Original Article

Burdens and Benefits of Continuous Glucose Monitoring Use in Patients of Type 1 Diabetes Mellitus

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ABSTRACT

Objective: The present study is designed to scan the positive outcomes and the barriers that hinder continuous glucose monitoring use in our set-up experienced by type 1 diabetes mellitus patients.

Methodology: In this cross-sectional study data was collected from all the patients and parents of patients with type 1 diabetes mellitus on insulin therapy enrolled with Meethi Zindagi. Data was collected through nonprobability convenience sampling from July to December 2023. The burdens and benefits of technology were assessed through a validated questionnaire in continuous glucose monitoring users and non-users. patients were distributed in two groups; CGM users and non-users to assess the burdens and benefits of CGM use.

Results: Out of 84 study participants, 60% were males and 40% were females. A total of 53 participants were continuous glucose monitoring users while 31 were non-users. Users described more benefits with significant p-values. Device users with HbA1c < 7% and participants of 01 and 13-18 years of age agreed with managing hypoglycemia, a sense of security, reduced finger prick frequency and better diabetes care with the device. Strong agreement about alarm usefulness was reported by parents of children of 1 year of age. Device users for >1-3 years reported stress-free diabetes care with this device. Among all the burdens, strong agreement was found with the high cost of sensors.

Conclusion: The study delivers evidence-based data on the benefits of continuous glucose monitoring for all type 1 diabetes mellitus individuals. At the same time, specific barriers should be identified and addressed to increase the use of continuous glucose monitoring.

Keywords: Continuous glucose monitoring, Diabetes mellitus, Self-monitoring of blood glucose, Type 1 diabetes mellitus.

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Introduction

The worldwide prevalence of diabetes is increasing day by day; according to an estimate in 2021, 10.5% of cases were reported in 20-79 years of age and this number may escalate to 12.2% in 2045.[1] The number is alarmingly high in Pakistan; International Diabetes Federation, in 2022, declared 26.7% of adult patients taking the total cases of diabetes in Pakistan around 33,000,000.[2]

Long-term complications of diabetes can be prevented by close blood glucose (BG) control initially, and patients remain out of risk for more than a decade after diagnosis.[3] Diabetes management includes a blend of daily-life modifications and BG monitoring.[4] Self-monitoring of blood glucose (SMBG) is commonly used for diabetes management. [5] However, for better glycemic control, the use of continuous glucose monitoring (CGM) devices is increasing in many countries and strategies for their usage are being provided.[6] According to the

American Diabetes Association (ADA) Standard of Care guidelines (2023), implementation of CGM is strongly recommended for Type 1 diabetes mellitus (T1DM) individuals who are solely on insulin therapy. [7] ADA elucidates device implementation from the onset of diabetes for careful BG monitoring helping in insulin dose adjustments and lifestyle changes. This benefits from eliminating the frequent finger-stick use in SMBG. [7]

CGM data provides continuous information of BG for better glycemic control improving the life- quality of diabetic patients. [8] Initially the research was conducted in adults and young CGM users. [7] Now, CGM has revealed advantages among adults, as well as older patients. [9] Regarding adolescents and children with new-onset T1D, early initiation of CGM is recommended for better clinical outcomes. [10]

Conversely, burdens are also reported with devices; including stress, lack of knowledge and resources. [8] Cost and size of the sensors were also some other challenges related to CGM uptake.[11]

CGM use is subjective to the awareness and financial standing of the patient or their caregivers. [12] Previous clinical records show that despite many benefits, there has been limited progress and acceptance of device uptake.[13] It is necessary to offer increased support for T1DM patients to make the most of CGM benefits and minimize burdens. Barriers to technology uptake may hamper growth towards augmented diabetes management.[5] Identifying these hurdles is important to address them. Quality standards in diabetes care are advocating to include CGM as a key technology to improve disease management. A Dutch study on T1DM adults delivers a comprehensive overview of the positive as well as negative experiences among CGM users. [14] Data depicting the importance of CGM in Pakistan is lacking.

In Asian countries, evidence-based data about patients' awareness and exploring the benefits of sensors is inadequate, even with a high burden of diabetes. Therefore, obtaining representative information about the CGM users in our setup is essential. The present study is designed to explore the profits and to identify the barriers determining CGM use in our system. Additionally, it seeks to assess the challenges and advantages experienced by individuals with T1DM using CGM sensors through a validated survey. [15]

Methodology

It was a cross-sectional study. Data was collected through nonprobability convenience sampling from July to December 2023. All the TIDM patients on insulin therapy alone, enrolled with the Meethi Zindagi (MZ) organization which identifies patients with diabetes all over Pakistan, were included in the study. Ethical approval was obtained from the HITEC-Institute of Medical Sciences Research cell (HITEC-IRB-28-2023). After obtaining informed consent, a validated questionnaire [16] (disseminated through the MZ platform) was filled out by T1DM patients and parents of patients <12 years. Individuals with type 2 diabetes mellitus (T2DM) or any other type of diabetes were excluded from this study. After data collection, patients were distributed in two groups; CGM users and non-users to assess the burdens and benefits of CGM use.

SPSS Version 25 was used for statistical analysis. Mean and standard deviation (SD) were calculated for quantitative variables and numbers, and percentages for categorical data. The independent sample t-test and One-way ANOVA were used to compare the means.

Results

Out of 84 study participants, 50 (60%) were males and 34 (40%) were females. The median (IQR) age was 12 (8-25.75) years and the mean HbA1c was 7.13 ± 0.82%. Fifty-three (63%) were CGM users while 31 (37%) were non-users.

Perceived benefits among users and non-users are shown in Table I. CGM users described more benefits with significant p-values (0.001). Perceived benefits among CGM users, categorized by age, HbA1c level, duration and initiation of CGM use, respectively are shown in Table II.

Those exhibiting HbA1c between 7-8% expressed the most significant agreement regarding easy diabetes management with sensors. Consensus was found regarding CGM's usefulness in managing hypoglycemia, sense of security, reduced finger prick frequency and better diabetes care in patients with HbA1c < 7%.

Participants from the age groups of 1 year and 13-18 years strongly agreed regarding easy diabetes care, hypoglycemia management, and a sense of security.

Table I: Perceived benefits of CGM among users and non-users. (n=84)

Variables	Users (n=53) Mean±SD	Non-users (n=31) Mean±SD	t-value (*p*-value)
CGM makes taking care of diabetes easier	4.34 ± 0.59	2.45 ± 0.96	9.92(0.001)
CGM helps take care of low blood sugars	4.25 ± 0.55	2.39 ± 1.12	8.67(0.001)
CGM alarms are helpful	3.43 ± 1.06	2.32 ± 0.87	4.92(0.001)
CGM makes me/would make me feel more secure	4.06 ± 0.89	2.13 ± 0.76	10.11(0.001)
CGM lets me/would let me do less fingerstick	4.09 ± 0.90	1.94 ± 0.77	11.13(0.001)
My family wants me to wear a CGM	3.92 ± 0.78	1.97 ± 0.84	10.80(0.001)
I take/ would take better care of my diabetes with a CGM	4.13 ± 0.92	1.87 ± 0.67	11.92(0.001)
CGM helps with managing blood sugar during exercise	3.28 ± 0.97	1.94 ± 0.77	6.61(0.001)

Table II: Benefits of CGM devices in users stratified by HbA1c, Age, Duration of CGM use and Initiation time of CGM after diagnosis (n=53)

Variables	HbA1c (%)				Age (years)					Duration of CGM use (years)				Initiation of CGM use (years)			
	<7 (n=23)	7-8 (n=24)	>8 (n=06)	F-value (*p*-value)	1 (n=02)	>1-13 (n=29)	13-18 (n=07)	>18 (n=15)	F-value (*p*-value)	0-1 (n=22)	1-3 (n=21)	>3 (n=10)	F-value (*p*-value)	0-1 (n=33)	1-5 (n=06)	>5 (n=14)	F-value (*p*-value)
	mean ± SD				mean ± SD					mean ± SD				mean ± SD			
Easy care of diabetes	4.30± 0.56	4.42± 0.58	4.17± 0.75	0.50 (0.61)	5.00 ±0 .00	4.21 ± 0.62	4.86 ± 0.38	4.27± 0.46	3.75 (0.02)	4.36 ± 0.49	4.43 ± 0.59	4.10 ± 0.73	1.10 (0.34)	4.30 ± 0.63	4.50 ± 0.54	4.36 ± 0.49	0.28 (0.75)
Managing hypoglycemia	4.30± 0.56	4.25± 0.53	4.00± 0.63	0.72 (0.49)	4.50 ± 0.70	4.07± 0.53	4.71 ± 0.49	4.33 ± 0.49	3.35 (0.03)	4.50 ± 0.51	4.14 ± 0.47	3.90 ± 0.56	5.47 (0.01)	4.09 ± 0.52	4.67 ± 0.51	4.43 ± 0.51	4.30 (0.01)
Usefulness of alarms	3.78 ± 1.13	3.17 ± 1.05	3.17 ± 0.41	2.28 (0.11)	5.00 ± 0.00	2.83± 0.60	3.8 ± 1.22	4.20 ± 1.01	12.53 (0.01)	3.77 ± 1.11	3.14 ± 0.96	3.30 ± 1.05	2.05 (0.13)	3.21 ± 0.92	3.00 ± 1.09	4.14 ± 1.09	4.97 (0.01)
Sense of security	4.22 ± 0.95	4.04 ± 0.81	3.50 ±0.84	1.60 (0.21)	5.00 ± 0.00	3.45 ± 0.69	5.00 ± 0.00	4.67± 0.49	24.07 (0.01)	4.27 ± 0.82	4.05 ± 0.86	3.60 ± 0.96	2.06 (0.13)	3.76 ± 0.86	4.50 ± 0.54	4.57 ± 0.75	5.94 (0.01)
Less fingerstick	4.30 ± 0.88	4.08 ± 0.88	3.33 ± 0.82	2.95 (0.06)	5.00 ± 0.00	3.45± 0.69	5.00 ± 0.00	4.80± 0.41	28.27 (0.01)	4.23 ± 1.02	4.05 ± 0.86	3.90 ± 0.73	0.49 (0.61)	3.85 ± 0.83	4.33 ± 0.81	4.57 ± 0.93	3.73 (0.03)
Family pressure	3.87 ± 0.76	3.96 ± 0.81	4.00 ± 0.89	0.10 (0.90)	5.00 ± 0.00	4.07 ± 0.70	4.57 ± 0.54	3.20± 0.41	12.47 (0.01)	3.91 ± 0.86	3.95 ± 0.74	3.90 ± 0.73	0.02 (0.97)	4.12 ± 0.74	3.83 ± 0.98	3.50 ± 0.65	3.46 (0.03)
Better care of diabetes	4.26 ± 1.01	4.04± 0.86	4.00± 0.89	0.39 (0.67)	4.50 ± 0.70	3.55 ± 0.83	5.00 ± 0.00	4.80 ± 0.41	16.28 (0.01)	4.41 ± 0.79	3.86 ± 1.06	4.10 ± 0.73	2.01 (0.14)	3.85 ± 0.97	4.50 ± 0.54	4.64 ± 0.63	4.82 (0.01)
Managing blood sugar during exercise	3.65 ± 0.93	3.04 ± 0.99	2.83 ± 0.41	3.34 (0.04)	4.50 ± 0.70	2.83 ± 0.60	3.29 ± 1.25	4.00± 0.93	8.50 (0.01)	3.59 ± 1.00	2.81 ± 0.81	3.60 ± 0.84	4.76 (0.01)	3.18 ± 0.88	3.33 ± 1.50	3.50 ± 0.94	0.53 (0.59)

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Table III: Perceived burdens of CGM among users and non-users. (n=84)

Variables	Users (n=53) mean±SD	Non-users (n=31) mean±SD	t-value(*p*-value)
CGM sensor readings cannot be trusted	2.13 ±0.856	3.94 ± 0.727	9.83(0.001)
CGM takes too much time to use	1.91 ± 0.861	4.03 ± 0.752	11.43(0.001)
CGM is not helpful	1.51 ± 0.724	4.48 ± 0.570	19.59(0.001)
CGM is painful to wear	1.96 ± 1.018	4.13 ± 0.718	11.39(0.001)
The CGM is too expensive to wear regularly	3.72 ± 1.446	4.74 ± 0.445	4.79(0.001)
CGM causes too much worry about blood sugars	2.00 ± 0.941	4.23 ± 0.717	11.37(0.001)
I feel/would feel embarrassed about wearing CGM	1.81 ± 0.810	4.48 ± 0.724	15.16(0.001)
It is too hard to understand CGM information	1.83 ± 0.826	4.06 ± 0.772	12.25(0.001)

Table IV: Burdens of CGM devices in users stratified by HbA1c, Age, Duration of CGM use and Initiation time of CGM after diagnosis. (n=53)

Variables	**HbA1c (%)**				**Age (years)**					**Duration of CGM use (years)**				**Initiation of CGM use (years)**			
	<7 (n=23)	**7-8 (n=24)**	**>8 (n=06)**	**F-value (*p*-value)**	**1 (n=02)**	**>1-13 (n=29)**	**13-18 (n=07)**	**>18 (n=15)**	**F-value (*p*-value)**	**0-1 (n=22)**	**1-3 (n=21)**	**>3 (n=10)**	**F-value (*p*-value)**	**0-1 (n=33)**	**1-5 (n=06)**	**>5 (n=14)**	**F-value (*p*-value)**
	mean ± SD				**mean ± SD**					**mean ± SD**				**mean ± SD**			
Untrusted readings	2.30 ± 0.82	2.04 ± 0.90	1.83 ± 0.75	0.96 (0.38)	1.50 ± 0.70	2.03 ± 0.73	1.43 ± 0.53	2.73 ± 0.88	5.79 (0.01)	2.05 ± 0 0.84	2.00 ± 0.77	2.60 ± 0.96	1.92 (0.15)	2.18 ± 0.76	2.00 ± 1.09	2.07 ± 0.99	0.16 (0.85)
Time-consuming	1.78 ± 0.85	1.83 ± 0.70	2.67 ± 1.21	2.85 (0.06)	1.50 ± 0.70	1.76 ± 0.78	1.43 ± 0.53	2.47 ± 0.91	3.80 (0.02)	2.14 ±0 0.89	1.57 ± 0.59	2.10 ± 1.10	2.81 (0.07)	1.88 ± 0.92	1.83 ± 0.75	2.00 ± 0.78	0.12 (0.89)
Not helpful	1.48 ± 0.73	1.50 ± 0.72	1.67 ± 0.81	0.16 (0.85)	1.00 ± 0.00	1.52 ± 0.68	1.14 ± 0.37	1.73 ± 0.88	1.44 (0.24)	1.50 ± 0.80	1.57 ± 0.67	1.40 ± 0.69	0.18 (0.83)	1.48 ± 0.66	1.33 ± 0.51	1.64 ± 0.92	0.43 (0.65)
Painful	1.65 ± 0.83	1.96 ± 0.95	3.17 ± 1.16	6.34 (0.01)	1.00 ± 0.00	2.10 ± 1.01	1.57 ± 0.78	2.00 ± 1.13	1.14 (0.34)	1.95 ± 1.09	1.67 ± 0.79	2.60 ± 1.07	3.07 (0.05)	2.09 ± 1.04	2.17 ± 0.98	1.57 ± 0.93	1.44 (0.25)
Too costly	3.65 ± 1.55	3.46 ± 1.38	5.00 ± 0.00	2.98 (0.06)	3.50 ± 0.70	3.45 ± 1.50	2.57 ± 1.39	4.80 ± 0.56	5.93 (0.01)	4.00 ± 1.34	3.48 ± 1.36	3.60 ± 1.8	0.74 (0.48)	3.76 ± 1.39	3.33 ± 1.50	3.79 ± 1.62	0.23 (0.79)
Causes too much worry	1.70 ± 0.82	2.04± 0.90	3.00 ± 0.89	5.40 (0.01)	3.00 ± 0.00	2.17 ± 0.92	1.86 ± 0.90	1.60 ± 0.91	2.18 (0.10)	2.05 ± 0.99	2.10 ± 0.83	1.70 ± 1.0	0.63 (0.53)	2.00 ± 0.82	2.50± 1.05	1.79± 1.12	1.22 (0.30)
Embarrassment	1.70 ± 0.76	1.88 ± 0.85	2.00 ± 0.89	0.46 (0.63)	2.50 ± 0.70	1.90 ± 0.77	1.14 ± 0.37	1.87 ± 0.91	2.38(0.08)	2.00 ± 0.87	1.67 ± 0.73	1.70 ± 0.82	1.03(0.36)	1.94 ± 0.78	1.33 ± 0.51	1.71 ± 0.91	1.59 (0.21)
Difficult to understand information	1.61 ± 0.83	1.96 ± 0.80	2.17 ± 0.75	1.65 (0.20)	2.00 ± 1.41	1.83 ±0.71	2.00 ± 1.41	1.73 ± 0.70	0.19(0.90)	1.95 ± 0.89	1.81 ± 0.81	1.60 ± 0.69	0.64(0.53)	1.85 ± 0.75	2.17 ± 0.98	1.64 ± 0.92	0.86 (0.43)

Parents of children under 1 year of age described strong agreement about the usefulness of alarms.

Individuals using CGM for >1-3 years reported the highest fulfilment in stress-free diabetes care with the device. Participants using the device for >1 year found it more promising in hypoglycemia management.

The majority of the CGM users, who started it after 1-5 and >5 years of diagnosis generally agreed with nearly all of its benefits.

Perceived burdens among users and non-users are shown in Table III. CGM non-users alleged more burdens, with significant p values, as compared to CGM users.

Table IV shows the perceived burdens among CGM users, categorized by age, HbA1c level, duration and initiation of CGM use, respectively. Most of the participants disagreed with low mean Bur-CGM scores. Participants with HbA1c > 8% strongly agreed that sensors were costly. Among all the burdens, a strong agreement was found with the high cost of the device and among all age groups, >18 years of age users established that the CGM was overpriced. Whatever the duration of technology use, and the time of CGM uptake after diagnosis, all the participants agreed that "CGM is too expensive to use regularly".

Discussion

CGM is a current strategy and an effective tool in the self-management of T1DM permitting a healthier life and improved diabetes monitoring. [8] However, the CGM use can be both challenging and demanding.[16] CGM practice should be encouraged among patients and healthcare workers as an essential part of diabetes treatment strategies to improve patients' lives.[17] It is important to identify the barriers to CGM use in common practice. We explored the experiences across different subgroups according to age, HbA1c levels, initiation and duration of CGM usage.

Many users in this study reported significant benefits such as better diabetes management, prevention of hypoglycemia, and a sense of security. The real-life experiences of T1DM patients have shown the effectiveness of technology for the day-to-day management of the disease. [16]

The study observed that CGM users generally achieved better HbA1c levels, with a higher percentage maintaining levels below 7%, compared to non-users. However, these differences were not always statistically significant. The same observations were previously described showing lower mean HbA1c among CGM users. [18] Keeping glycemic metrics in range results in improved clinical outcomes by reducing hyperglycemia-related complications. [19] CGM users with >8% HbA1c agreed with insertion pain which led some users to hesitate in adopting the technology. Painful and annoying experiences were reported with the device previously. [20]

Age-specific insights from the study highlighted varying experiences with CGM. Diverse age groups of T1DM individuals can have variable challenges and may accept the technology differently. [18] Parents of infants emphasized the device's ability to reduce their anxiety for their children. Studies state that parents are eager to use this growing technology for better life quality, fewer finger-sticks and reduced hypoglycemic episodes in their T1DM child. [18, 21]

The contributors described distinct observations and experiences regarding CGM alarms. Parents of infants and young adults were satisfied with alarms but disagreement with their usefulness was established among >1-13 years of age in CGM-users. Consistent with the previous data, CGM alarms were found bothersome in children particularly during sleep or in social settings. [16] CGM alerts help in better control and safe monitoring of diabetes but generate stress

Challenges to CGM use included insertion pain, which led some non-users to hesitate in adopting the technology. Literature corroborates these findings highlighting the experiences of children on CGM-device who reported pain during sensor insertions.[20] High cost was a substantial hurdle for CGM practice in all age groups. Divan et al, while exploring the burdens and benefits of CGM technology in adults, did not find this device as budget-friendly.[18] Adolescents, despite recognizing CGM's advantages, faced challenges related to wearing the device and its social implications[16], which sometimes reduced their enthusiasm for its use as seen in our study.

Better diabetes care was acknowledged by individuals whose duration of CGM usage was >1-3. Research validates these findings and describes better glycemic control in patients using CGM for shorter duration compared to prolonged use. [22] Possible reasons for these findings may include patients' burnout and trouble sustaining a healthy lifestyle with continued CGM use.[23] Thus, guidance and counselling by physicians and family support may help patients to consistently use the device.

However, further exploration is required to determine the fluctuating conduct of CGM users in T1DM management.

Long-term CGM users, particularly those using the device for over a year, reported notable benefits in managing hypoglycemia and enhancing overall diabetes care. Hypoglycemia in T1DM may have immediate and delayed clinical consequences and can cause economic burden as well**.** [22] Therefore, early detection and timely regulation of hypoglycemic episodes are important.

High costs were a significant barrier across all age groups, limiting both initial adoption and consistent use. Real-life data and trial studies' findings can encourage policymakers to make CGM reimbursement rules and cost policies for easy CGM access.[14]

Whatever the time of initiation of CGM following a diagnosis, the device was found beneficial for easy care of diabetes, managing hypoglycemia and sense of security. Varying experiences had been recounted. TIDM individuals who switched to the device years after diagnosis found it helpful in disease monitoring. [24] Likewise, parents who introduced sensors soon after the diagnosis of their children acknowledged that early CGM initiation reduced the disease burden. [10] Moreover, recent data demonstrated that early intensified glycemic control at the start of diagnosis is vital for reducing the long-term hazards of diabetes.[25] Consistent with our results, the cost was found a potential barrier to the sustained use of sensors so technology covering in insurance plans was suggested. [10]

Conclusion

This study delivers evidence-based data on the benefits of CGM for all TIDM patients. CGM uptake can be expanded by spreading awareness in T1DM individuals. Essential guidance may be needed for device use and interpreting readings, to get the maximum benefit out of CGM[6]. Tailored solutions for challenges, such as alarm modifications and more discreet device designs, could improve user experiences. Additionally, the development of budget-friendly alternatives would help expand CGM adoption across diverse socioeconomic groups.

By recognizing the potential of CGM as an essential component of T1DM treatment strategies, healthcare providers can guide patients toward improved glycemic control and a better quality of life. Proper training and ongoing support are critical to ensuring that users can fully benefit from this advanced technology for diabetes care.

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