**	**Urban**	**Total**
10–25%	11	21	32
26–50%	10	31	41
Less than 10%	21	24	45

More than 50%	5	23	28
None	19	11	30
Not sure	7	20	27
Total	**73**	**130**	**203**

Table 11: Chi-Square for Setting Differences in Adoption (Q23)

Test	**Value**	**Df**	**Sig. (2-sided)**
Pearson Chi-Square	19.584a	5	.001
Likelihood Ratio	19.666	5	.001
N of Valid Cases	203		
a: 0 cells <5; minimum expected count = 9.71.			

Q24. Primary reason for non-adoption

Interpretation. High cost (38.9%) and lack of awareness (28.1%) dominate barriers; limited availability (11.3%) and preference for traditional methods (8.9%) follow.

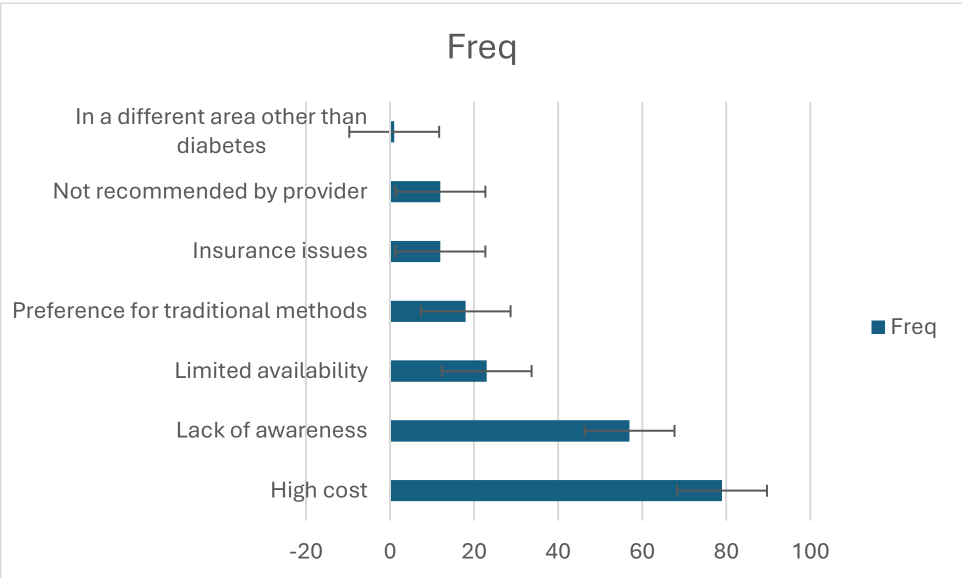

Figure 8: Main Reasons for Non-Adoption of CGMs (Q24)

Table 12: Main Reason Patients Do NOT Use CGMs (Q24)

Reason	**Freq**	**%**
High cost	79	38.9
Lack of awareness	57	28.1
Limited availability	23	11.3
Preference for traditional methods	18	8.9
Insurance issues	12	5.9
Not recommended by the provider	12	5.9
In a different area other than diabetes	1	0.5
Total	**203**	**100.0**

Q25–Q25b. Non-Internet CGMs: use and reasons when not used

Table 13:Use of non-Internet CGMs (Q25)

Response	**Freq**	**%**
Yes, widely used	54	26.6
Yes, sometimes used	62	30.5
No, not used	47	23.2
Not sure	40	19.7
Total	**203**	**100.0**

Interpretation (reasons when not used). Drivers include lack of awareness, limited availability, cost, preference for internet-enabled CGMs, data transfer/storage concerns, and provider familiarity.

Table 14: Reasons Non-Internet CGMs Not Used (Q25b, multi-select)

Reason (selected or in combination)	**n**	**%**

Unspecified combination	50	24.6
Lack of awareness	31	15.3
Not applicable / No opinion	29	14.3
Limited availability	15	7.4
Cost	5	2.5
Data transfer/storage concerns	7	3.4
Provider preference/familiarity	3	1.5
Preference for internet-enabled CGMs	2	1.0
(All recorded combinations total N=203)		

Q26. Type of CGMs most used

Interpretation. Real-time CGM (43.3%) exceeds flash/intermittent (23.6%); N/A 19.7%; Don't know 13.3%.

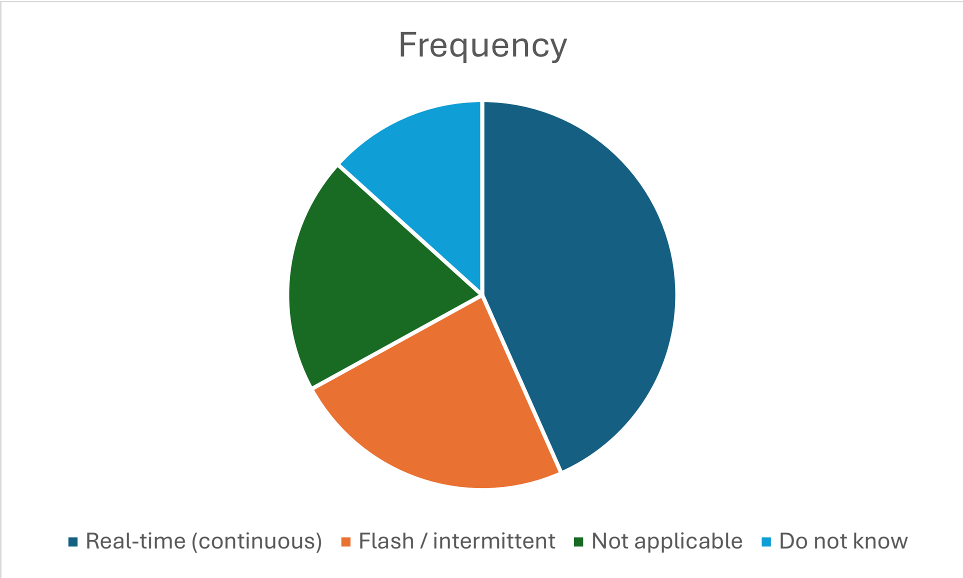

Figure 9: Type of CGMs Most Commonly Used (Q26)

Table 15: Type of CGMs Most Commonly Used (Q26)

Type	Freq	%
Real-time (continuous)	88	43.3
Flash / intermittent	48	23.6
Not applicable	40	19.7
Do not know	27	13.3
Total	**203**	**100.0**

Q27. Encountered barriers (multi-select)

Interpretation. Barriers commonly cited (alone or in combos): device cost, limited availability, lack of training, patient reluctance, insurance issues, and technical difficulties.

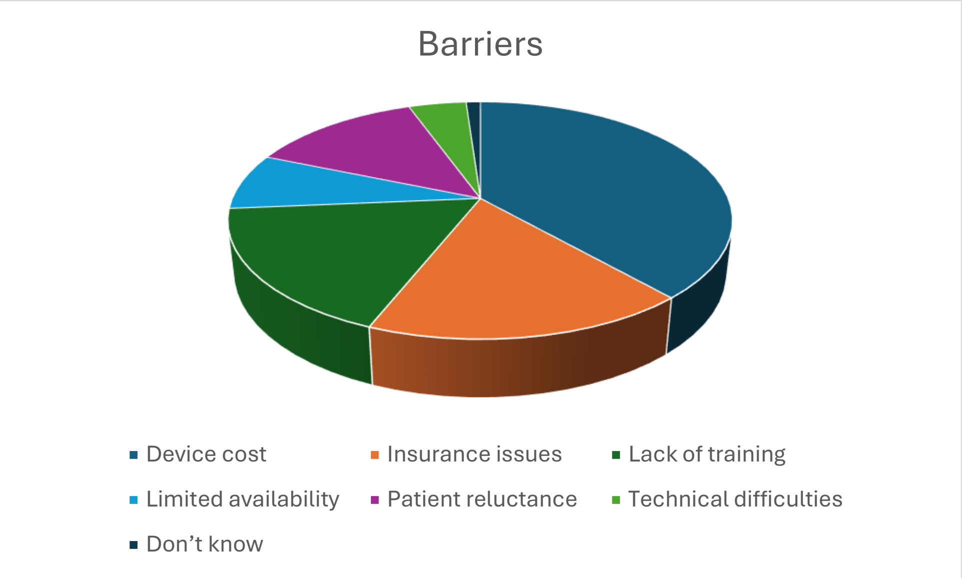

Figure 10: Barriers Encountered in CGM Use (Q27)

Table 16: Barriers Encountered to CGM Use (Q27, multi-select)

Barrier (alone or in combination)	n	%
Device cost	35	17.2

Insurance issues	16	7.9
Lack of training	16	7.9
Limited availability	7	3.4
Patient reluctance	12	5.9
Technical difficulties	4	2.0
Don't know	1	0.5

Adoption is clinician-led: 70% have recommended CGMs. Patient use is heterogeneous—22.2% report <10% users, 20.2% report 26–50%, and 13.8% report >50%; urban sites show more >50% users than rural, a significant difference (χ^2=19.584, p=.001). Non-adoption is driven mainly by high cost (38.9%) and lack of awareness (28.1%), with limited availability (11.3%) and preference for finger-pricks (8.9%) also notable. Non-internet CGMs are used in 57.1% of practices; when not used, reasons include awareness gaps, availability, cost, data-sharing concerns, and provider preferences. Real-time CGM predominates (43.3%) over flash (23.6%). Common barriers combine cost, training gaps, availability, patient reluctance, insurance, and technical issues.

4.2.4.2 Qualitative synthesis

In both interviews, adoption is the local care structure paradigm and resourcing paradigm. In Kerala, CGM adoption happens ad hoc and only among patients who can cover the cost of consumable sensors or independently manage ordering and follow-up. Clinicians reported that finger-prick testing is pseudonymous rather than electronic, and CGM is selectively implemented when problems of elevated and/or inconsistent results warrant the additional effort and cost. In Ireland, CGM seems integrated into routine care: patients already have downloaded reports or are glancing at the app, and requests to review e-mails together are made, normalising continued patient use.

In CGM cases, patient behaviour is comparable in both settings. Daily patterns, correlations, alarms, and real-time trends determine the time of meals, dose modification, and activity selection. There is increased confidence as patients report. Meanwhile, a sub-group in each environment will stall or regress: alarm fatigue, anxiety triggers caused by excessive alerts, adhesive or comfort concerns can chip away at excitement without training and customised configurations.

The barriers may differ in nature, but they ultimately lead to similar outcomes. In Kerala, price and lack of accessibility are primary; even interested patients are repeatedly hit with costs and pragmatic access barriers. In Ireland, the bottlenecks centre less on finances and more on operational issues: clinician resources to perform onboarding and review data, inconsistent exposure to the population outside units of specialists, and controlling the data flow and alerts. In both interviews, awareness and provider confidence are involved in developing recommendations. Non-internet CGMs circumvent connectivity limitations and may be appropriate for privacy-conscious consumers. However, ease of sharing and remotely reviewing data depends on local workflows, the ability to follow up, and patient preference.

4.2.5 Infrastructural, Economic, and Educational Factors (Objective 4)

4.2.5.1 Quantitative results

Q28. Cost barrier – A clear majority views cost as a barrier.

Table 17: Is cost a significant barrier? (Q28)

Response	Freq	%
Yes	128	63.1
Not sure	33	16.3
No	42	20.7
Total	**203**	**100.0**

Cost is the dominant constraint: 63.1% say "Yes," while only 20.7% say "No." A further 16.3% are unsure, indicating residual uncertainty, but a clear majority view cost as prohibitive.

Q29. Accessibility – Supply is inconsistent; "occasionally/rarely available" dominates.

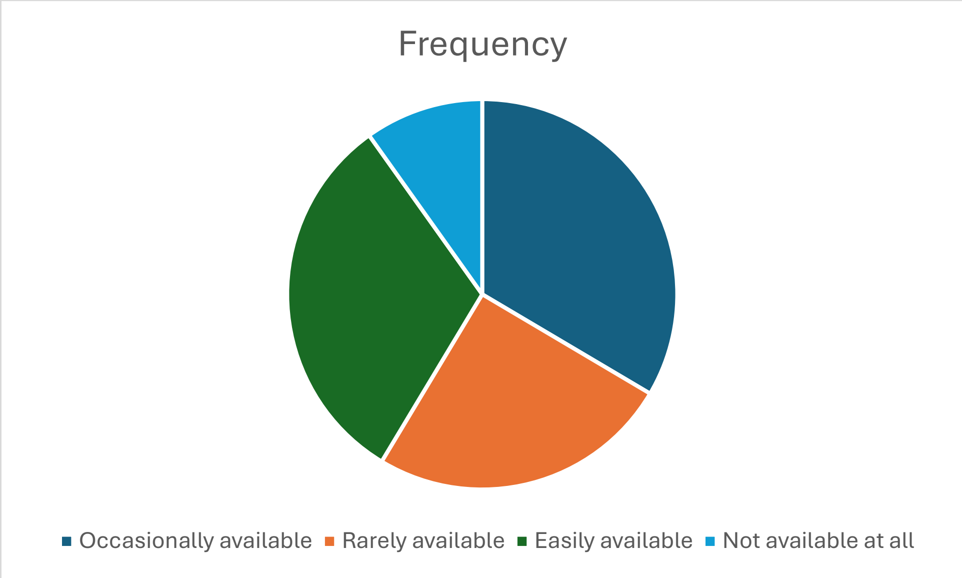

Figure 11: Accessibility of CGMs in Practice Settings (Q29)

Table 18: Accessibility of CGMs (Q29)

Category	Freq	%
Occasionally available	68	33.5
Rarely available	51	25.1
Easily available	64	31.5
Not available at all	20	9.9
Total	**203**	**100.0**

Access is inconsistent; 58.6% report occasionally/rarely available, vs 31.5% "easily available." 9.9% report no availability, underscoring supply/distribution gaps

Q30. HCP education availability – Education exists, but skews to ad-hoc/occasional.

Table 19: CGM Education Programmes for HCPs (Q30)

Category	Freq	%
Yes, occasionally	69	34.0
Yes, regularly	62	30.5

No	47	23.2
Not sure	25	12.3
Total	**203**	**100.0**

Education exists (combined 64.5% "yes"), but skews ad-hoc: "occasionally" (34.0%) edges "regularly" (30.5%). Nearly 1 in 4 report no programmes.

Setting differences in HCP education (Q30 × Setting) – Urban sites report far more regular programmes.

Table 20: HCP Education × Setting (Q30 Cross-tab)

Category	Rural	Urban	Total
No	28	19	47
Not sure	7	18	25
Yes, occasionally	28	41	69
Yes, regularly	10	52	62
Total	**73**	**130**	**203**

Urban sites host far more regular programmes (52 vs 10 rural) and occasional ones (41 vs 28), indicating a pronounced urban advantage in training access.

Table 21: Chi-Square for Q30 × Setting

Test	Value	df	Sig. (2-sided)
Pearson Chi-Square	23.296a	3	.000
Likelihood Ratio	24.152	3	.000
N	203		
a: 0 cells <5; min expected = 8.99.			

The association is statistically significant (χ^2=23.296, p<.001), confirming training availability differs by setting (urban > rural). Assumptions are met (no cells <5).

Q31. HCP training attendance – Almost half trained in the last year.

Table 22:Attended CGM Training (Q31)

Category	Frequency	%
Yes, within the last year	87	42.9
Yes, >1 year ago	42	20.7
No, never	62	30.5
Not sure	12	5.9
Total	**203**	**100.0**

42.9% trained within the last year, but 30.5% have never attended—revealing a substantial training gap despite active offerings.

Q32. Patient awareness – Most rate awareness moderate to high, but "low/very low" is substantial.

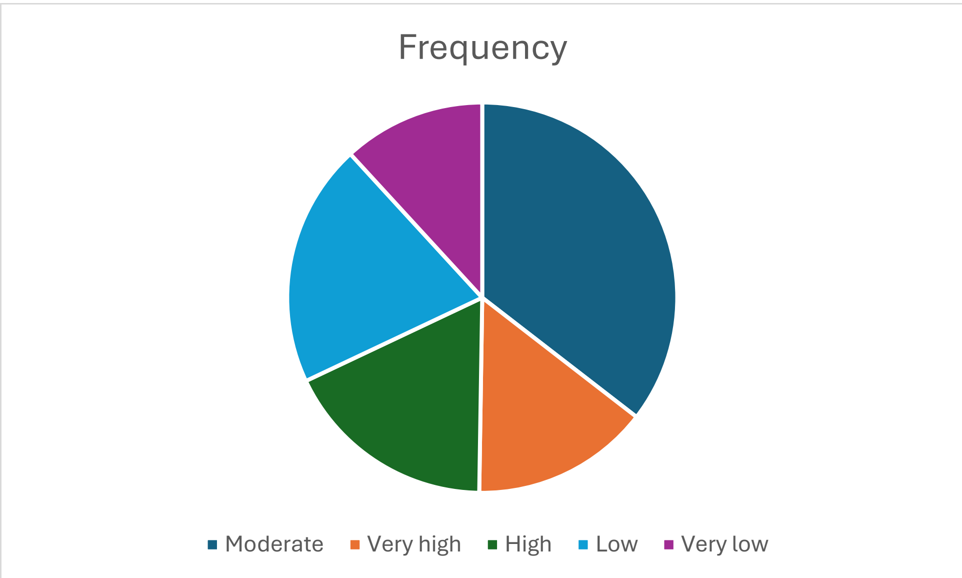

Figure 12: Patient Awareness of CGMs (Q32).

Table 23: Patient Awareness of CGMs (Q32)

Category	**Freq**	**%**
Moderate	72	35.5
Very high	30	14.8
High	36	17.7
Low	41	20.2
Very low	24	11.8
Total	**203**	**100.0**

Awareness is mixed: 68.0% rate moderate/high/very high, while 32.0% report low/very low—a sizable segment requiring outreach and education.

Q33. Factors affecting uptake (multi-select) – Affordability is prominent; multiple ecosystem factors co-occur.

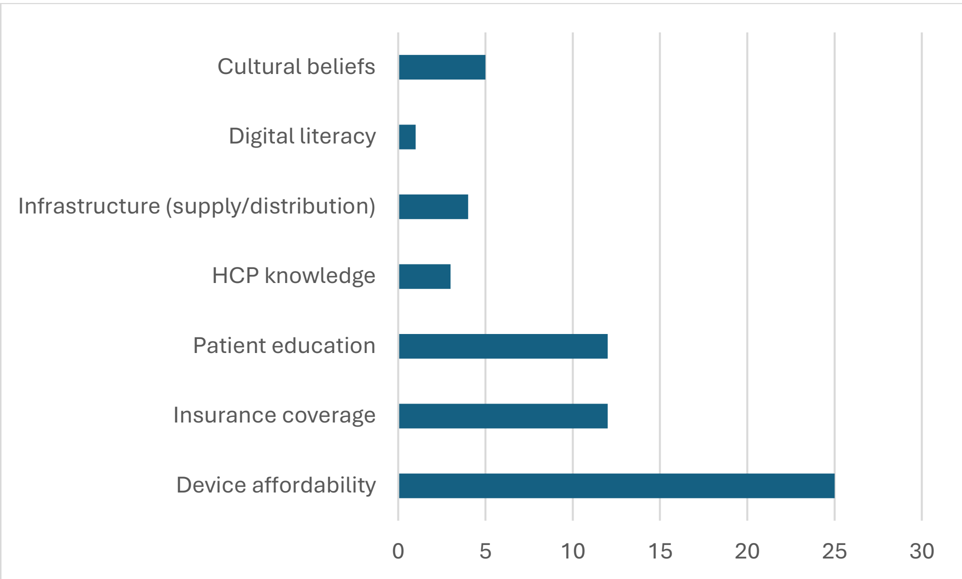

Figure 13: Drivers Affecting Uptake of CGMs (Q33)

Table 24: Drivers Affecting Uptake (Q33, multi-select summary)

Factor (alone or in combinations)	**n**	**%***
Device affordability	25	12.3

Insurance coverage	12	5.9
Patient education	12	5.9
HCP knowledge	3	1.5
Infrastructure (supply/distribution)	4	2.0
Digital literacy	1	0.5
Cultural beliefs	5	2.5
Plus all recorded combinations (instrument list) to N=203		

Device affordability is the most prominent single factor. However, barriers are multifactorial—insurance, patient education, HCP knowledge, infrastructure, digital literacy, and cultural beliefs frequently co-occur in combinations.

Cost is the dominant barrier (63.1% "Yes"), while accessibility is uneven: two-thirds report CGMs are occasionally/rarely available. HCP education exists (64.5% "yes"), but urban sites are far likelier to host regular programmes (χ^2=23.296, p<.001). Nearly half of respondents attended training within a year (42.9%), yet one-third never have (30.5%). Patient awareness is mixed, with moderate/high common but low/very low, totalling 32%. Multi-select drivers reaffirm affordability, insurance, education, and supply infrastructure as co-occurring determinants—indicating that economic relief without provider/patient education and reliable distribution will underdeliver on CGM uptake and sustained use.

4.2.5.2 Qualitative analysis (Kerala vs Ireland)

In Kerala, the economic situation makes CGMs unaffordable to most families: uninsured, the devices are positioned as non-essential, and the monthly sensor supplies cannot be funded by patients. This makes continued utilisation financially infeasible, even on the part of motivated patients, without change. Training gaps add to this burden: CGM education is absent in curricula; physicians who are generalists report relying on informal, disparate education, with many feeling ill-equipped to prescribe/manage CGMs. The whole issue of patient education is also undeveloped, with language mismatch (English material preferring Malayalam understanding). However, Kerala already has an established primary care and diabetes educator system that could be deployed with little effort in the event of funded curricula, Malayalam-accessible resources, and certification mechanisms.

Pervasive infrastructure gaps include a lack of sensors in local pharmacies, a limited availability of technical support in the region, and a shortage of equipment to download information to the computers/software. The core barriers (cost, supply chains, and provider readiness) remain unsolved even by the so-called offline-capable CGMs, with uptake in rural settings essentially zero, reflecting barriers due to awareness, staffing, and access to specialities.

In Ireland, CGM is primarily facilitated by these infrastructural and economic influences: integrated diabetes services, EHR, pharmacy distribution, privately funded LTI, and public coverage have become the norm. There are arranged learning sessions on patient education and frequent workshops on the same topics for the providers, but ongoing disparities such as GP gaps persist. However, there are threats to sustainability: the rising cost of healthcare, rising eligibility, and labour shortage (lack of diabetes technology nurses) pose a risk to capacity, and there is pressure on coverage policies regarding cost-effectiveness. Further investment into human infrastructure (competency standards, regional training centres) and in a future where data is operated across many platforms and systems without difficulty is recommended to eliminate future bottlenecks.

It becomes apparent how cross-learning can lead to interventions: Kerala can implement what it has already been doing in targeted subsidies and develop CME-linked certification of educators. At the same time, Ireland can follow Kerala in the context of the community health worker model and see how it can be scaled up. In both contexts, sustainability is a question of aligned finance, sustainable supply chains and regular, place-based education to turn devices into lasting, equitable use.

4.2.6 Recommendations for Integration and Accessibility (Objective 5)

4.2.6.1 Quantitative results — tables + interpretation

Table 25: Strategies to increase CGM use (Q34, multi-select as recorded — excerpts)

Response pattern	**n**	**%**
Better insurance coverage *(single)*	26	12.8
Lower device costs *(single)*	17	8.4

Patient education programmes *(single)*	9	4.4
More provider training *(single)*	5	2.5
Improved device availability *(single)*	3	1.5
Community awareness campaigns *(single)*	3	1.5
Lower costs + insurance + training + patient education + availability + campaigns	20	9.9
Better insurance + patient education	14	6.9
Lower costs + better insurance	11	5.4

Financing levers dominate—better insurance and lower device costs are the top singles. Many respondents prefer bundled fixes (cost + coverage + provider training + patient education + availability + awareness), indicating the need for a system-wide package rather than a single intervention.

Table 26: Support for government-subsidised CGM programme (Q36)

Response	**Freq**	**%**
Strongly support	94	46.3
Support	72	35.5
Neutral	30	14.8
Unsure	6	3.0
Do not support	1	0.5
Total	**203**	**100.0**

81.8% *support/strongly support* public subsidy, with minimal opposition (0.5%). This signals a strong policy mandate for government-backed CGM access.

Table 27: Chi-square (strategy patterns × grouping; instrument test)

Test	Value	df	Sig. (2-sided)
Pearson Chi-Square	319.281a	560	1.000
Likelihood Ratio	185.730	560	1.000
N	203		

The matrix is too sparse (≈98.5% cells <5; min expected ≈0), so χ^2 results ($p=1.000$) are not reliable/interpretable. Use descriptive findings from Table 28 instead of inference here.

Respondents prioritise financing and affordability to expand CGM access. The strongest single levers are better insurance coverage (12.8%) and lower device costs (8.4%), with additional support for patient education, provider training, device availability, and community awareness. Notably, a large bloc endorses a comprehensive bundle—lower costs plus coverage, training, education, availability, and campaigns (9.9%). Policy appetite is high: 81.8% *support/strongly support* a government-subsidised programme. Given the sparsity of multi-select combinations, inferential tests are uninformative; the descriptive signal is clear—finance + education/training + supply is the preferred integration pathway.

4.2.6.2 Qualitative analysis (Kerala vs Ireland)

Kerala. Clinicians suggested implementing specific scholarships (e.g., patients with insulinisation, frequent hypoglycaemia, and pregnancy) and mass purchase to reduce repeated sensor costs, causing routine use bottlenecks. They emphasise regular enrollment in local availability through accredited dealers or pharmacies and simple support of the equipment (adhesives, substitutes). To integrate them, they give priority when they uplift the providers' skills with the help of CME modules on AGP/TIR interpretation and Malayalam patient education (simple visuals, alarm-tuning guides). Visibility and education in the primary care setting, via CGM beyond the tent and via diabetes camp interaction with CGM, can all help normalise CGM; offline capabilities can be used, provided clinicians can still access the information in uploaded files during clinic visits.

Ireland. The coverage and supply are less of a concern. Still, the recommendations include continuing funding, extending eligibility when clinically warranted, and increasing workforce capacity (additional diabetes tech nurses, time to review the data). The clinicians report that they would like to see standardised training outside of specialist centres, specifically the training of GP teams, and individualised alarm settings to reduce fatigue. To facilitate a smoother integration, they focus on interoperable data flows (clinic software/app portals) and structured patient reminders of education at critical stages (therapy alterations, pregnancy, adolescence, frailty).

Cross-cutting guidance. The approaches advocated in both transcripts are similar: a three-pillar approach: (1) Finance/affordability (subsidies, cost caps); (2) Human capability (provider training + culturally/linguistically matching patient education); and (3) Reliable supply/logistics (pharmacy distribution, predictable stock, basic technical support). In Kerala, combined community-level outreach and local pathway; in Ireland, add primary-care upskilling and data / IT integration. Lastly, the two settings report the usefulness of small and practical bundles, e.g., "subsidy + education + availability" to transform willingness into consistent and equal CGM use.

4.3 Discussion

4.3.1 Linking Findings to Literature Review

4.3.1.1 Epidemiology, adoption trends, and urban–rural disparities

Our data yield substantially higher normalisation of CGM use in Ireland than Kerala: most respondents had CGM-using centres (63.5%), had recommended CGM use (70%), and interviews described regular Irish use and occasional, as-able-to-pay use in Kerala. Such a pattern repeats the epidemiological and systems narratives of the review--Kerala experiencing a high incidence of diabetes due to its high urbanisation rate compared to Ireland, and Irish services recording more successful technology readiness than Kerala, with fewer people in demand than can be supplied (Bent et al., 2021). The high urban-rural divide in access to education and patient utilisation in our results (more than 50 per cent of users in urban clinics) also reflects the report on how structured Irish pathways+ compensation can overcome eras of weakness related to market-driven, out-of-pocket developments in India, where rural gaps have persisted (HIQA, 2023).

Professional and patient perceptions (2.4)

Perceptions of CGM were highly positive: eight in ten clinicians thought that CGMs are more efficacious, in comparison to finger-prick, and three in four thought that CGMs were easy/very easy to use by a patient, with a high confidence level in explaining. Interviews, however, threw out human-factor caveats such as alarm fatigue, information overload, and the need to adjust for different users/levels of digital literacy, particularly older or low digital-literacy settings. This is consistent with the review in that knowledge and intentional training among clinicians is a key to adoption, and usability on the patient side depends on a common understanding and interpretation. To conclude, our respondents are positively located in that tools are empowering only when situated within powerful teams and routinised patterns, the readiness prerequisites discussed by the literature (Garg et al., 2022; Lind et al., 2024).

4.3.1.2 Observed results

In line with the review, CGM users in our sample reported significant clinical and behavioural improvements: 61.1% noticed improved glycaemic control, 67.5% indicated fewer hypoglycaemic episodes, and most stated increased engagement (agree/strongly agree ≈ 82%). The mechanisms were described qualitatively regarding the visibility of post-prandial excursions, nocturnal lows, and real-time feedback enabling dose, meal, and activity modifications. Some minorities stopped using or restored due to alarm burden or skin/adhesive problems, indicating the importance of coaching and device fit. These trends reflect trial and real-world evidence in the review: CGM lowers HbA1c and time-in-range and reduces hypoglycaemia when used by individuals who can act on the data or when the service can provide support in the interpretation, although benefits may be dampened by imposing an undue user burden without coordinated instruction (Migdal et al., 2020; Robbins et al., 2022).

4.3.1.3 Barriers and enablers

Our hierarchy of barriers - cost (38.9%) and awareness (28.1%), followed by limited availability, training gaps, insurance barriers, and technical barriers, nearly perfectly aligns with the economic/ infrastructural factors identified in the review. The structured difference in HCP education access between urban and rural areas in our findings assists in understanding adoption gradients: programmes are more regularly conducted by urban teams than in rural areas; opportunities are reported less, and uncertainty is mentioned more frequently in rural than urban areas. Interviews in Kerala highlighted stockouts in pharmacies, skimpy local support, and out-of-pocket burden; Irish interviews emphasised the time research took by staff on recruiting, training, and checking data, as well as uneven primary-care knowledge. The literature also emphasises affordability and supply chains on the one hand, and integration with e-health/workflows on the other as correlated requirements of sustained use (Sathish et al., 2020; Ruissen et al., 2023).

4.3.1.4 Policy and program strategies

There was a clear appetite in our sample to get a CGM programme government-subsidised: 81.8% were supportive of that. The biggest change levers were a mixture of access to financing (insurance, lower costs), access to capacity (provider training, patient education) and stable supply. This package reflects the system-level recommendations in this review: expanding coverage with the support of structured care pathways, interoperable data passing and ongoing education to transition CGM into a routine care practice. The review experience in Ireland is a useful purview of our Irish results-reimbursement and clinic operationalisation, which brought Type 1 use to the mainstream, and the fragmentation of policy barriers in India/Kerala augers well with our cost and availability considerations. In summary, our mixed-methods findings confirm the findings of the literature that equitable scale needs to be supported by aligned funding alongside human and logistical infrastructure (HIQA, 2023; Sia et al., 2021).

4.3.2 Novel Findings

This study contributes four areas of novelty that extend the review: (1) real-world evidence on non-internet CGMs; (2) cross-cultural contrasts between Kerala and Ireland; (3) training and education gaps mapped quantitatively and qualitatively; and (4) patient–provider communication differences by setting.

4.3.2.1 Non-internet CGMs: prevalence, uses, and limits

Previous literature identifies that offline/intermittently scanned CGMs can help navigate connectivity challenges, although rigorous adoption data has been complex. Our survey demonstrates that 57.1 per cent of practices use non-internet CGMs (widely/sometimes), 23.2 per cent do not use, and 19.7 per cent do not know (Q25). The predominant reasons expressed when not used were the lack of awareness, low availability, price, preference for internet-enabled devices, data-transfer/storage issues, and provider familiarity (Q25b). The transcripts elucidate why offline can be a solution although not a silver bullet: in Kerala, it does not compel its patients to rely on connectivity, but permits downloads in-clinic, however, resupply of sensors, stockouts at the pharmacy, and the ability to process and interpret results are limiting factors; in Ireland, offline alternatives exist amidst substantial reimbursement of rtCGM, and attractiveness due to workflow convenience and policy issues drive patient preferences. The results contribute to a body of literature limited to discussing the feasibility of various options with little or no concrete or comparative prevalence and barrier data (Kesavadev et al., 2021; HIQA, 2023).

4.3.2.2 Cross-cultural comparison (Kerala Vs Ireland): structurally different bottlenecks.

An innovative point of departure is the close matching of survey trends and means of action on the transcript level. In Kerala, the most central deterrent is the economic aspect (out-of-pocket sensors), which is strengthened by the supply aspect (not commonly stocked), the language barrier (not localised materials), and the stigma/visibility determinant-based adoption, which is intermittent and reliant on the case. In Ireland, coverage and distribution normalise use, moving bottlenecks to human capacity: onboarding time, alarm/data fatigue in a subgroup and knowledge gap in primary care. This transnational trend explains why effectively similar positive attitudes in the survey (e.g., 83.2% of them believe CGMs can be more effective) are not reflected equally in routine practice in various regions.

4.3.2.3 Evaluations of education/training gaps, quantified and qualified

We offer a two-pronged approach to training. Quantitatively, access to education is more urban-oriented (Q30 x setting: chi-square significant), and 42.9 per cent of HCPs were educated in the last year, but 30.5 per cent never trained (Q31). Kerala interviews report little formal CME, little Malayalam material, and low confidence interpreting AGP/TIR outside a specialist setting. The structure report shows that Irish clinicians report structured education in specialist centres, but inconsistent GP knowledge, which forms a bottleneck as CGM scales up to insulin-treated T2D. What is novel is that the desired capabilities are specified regarding where they are lacking: interpretation skills and localised patient materials in Kerala, primary-care upskilling and protected review time in Ireland. These translated abstract training needs into actionable or executable curricula, workforce planning objectives, and goals.

4.3.2.4 Patient–provider communication and perceptions by setting

Our data demonstrate that CGM-related conversation during the visits is relatively high (Q20: 67%), yet the quality of the conversation also varies depending on the setting. In urban services in Ireland, structured data conversations are described as data being brought by the patient in the form of the app summary, time-in-range being reviewed by clinicians and alarms being customised to minimise fatigue. In Kerala, where the number of CGM users is relatively low, the visit conversation may be episodic and problem-based (such as unexplained highs/lows), with in-house downloads (of offline devices) as a replacement for continuous sharing. These context-dependent communication ecologies contribute to understanding engagement scores (the majority report feeling more engaged due to CGMs) and why some disengage: the lack of specific alarms and guidance may lead to alert anxiety or adherence complications, and hence stop the use. The new twist is the association of engagement with the operational practices (personalisation, review cadence) and not just features of the device.

4.3.2.5 Integrative implications

The findings suggest that the CGM scale-up problem is more of a bundle issue than a single-lever solution. In the weak financing and distribution case (Kerala), non-internet CGMs are shown to improve feasibility. Still, they cannot resolve cost and capacity issues without engaging subsidies, pharmacy-level stocking, and local training/education. In a strong coverage area (Ireland), the barrier to growth is human infrastructure - competency standards, primary care upskilling, protected time and interoperable data flows to maintain conversation in the visit. Finally, the quantitative policy appetite (81.8% support subsidy) and preference in bundled strategies (Q34 combinations) support a system-oriented action: finance + capability + supply + awareness, with tuning in urban/rural and country settings. This proportionality of the investment in what must be funded (devices and sensors) and what needs to be created (people, materials, and processes) is the main contribution of the study to the debate concerning diffusion (Kesavadev et al., 2021; HIQA, 2023).

4.4 Conclusion

This mixed-methods study helps to understand where CGMs bring value and in what circumstances they unlock the value across Kerala and Ireland. Quantitatively, high perceived usability and effectiveness were reported, observable improvements in glycaemic control were observed, hypoglycaemic events were reduced, and engagement was increased. However, adoption is heterogeneous, with urban environments reporting more frequent users and regular access to education. In contrast, the numerous rural environments report a lack of access to education and training. The most often experienced barriers are cost, awareness, and supply, which are usually accompanied by training and workflow barriers.

The patterns can be described qualitatively. e.Evidence in Kerala CGMs is ad hoc and exists out-of-cost, with stockouts and a dearth of interpreters; non-internet CGMs alleviate connectivity problems but do not address barriers or shortages. In Ireland, coverage/ distribution normalises use, at the expense of human capacity (onboarding time, alarm/setting configuration, primary-care familiarity) and data workflow. In both contexts, engagement is less affected by the device than by coaching, personalised alarms, and regular data discussions during the clinic.

Two cross-cutting conclusions are drawn. Second, surviving is not about one lever, but about bundling: financing/affordability, education/training of clinicians and patients, and reliable supply/IT integration. Second, strategies should be site-tailored: subsidies, drugstore stocking and local-language text in Kerala; the capacity of the workforce, upskilling of primary care and interoperability in Ireland. These lessons inform the suggestions in Chapter 5, which centre around strategic funding and human and logistical capacity to turn goodwill toward CGMs into long-term, equitable use.

5. Conclusions and Recommendations

5.1 Summary of Main Findings and Implications

- **Objective 1 (Perceptions & usability):** Respondents consider CGMs more effective than finger-prick (approximately 83 per cent more effective) and tend to gauge their usability as easy for patients; there is high confidence in explaining the devices by clinicians, strong potential attitudinal support to scale use in routine care.

- **Objective 2 (perceived effect):** Reported associations were improved glycaemic control (6125 Y), reduced number of hypos (6812 slight/significant) and patient engagement. Implication, clinical and behavioural value are worth the investment and workflow integration.

- **Objective 3 (Adoption & barriers):** Adoption is widespread (70%), but usage in patients is mixed, with urban sites reporting a significantly higher percentage using >50 %; also, differences in setting are significant. Implication: Focus on rural catch-up activities and field-based empowerment.

- **Cost pressure (Obj. 4):** Cost pressure is the most comprehensive barrier (≈63% "yes"), followed by awareness and availability. Implication: The key to scale is financing and procurement reforms.

- **Access & supply (Obj. 4):** Accessibility varies (mostly reported as occasional/rarely); education programmes on HCP are accessible more often in urban places. Implication: focus on supply chains and training distribution rather than the cost of the devices.

- **Education (Obj. 4):** 42.9 per cent had training in the past 12 months, 30 per cent had never trained; there is a significant urban-rural disparity in the availability of the programme. Implication: Established pathways of fair access to training are needed, particularly in primary care.

- **Non-internet CGMs (Ob. 5 indicator signal):** approximately 57 per cent of practices (broadly/frequently); non-use reasons encompass awareness, accessibility, expense, and preferences. Implication: Use of offline/ flash can increase reach when clinic download procedures and education accompany it.

- **Policy appetite (Obj. 5):** 81.8 per cent would approve a government-subsidised programme; the preferred levers cluster (lower cost + insurance + training + patient education + availability + awareness). Implication: Single levers are less favoured than bundled, system-level policy packages.
- **Kerala vs Ireland (cross-objective differentiation):**
    - *Kerala:* Adoption is sporadic and constrained by out-of-pocket costs, variable supply, and limited interpretation capacity; offline devices help with connectivity gaps, not affordability or training.
    - *Ireland:* Coverage and pharmacy distribution normalise use; bottlenecks shift to human capacity (onboarding time, alarm/data burden, uneven GP familiarity) and data workflows.
- **Urban vs rural (cross-objective differentiation):** Urban clinics observe more frequent use of patients and access to education; rural clinics more often reflecting the response of none and less programmes. Implication: This implies that the focus on the rural strategies should be subsidised access, reliable stocking, and training on outreach concept.
- **Practice and policy implications:** Scale necessitates a package: financing (subsidies/coverage and price controls), human capability (HCP training and patient education), and stable infrastructure (supply chains, clinic download/IT workflows and alarm-tuning protocols).
- **Digital health adoption:** Initial uptake is less based on hardware and more based on coaching, personalisation and routine data review in clinic; safeguard time to review CGM data and integrate into existing care practices.

5.2 Differences Between Findings and Literature

- Alignment-effectiveness: Our findings are consistent with that of previous studies, presenting that CGMs helped improve glycaemic control, limit hypoglycaemia, and increase engagement, these effects are supported by both the findings and the selected respondents who all stated that CGMs had high perceived effectiveness.

- Alignment-adoption drivers- As anticipated, reimbursement, organised services, and specialist pathways were found to be drivers of adoption (as applied in Ireland), whereas out-of-pocket financing and fragmented service delivery were found to be inhibitors of adaptation (as is the case in Kerala).
- Alignment-human factors Symptom Prometheus resulted from alarm fatigue, information overload, and the need to be customised to meet the education demands; clinician training remains a prerequisite to sustained use.
- Originality-non-internet CGMs: We describe the prevalence and reason codes of off/flash use in different settings, an aspect under-explained in previous research. Offline equipment assists feasibility, but cannot bridge cost/supply or interpretation gaps on its own
- Novelty- urban-rural analytics- The urban-rural disparities with statistically notable patterns in adoption and access to education are new to the literature because this paper places them in quantifiable figures and contextualises them based on the site and the programme availability.
- Novelty- training distribution: we plot who and when and where limits in training are thick (30.5 never trained; urban disparities in programme frequencies), turn generic training needs into empirical work force planning.
- Novelty-communication ecology: We disentangle differences in engagement to practices (use of personalised alarms, collaborative review of TIR, clinic download rituals) instead of device type- we explain why similar attitudes translate into unequal everyday usage.
- Divergence--barrier hierarchy description: What our data showed is that there is widespread acceptance that cost and awareness are barriers however, our data suggest that co-occurrence of barriers (cost + availability + training + insurance + technical issues) are important to consider and therefore a single lever solution would be ineffective.
- Divergence--Kerala experiences on the ground: The burden of recurring sensor fees, medicinal pharmaceutical stockouts and a lack of local support seems heavier than implied in some previous reports; without subsidies and guaranteed supplies, offline solutions are too limited to reach.

- Gaps fulfilled-policy appetite and bundle choice policy quantitative endorsement (81.8) of government subsidy and multi-lever strategies frequently chosen supporting the call to practice in the literature on both design in policy packages.
- Capacity of primary care dealt with- Intellectual diversity in Ireland, and limited created CME in Kerala offers evidence of the disproportionate familiarity of GPs in one jurisdiction and the limited institutional access to CME in the other jurisdiction presents evidence of the particular point of training investment in both contexts.

5.3 Practical and Academic Recommendation

Practical recommendations

- **Policy changes (financial/procurement):** Implementation of subsidies or insurance inception at different tiers prioritising insulin-treated populations, recurrent hypoglycaemics, pregnancy, or T2D with high risk of complications; use of price controls on sensors and centralised procurement to reduce recurrent expenditure; listing CGMs/sensors as essential and stabilise supply. Tie the use of structured education to assure safe, effective use.
- **Training programmes for healthcare providers:** Develop a curriculum based on competencies in primary care and specialist teams (AGP / TIR interpretation, alarm-tuning, device troubleshooting, shared decision-making). Provide modular CME (introductory, intermediate, and advanced), simulation cases and certification. Not negatively affecting clinic time by allocating time to review the CGM data and assigning specific roles (e.g., diabetes tech nurses/educators) to support it in the long term.
- **Patient education and awareness**: Provide local language materials (quick-start, alarm guides, What to do action plans) and small group education during diagnosis and/or therapy changes. Engage the community through camps, pharmacies, and primary care to reduce stigma and make wearable tech a standard practice. Add goal-setting and touchpoints to sustain activity.
- **Rural access & offline paths:** Scale non-internet/flash CGMs to low-connectivity areas with clinical downloading stations, loaner readers, and regularly scheduled reviews. Combined with SMS and phone reminders and rudimentary paper or app-based journals. Ensure that medication is stocked in the

pharmacies outside cities and that there is a minimum technical support footprint (adhesives, replacements).

- **Workflow & data integration**: Standardise template-driven personalisation of alarms; embed CGM evaluation into diabetes visit experience; adopt upload/report-compatible tools that interoperate with current records; monitor time-in-range, and action follow-up.

Academic recommendations

- Explore behavioural impacts of CGM in LMICs (long-term engagement, alarm fatigue profile, adherence to coaching).
- Carry out comparative research in more LMIC-HIC pairs to generalise context effects on diffusion.
- Exploit mixed-methods/implementation science designs to test policy/training/technology packages; compare cost-effectiveness across different subsidy and procurement settings.
- Explore increased use and support of primary care upskilling through modular CME, tele-mentoring, and community-based support (e.g., health workers) to ensure high scalability and equity.
- Evaluate download-based workflows and assess their clinical impact and feasibility in rural clinics through CGM strategies that are applied offline.

5.4 Limitations and Contributions of the Research

Limitations

First, patients are not in the sample; although broad and multi-role, it may not represent patient variants, reducing the generalisability. Second, the survey is based on self-reported perceptions, which are prone to recall and desirability effects; perceived benefits can be tempered by neighbourly exuberance or exposure to the program. Third, geography is limited to Kerala and Ireland: with an inter-regional contrast being revealing, inferences beyond India (all states) or Europe (all systems) must be circumspect. Fourth, the proportion of the most digitally left out rural practitioners might be under-represented, where the infrastructure constraints are also most severe because of the area of the internet-based data collection. Conclusively, the multi-nature of the mode on multiple items leads to sparse matrices, which limit the aspect of inferential testing; chi-square statistics are not always interpretable, thus there is a need to depend on descriptive patterns.

Contributions

Nevertheless, the study has made several contributions despite such limitations. It provides the first comparative account of CGM perceptions and practices in Kerala and Ireland and displays how financing, supply and training patterns influence diffusion. It gives a quantitative breadth (perceptions, adoption, barriers, policy appetite) combined with a qualitative depth (mechanisms of engagement, usability frictions, workflows), resulting in actionable insights which can be used to design services. It presents empirical data on non-Internet CGMs and answers the questions of their prevalence, rationales of usage/against usage, and operational needs in an area where data are scarce. It measures urban-rural gaps in adoption and receiving education and identifies the training bottlenecks (never-trained proportion; urban superiority in regular programmes), understanding where to focus efforts supporting workforce investments. Lastly, it uses stakeholder preferences to make system-level recommendations suitable for resource-diverse contexts, such as bundled financing, capacity building, and supply/IT integration.

5.5 Suggestions for Future Research

They should be extended both in scope and in depth. First, it is necessary to perform larger, multi-stakeholder studies incorporating patient voices, caregiver perspectives and primary care team opinions to triangulate professional views with the lived experience and results. Second, ensure that longitudinal cohorts are designed to follow CGM adoption, engagement and clinical impacts over time, including transitions (such as escalation of therapy during pregnancy, ageing) and durability of improvements. Third, ensure cross-cultural comparisons to other regions (e.g. in Canada), with differences in financing and infrastructure, that can allow meta-inferences about policy and service patterns.

Fourth, rigorously test non-Internet/flash CGM pathways as scalable rural or low-connectivity solutions: clinic-download, loaner readers, stocking, education bundle and clinical outcomes, adherence and cost measure. Fifth, use implementation frameworks to test the application of bundled interventions that couple subsidies/coverage, provider training, patient education, and data-workflow integration; incorporate hybrid effectiveness-implementation endpoints (e.g., time-in-range and adherence to review protocols). Sixth, analyse primary care upskilling frameworks (tele-mentoring, micro-credentialing), community health worker engagement, and reach and equity. Lastly, explore behavioural and psychosocial factors - alarm-tuning approaches, data-fatigue reduction methods and personalised coaching to find minimal viable supports maximising sustained, confident use in urban and low-density areas.

Taken together, the studies would take the field beyond describing key challenges and insights into a set of tested playbooks to integrate CGM equitably into care workflows, financing, training, and supplies in ways that didn't sacrifice clinical and behavioural benefits the technology offers.

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Appendices

Appendix A- Online Survey (Google Form)

Perceptions and Impact of Wearable Glucose Monitors in Urban and Rural Diabetes Management in Kerala and Ireland

My name is Anjaly Joy, and I am a Master's student at Griffith College Dublin, currently studying Medical Device Technology and Business. As part of my academic research, I am conducting this survey to explore Perceptions and Impact of Wearable Glucose Monitors in Urban and Rural Diabetes Management in Kerala and Ireland specifically focusing on Physician, Diabetes educator, Nurse, Pharmacist.

Your participation is entirely voluntary and anonymous. The survey will take approximately 5–10minutes to complete. All information collected will be kept confidential and used solely for academic purposes

I understand that my participation is voluntary and anonymous, and I can skip any question or withdraw at any time *

- ◯ Yes
- ◯ No

What is your gender? *

- ◯ male
- ◯ Female
- ◯ Prefer not to say
- ◯ Non-binary / Third gender

Which country do you primarily practice in? *

- India (Kerala)
- Ireland
- Other: ____________________

Is English your first language? *

- Yes
- No

Appendix C- Ethics Package

Ethics Application & Declaration Form

DISSERTATION TITLE: Perceptions and Impact of Wearable Glucose Monitors in Urban and Rural Diabetes Management in Kerala and Ireland

RESEARCHER’S NAME: Anjaly Joy

PROGRAMME OF STUDY: MSc in Medical Device Technology & Business

SUPERVISOR'S NAME: Celine Coffey

DECLARATION:

The information in this application form is accurate to the best of my knowledge. I undertake to abide by the principles outlined by Innopharma/Griffith College ethics policy in my research dissertation. I confirm that I have completed a full ethics assessment for my research dissertation as per the college guidelines. I will not begin my primary research until such approval from my supervisor and/or ethics Committee has been obtained.

I pledge to carry out my research according to the Innopharma/Griffith College academic integrity standards. Any results presented in my dissertation will be from my own, original research, I will reference and/or acknowledge any material or sources used in its preparation and I will not plagiarise the work of anyone else.

For Student:

STUDENT SIGNATURE:

DATE: 06/07/2025

The research contained within this research dissertation proposal has been approved.

For Supervisor:

Ethics Committee Approval Required: Yes ☐ No ☑

SUPERVISOR SIGNATURE: Celine Coffey

DATE: 06/07/2025

For Ethics Committee (if required):

Ethics Committee Approval Given: Yes ☐ No ☐

ETHICS COMMITTEE MEMBER SIGNATURE:

DATE: 06/07/2025

NOTE: Supervisors are responsible for ensuring their students fill in this form correctly and that all ethical areas have been considered.

SECTION 1: DESCRIPTION OF RESEARCH STUDY

1.1 Purpose and objectives of research

The purpose of this research is to investigate and compare the perceptions, adoption rates, and perceived impacts of wearable glucose monitors (continuous glucose monitoring devices, or CGMs) among healthcare professionals in urban and rural diabetes management settings in both Kerala and Ireland. The study aims to identify the key barriers and facilitators to the implementation and sustained use of CGMs in these diverse healthcare environments. By understanding the factors influencing the uptake and effectiveness of wearable glucose monitors, the research seeks to results and recommendations that can improve diabetes management strategies and promote better health outcomes for people with diabetes in Kerala and Ireland.

The objectives of the research are as follows:

• To assess perceptions of the effectiveness and usability of wearable glucose monitors in diabetes management across urban and rural healthcare settings in Kerala and Ireland.

• To evaluate the observed impact of wearable glucose monitors on patient glycaemic control and self-management, as reported by healthcare providers in Kerala and Ireland.

• To compare the adoption rates, usage patterns, and perceived barriers to wearable glucose monitor use among healthcare professionals in urban versus rural diabetes care environments in Kerala and Ireland

• To identify infrastructural, economic, and educational factors influencing the implementation and sustained use of wearable glucose monitoring devices from the perspective of clinicians and diabetes educators in Kerala and Ireland

• To gather recommendations for improving the integration and accessibility of wearable glucose monitors in diabetes management programmes throughout Kerala and Ireland

1.2 Research methodology:

This research will use a mixed-methods approach to collect primary data, integrating both quantitative and qualitative strategies in alignment with a pragmatic philosophical stance. Quantitative data will be gathered through a structured survey consisting of 25 close-ended questions targeting registered medical professionals actively involved in diabetes care—such as endocrinologists, diabetologists, general practitioners, and diabetes nurse educators—in Kerala and Ireland. The survey, administered via Google Forms for accessibility, will explore participants' knowledge, perceptions, adoption patterns, perceived barriers, and recommendations regarding wearable glucose monitors. Purposive sampling will ensure the inclusion of professionals with direct experience managing glucose monitoring, while snowball sampling will expand reach by encouraging participants to refer colleagues.

For the qualitative component, two in-depth interviews will be conducted online using Zoom. One interview will be with a clinician from Kerala who primarily manages patients with traditional glucose monitoring, while the second will be with an Irish healthcare provider experienced with CGM technology. Each interview, lasting approximately 35–40 minutes, will follow a semi-structured guide of 10 open-ended questions to get detailed perspectives on device effectiveness, usability, barriers, and integration.

All participants will provide informed consent, and data will be stored securely to ensure confidentiality. Ethical approval will be obtained prior to data collection. This allows for the triangulation of findings, thereby understanding the factors associated with the research topic.

SECTION 2: POSSIBLE ETHICAL ISSUES

Answer 'yes' or 'no' to the following questions.

SUBJECT MATTER

Does the research proposal involve:

Research into specific company activities that would be deemed sensitive or confidential

No

Research into politically and/or racially/ethnically and/or commercially sensitive areas

No

Sensitive, personal, professional or corporate issues

No

RESEARCH PROCEDURES

Does the research proposal involve:

Research that might damage the reputation of companies or participants

No

Research that may negatively affect the reputation of Griffith College/Innopharma

No

Use of personal records without consent

No

Use of company data without consent
No
The offer of any inducements to participate
No
Audio or visual recording without consent
No
Using a language other than English
No

PARTICIPANTS

Does the research proposal involve:

People who are not competent and/or fluent in English
No
Does your research group include any of the following vulnerable groups
No

(Adults with psychological impairments; Adults with learning difficulties; Adults under the protection/control /influence of others (e.g. in care/prison); Relatives of ill people (e.g. parents of sick children); Hospital or GP participants recruited in a medical facility; persons under the age of 18)

If you have answered NO to ALL questions, please go straight to Section 4.

If you have answered YES to ANY question in SECTION 2, you must fill in SECTION 3.

SECTION 3: STEPS TAKEN TO AVOID ETHICAL ISSUES

[Only fill in this section if you answered YES to ANY of the questions in Section 3. For example, if you answered yes to including participants who are not fluent in English, you might put forward a plan that offers your survey in two languages to take this into account. Another example could be a study where the researcher wants to include information about the care received by children with a long-term condition but it would not be ethical to approach the children directly but it might be acceptable to instead ask parents questions about their child's care. If these plans are acceptable to your supervisor, you may not need to apply for ethical approval from the Ethics Committee].

3.1. If your ethics relates to ***Subject Matter***, outline your action plan to work around any sensitive issues.
3.2. If your ethics relates to ***Research Procedures***, outline your action plan to deal with possible ethical issues in your research procedures.
3.3. If your ethics relates to ***Participants***, outline how you will protect vulnerable persons or those that do not have English as their first language.

SECTION 4: ABOUT YOUR PARTICIPANTS

4.1. Outline your participant profile and why you have chosen them for this study

The participants for this study will be registered medical professionals who are actively engaged in diabetes care within Kerala (India) and Ireland. This includes endocrinologists, diabetologists, general practitioners, and diabetes nurse educators. All participants will have a minimum of one year's experience in managing patients with diabetes and direct experience in recommending or overseeing glucose monitoring methods, whether through traditional finger-prick testing or continuous glucose monitoring (CGM) devices.

These professionals are directly involved in diabetes management and thus have firsthand knowledge of the practical challenges and opportunities associated with integrating wearable glucose monitors into routine care.

By including participants from both urban and rural settings in Kerala, as well as from Ireland, the study can compare perspectives and practices across diverse healthcare environments—where CGM adoption and access vary significantly.

Healthcare providers such as endocrinologists and diabetes educators play a critical role in patient education, device recommendation, and the ongoing evaluation of diabetes management technologies. Their views on the effectiveness, usability, and barriers to CGM implementation are essential for understanding real-world adoption and for formulating actionable recommendations.

Selecting these professionals ensures that the research gathers in-depth, relevant, and actionable insights from those most equipped to comment on current practices and the potential for future integration of wearable glucose monitors in diabetes care.

4.2 How do you plan to gain access to/contact/approach your participant(s).

To recruit suitable participants for this study, a purposive sampling strategy will be employed, targeting medical professionals actively involved in diabetes care in Kerala and Ireland. Potential participants will be identified primarily through professional networks such as LinkedIn, using the platform's search features to locate endocrinologists, diabetologists, general practitioners, and diabetes nurse educators who meet the study's inclusion criteria.

Once potential participants are identified, they will be contacted directly through professional messaging on LinkedIn or via institutional email addresses where available. The initial contact will include a brief introduction to the researcher, an overview of the study's purpose, and an invitation to participate in either the survey or interview component, depending on their experience and willingness. The Participant Information Leaflet (PIL) will be attached, outlining the study's objectives, data confidentiality, voluntary participation, and the right to withdraw at any time.

To expand the pool, snowball sampling will also be utilised: initial participants will be asked to refer eligible colleagues within their networks who may also be interested in participating. This approach is particularly valuable in reaching professionals in rural or less accessible settings.

All communications will be conducted respectfully and ethically, ensuring that no personal or sensitive data is shared without explicit consent. Ethical approval will be obtained prior to commencing participant recruitment, and all participants will be asked to provide informed consent before taking part in the study.

SECTION 5: INFORMATION, CONSENT AND CONFIDENTIALITY

5.1 Participant Information Letter (PIL) for participants

Please confirm below that your information letter covers:
Description of the research topic and method
Yes
Details of what participation will involve
Yes
Rights to anonymity Yes
Confidentiality Yes
Rights to withdraw from the research
Yes
The contact details of the researcher and supervisor (if necessary)
Yes

5.2 Informed Consent Form (ICF) for participants

Please indicate below if your research requires a signed consent form by selecting the relevant option only:

Yes: My research requires signed consent, and I have attached an ICF in the appendices of my application.

SECTION 6: STORAGE OF DATA

[Please ensure that you are abiding by GDPR and the national Data protection laws https://www.hrb.ie/funding/gdpr-guidance-for-researchers/gdpr-and-health-research/).

*The student is responsible for storage of data and this will be handed over to the college in an electronic format as part of the thesis submission i.e. primary data and completed ICFs where applicable will be added to the primary data folder on moodle. The rationale is to keep data **as long as it is still useful** and there is an intention to use it further **for research** so if this is not the case then this can be stipulated here and a shorter retention period given.]*

6.1. How will you store the research data and for how long? How will you manage data protection issues?

The research data collected for this study—including survey responses and interview transcripts—will be stored in a secure, password-protected One Drive accessible only to the principal researcher and the supervisor. No personal identifiers or sensitive information (such as names, email addresses, or IP addresses) will be collected or linked to the data, ensuring participant anonymity at all stages.

Survey data collected via Google Forms will be regularly exported and backed up to this secure drive. Interview audio files will be transcribed, and both the recordings and transcripts will be stored in encrypted folders. Only anonymised, coded data will be used during analysis and in any dissemination of research findings.

In line with ethical guidelines, all data will be retained for a period of six months following the completion of the study. After this period, all digital files—including raw data, transcripts, and backups—will be permanently deleted.

To manage data protection issues, participants will be fully informed about how their data will be used, stored, and deleted through the Participant Information Leaflet and informed consent process. The data will be retained for one year since completion of research.

SECTION 7: NON-DISCLOSURE AGREEMENT & STUDENT CONSENT

7.1 **Non-Disclosure Agreement (NDA)**
Will the final dissertation contain any information pertaining to any source what would warrant the use of a Non-Disclosure Agreement (NDA) e.g. industry-based research?

No

7.2 **Student consent**
If a Non-Disclosure Agreement (NDA) is not required, does the student consent to allow their completed dissertation to be held/published by Innopharma/Griffith College?

Yes

SECTION 8: RECORDING AND RETENTION OF DISSERTATION VIVA

8.1 **Viva Recording**
The Dissertation viva will be recorded. This recording may be used to facilitate assessment by Innopharma staff, a third reader if necessary and/or if requested by the external examiner for the Programme. The recording will be held in line with current GDPR guidelines and will not be made publicly available.

SECTION 9: DOCUMENT CHECKLIST

NOTE: Applicants must attach the following documents in electronic format to the appendix.

Which documents are added to the appendix? Please tick N/A if not applicable:

9.1 Participant Information Letter (PIL) for participant

Yes

9.2 Informed Consent Form (ICF) for participant

Yes

9.3 Questions/survey for interviewees/focus groups etc *(can be in draft form)*

Yes

9.4 Any other documents e.g. Non-Disclosure Agreement

N/A

I confirm that this application is complete and all required documents are included in the appendix.

For Student:

STUDENT SIGNATURE:

DATE: 27/06/2025

SECTION 10: APPENDIX

Survey Questionnaire

1. **I understand that my participation is voluntary and anonymous, and I can skip any question or withdraw at any time**
   ☐ Yes
   ☐ No
2. **What is your gender?**
   ☐ Male
   ☐ Female
   ☐ Non-binary / Third gender
   ☐ Prefer not to say
3. **Which country do you primarily practice in?**
   ☐ India (Kerala)
   ☐ Ireland
   ☐ Other (please specify): ____________________
4. **Is English your first language?**
   ☐ Yes
   ☐ No
5. **Are you fluent in English?**
   ☐ Yes
   ☐ No
   ☐ Somewhat
6. **What is your primary practice setting?**
   ☐ Urban
   ☐ Rural
7. **What is your professional role?**
   ☐ Physician
   ☐ Diabetes educator
   ☐ Nurse
   ☐ Pharmacist
   ☐ Other (please specify): ________________
8. **How familiar are you with wearable/continuous glucose monitors (CGMs)?**
   ☐ Very familiar
   ☐ Somewhat familiar
   ☐ Slightly familiar
   ☐ Not familiar at all

9. **Are you currently utilising continuous glucose monitors (CGMs) in your present clinical role?**
☐ Yes
☐ No

If "Yes":

Q8a. For how many years have you been using CGMs in your current role?
☐ Less than 1 year
☐ 1–3 years
☐ 4–6 years
☐ More than 6 years

If "No":

Q8b. Have you utilised CGMs in any of your previous clinical roles?
☐ Yes, I have used CGMs in a previous role
☐ No, I have never used CGMs in any clinical role

10. **Does your centre currently use CGMs?**
☐ Yes
☐ No
☐ Not sure

11. **Have you ever personally used or recommended CGMs in your practice?**
☐ Yes
☐ No

9a. If you have never used or recommended CGMs, what is your perception of these devices?
☐ Very positive
☐ Somewhat positive
☐ Neutral
☐ Somewhat negative
☐ Very negative

12. **How effective do you believe CGMs are for diabetes management compared to traditional finger-prick testing?**
☐ Much more effective
☐ Somewhat more effective
☐ About the same
☐ Less effective
☐ Not sure

13. **In your opinion, how easy are CGMs for patients to use?**
☐ Very easy
☐ Somewhat easy
☐ Somewhat difficult

☐ Very difficult

☐ Not sure

14. **Do CGMs require significant time or resources from your center or staff?**

☐ Yes, significant

☐ Somewhat

☐ Not much

☐ Not at all

☐ Not sure

15. **Is the process of implementing or using CGMs time-consuming in your setting?**

☐ Very time-consuming

☐ Somewhat time-consuming

☐ Not very time-consuming

☐ Not at all time-consuming

☐ Not sure

16. **How confident are you in explaining the use of CGMs to patients?**

☐ Very confident

☐ Somewhat confident

☐ Not very confident

☐ Not at all confident

17. **Which of the following do you think are advantages of CGMs? (Select all that apply)**

☐ Real-time glucose data

☐ Fewer finger pricks

☐ Better glycaemic control

☐ Alerts for high/low sugar

☐ Data sharing with providers

☐ None of the above

☐ Others

☐ Unsure

18. **In your experience, have patients using CGMs shown better glycaemic control than those using finger-prick tests?**

☐ Yes

☐ No

☐ Not sure

☐ Not applicable (have not seen CGM users)

19. **How would you rate the impact of CGMs on patients' ability to self-manage their diabetes?**

☐ Very positive

☐ Somewhat positive

☐ Neutral

☐ Somewhat negative
☐ Very negative

☐ Not Applicable *(have not seen CGM)

20. **Have you observed a reduction in hypoglycaemic events among patients using CGMs?**
☐ Yes, significant reduction
☐ Yes, slight reduction
☐ No change
☐ Not sure
☐ Not applicable (have not seen CGM)

21. **How often do patients talk about CGMs or discuss their CGM data with you during visits?**
☐ Always
☐ Often
☐ Sometimes
☐ Rarely
☐ Never

☐ Not Applicable *(have not seen CGM)

22. **Do you feel that CGMs increase patient engagement with their own diabetes care?**
☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

☐ Not Applicable *(have not seen CGM)

23. **Have you ever recommended a CGM to a patient?**
☐ Yes
☐ No

24. **Among your diabetes patients, what percentage currently use CGMs?**
☐ None
☐ Less than 10%
☐ 10–25%
☐ 26–50%
☐ More than 50%
☐ Not sure

25. **What is the main reason patients do NOT use CGMs in your setting? (Select one)**

☐ High cost
☐ Lack of awareness
☐ Limited availability
☐ Preference for traditional methods
☐ Not recommended by provider
☐ Other: _______________

26. **Are there CGM devices used in your practice that do NOT require internet connectivity for basic glucose monitoring?**
☐ Yes, widely used
☐ Yes, sometimes used
☐ No, not used
☐ Not sure

25.a. If CGMs that do not require internet are NOT used in your practice, what is the main reason? (Select all that apply)
☐ Lack of awareness about such devices
☐ Limited availability in your region
☐ Preference for internet-enabled CGMs
☐ Concerns about data transfer or storage
☐ Cost of non-internet CGMs
☐ Provider preference or familiarity
☐ Not applicable / No opinion
☐ Other (please specify): _______________

25 b. In your opinion, would increased access to non-internet CGMs improve patient uptake or adherence in your area?
☐ Yes
☐ No
☐ Not sure
☐ Please elaborate (optional): _______________

27. **What type of CGMs are most commonly used by your patients?**
☐ Real-time (continuous) CGM
☐ Flash/intermittent CGM
☐ Do not know
☐ Not applicable (no CGM users)

☐ Others, please specify _______

28. **Which of the following have you encountered as barriers to CGM use? (Select all that apply)**
☐ Device cost
☐ Lack of training
☐ Limited device availability
☐ Patient reluctance
☐ Insurance issues
☐ Technical difficulties
☐ Other: _______________

29. **Is the cost of CGMs a significant barrier for most of your patients?**
☐ Yes
☐ No
☐ Not sure

30. **How accessible are CGMs in your practice area?**
☐ Easily available
☐ Occasionally available
☐ Rarely available
☐ Not available at all

31. **Are there educational programmes on CGM use for healthcare professionals in your region?**
☐ Yes, regularly
☐ Yes, occasionally
☐ No
☐ Not sure

32. **Have you attended any education or training programme on the use of CGMs?**
☐ Yes, within the last year
☐ Yes, more than a year ago
☐ No, never attended
☐ Not sure

33. **How would you rate patient awareness of CGMs in your community?**
☐ Very high
☐ High
☐ Moderate
☐ Low
☐ Very low

34. **Which of the following factors most affect patient uptake of CGM in your area? (Select all that apply)**
☐ Device affordability
☐ Healthcare provider knowledge
☐ Patient education
☐ Infrastructure (supply/distribution)
☐ Cultural beliefs
☐ Digital literacy
☐ Insurance coverage

☐ Other (please specify): ______________

35. **Which strategies would most help increase CGM use in your setting? (Select all that apply)**

☐ Lower device costs
☐ Better insurance coverage
☐ More provider training
☐ Patient education programmes
☐ Improved device availability
☐ Community awareness campaigns

☐ Other (please specify): _____________

36. **Who should play the leading role in promoting CGM use?**
☐ Government health authorities
☐ Hospitals/clinics
☐ Device manufacturers
☐ Health insurance providers
☐ Patient advocacy groups
☐ All of the above

37. **Would you support a government-subsidised CGM programme for people with diabetes?**
☐ Strongly support
☐ Support
☐ Neutral
☐ Do not support
☐ Strongly do not support

☐ Unsure_____________

38. **Did you understand all the questions in this survey?**
☐ Yes
☐ No
☐ Somewhat

39. **Were the questions clear and easy to comprehend?**
☐ Yes
☐ No
☐ Somewhat

40. **If any question was unclear, please specify which one(s) or provide your feedback (optional):**

Interview Questions

1. To begin, can you describe the typical methods of blood glucose monitoring used in your practice, and how you perceive the role of continuous glucose monitors (CGMs) compared to traditional finger-prick testing in your setting?
2. For your setting (Kerala/Ireland), how would you assess the general usability and acceptability of CGMs for patients? What challenges or advantages do your patients experience with either method?
3. What is your level of experience with CGM devices (e.g., duration, frequency of use, types of devices used)?
4. Based on your clinical experience, what impact—positive or negative—have you observed CGMs (or traditional monitoring, if CGMs are not used) having on patients' glycaemic control and diabetes outcomes?
5. Do you see any benefits to patient outcomes from CGM use, such as increased confidence, improved compliance, greater disease ownership, or enhanced knowledge? Please elaborate with examples if possible.?
6. How do you see CGMs (or the current monitoring method) influencing patient engagement, motivation, and self-management of diabetes in your practice? Can you share specific examples?
7. How prevalent is the use of CGMs among your patients? What are the key trends or changes you have noticed over time in the adoption of wearable glucose monitoring devices in your region?
8. Are you aware of CGM devices that do not require internet connectivity for their basic functioning? If so, are these types of CGMs being used in your practice or region?
9. If non-internet-enabled CGMs are not being used, what do you think are the main reasons for their limited adoption (e.g., awareness, availability, patient/provider preference, or technical constraints)?
10. Do you believe that wider use of non-internet CGMs could help address barriers in rural or low-connectivity settings? Why or why not?
11. From your perspective, what are the main barriers—whether economic, cultural, educational, or infrastructural—to adopting CGMs in your community or healthcare system?
12. Have you or your patients faced any specific logistical, technical, or time-related challenges when using (or attempting to use) CGMs? How do these compare to challenges with traditional finger-prick monitoring?
13. How do you think local healthcare infrastructure and economic conditions (such as device availability, cost, and insurance) affect the implementation and sustained use of CGMs in your setting?
14. What is the current level of education and training for both healthcare providers and patients on the use of CGMs in your region? What gaps or strengths do you observe, and how do they influence patient care?

15. Finally, based on your experience, what recommendations would you make to policymakers or healthcare leaders to improve the adoption and integration of CGMs into diabetes management programmes in Kerala or Ireland? What lessons could each setting learn from the other?

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Participant Information Letter

Title: Perceptions and Impact of Wearable Glucose Monitors in Urban and Rural Diabetes Management: A Study in Kerala

I would like to invite you to take part in a research study. Before you decide, it is important that you understand why this research is being done and what your participation would involve. Please take time to read the following information carefully. If you have any questions or need more information, please ask. Take time to decide whether or not you wish to take part.

My name is Anjaly Joy, and I am a master's student at Griffith College completing this research as part of my Msc in Medical Device & Technology degree.
I am doing this study to better understand how healthcare professionals in Kerala and Ireland view and use wearable glucose monitors (such as continuous glucose monitoring devices) in diabetes management. The aim is to explore perceptions, usage patterns, and challenges so that recommendations can be made for better integration of this technology in both urban and rural diabetes care settings. This study will form part of my dissertation for my degree.

If you agree to take part, you will be requested to complete a short survey with close-ended questions about your experience with glucose monitoring devices. Some participants may also be requested to perform an online interview (via Zoom), which will last about 35–40 minutes. If you are requested to perform the interview, your answers will be audio-recorded (with your consent) so they can be transcribed and analysed later. Participation will not impact your job, schedule, or patient care.

You have been invited because you are a registered medical professional (such as an endocrinologist, diabetologist, general practitioner, or diabetes nurse educator) currently involved in diabetes care in Kerala or Ireland. Your experience and insights are valuable to understanding the use and challenges of wearable glucose monitoring in your setting.

Please note:

- Participation is completely voluntary.
- Choosing not to participate will have no negative consequences.
- You may skip any question or withdraw from the study at any time without giving a reason.
- If you wish to withdraw, please contact Anjaly Joy at anjaly.joy@student.griffith.ie

There are no significant risks expected from taking part in this study. Your answers will be confidential, and you will not be identified in any reports or publications. Some questions may touch on challenges in your practice, but you do not have to answer any question you find uncomfortable. The main benefit is that your participation may help improve the understanding and future integration of wearable glucose monitoring in diabetes care.

All information you provide will remain confidential and anonymous. Your name or identity will not be linked to your responses. Signed consent forms and audio recordings will be kept securely and will only be accessible to the researcher. Confidentiality may only be broken if there is a strong belief that you or someone else is at risk of serious harm, in line with legal and ethical guidelines. You can request access to your information at any time under freedom of information regulations.

Signed consent forms and original audio recordings will be retained in a secure, password-protected drive, accessible only to the researcher, until after my degree has been conferred. A transcript of interviews (with all identifying information removed) will be retained for a further two years after this. All other digital data will be permanently deleted after six months. Your information will not be shared with anyone outside of the research project.

The results of this research will be used for my dissertation as part of my degree programme at [Your Institution]. The dissertation may be made available in the college library or in an online repository. No identifying information will be published. Results may also be presented in academic settings, but only as anonymous, combined data.

If you have questions or would like more information, please contact:

Researcher Details

Name: Anjaly Joy

Phone: +353 89 435 9647

Mail: anjaly.joy@student.griffith.ie

Supervisor Details

Name: Celine Coffey

Mail: Celine.coffey@griffith.ie

Thank you very much for taking the time to consider this invitation.

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Consent to Take Part in Research

- I, [participant name] voluntarily agrees to participate in this research study.
- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.
- I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participation involves participating in an audio-recorded interview about my experiences with glucose monitoring devices in diabetes care.
- I understand that I will not benefit directly from participating in this research.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this research, my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.
- I agree to my interview being audio-recorded.
- I understand that disguised extracts from my interview may be quoted in dissertation, conference presentations, published papers, e-journals, library, etc.
- I understand that I will adhere to all codes of conduct and employee confidentiality for company XXX and there is no expectation to breach these by partaking in this research. A signed confidentiality statement between researcher and company may be included if necessary.
- I understand that if I inform the researcher that myself or someone else is at risk of harm, they may have to report this to the relevant authorities. The researcher will discuss this with me first but may be required to report with or without my permission.
- I understand that signed consent forms and original audio recordings will be retained in Griffith college authorised One Drive folder till one year after completion of research.

- I understand that a transcript of my interview in which all identifying information has been removed will be retained for one year from completion of research.
- I understand that under freedom of information legislation, I am entitled to access the information I have provided at any time while it is in storage as specified above.
- I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Researcher Details

- Name: Anjaly Joy
- Phone: +353 89 435 9647
- Mail: anjaly.joy@student.griffith.ie

Supervisor Details

- Name: Celine Coffey
- Mail: Celine.coffey@griffith.ie

Thank you very much for taking the time to consider this invitation.

Signatures

Signature of participant: ____

Full name (printed): ____

Date: ____________________

Signature of researcher: ____

I believe the participant is giving informed consent to participate in this study.

Date: ____________________