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A Literature Review for Intelligent Glucose Monitoring Systems for Geriatric Patients

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Abstract

When people get older some will have their insulin receptors non-responsive to the hormone leading to excess glucose levels in the blood circulation and the condition is called type 2 diabetes mellitus (DM). Individuals with type 2 DM get treatment that will reduce blood glucose level and in order to see whether or not the treatment is a success individual patient need a continuous glucose monitoring (CGM). This article is a literature survey that focuses on how to develop an intelligent glucose monitoring machine that works for geriatric patients both invasive and non-invasiveness ways. The authors focused on both developed and developing nations. It was found out that developed world geriatric patients use variety which involves an under-the-skin sensor for continuous blood sugar tracking. The sensor sends that glucose level wirelessly to an android device which then uses Wi-Fi 4G to share the glucose levels in database and health practitioners (Rghioui, A et al. 2020), whilst developing nations use blood glucose monitoring machines whereby the diabetic individuals uses a lancet to prick themselves and the blood glucose level is written down to show their health practitioner when they go for review the use of needle prick before and after every meal is painful and puts the patient at a risk of developing an infection at the pricked finger. There is a need therefore to come up with a non-invasiveness method which the authors will produce another paper later after this article.

Keywords
Type 2 Diabetes Mellitus, Developing Nations, Developed Nations, Insulin, Geriatric Patients

1. Introduction
Type 2 diabetes mellitus is a chronic health condition that requires lifelong management, and its prevalence increases with age. This condition is when an individual has excess blood sugar levels which is either due to unresponsiveness of fat, muscle and liver cells to insulin hormone.

Human pancreas makes insulin, a key that unlocks your cells to absorb energy from food (glucose). But in type 2 diabetes, the cells become stubborn and ignore the key, leaving glucose stuck in your bloodstream. At first, your pancreas tries harder, making more insulin, but eventually gets tired and quits producing enough.
(Kassel, 2023). Figure 1 shows how diabetes 2 occurs.

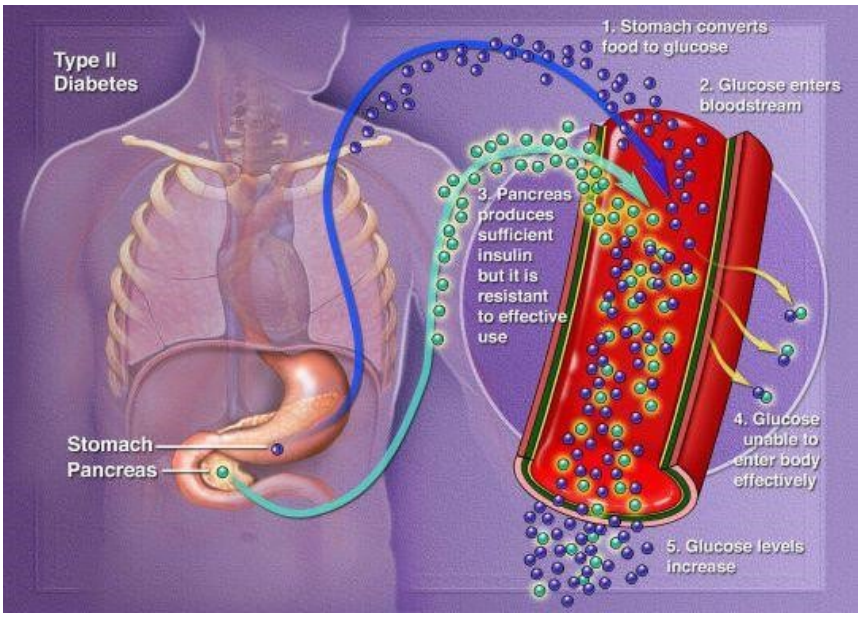

Figure 1. How diabetes 2 is caused

When blood sugar levels are left untreated, it affects many body organs such as the eyes, nerves, kidneys and blood vessels. its complications are peripheral neuropathy, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, bone and joint problems, infection of the gums (gingivitis) and tooth cavities as well as peripheral neuropathy caused by damaged nerves or poor blood circulation leading to skin infection and ulceration and the at the end a person can be amputated. This has become a concern to many scientists who then came up with ways to type 2 diabetes management. This includes the use of medication and continuous glucose monitoring using invasive, non-invasive, or semi-invasive method. The popular methods that are currently used is invasive that involves finger prick before and after meals and then test blood glucose levels. Keeping your blood sugar levels in check is crucial for everyone, not just people with diabetes. Monitoring your glycaemia values helps you understand how your body reacts to food, exercise, and medication, allowing you to make healthy choices and reach your desired blood sugar goals. There are different ways to track your blood sugar that are listed below:

- HbA1c: This blood test provides a 3-month snapshot of your average blood sugar levels. It offers a comprehensive look at how well you've been managing your glucose.
- SMBG: This involves using a finger prick glucometer to measure your blood sugar at specific times, like before and after meals. It's like taking snapshots of your glucose levels throughout the day.
- CGMS: This system uses a sensor placed under your skin to continuously monitor your blood sugar levels. It's like having a 24/7 detective watching your glucose, giving you a continuous stream of data.

1.2 Background to the study

Here explain what invasive and non-invasive all is about and show some pictures of geriatric patients putting references. Currently, pricking a finger and analyzing the blood sample (in vitro) remains the main way to measure blood sugar in both hospitals and home settings. It's familiar, convenient, and practical, especially in hospitals where precise measurements are required for diagnosing diabetes. This method utilizes automated analyzers to accurately measure blood sugar levels, often using morning samples from fasting patients. (American Diabetes Association standards of medical care in diabetes 2015) Traditional methods, which require finger pricking with a lancet to

draw blood samples, can be invasive and deter individuals due to needle phobia and financial constraints. Moreover, despite sterilization procedures, infections remain a potential concern, with documented cases occurring annually (S. Vaddiraju *et al.)* Low adherence to regular blood glucose monitoring is linked to several drawbacks, including its negative impact on quality of life. (W.M. Ong *et al.)*

Figure 2. Patient using glucometer that uses blood

Figure 2 above shows a patient with a glucometer that uses blood. This is invasive type of measuring blood glucose level. Non-invasive blood glucose monitoring makes it possible, allowing you to track your levels painlessly and conveniently. Instead of needles, light, microwaves, or even electrical signals become your allies in understanding your body's sugar balance. (Siddiqui S.A et al 2018) It turns out, sugar hangs out in more places than just your blood. Glucose isn't just found in blood. It also hangs out in other bodily fluids like saliva, tears, sweat, and even the watery environment that surrounds your cells (interstitial fluid). Exciting advancements aim to harness this by creating painless and convenient ways to monitor your glucose levels and automatically deliver medication, without the need for finger pricks. These cutting-edge technologies have the potential to transform diabetes management by offering: Painless monitoring: No more finger pricks! These systems can track your blood sugar levels continuously and painlessly, providing valuable insights without the discomfort.

An automated insulin delivery system that uses real-time glucose monitoring to provide stress-free blood sugar control. Closed-loop systems take the burden of constant monitoring and medication adjustments off your shoulders, offering greater peace of mind and improved control. Direct benefits for millions: With hundreds of millions living with diabetes globally, these advancements hold immense promise for improving the lives of countless individuals.

Benefits of the use are as follows:The development of non-invasive monitoring and closed-loop systems isn't just exciting research, it's a practical solution with tangible benefits for people with diabetes:

1. Improved blood sugar control: Continuous monitoring and automatic adjustments can lead to tighter control of blood sugar levels, reducing the risk of complications.
2. Enhanced quality of life: Ditching the finger pricks and constant calculations can free up time and energy, allowing people with diabetes to live more active and fulfilling lives.
3. Reduced healthcare costs: Improved control and fewer complications can potentially lead to significant cost savings for individuals and healthcare systems. (Takeuchi K and, Kim B 2018.) (Bollella P. et al 2019)

Figure 3 shows different methods used to measure blood sugar levels on geriatric patients. (BioRender.com)

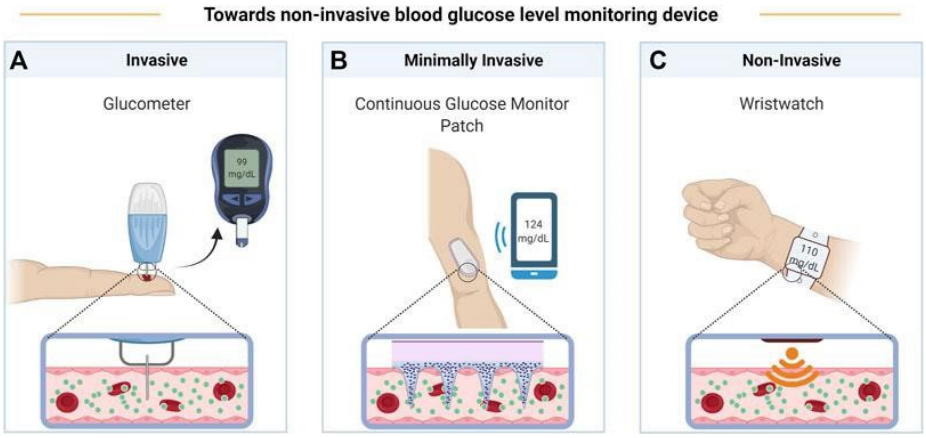

Figure 3. Steps moving from invasiveness, minimally invasive and non-invasive methods.

1.3 Problem Statement

Geriatric patients in developed and developing world are being checked their blood sugar level using invasive means and it is so painful and cumbersome which leads them to end up testing themselves once or a few times than they are expected to do.

1.4. Objectives

Have a clear record of what kind of invasive and non-invasive systems we have in the world to measure glucose levels for geriatric patients using literature. Currently the most popular glucose monitoring machine being used in the whole world is the invasive method, that uses blood from the lancet needle prick. The reading will be recorded on hard copy for use by physician to review whether the patient is responding to the medication being given. The other method is considered minimally invasive as it measures body fluid glucose level which can be correlated with blood sugar level. One of the examples is continuous glucose monitoring system where a small sensor is placed under the skin usually on arm. The sensor continuously senses blood sugar level and sends the results to a smart phone. This type of glucose monitoring alerts the individual when the blood sugar level becomes too low (hypoglycemia) or when it becomes too high (hyperglycemic). The other method is non-invasive whereby a wearable device is worn that might look like a watch. This device has sensors that measures interstitial glucose level without pricking the patient. The other method s when a patient has to touch a surface that the takes glucose level using the same method as wearable device.

2. Case Studies: Glucose Monitoring Systems for Older Adults with Type 2 Diabetes in Developed, Semi-Developed, and Developing Nations.

2.1 Developed based systems

The history of diabetes diagnosis began with testing urine for sugar way back in the 1800s. These early attempts, though seemingly crude, paved the way for the modern methods we use today. A key breakthrough came in 1908 when chemist Stanley Benedict developed a special chemical test that made detecting glucose in urine much easier and more reliable. This represented a pivotal shift in how diabetes is diagnosed and managed. This innovation offered a more reliable and practical method compared to previous techniques. Benedict's copper reagent, with some modifications, remained the gold standard for urine glucose testing for over five decades. This ground-breaking method had a profound impact on diagnosing and managing diabetes. It not only improved countless lives immediately but also sparked further advancements in blood glucose monitoring, paving the way for even better care in the future. (Clarke SF, Foster JR 2012). Back in 1965, Ames made history with the Dextrostix, the first-ever blood glucose test strip. This revolutionary invention, powered by glucose oxidase, opened a new chapter in diabetes management. While not intended for home use, it marked a significant step towards empowering individuals to take control of their health. Before 1970 it was quite difficult to monitor blood sugar level. By 1980, the Dextrometer brought the vision of blood sugar self-monitoring to life, offering a digital window into blood sugar with each Dextrostix. It wasn't perfect, but it was a major leap. Technological breakthroughs led to the development of cost-effective and less invasive glucose monitoring devices. This empowered individuals with type 1 diabetes to self-manage their condition more effectively. Alongside developments in A1C testing and insulin pumps, this progress laid the foundation for the pivotal Diabetes

Control and Complications Trial (N Engl J Med 1993). As time went by there was great improvement and less blood was being used.

Before CGM, managing diabetes felt like flying blind. Then, in 1999, a revolution took flight:
the first "professional" CGM. While patients couldn't see the data in real-time, it secretly tracked their glucose for 3 days, offering doctors a treasure trove of insights. But needing finger pricks for calibration felt like a step back. Enter the Glucowatch, a wristwatch wonder that measured glucose without needles. Sadly, skin irritation kept this dream machine from taking off. In 2004 the game changed again. Medtronic's Guardian Real-Time CGM sounded the alarm for dangerous highs and lows, giving patients unprecedented awareness. And two years later, they went even further, unleashing the world's first combo: an integrated pump and sensor. Meanwhile, Dexcom joined the real-time revolution with their STS in 2006. By 2008, Abbott hopped on board with the Freestyle Navigator. But back then, all these pioneers still relied on finger pricks for critical insulin decisions. Just two decades ago, diabetes management relied heavily on blind guesses and finger pricks. But CGM arrived, transforming the landscape. In 2015, Dexcom's G5 Mobile and later the G6 (2018) connected seamlessly to smartphones, putting real-time data at your fingertips.

2.1System based

A study that was conducted to determine the prevalence of DM in US has shown that the prevalence of the disease has increased amongst US population in the past decade and it also shows that black and Mexican Americans were more likely to have the disease compared to white Americans(Fang L et al 2023).In US they use blood from a lancet prick and put it on test strip that has been inserted on an electronic glucometer. This is done whenever the patient needs to check their blood glucose level for continuous monitoring. The lancet and test strip are used once and can be discarded after use. This causes a lot of discomfort, and the patient can also be pricked on arm or thigh (Figure 4).
Steps used to self-test blood sugar level:

a. Wash hands.
b. Dry hands with a clean cloth
c. Insert test strip in the electronic glucometer.
d. Use alcoholic swab to clean the finger that is going to be pricked.
e. Using a one-use lancet prick the finger and discard it in a sharp tin.
f. The blood is then applied on the test strip then wipe and hold the bleeding site with an alcohol swab.
g. The blood sugar level will be displayed on electronic glucometer.

Figure 4. Electronic glucometer used to test blood sugar level.

2.2 Japanese based system

Diabetes continues to be a rapidly growing health crisis, with millions of people currently affected. Projections indicate that by 2045, the number of individuals living with diabetes could reach a staggering 700 million. Luckily, a Japanese start-up has developed a game-changer: a needle-free blood sugar test, offering hope and relief to those managing this challenging condition. While both types share high blood sugar as a core feature, they diverge in their origins. Type 1, often striking children and young adults, stems from an immune attack on pancreatic cells, while type 2, usually seen in middle-aged individuals and beyond, arises from a complex interplay of genetics and lifestyle factors (Sawaji Osamu 2020). For many diabetes patients, the finger prick is a daily ritual, sometimes happening 4-5 times a day. The standard procedure begins with a minor puncture of the fingertip using a lancet. The resulting droplet of blood is then transferred to a test strip for analysis. The meter then works its magic, analyzing the blood and displaying your blood sugar level in a flash. While a single prick may seem like a minor inconvenience, the cumulative toll of thousands of pricks over months and years can take its toll. The pain, though often described as mild, can become

bothersome and even discourage some patients from monitoring their blood sugar as frequently as needed (Sawaji Osamu 2020).

In Japan they are eliminating the use of finger prick by using Light Touch Technology. Light Touch has developed a ground-breaking prototype sensor that measures blood sugar levels without drawing a single drop of blood. This revolutionary device uses advanced laser technology to analyses the sugar concentration in your interstitial fluid, a fluid found just beneath your skin. No more pricking, no more pain, just accurate and convenient blood sugar monitoring at your fingertips. Light Touch's sensor is the first non-invasive device to meet the stringent measurement precision standards set by the International Organization for Standardization (ISO). This means you can trust the readings, making informed decisions about your diabetes management with confidence (Sawaji Osamu 2020). While Light Touch's prototype is a significant breakthrough, the journey to bring this technology to market is still ongoing. Further research, clinical trials, and regulatory approvals are needed before the sensor becomes widely available. But with the dedication and expertise of the Light Touch team, and the growing enthusiasm of the diabetes community, it's only a matter of time before this innovative solution alleviates the pain and burden of diabetes management for millions around the world (Sawaji Osamu 2020).

Light Touch's ground-breaking sensor, a small, cylindrical device only 15 cm long, harnesses the power of laser technology to painlessly measure blood sugar levels without drawing a single drop of blood. Here's how Light Touch Technology works:

- A gentle touch: Simply point the sensor at your fingertip.
- Laser power: A safe, low-powered laser beam shines onto your skin.
- Unlocking the secrets: The laser analyses the sugar concentration in your interstitial fluid, just beneath your skin.
- Pain-free, seamless results: In seconds, the sensor measures your blood sugar level without any discomfort or heat.
- Smart connectivity: Instantly receive your results on your smartphone for easy monitoring and data tracking.

Light Touch is paving the way for a future where blood sugar monitoring is painless, convenient, and empowering. While the prototype sensor is a significant breakthrough, the road to making it widely available is still ongoing. Clinical trials, regulatory approvals, and further refinement are key steps before this life-changing technology reaches every corner of the world. But with Yamakawa's unwavering dedication and the growing excitement within the medical community, it's only a matter of time before Light Touch shines its light on a brighter future for diabetes management (Sawaji Osamu 2020). Figure 5 shows Light Touch Technology System as explained above.

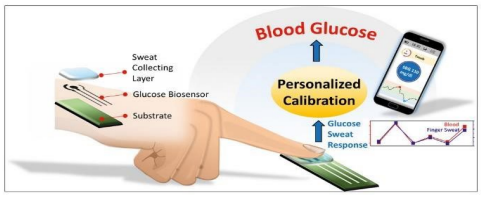

Figure 5. Light touch method of checking diabetes

2.3 Canadian based systems

In Canada Sensor-based glucose monitoring systems called CGM (continuous glucose monitoring machine) and flash are being used by diabetic patients. There are also options with Dexcom, Libre, and Medtronic available in the country (Bailey, T., et al 2015). Continuous Glucose Monitoring (CGM) is like a tiny superhero living under your skin, reporting your blood sugar levels every few minutes. That's what CGM does, providing a real-time, continuous picture of your glucose trends. It gives an alarm when sugar levels are too high or low giving detailed data reports, and even insulin pump integration. Flash Glucose Monitoring (Flash) is like a sneaky ninja that scans your glucose level every 15-60 minutes, storing the data until you gently scan the sensor with your smartphone. No needles, no continuous data stream, but still offering valuable insights into your glucose patterns and trends (Veeze HJ. et al Poster 136 ISPAD

2014). The three companies offering Canada glucose monitoring machines are further explained below that are Dexcom, Libre and Medtronic.

Figure 6. Dexcom G6 CGM system

It has real-time glucose readings, customizable alerts, trend arrows, 10-day sensor wear, water-resistant transmitter, compatible with multiple insulin pumps. This device delivers the most data and insights for proactive diabetes management.it is ideal for those who need tight control or prefer detailed information. This device has the highest upfront cost, covered by some provincial insurance plans (Figure 6 and (Figure 7).

Figure 7. Freestyle Libre 2 Flash system

1. Features: Scans glucose every 15 minutes, 14-day sensor wear, no finger pricking required, discreet and water-resistant, optional real-time glucose alarms with smartphone app.
2. Function: Easy-to-use and budget-friendly option for general glucose monitoring and trend analysis. Great for active individuals or those who dislike finger sticks.
3. Cost: Lower upfront cost, widely covered by provincial insurance plans (Garg, S. K., et al 2017).

Figure 8. Medtronic Guardian 4 Sensor system

1. Features: Continuous glucose readings, compatible with Medtronic insulin pumps, 7day sensor wear, water-resistant transmitter.
2. Function: Seamless integration with Medtronic pumps for closed-loop insulin delivery. Best suited for existing Medtronic pump users seeking real-time glucose data.
3. Cost: Moderate upfront cost, covered by some provincial insurance plans ((Figure 8).

2.4 South Africa based systems

Continuous glucose monitoring has revolutionized diabetes management, offering people real-time insights into their blood sugar levels. And with new sensors, apps, and features constantly emerging, the possibilities are endless. From sleek devices to sophisticated software, we're awash in tools for tracking blood sugar in real-time. But the real magic of CGM might lie in retrospection. While the beeps and alerts of real-time data are helpful, it's the deeper insights revealed by looking back that truly hold the key to better blood sugar control. Imagine CGM as a time machine, transporting us beyond the immediate moment to uncover hidden patterns and trends in our glucose levels.

Retrospective analysis unlocks CGM's full potential by:

1. Unmasking hidden patterns: CGM data paints a detailed picture of glucose fluctuations throughout the day. By analyzing this data later, we can identify subtle patterns that might be missed in the moment, like hidden post-meal spikes or nocturnal dips.
2. Fine-tuning therapy: Armed with these insights, we can tweak our insulin doses, meal timing, and lifestyle habits with greater precision, leading to tighter glycaemia control and improved overall health.
3. Identifying hidden risks: Retrospection can also reveal hidden risks, like an increased risk of hypoglycemia during certain times of day or after specific activities. This knowledge empowers us to take preventive measures and avoid dangerous lows. While real-time monitoring keeps us in the loop, it's retrospective analysis that truly transforms CGM from a cool gadget to a powerful tool for optimizing diabetes management. It's the slow burn of discovery, the satisfaction of piecing together the puzzle of our glucose patterns, and the confidence that comes with wielding that knowledge to take control of our health. (Pearson I 2001)

In essence, the Freestyle Libre presents patients and healthcare professionals with distinct tools that, despite sharing the same core technology, empower each party to manage diabetes effectively. For patients, it's about instant access and autonomy, while for healthcare providers, it's about gaining comprehensive insights and guiding better treatment decisions. Both formats ultimately lead to a more informed and empowered approach to diabetes care.

2.5 Indian based systems

India's CGM market is booming, and it is expected to increase by USD 325.72 million by 2029, it's growing at a steady 11.93% per year. That's good news for people with diabetes, as CGM makes monitoring blood sugar easier and more accurate. In India they are ditching the finger pricks for painless, continuous glucose monitoring. This sleek technology uses a sensor-transmitter-receiver combo to provide continuous, real-time data on your blood sugar, like a live stream of your inner glucose world. Continuous glucose monitoring machine can be used for 14 days without having to prick your finger every day.

The following are the different types of glucose monitoring machines:

1. Contour Plus Blood Glucose Monitoring System

Living with diabetes means constantly juggling medication, lifestyle choices, and monitoring your blood sugar levels. That's where the Contour Plus Blood Glucose Monitoring System shines. It gives you results on how you're eating habits and lifestyle affects your blood sugar levels. But accuracy is key, especially for those sensitive low blood sugar readings. And that's where Contour Plus excels. No more worrying about unreliable numbers. Its innovative technology delivers precise measurements, even at those crucial low levels.

2. Actofit CGM

ACTOFIT harnesses the power of the Freestyle Libre CGM, a tiny sensor that sticks to your arm and tracks your glucose levels for up to 14 days. It sends glucose level notifications on your smart phone. The phone that will be used should have a specific application called NFC technology that communicates with the sensor.

3. Ultrahuman M1 Smart Glucose Monitoring

This device uses a continuous glucose monitoring (CGM) system, which allows you to continuously track your blood sugar levels without finger pricks. It also comes with various health-tracking features to give you a complete picture of your health. The sensor offers easy application to the upper arm and can be worn for up to two weeks.

4. amiciCare Real-time blood glucose tracker

This continuous glucose monitoring system (CGM) uses a tiny sensor placed under your skin to track your blood sugar levels 24/7. Forget missed spikes or dips - you'll have a constant stream of data, helping you stay on top of your diabetes. With continuous data and easy access, this CGM empowers you to make informed decisions about your diabetes. You can adjust your medications, tailor your diet, and stay active with confidence, knowing you'll always be aware of your blood sugar levels.

5. FreeStyle Libre Glucose Monitoring System

This system features a reader you can use forever and a tiny sensor that sticks to your arm for 2 weeks. Think of it as a tiny detective watching your blood sugar levels day and night (continuous glucose monitoring!) alongside blood ketones. No more guessing, just a quick scan with the reader (even through clothes!) reveals your levels anytime, anywhere. (Shruti Bhattacharya 2023)

2.6.Semi Developed based systems

2.6.1 Brazilian based system

Type 2 diabetes is witnessing a dramatic increase in semi-developed and developing countries like Brazil, where lifestyle changes and healthcare access play a role. (American diabetes association 2019). Keeping blood sugar levels under control is crucial for preventing diabetes complications like nerve damage, eye problems, and heart disease. While the A1c test, a three-month average of blood sugar, has been the traditional way to monitor diabetes, it doesn't capture daily fluctuations. (Alexander CM et al 2018). A1c also known as HBA1c measures glucose level in hemoglobin. While A1c is important, it has limitations that are:

1. Blind Spots: A1c doesn't capture the day-to-day ups and downs of blood sugar or how often it dips too low (hypoglycemia).
2. One Number, Many Possibilities: Different patterns of high and low blood sugars can lead to the same A1c value, making it a less precise measure.

This is where time in range (TIR) comes in. TIR measures the percentage of time your blood sugar stays within a healthy target range (Danne T et al 2017). Here's why it's gaining traction:

1. Detailed Picture: TIR captures both blood sugar variability and hypoglycemia risk, giving a more complete picture of your overall control.
2. Better Outcomes: Studies indicate that consistently maintaining blood sugar levels within your target range (TIR) is crucial for preventing diabetes complications.

With the rise of continuous glucose monitoring (CGM), doctors can now track blood sugar continuously and in real-time. This detailed data allows them to personalize TIR goals and adjust therapies to keep you within your target range more often (American Diabetes Association 2019). Recently, a group of diabetes experts agreed that TIR is a valuable and appropriate clinical target, further solidifying its role in diabetes management. In short, while A1c remains important, TIR paints a more detailed picture of your blood sugar control and its potential impact on long-term health. CGM and TIR unlock a new era of personalized diabetes care in Brazil, empowering you to stay in the healthy zone more and outsmart complications. This is crucial as the number of people with diabetes in Brazil is projected to surge by 74% between 2017 and 2045.In Brazil, a country teeming with over 200 million people, diabetes casts a long shadow. One in ten adults, a staggering 12.5 million individuals, were diagnosed with diabetes in 2017. This makes Brazil the fourth most affected nation by diabetes globally, a stark reminder of the widespread impact of this chronic disease (Karuranga S et al 2018). The use of Freestyle Libre flash glucose monitors is becoming more common in Brazil, although widespread adoption is yet to be achieved.

2.6.3 Malaysia based system

In Malaysia the glucometer that is commonly used is the one that uses a test strip and an electronic glucometer. It provides with rapid results and they consider it very reliable. However, it comes with limitations that is painful finger prick whenever an individual wants to have their blood glucose level checked (David C et al 2010). The image Figure

9 shows a full set of glucometers that they commonly used. The way the following glucometer works has been explained in this article and it is quite the same.

Figure 9. Glucometer, test strips and lancet prick 1

Research conducted by Haak et al. (2017) suggests that flash glucose monitoring (FGM) could be a viable alternative to traditional blood glucose monitoring for people with type 2 diabetes who are on insulin therapy. In light of this promising research, Malaysia is considering adopting FGM systems, aligning with the practices of other countries ((Figure 10).

Figure 10. glucometer, test strips and lancet prick 2

A person with type 2 diabetes checks their blood sugar with a flash glucose monitoring system. The discreet sensor sits comfortably on their arm, and a nearby smartphone displays the glucose reading in a user-friendly format. This study adds valuable data to the growing body of research on flash glucose monitoring as a potential game-changer in diabetes management. While further research is needed, studies like this pave the way for more personalized and effective approaches to controlling blood sugar for people with T2DM.Therefore in Malaysia flash glucose monitoring system has not been fully implemented (MYHEALTH MINISTRY OF HEALTH MALAYSIA).

2.6.4 Chinese based systems

China is one of the semi-developed countries that is manufacturing most glucometers that uses a test strip. These glucometers measures blood glucose levels and they are well known to be very accurate. One of the professional companies that makes them is called LYSUN. Continuous glucose monitoring machine in China is not yet on bigger market in China because it is too expensive and has no reimbursement. Th prevalence in type 2 DM may increase the chance of CGM use as it provides with continuous glucose level measurements, and this will decrease the chances for a patient to be hypoglycemic. The use of CGM also decreases the chances for patients to end up being hyperglycemic

which affects multiple body organs such as the kidneys, eyesight as well as the nervous system. Imagine managing diabetes with real-time blood sugar insights, without breaking the bank. That's the promise of China's CGM boom, spearheaded by companies like Yuwell and Weitai in 2021. Even giants like Sinocare are in the game. This innovation translates to affordable CGM options, like Abbott's sensor under 300 yuan. For countless patients, it's a game-changer, empowering them to manage their diabetes more effectively.

Companies like Weitai Medical are setting the pace with their silicone-based bionics technology, creating a connected ecosystem of devices and expert support. This innovative approach is not only driving a massive demand in China, but also holds promise for revolutionizing diabetes management globally. The following are the market key developments in China in the advancement of glucose monitoring:

a. Diabetes Tech Makes Waves in 2021-2022: A landmark partnership, a major upgrade, and a hefty investment mark milestone in digital diabetes management.
b. From China to the World: Chinese innovations in CGM and AI are set to reshape the landscape of diabetes care.
c. Three Steps, Giant Leaps: These key developments in CGM are paving the way for a future where everyone with diabetes can access smarter, more effective solutions. (https://www.knowledge-sourcing.com/report/china-continuous-glucose-monitoringmarket)

2.7 Developing Nations based systems

2.7.1 Zambian based systems

In Zambia, a study revealed that 8% of the population had elevated blood sugar levels, with diabetes affecting 3% of men and 4% of women. The doubling of estimated type 2 diabetes mortality in Zambia from 2008 to 2009 (100 to 200) raises concerns about an even greater underestimation of the disease's burden, given the difficulties in data collection and analysis. Diabetes often overlaps with other diseases like heart and kidney problems, making it easy to miss its role in deaths. Even though it might be the main reason someone dies, other diseases like pneumonia, TB, HIV, or sepsis might get blamed instead. This means diabetes deaths are likely much higher than the numbers show. (Ministry of Health. Lusaka, Zambia: Ministry of Health; 2011).

The Zambian government's needs assessment for the Noncommunicable Disease program, while acknowledging resource and awareness challenges, enables the creation of targeted diabetes management strategies (Zambia National Assembly 2012). While recognizing the importance of HbA1c for glycemic control, Zambia struggles with its full utilization in healthcare settings, particularly at government facilities. Additionally, limited home blood glucose monitoring accessibility for most diabetic outpatients at the UTH, the nation's primary referral center, highlights a critical gap in managing the disease. These challenges contribute to the observed high morbidity and mortality rates (561 cases and 114 deaths, respectively, in 2010 due to diabetes), urging immediate action to improve diabetes management strategies (University Teaching Hospital. Lusaka, Zambia: University Teaching Hospital; 2010).

HbA1c data, a critical tool for assessing blood sugar control in diabetic patients, is unfortunately lacking in Zambia. This gap in information makes it challenging to accurately understand the current state of diabetes management. This necessitates innovative approaches to gather the necessary information and guide diabetes management. In Zambia they commonly use glucometers that measures glucose levels from blood taken on the surface pricked by a lancet.

2.8 Zimbabwe based systems

Diabetes is like a silent storm brewing in Zimbabwe: This non-communicable disease is on the rise, even in low-income settings. It is often diagnosed late, when complications have already emerged like diabetic foot, diabetic neuropathy and nephropathy. It poses a serious threat to health and well-being. Slow onset, limited access to healthcare, and socio-economic hardships is leaving many vulnerable to its grip. There is hope to its improved management. We can shield patients from devastating complications like kidney damage, nerve problems, vision loss, heart disease, and even amputations by use of medication, diabetic diet and continuous glucose monitoring. Diabetes affects over 5.7% of Zimbabwe's population, totaling around 850,000 individuals (Mutowo et al., 2015). The staggering cost of treatment, exceeding $1,300 USD, presents a major hurdle for both patients and the healthcare system. In Zimbabwe they are still using HBA1c laboratory test as their main diagnostic method to rule out whether or not an individual is diabetic. The commonly used method for type 2 diabetic patients to monitor blood glucose level is the use of lancet prick which can be painful. An individual who test themselves at home will have to document their test results in a small notebook for review at either a local clinic or hospital. Continuous glucose monitoring method

is not yet implemented in the country as the method is too expensive and the image below shows a patient in Zimbabwe being tested for blood glucose level using an electronic glucometer that reads glucose sensors on a test strip (Figure 11).

Figure 11. individual being tested for blood sugar level

2.9 Cameroon based systems.

For people with diabetes in Cameroon, regularly monitoring and controlling blood sugar levels is crucial to prevent complications and manage their condition effectively. Blood sugar monitors offer a convenient, quick, and easy way to track these levels, empowering individuals to act. Whether it's adjusting insulin intake or managing food choices, this valuable information helps navigate their target range and optimize their well-being. Researchers in Cameroon studied the connection between patients self-checking their blood sugar and their ability to manage their diabetes. While few patients owned a glucometer, most who did used it inconsistently. This lack of consistent SMBG might contribute to the country's poor glycemic control.
Pocket-Sized Helpers: Understanding Blood Glucose Monitors

Blood glucose monitors (BGMs) also known as glucometers, are essential tools for diabetic individuals to measure blood glucose level. These handy devices provide quick and easy measurements from a tiny blood sample, typically taken from a fingertip.

How it Works:

1. Glucometer kits come equipped with lancets, tiny needles used to prick your finger for a blood sample.
2. Simply insert the test strip into the monitor, and it's ready to go.
3. Prick your fingertip with the lancet and touch the blood droplet to the test strip.
4. The meter will analyze the sample and display your current blood sugar level on the screen in seconds.

Benefits of BGMs in Cameroon:

1. Empowerment: Regular monitoring allows you to understand your blood sugar patterns and make informed decisions about your diabetes management.
2. Convenience: They are portable and easy to use, making them ideal for self-testing at home, work, or on the go.
3. Improved Control: By tracking your blood sugar levels, you can adjust your diet, exercise, and medication as needed to stay within your target range.

2.10 Conclusion to the case studies

The literature review has shown that many countries from developed, semi-developed and developing countries, many people still depend on invasive method of measuring blood glucose levels which is painful to the patients and causes a lot of discomfort. In developed countries such as United states of America, Canada they now have a semi-invasive method for continuously monitoring blood glucose level. The sensor is inserted just under the skin and the information is send to an individual mobile device. The developed countries are also working on a non-invasive device that uses infrared radiation to measure blood glucose level.

Semi-developed countries commonly use invasive method to measure blood glucose level. they also take blood sample from a patient and measures glycaenated blood for the past 3 months also called HBA1c. China and Malaysia is still implementing the use of continuous glucose monitors which sends blood glucose level to a mobile phone. Developing countries such as Zimbabwe still depend on invasive glucometers that uses a needle or lancet prick to measure blood

glucose level in rural areas. In other areas where there are Laboratories, they contact HBA1c to rule out the diabetic status of an individual. From the literature review that has been done there is no country that has officialized the use of saliva as a diagnostic and monitoring method of blood glucose level. This is because the salivary glucose level as to be correlated with blood glucose and this becomes more complicated as saliva glucose can be affected by what individual eats.

3. Materials and methods used in the systems.

This information was taken on google and the other on google scholar. It was obtained from the use of literature to asses' gadgets being used in different countries in the whole world. The method used started from developed countries, semi-developed then finally developing countries. The method used to obtain information for developed countries like Canada and United States based gadgets for glucose monitoring was obtained through literature review on google scholar. This information was mainly taken from articles, journals and books that were written a long time ago. Most of the information was copied and then pasted for rephrasing so that all the important information to be captured without leaving any. All the references were entered to prevent plagiarism. the developed countries have implemented the use of continuous glucose monitoring devices. The same method was used to obtain information for semi-developed countries like Malaysia. These countries have published articles that has information on commonly used glucometers and they have also noted reasons for their preferences. Developing countries has also published information on their glucose monitoring machines preference. The information was inadequate so the writer of this article has to ask around on patients who are diabetic. Developing countries like Zimbabwe prefer glucometers that requires finger prick to obtain blood because that is what they have in their country and it is very affordable though uncomfortable to use.

4. Results obtained from the study

The results from this literature review has shown that many countries are still depending on the invasive method to measure and monitor blood glucose level. Developed nations like Japan are increasingly utilizing subcutaneous continuous glucose monitoring devices for improved health management. These devices will then send blood glucose level to a smart phone where the information is stored for physicians to review. In some developing countries, blood glucose monitoring still relies on traditional methods involving lancet finger pricks, test strips, and glucometers. These readings can be documented on a separate book for review when they visit a nearby clinic or hospital. The use of invasive methods is causing a lot of discomfort on patients, and this has led some patients in developing countries to use herbal medication instead of going to hospital for proper health education. A non-invasive method will be very helpful as it is less painful and user friendly. The study on the use of saliva to measure glucose level will be contacted from 10 February to 10 May 2024.

5. Recommendations and Conclusion

This literature review is very important as it has broadened readers knowledge on the importance of monitoring glucose level in the human body. This article literature review was mainly focused on gadgets being used to measure blood glucose level in developed, semi developing and developing countries. The information obtained shows that the gadget commonly used is invasive which is very uncomfortable and may introduce infection on the frequently pricked site. The other problem is that the other method that measures blood glucose level continuously is expensive and most people in developing countries are unable to afford the whole set as it also uses a smart phone. This information has given the researcher the need for the introduction of non-invasive method of measuring blood glucose level. The use of gadget that uses saliva will solve the problem being faced by geriatric patients who uses needle prick to test their blood glucose level.

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