

Article

High User Satisfaction Rates with DEXCOMTM Continuous Glucose Monitoring Device in People with Type 1 Diabetes—A Pilot Cross-Sectional Study

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Abstract

Background/Objectives: DEXCOMTM continuous glucose monitoring devices (DCGMs) have been shown to improve glycaemic control and complication rates in people with Type 1 diabetes (T1DM). However, little qualitative data exists regarding user satisfaction, useful features and the overall lived experience of using a DCGM which will strongly impact one's quality of life (QOL), compliance and the self-management of diabetes. This study aimed to assess DCGM users' satisfaction rates and experiences with device features in patients with T1DM in Ireland. **Methods:** A questionnaire consisting of open- and closed-ended questions together with a glucose monitoring satisfaction survey (GMSS) was offered to all patients attending Sligo University Hospital (SUH) diabetes clinic who used a DCGM for at least six months. **Results:** Data was analysed for 73 participants. Self-reported QOL improved in 88% of participants and 52% of participants reported fewer hypoglycaemic events. The features most liked by participants were alerts given when the glycaemic target was not in range, improved quality of life, improved hypoglycaemia awareness and the need for reduced finger pricking. However, concerns were also identified about redundant alarms and sensor failures, phone incompatibility and skin reactions. DCGM was associated with good levels of glucose monitoring satisfaction with an overall satisfaction score of 3.67 ± 1.24 out of 5. Participants reported high openness (4.01 ± 0.91), increased trust (3.77 ± 1.16) and low emotional (1.70 ± 0.97) and behavioural burden (2.38 ± 1.10) with DCGM usage. Male participants who had diabetes for a mean duration of 20.06 ± 0.89 years and used DEXCOMTM for approximately 2 years demonstrated significantly higher levels of satisfaction ($p < 0.05$). **Conclusions:** The findings of this study provide a first exploration of patients' perspectives on DCGM devices in an Irish setting. Results suggest that DCGM users are highly satisfied with the device with an increase in self-reported QOL. Adaptations to features based on patient feedback should be considered to further enhance user satisfaction and maximise QOL benefits.

Keywords: DEXCOMTM; Type 1 diabetes; continuous glucose monitoring; quality of life



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1. Introduction

There are approximately 8.75 million people diagnosed with type 1 diabetes worldwide with rising prevalence [1]. Diabetes is associated with poor quality of life, increased economic burden on healthcare systems and increased mortality rates [2]. Type 1 diabetes

occurs due to the destruction of insulin-producing pancreatic cells leading to a state of complete insulin deficiency. Individuals with T1DM require life-long insulin replacement with the personal burden of regular testing, as well as the management of hyperglycaemia and hypoglycaemia with food intake, exercise and other day-to-day activities [3]. Tight glucose control reduces complication rates.

Traditional methods of blood glucose measurement involved cumbersome finger pricking. This is intrusive in terms of day-to-day life, often disliked by users and provides sporadic glycaemic information. Compliance often leads to significant barriers in self-management. With advancements in technology, the ability to support individuals with type 1 diabetes has never been better. One popular technology that continues to support these individuals is continuous glucose monitoring (CGM). CGM was first introduced in 1999, providing frequent real-time interstitial fluid glycaemic concentrations, and transmitting to a reader, mobile phone, and iCloud [1–4].

DEXCOM™ is a popular CGM brand which was founded in 1999 [5]. It consists of a sensor which is inserted underneath the skin to transmit continuous glucose readings to a device (smart phone or receiver) [5]. Whilst several studies exist on the improvement of glucose control, reduction in glycated haemoglobin levels and hospital admissions for hypoglycaemia with DEXCOM™ usage, and the benefits of CGM in the management of long and short term complications of diabetes [6,7] little is available pertaining to lived patient experiences with high interindividual variability in adherence and discontinuation rates [8], and no data exists on users' perspectives on device features and their impact on self-reported quality of life in Ireland [9–12].

Ongoing and continuous self-management of T1DM contributes to the personal burden it imposes on the individual, families and health services. Research has demonstrated lower health-related quality-of-life ratings, employment attendance and performance rates in patients with T1DM [13–15].

Interval blood glucose readings provide limited insights into ongoing fluctuations in glycaemic concentrations. Feedback on glycaemic levels in real time has been shown to reduce time in hyperglycaemia and hypoglycaemia, "time out of range" and thus improves glycated haemoglobin (HbA1c) and reduces complication rates [5,9–12]. Albeit usage rates are increasing in Ireland with reimbursement of costs being introduced, the inability to withstand interindividual variability remains high in adherence, problems experienced, real-time interpretation of the data and application to reactive insulin adjustment decisions. Machine size, constant reminders of diabetes, pain at insertion sites, reactions to adhesives and disconnections are all commonly reported annoyances [2,16].

This pilot study aims to assess patients' perceptions of DCGM device features and explore its impact on users' satisfaction and self-reported QOL to aid with the management of T1DM.

2. Materials and Methods

This single-centre pilot, cross-sectional, anonymous study was conducted from September 2022 to December 2023 in the Diabetes Outpatient Clinic in Sligo University Hospital, Ireland. All individuals with Type-1 diabetes using a DEXCOM™ (Dexcom, Inc., San Diego, CA, USA) CGM device for more than 6 months were given information on the study and written informed consent was obtained. Subjects were requested to complete a paper questionnaire and return it to a designated area in the clinic.

Inclusion criteria:

Participants with T1DM using DCGM for 6 months or more.

Exclusion criteria:

- Any other type of diabetes.
- Use of DCGM for any condition outside of Type-1 diabetes.
- Use of DCGM for less than 6 months.
- Use of any other brand of CGM.

Questionnaire:

Part 1

Consisted of 12 questions which included patients' demographics, clinical questions and device features.

Demographics:

1. "What age are you?"
2. "What is your gender?"

Clinical questions:

3. "How long have you been diagnosed with Diabetes?"
4. "How long have you been using the DEXCOM™ device?"
5. "Typically, how often do you look at your DEXCOM™ readings per day?"
6. "How many, if any self-treated hypoglycaemia events occurred in the past week?"
7. "Would you recommend DEXCOM™ to others with Diabetes?"
8. "Do you recognise hypos or is it the DEXCOM™ that alerts you?"
9. "Have hypos got more/less/same frequency since starting DEXCOM™?"
10. "Does DEXCOM™ impact your quality of life (better, same, worse)?"

Device features:

11. "Have you any features that you especially like about DEXCOM™?"
12. "Have you any features that you especially dislike about DEXCOM™?"

Part 2

Consisted of a Glucose Monitoring Satisfaction Survey (GMSS) [17].

The GMSS for T1DM contained four subscales (openness, emotional burden, behavioural burden, trust) as well as a total score. Each was obtained by calculating the mean item response score for the groups of items below. Responses were given on a five-point scale from 1 (strongly disagree) to 5 (strongly agree).

1. Openness (higher scores indicated greater openness): Items 1, 8, 10, 14 (e.g., "Helps me feel less restricted by diabetes")
2. Emotional burden (higher scores indicated greater burden): Items 2, 5, 9, 13 (e.g., "Makes me think about diabetes more than I want to")
3. Behavioural burden (higher scores indicated greater burden): Items 3, 6, 11, 15 (e.g., "Is too much of a hassle to use.")
4. Trust (lower scores indicated greater trust): Reverse code items 4, 7, 12 (e.g., "Gives me numbers that I don't entirely trust").

Total scale (higher scores indicated greater satisfaction): Mean of items 1–15 (reverse code items: 2–7, 9, 11–13, and 15)

2.1. Data Analysis

Data analysis was conducted using SPSS version 22. Descriptive statistics were calculated for each survey item. One-way ANOVA tests were used to determine whether

differences existed when comparing more than two groups, with a post hoc analysis performed to determine where these differences occurred.

2.2. Ethical Approval

This study gained ethical approval from the Research Ethics Committee (REC) at Sligo University Hospital (Ref No. 906)

3. Results

3.1. Characteristics of Participants

In total, eighty-eight questionnaires were completed. Fifteen were excluded as participants were not using DCGM for more than 6 months at the time of survey completion. Therefore, data for seventy-three participants was analysed. Table 1 summarises the characteristics of the participants.

Table 1. Baseline characteristic of participants.

Characteristics of Participants	
Gender, n = 73	Male
	48 (66%)
	Female
	25 (34%)
Age, years, mean	
46.04 ± 16.38	
Duration of diabetes, years, mean	
20.86 ± 13.8	
DEXCOM™ usage, years, mean	
1.9 ± 1.81	

Data is presented as mean and standard deviation (±) (SD).

3.2. DEXCOM™’s Impact on Hypoglycaemia Awareness and Quality of Life

Closed-ended questions for hypoglycaemia awareness showed 25% of participants perceived that they had reduced hypoglycaemia awareness and relied on DEXCOM™ for alerts. Among the participants, 97% reported that they would recommend DEXCOM™ to a friend, 52% reported less hypoglycaemia since using DEXCOM™, and 88% reported a positive impact on their quality of life. Refer to Table 2 below for more information.

Table 2. Participant responses for open- and closed-ended questions asked.

Closed- and Open-Ended Questions	Responses
How often do you look at your DEXCOM™ readings daily?	17.5 ± 16.11 (Mean times per day ± SD)
How many self-treated hypoglycaemic events occurred in the past week?	2.56 ± 2.45 (Mean times per day ± SD)
Do you recognise hypos or is it the DEXCOM™ that alerts you?	45%—DEXCOM™ and themselves 25%—Recognises hypos before DEXCOM™ 25%—DEXCOM™ alerts of hypos
Have your hypos got more/less/same frequency since starting DEXCOM™?	More—14% Less—52% Same—21% No Response—13%
Does DEXCOM™ impact your quality of life (better, same, worse)?	Better—88% Same—11% Worse—1%
Would you recommend DEXCOM™ to others with diabetes?	Yes—97%

Hypos—hypoglycaemic events.

3.3. Features Liked About DEXCOM™

Fifty-nine participants responded to features they liked about DEXCOM™. The majority of participants (44%) liked the glycaemic and continuous blood glucose readings provided (22%). Refer to Table 3 below for more information.

Table 3. Features liked about DEXCOM™.

Features Liked	Responses (n = 59)
Alerts	26 (44%)
Continuous glucose monitoring	13 (22%)
Lack of finger pricking	7 (12%)
Integration into devices (fit bits/car)	5 (8%)
All features	2 (3%)
“Easy to check”	2 (3%)
Good customer service	1 (2%)
“Very helpful”	1 (2%)
“Peace of mind”	1 (2%)
30 min warm up	1 (2%)

3.4. Features Disliked About DEXCOM™

Sixty-four participants responded to features they disliked about DEXCOM™. Among the participants who responded, 30% indicated there were no disliked features. Refer to Table 4 below for further information.

Table 4. Features disliked about DEXCOM™.

Features Disliked	Responses (n = 64)
No features disliked	19 (30%)
Sensor easily dislodges	7 (11%)
Alert volumes	9 (14%)
Inaccurate readings	9 (14%)
Sensor failure prior to change	12 (19%)
Phone incompatibility	3 (5%)
Skin reactions	3 (5%)
Lack of ketone monitoring	1 (2%)
Large size	1 (2%)

3.5. Glucose Monitoring Satisfaction Survey (GMSS) Responses

Participants reported an overall high satisfaction with DEXCOM™ continuous glucose device usage (3.67 ± 1.24 out of 5). Table 5 demonstrates the data obtained in the four subscales in the GMSS. Responses were given on a five-point scale from 1 (strongly disagree) to 5 (strongly agree). Participants were very open to (4.01 ± 0.91) and trusted (2.38 ± 1.10) the use of DEXCOM™, and reported lower emotional (2.33 ± 1.16) and behavioural burdens (1.70 ± 0.97).

Table 5. GMSS results.

GMSS Scale	Mode (Score Out of 5)	Mean (Score Out of 5)
GMSS mean total score	5	3.67 ± 1.24
Openness	4	4.01 ± 0.91
Emotional burden	2	2.33 ± 1.16
Behavioural burden	1	1.70 ± 0.97
Trust	2	2.38 ± 1.10

Data is presented as mean and standard deviation (±) (SD); Higher scores indicate higher openness and user satisfaction; Lower scores indicate higher trust, less emotional and behavioural burden.

3.6. GMSS Results and Hypoglycaemia Frequency

Following DEXCOM™ usage, the data suggests that participants who reported a reduction in hypoglycaemia episodes (52%) were more open (4.16 ± 0.96 ; $p < 0.05$) and had lower emotional burden (2.04 ± 1.01 ; $p < 0.05$) compared to those who experienced more hypoglycaemic episodes (14%). See Table 6 for a breakdown of GMSS scores based on hypoglycaemia frequency.

Table 6. GMSS results and hypoglycaemia frequency.

GMSS Criteria	Reduced Hypoglycaemia Episodes	Increased Hypoglycaemia Episodes	p-Value
Openness	4.16 ± 0.96	3.74 ± 0.75	0.004 *
Emotional burden	2.04 ± 1.01	2.72 ± 1.12	0.002 *
Behavioural burden	1.62 ± 0.98	1.74 ± 0.82	0.457
Trust	2.31 ± 1.17	2.69 ± 1.07	0.149

Data is presented as mean and standard deviation (±) (SD); GMSS scored from 1 to 5. Higher scores indicate higher openness and user satisfaction. Lower scores indicate higher trust, less emotional and behavioural burden.
* = p -value < 0.05.

3.7. Glucose Monitoring Satisfaction Survey (GMSS) Analysis

Those who scored highest on openness (a score of 4 + 5) were males ($p = 0.005$). Participants who scored lowest (a score of 1 + 2) on the behavioural burden aspect of the questionnaire had diabetes for a shorter duration compared to those who had neutral scores (a score of 3) (20.06 ± 0.89 years compared to 26.88 ± 2.97 years) ($p = 0.04$). Males who used DEXCOM™ for longer (2.09 ± 0.15 years) had lower emotional burden scores (1 + 2) than those who had higher scores (a score of 4 + 5) (1.41 ± 0.12 years) ($p = 0.04$). Increased trust (a score of 1 + 2) was seen in participants who used DEXCOM™ for longer (2.07 ± 0.166 years) compared to those who had neutral scores (a score of 3) (1.26 ± 0.16 years) ($p = 0.04$). Refer to Table 7 for further information.

Table 7. Statistical analysis for the GMSS for age, gender, duration of diabetes and DEXCOM™ usage.

Category	GMSS Five-Point Scale	Age (Years)	Gender (Male/Female)	Duration (Years)	DEXCOM™ Usage (Years)
Openness	Scores 1 + 2	49.7 ± 3.88	(M)—5 (F)—11	23.93 ± 2.93	1.74 ± 0.26
	Score 3	47.59 ± 2.13	(M)—32 (F)—26	19.97 ± 1.68	1.42 ± 0.13
	Scores 4 + 5	45.34 ± 1.11	(M)—153 (F)—63	19.41 ± 0.1	2.08 ± 0.14
	<i>p</i>	0.38	0.0005 *	0.60	0.05
	<i>p</i> < 0.05	N/A	Between scores (4 + 5) and (1 + 2)	N/A	N/A
Emotional Burden	Scores 1 + 2	45.13 ± 1.23	(M)—130 (F)—51	19.6 ± 1.00	2.09 ± 0.15
	Score 3	45.13 ± 2.34	(M)—24 (F)—25	22.23 ± 2.49	1.79 ± 0.17
	Scores 4 + 5	49.02 ± 1.99	(M)—35 (F)—24	23.23 ± 1.73	1.41 ± 0.12
	<i>p</i>	0.26	0.006 *	0.16	0.04 *
	<i>p</i> < 0.05	N/A	Between scores (1 + 2) and (3)	N/A	Between scores (1 + 2) and (4 + 5)
Behavioural Burden	Scores 1 + 2	46.06 ± 1.06	(M)—19 (F)—7	20.06 ± 0.89	1.93 ± 0.18
	Score 3	48.27 ± 3.42	(M)—19 (F)—7	26.88 ± 2.97	1.85 ± 0.37
	Scores 4 + 5	40.7 ± 2.10	(M)—10 (F)—8	21.32 ± 3.00	1.7 ± 0.324
	<i>p</i>	0.30	0.49	0.04 *	0.86
	<i>p</i> < 0.05	N/A	N/A	Between scores (1 + 2) and (3)	N/A
Trust	Scores 1 + 2	46.07 ± 1.44	(M)—82 (F)—53	20.65 ± 1.15	2.07 ± 0.166
	Score 3	42.41 ± 2.37	(M)—29 (F)—12	21.1 ± 2.67	1.26 ± 0.16
	Scores 4 + 5	48.73 ± 2.44	(M)—31 (F)—10	20.78 ± 2.13	2.00 ± 0.30
	<i>p</i>	0.21	0.16	0.98	0.04 *
	<i>p</i> < 0.05	N/A	N/A	N/A	Between scores (1 + 2) and (3)

Data is presented as mean and standard deviation (±), *p* = *p*-value, (M) = male, (F) = female, age = mean age (years), gender = number of participants per gender, duration = mean duration of diabetes (years), DEXCOM™ usage = mean duration of DEXCOM™ usage (years), strongly agree (score of 5), agree (score of 4), neutral (score of 3), disagree (score of 2) and strongly disagree (1). Higher scores indicate higher openness, and lower scores indicate higher trust as well as less emotional and behavioural burden, * = *p* value < 0.05.

4. Discussion

This study aimed to explore satisfaction rates and patients' perceptions of DCGM device features and assess its impact on self-reported quality of life. The results suggest that DCGM was associated with a greater use of the glucose-monitoring satisfaction with

an overall satisfaction score of 3.67 ± 1.24 out of 5 among participants on the GMSS. Participants liked the continuous nature of the device. Self-reported quality of life improved in 88% and results highlights that DCGM device usage assists with hypoglycaemic unawareness by alerting users. A quarter participants relied on DCGM for hypoglycaemic alerts and 45% of cases of hypoglycaemia were detected by both users and the DCGM. Participants who reported a reduction in hypoglycaemic episodes with DCGM were more open and experienced less emotional burden from using the device compared to those who had increased hypoglycaemic episodes ($p < 0.05$).

Participants liked the continuous nature of glucose readings, predictive alerts, integration into devices and lack of finger pricking. These features seek to enhance patient engagement, which leads to better self-management and health [18]. Features disliked included alert volumes, easy sensor dislodgement, inaccurate readings, phone incompatibility, and sensor failure prior to expiration. Respondents also reported the fear or mistrust of readings leading to adjustment hesitancy, as shown in previous studies [19]. Similar results were seen in an American series by Yu et al. [18]. Results showed that CGM hypoglycaemia-informing features very helpful, but some challenges occurred. These included unreliable readings, sensor failure prior to change, and continuous alarms when attempting to achieve normoglycemia. Participants found alarms redundant and sometimes even annoying. These disliked features highlight limitations faced with CGM technologies which can lead to disruptions in management and a reduction in patients' compliance with the device [18]. The large sample size of the recent Yu et al. study alongside similar results increases the reliability of the findings. Contemporary iterations of DCGM now allow the silencing of alarms to facilitate a reduction in alarm fatigue [5]. Reflection on older models has allowed DEXCOM™ to identify several causes for sensor failure. These include inserting the sensor into an inappropriate location, not ending previous sensor sessions, lack of cleaning the insertion site and poor sensor adhesion [5]. The company has developed guidance material to mitigate these issues for newer models [5]. Advancing technology and modern versions of CGM devices provide a platform for enhanced user experience and overall satisfaction in diabetes management. Furthermore, cost has also been identified as a disliked feature of DCGM [20]. In Ireland, this variable has been addressed by recent changes which facilitate the free availability of devices where the cost of devices is seen as prohibitive [20].

In this current study, males experienced less emotional burden ($p < 0.05$) and higher openness ($p < 0.05$), as previously shown in an American population [21]. This consistent finding suggests that males experience less emotional distress by incorporating CGM into their disease management. This theory should be further investigated as part of efficacy studies of higher statistical power for a more comprehensive understanding. Albeit there was no significant difference for satisfaction by age in this current study, the results showed that participants in their early to mid-forties had less emotional burden consistent with other studies demonstrating that this age cohort experiences the least emotional burden overall when managing their diabetes with CGM devices [21]. Kelly et al.'s study also reported higher diabetes distress scores for participants in their mid-thirties [21] and our study demonstrates this burden increasingly experienced in age ranges distributed on either side of this range. This theory should be investigated further in future studies to fully comprehend the optimal age for CGM introduction.

The findings of this study are supported by the DIAMOND prospective randomised control trial [6]. In this 24-week trial, the CGM group had a greater increase in hypoglycaemic confidence and a decrease in diabetes distress. Notably, no difference was seen between the two groups in well-being, health status, or hypoglycaemic fear. Compared to this current study, although a different satisfaction survey was used and hypoglycaemic data were based on closed-ended questions, less hypoglycaemic events occurred with

DCGM, with greater user satisfaction further supporting a decrease in diabetes distress and hypoglycaemic confidence. Lower hypoglycaemic events were recorded in 52% of participants, similar to the IN CONTROL study [22]. Participants who reported fewer hypoglycaemic episodes were more open to DCGM and had less emotional burden from using the device compared to those who experienced increased episodes ($p < 0.05$). However, a non-linear relationship was observed as no difference was found between groups for behavioural burden and trust regardless of frequency of hypoglycaemic episodes ($p > 0.05$). Previous literature by Moreno et al. concluded that, within their study cohort, there was no association between glycaemic control and treatment satisfaction ($p = 0.019$) [23]. There are some similar but also contrasting variables which may have resulted in different outcomes between the studies. Both studies were single-centre survey design and share a similar sample size ($n = 73$ vs. $n = 75$). Moreno et al.'s study differs in the CGM device used as they included advanced hybrid closed loop systems where the current study assessed DCGM. Furthermore, most participants in the current study were male, contrasting with the predominantly female cohort observed in Moreno et al.'s study. Finally, the current study utilised the GMSS as a key outcome measure, whilst Moreno et al. opted for the Diabetes Treatment Satisfaction Questionnaire for Diabetes Mellitus to assess treatment satisfaction [23]. It is important for future studies to consider this and to further investigate which combination of methodological design variables could be considered as a 'Gold Standard' for use in larger trials in this field.

A web-based survey on the impact of hypoglycaemia on QOL among adults with T1DM by Chatwin et al. included 219 adults from Europe (Denmark, Germany, Netherlands) and United Kingdom. This study highlighted that profound hypoglycaemia could affect important areas of lives of patients with T1DM. These include relationships, leisure, sleep, sex life, and physical and mental health [23]. The findings suggest there is a correlation between improvement of hypoglycaemia and QOL. Despite extensive literature searching, no grading classification could be located to interpretate overall GMSS scores. This highlights a need for an official scoring criterion to be developed to aid in determining the most effective CGM devices for improving quality of life for people with T1DM.

The key implication of this study is discovering that Irish patients appear satisfied using DEXCOMTM, as well as identifying the key features they would like to be included or continued in the technology. Positive feedback was provided in relation to the device's regular alerts and reduced need for finger pricking. Suggested features to improve include sensor failures, skin reactions, phone incompatibilities and easy sensor dislodging. Incorporating patient feedback may encourage more patients with T1DM to utilise DEXCOMTM. The increased monitoring of blood glucose through technology such as DEXCOMTM may improve the overall management of T1DM and aid in reducing the burden of the illness.

Limitations of this study includes a small sample size. Information may not be representative for all patients with T1DM that use DEXCOMTM or those who discontinued use. No objective measures of glycaemic control were included in this study, although the findings of this pilot trial suggest a need for a larger fully powered trial to analyse such outcome measures. The lack of a control group for comparison between different or no CGM devices limits the overall usability of the findings, although once more highlights the need for inclusion within the methodological design of a future larger trial. DEXCOMTM users were only included in this study, therefore the information obtained may not be generalisable to alternative CGM devices. The educational status of participants was not assessed; therefore, the information may not have been fully understood by participants resulting in response bias.

The findings of this study provide a first exploration of patients' perspectives with T1DM on DCGM devices in an Irish setting. Participants expressed high satisfaction rates

with higher openness and trust and felt lower emotional and behavioural burden using the device. The majority of users (97%) reported that they would recommend DCGM to a friend. Male participants who had diabetes for a mean duration of 20.06 ± 0.89 years and used DEXCOM™ for approximately 2 years demonstrated significantly higher levels of satisfaction ($p < 0.05$). Features disliked such as redundant alerts, sensor failures, skin reactions, phone incompatibilities and easy sensor dislodging are key adaptations that can be considered to further enhance user satisfaction and maximize self-reported QOL.

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