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Use of Personal Continuous Glucose Monitoring (CGM) with Support in People with Type 1 and 2 Diabetes Treated with Insulin in the Outpatient Clinic: A Single-Center Retrospective Cohort Study

ABSTRACT

Objective: The aim of this study was to assess how short-term personal CGM with professional support would affect treatment decisions and glucose control in people with type 1 (T1D) and 2 (T2D) diabetes treated with insulin in clinical practice.

Materials and methods: This was a single-center retrospective cohort study of insulin-treated patients with diabetes who attended the diabetes clinic between March 2021 and March 2022 in Ruttonjee Hospital. It included 90 people with diabetes who were offered a physician-initiated 10 to 14-day CGM (rtCGM or isCGM) in addition to usual care (CGM group), and 90 people with diabetes with usual care alone (control group) after propensity score matching. Upon completion of CGM, the downloaded report was read by physicians for treatment advice (CGM group).

Results: The overall mean HbA1c decreased in the CGM group compared with the control group (adjusted group difference, –0.40%; 95% CI, –0.68 to –0.12%; p = 0.005). In T2D, mean HbA1c decreased in the CGM group compared with the control (adjusted group difference, –0.46%; 95% CI, –0.78% to –0.15%; p = 0.005). The mean HbA1c decrease was non-significant in T1D between CGM and control groups. CGM intervention resulted in 69% in the CGM group had an additional pharmacological adjustment, 60% had dietary advice, and 13.3% had corrected matching of insulin doses to carbohydrates.

Conclusions: This study demonstrated that a 10 to 14-day CGM with professional support is beneficial in improving glucose control for people with diabetes treated with insulin in the outpatient clinic. (Clin Diabetol 2023; 12; 2: 95–104)

Keywords: continuous glucose monitoring, diabetes, insulin, outpatient

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Introduction

Continuous glucose monitoring (CGM) has rapidly improved diabetes management. CGM can reveal glycemic patterns easily and quickly, which enables a prompt titration of therapy to achieve glycemic targets. Time-in-range (TIR) has been shown to be associated with the risk of microvascular complications [1]. In the 2019 international consensus statement on TIR for CGM data interpretation, the recommended percentage of time within target glucose range of 3.9–10.0 mmol/L is < 70% for most type 1 and type 2 diabetes [2].

Evidence has shown that CGM reduces hypoglycemic events, glycemic variability, glucose, and HbA1c levels [3]. The benefits of CGM in type 1 diabetes (T1D), when compared to self-monitored blood glucose (SMBG), have been well established in many studies, such as the DIAMOND, GOLD, and JDRF trials [4–6]. In recent years, randomized controlled trials (RCT) and meta-analyses have demonstrated the benefits of CGM over SMBG in type 2 diabetes (T2D), especially among those treated with insulin [7, 8]. Smaller studies have suggested that real-time CGM (rtCGM) could potentially improve lifestyle changes and adherence to treatment in people with T2D [8].

The American Diabetes Association (ADA) [9], American Association of Clinical Endocrinology (AACE), and American College of Endocrinology (ACE) [10] guidelines all recommend CGM over SMBG.

In Hong Kong, utilization of CGM in routine clinical practice in the outpatient clinic remained relatively low. This may partly be related to the high cost of CGM devices. In addition, a lack of education, training, and support for patients could hinder the optimal benefits of CGM. This study aimed to assess how short-term "personal CGM with professional support" would affect glucose control for people with diabetes treated with insulin in the outpatient clinic. In this study, people with T1D or T2D in CGM group were offered a single 10- to 14-day personal CGM on top of "usual care". They received a brief education on the use of CGM, followed by a post-review with the diabetes nurse after their CGM reports were read by endocrinologists. During the CGM period, they were asked to document their meal intake, physical activity and insulin dose injected. The CGM group was compared with people who received the "usual care" (control group) in the diabetes clinic. In the control group, they were managed as usual in the diabetes clinic, where physicians would adjust diabetes medicine after reviewing blood tests including HbA1c, SMBG record if available, and any reported hypoglycemic events.

The primary objective of this study was to compare the mean change in HbA1c from baseline to the next follow-up visit at 12–20 weeks intervals between the CGM group and "usual care" (control) group. The secondary objectives were to compare the percentage of people achieving HbA1c reduction between the two groups, and to describe and compare with clinical interventions made as a result of the add-on CGM with professional support versus usual care alone.

Materials and methods

Study devices

In this study, Dexcom G6 and Freestyle Libre were the personal CGM devices used, both approved by the U.S. Food and Drug Administration. Dexcom G6 is a 10-day rtCGM, while Freestyle Libre is a 14-day intermittently scanned CGM (isCGM). Their mean absolute relative difference (MARD) is 9% and 9.4% respectively [11, 12].

Study survey on glucose monitoring satisfaction

The validated English or Chinese Glucose Monitoring System Satisfaction (GMSS) survey versions T1D and T2D were used in this study in the CGM group [13].

Its use was aimed to detect any negative impact or dissatisfaction with the use of CGM devices in the CGM group. GMSS is a 15-item self-report using a five-point Likert-type scale rating from one (strongly disagree) to five (strongly agree) for both T1D and insulin-using T2D patients. It comprises four subscales, which capture various key features contributing to device satisfaction. Three of the four subscales are shared by both T1D and insulin-using T2D patients: openness, emotional burden, and behavioral burden. The fourth subscale is trust for T1D and worthwhileness for T2D.

Study design and participants

This was a single center retrospective cohort study that evaluated the effectiveness (change in HbA1c) of a 10–14 days CGM with professional support on top of usual care (CGM group), compared to usual care (control group) in insulin-treated people with T1D and T2D in an outpatient clinic.

The setting was the diabetes clinic in Ruttonjee Hospital, Hong Kong, between 1st of March 2021 and 31st of March 2022. At the time, there were four endocrinologists and four diabetes (DM) nurses.

Under the usual care, patients were instructed by doctors to modify their lifestyle or diabetes medications according to their HbA1c during their regular outpatient visits. Blood tests were arranged before each visit, and subsequent visits would be made at 12 to 20 weeks intervals. DM nurse clinic visits would be arranged if deemed necessary by physicians or patients in between follow-ups.

From March 2021 onwards, CGM devices were purchased under department funding for people with diabetes to use in the diabetes clinic. In addition to usual care, patients were offered a single 10 to 14-day CGM. The decision to use the CGM was made by the endocrinologists. Such decision was mainly related to the following factors: patients on multiple insulin injections, frequent or nocturnal hypoglycemia, wide blood glucose variability, occupational factors (e.g., shift work, professional drivers), or suboptimal glycemic control.

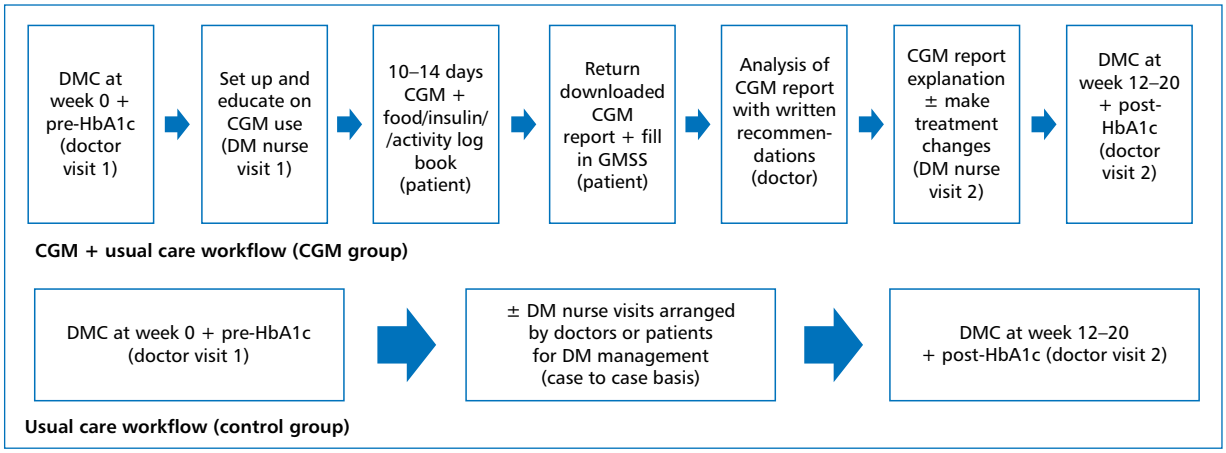

Figure 1. The Process Workflow for CGM + Usual Care (CGM Group) and Usual Care (Usual Care Group)
CGM — continuous glucose monitoring; DM — diabetes mellitus; DMC — diabetes clinic; HbA1c — glycated hemoglobin

All of the people who used CGM underwent a one-on-one brief training and post-evaluation session with the DM nurse. Sensor placement was performed by a trained staff or a DM nurse. During CGM use, the users were instructed to record their food diary, insulin dose, and physical activities in a logbook. They were asked to perform finger-stick blood glucose as usual, and at times of hypoglycemia or erroneously high or low readings from CGM. Upon the completion of the 10 to14 day-CGM, patients would discard the CGM device, and return to DM nurse the downloaded CGM report, together with the food/insulin/activity log book. They were then invited to do a post-CGM device satisfaction survey, GMSS. The CGM report and the logbook were given to an endocrinologist for review. A one-on-one post-evaluation session with DM nurse was next arranged to discuss the CGM glycemic patterns, and make any changes as recommended by the endocrinologist. The process workflow for CGM + usual care (CGM group) and usual care (usual care group) are shown in Figure 1.

Participants

People were included if they were adults over 18 years of age with T1D or T2D, and were using insulin. Mode of insulin injection was subcutaneous via an insulin pen. Exclusion criteria included newly diagnosed diabetes, pregnancy, hospitalization, on an unstable dose of steroids, active malignancy, no baseline (pre-HbA1c) and post-HbA1c levels. People who were given CGM, but had less than 5 days of CGM data, were also excluded from the study.

A total of 139 people with diabetes who attended the diabetes clinic received a CGM between 1st of March 2021 and 31st of March 2022. Forty-nine people were excluded and, finally, 90 people were enrolled in CGM group. The usual care (control) group was selected from the people who received usual care and had attended the diabetic clinics over a 3-month between March 2021 and March 2022. Of the 1140 people screened, a total of 401 were enrolled in the control group. To adjust for the baseline differences in the significant clinical parameters between CGM and the control groups, a propensity score matching analysis was performed for age, gender, baseline A1c, type of DM, and number of insulin injections per day. The final samples for matched comparisons comprised 90 CGM subjects and 90 control subjects. The inclusion flowchart for the retrospective cohort can be found in Figure 2.

Data collection

Electronic medical records were retrieved from the Clinical Medical System between 1st of March 2021 and 31st of March 2022. Data collection included demographics, diabetic medications, HbA1c levels, and CGM-associated intervention. Baseline or pre-HbA1c level was defined as the HbA1c at the initial clinic visit prior CGM insertion. Post-HbA1c was defined as HbA1c measured prior next clinic visit, which was 12–20 weeks from the initial visit. All HbA1c samples were measured by whole blood samples obtained by venipuncture. HbA1c was analyzed by the method that utilized non-porous ion exchange, high performance liquid chromatography (HPLC) with less than 2% CV, via the Tosoh automated Glycohemoglobin Analyzer HLC723G8 in the Hong Kong East Cluster Hematology laboratory. It is certified by the National Glycohemoglobin Standardization Program (NGSP). CGM data were obtained directly from the download CGM report, which included glucose management indicator (GMI),

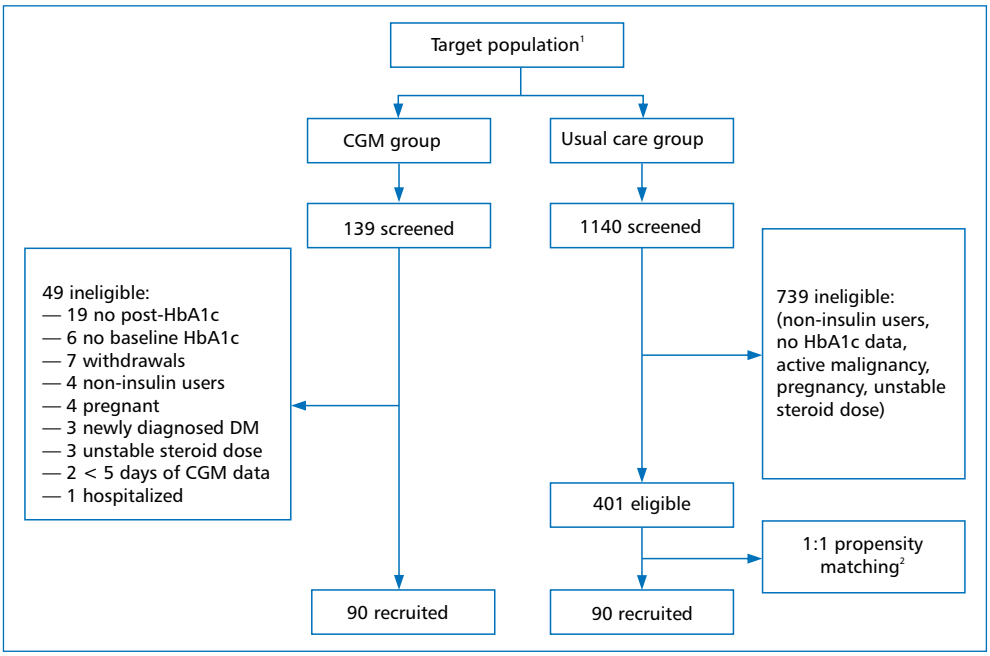

Figure 2. Inclusion Flowchart for Retrospective Cohort Study
[1]Patients who attended diabetes clinic from 1/3/2021 to 31/1/2022
[2]Propensity score matching criteria: age, gender, baseline HbA1c, type of diabetes, number of insulin injections per day
CGM — continuous glucose monitoring; DM — diabetes mellitus; HbA1c — glycated hemoglobin

mean glucose, coefficient of variation (CV), standard deviation (SD), time above range (TAR), time in range (TIR), and time below range (TBR). CGM-associated interventions were those changes made corresponding to the CGM data interpretation encounter. Any DM nurse visits and the associated interventions were also recorded in the usual care group.

Outcomes

The primary outcome was the mean change in HbA1c from baseline to next clinic visit at an interval of 12 to 20 weeks. Secondary outcomes include the percentage of people achieving HbA1c reduction, and CGM-associated interventions. Pharmacological interventions consisted of adding or changing the dose of oral hypoglycemic agent, adding a GLP-1 receptor agonist (GLP-1 RA), change in insulin regimens or insulin type, adjust the dose of insulin. Nonpharmacological interventions included patient education on the correct matching of insulin doses to carbohydrates (CHO), hypoglycemic management, exercise management, and dietary advice (CHO type, CHO portion, meal times).

Statistical analysis

To reduce the confounding effects and to adjust baseline differences between CGM and usual care (control) group, a propensity score matching analysis was performed with 1:1 ratio. Covariates of clinical significance used included age, gender, type of DM, baseline HbA1c, and the number of insulin injections per day.

A comparison between groups was performed using the chi-squared or Fisher exact tests for categorical variables, and independent samples t-test or Mann Whitney U test for continuous variables. Normality of data was checked for continuous variables. To evaluate the change in HbA1c level, the differences within-group was assessed by a paired sample t-test for normally distributed data, and Wilcoxon signed rank test for T1D group due to the small sample size. Differences in the change in HbA1c between CGM and usual care groups were also assessed by multiple linear regression with baseline HbA1c level as a covariate.

Propensity matching was performed using R version 4.2. All other data analysis was performed using SPSS version 23.0. For all statistical analyses, a $p < 0.05$ (two-sided) was considered to be statistically significant. The data are presented as the mean ± standard deviation.

Ethics approval

Ethical approval was obtained from Hong Kong East Cluster Research Ethics Committee (Ref HKE-CREC-2002-052).

Results

Baseline characteristics

The overall baseline characteristics of the people in the CGM group and the control can be found in Table 1. Of the 90 people in the CGM group, 50 received Dexcom G6 and 40 received Freestyle Libre. 25 (27.8%) were T1D, and 65 (72.2%) were T2D. The overall mean age was 58.5 years (± 12.9 years), the mean duration of DM was 18.5 years (± 8.6 years), and the mean baseline HbA1c was 8.41% (± 1.19%). There were no significant differences between the CGM group and the control group among T1D or T2D in terms of age, gender, baseline HbA1c, type of DM, and treatment modalities.

Patients with T1D were relatively younger (50.88 years old vs. 61.49 years old), and had a lower HbA1c level than those with T2D (8.01% vs. 8.53%). The majority of T1D patients were on 4 or more insulin injections per day. In patients with T2D, 23.1%, 40%, 24.6%, and 12.3% were on 1, 2, 3, and 4 insulin injections per day respectively. In addition, 87.7% of T2D also had metformin and 52.3% had SGLT2 inhibitor as oral diabetes medicine.

Clinical outcomes

Change in HbA1c

Mean HbA1c was 8.41% (SD, 1.19%) at baseline and 7.77% (SD, 0.97%) at follow-up in the CGM group, and 8.41% (SD 1.40%) and 8.17 (SD, 1.34%), respectively in the control group (adjusted group difference, –0.40%; 95% CI, –0.68 to -0.12%, p = 0.005) (Tab. 2).

Among T2D patients, mean HbA1c was 8.53% (SD, 1.04%) at baseline and 7.83% (SD, 0.96%) at follow-up in the CGM group, and 8.59% (SD 1.37%) and 8.35 (SD, 1.34%), respectively in the control group (adjusted group difference, -0.46%; 95% CI, –0.78% to –0.15%; p = 0.005). The adjusted group difference of -0.23% was non-significant among T1D patients (p = 0.440) (Tab. 2).

Multiple linear regression model showed that the baseline HbA1c had a significant impact on HbA1c reduction (p < 0.001). After adjustment of baseline HbA1c, the reduction in HbA1c remained significantly greater in the CGM group compared with the control group (p = 0.001) among all participants (p = 0.001) or those with T2D (p = 0.001).

Percentage achieving HbA1c reduction

Significantly more people achieved HbA1c reduction in the CGM group compared with the control group (70% vs. 50%, p = 0.006). HbA1c reduction was found in 76.9% of T2D patients in the CGM group, compared with 48.5% in the control group (p=0.004). Among T1D patients, 52% and 54.5% had HbA1c reduction in CGM and control group respectively (p = 0.861).

CGM-associated intervention

Eighty (88.9%) CGM users brought back logbooks with dietary information. Table 3 shows the percentage of people whose diabetes regimens were altered and the types of advice given based on CGM report in the CGM group. After the CGM report was reviewed by the endocrinologists, followed by a post-evaluation with the DM nurse, a total of 62 (68.9%) people in the CGM group had diabetic medications adjusted. Forty-nine (54.4%) had insulin dose adjustment, 12 (13.3%) had change in insulin regimen or type, and 12 (13.3%) were advised to correct matching of insulin doses to carbohydrates. Dietary advice in terms of CHO type and portion was the most common lifestyle recommendation.

Compared with CGM group, the control group that had usual care alone, 26 (29%) of them had attended DM nurse clinic in between the diabetes clinic follow-ups. Ten (11%) had diabetic medications adjusted, and others were given general education on diabetes or lifestyle advice.

CGM satisfaction

Of the 90 CGM users, a total of 80 GMSS surveys were collected, where 21 were from T1D group (9 Dexcom G6, 12 Freestyle Libre) and 59 were from T2D group (31 Dexcom G6, 28 Freestyle Libre).

The total satisfaction score and subscales' scores for T1D and T2D can be found in Figure 3. There was also no significant difference between participants who used Dexcom G6 and those who used Freestyle Libre in both T1D and T2D groups (p = 0.588 and p = 0.642 respectively).

CGM users' responses to GMSS survey are shown in Tables 4 and 5. It was found that 71.4% of T1D and 89.8% of T2D patients agreed or strongly agreed that CGM helped them to feel more satisfied with how things are going with their diabetes; 71.4 % of T1D and 64.4% of T2D participants disagreed or strongly disagreed that it made them feel more frustrated with their diabetes; 77.9% of T2D patients agreed or strongly agreed that it helped them understand how food and activity affect them; 61.9% of T1D patients disagreed or strongly disagreed and 23.8% were neutral with the statement "gives me numbers that I don't entirely trust".

Discussion

The present study was a retrospective cohort, and the population was all insulin-treated people either

Table 1. Clinical Characteristics of Participants

	CGM group	Control group (usual care)	P-value	CGM group T1D	Control group T1D	P-value	CGM group T2D	Control group T2D	P-value
Number of participants	90	90		25 (27.8%)	22 (24.4%)		65 (72.2%)	68 (75.6%)	
Age [years]	58.5 ± 12.9	58.0 ± 11.4	0.443	50.88± 17.81	48.41 ± 11.53	0.571	61.49 ± 9.06	61.15 ± 9.48	0.830
Gender									
Male	53 (58.9%)	51 (59.0%)	0.880	11 (44.0%)	10 (45.5%)	0.920	42 (64.6%)	41 (60.3%)	0.607
Female	37 (41.1%)	39 (43.3%)		14 (56.0%)	12 (54.5%)		23 (35.4%)	27 (39.7%)	
Duration of DM [years]	18.5 ± 8.6	18.3 ± 9.9	0.872	19.0 ± 11.8	16.09 ± 10.32	0.376	18.35 ± 7.12	19.03 ± 9.68	0.646
Baseline HbA1c [%]	8.41 ± 1.19	8.41 ± 1.40	0.076	8.01 ± 1.49	7.83 ± 1.36	0.536	8.53 ± 1.04	8.60 ± 1.37	0.771
Number of insulin injections per day	2.7 ± 1.1	2.6 ± 1.0	0.318	3.92 ± 0.57	3.95 ± 0.21	0.781	2.26 ± 0.96	2.16 ± 0.80	0.650
Number of insulin injections per day									
1	15 (16.7%)	12 (13.3%)	0.531	0 (0%)	0 (0%)	—	15 (23.1%)	12 (17.6 %)	0.436
2	27 (30.0%)	38 (42.2%)	0.088	1 (4.0%)	0 (0%)	1.000	26 (40.0%)	38 (55.9 %)	0.067
3	18 (20.0%)	14 (15.6%)	0.436	2 (8.0%)	1 (4.5%)	1.000	16 (24.6%)	13 (19.1 %)	0.443
4	28 (31.1%)	26 (28.9%)	0.745	20 (80.0%)	21 (95.5%)	0.194	8 (12.3%)	5 (7.4 %)	0.336
5	2 (2.2%)	0 (0%)	0.497	2 (8.0%)	0 (0%)	0.491	0 (0%)	0 (0%)	—
OHA									
Metformin				8 (32.0%)	3 (13.6%)	0.138	57 (87.7%)	60 (88.2%)	0.923
Sulfonylurea				0 (0.0%)	0 (0.0%)	—	21 (32.3%)	18 (26.5%)	0.460
DPP4i				3 (12.0%)	1 (4.5%)	0.611	19 (29.2%)	18 (26.5%)	0.723
SGLT2i				0 (0%)	1 (4.5%)	0.468	34 (52.3%)	42 (61.8 %)	0.271
Acarbose				0 (0%)	0 (0%)	—	1 (1.5%)	0 (0%)	0.489
Thiazolidinedione				0 (0%)	0 (0%)	—	4 (6.2%)	7 (10.3 %)	0.386
GLP-1 RA				0 (0%)	1 (4.5%)	0.468	17 (26.2%)	13 (19.1%)	0.332

DM — diabetes mellitus; DPP4i — dipeptidyl peptidase 4 inhibitor; GLP-1 RA — glucagon-like peptide-1 receptor agonist; HbA1c — glycated hemoglobin; OHA — oral hypoglycemic agent; SGLT2i — sodium-glucose cotransporter-2 inhibitor; T1/2D — type 1/2 diabetes
Data are n (%) or mean ± standard deviation

Table 2. HbA1c Outcome

	Baseline		Follow-up (12 to 20 weeks)		Mean adjusted difference, CGM – Control (95% CI)	P-value
	CGM (n = 90)	Control (n = 90)	CGM (n = 90)	Control A (n = 90)		
HbA1c, mean ± SD, %	8.41 ± 1.19	8.41 ± 1.40	7.77 ± 0.97	8.17 ± 1.34	–0.40 (0.68 to –0.12)	0.005
	T1D (n = 25)	T1D (n = 22)	T1D (n = 25)	T1D (n = 22)		
HbA1c, mean ± SD, %	8.09 ± 1.49	7.83 ± 1.36	7.63 ± 1.00	7.60 ± 1.19	–0.23 (–0.82 to 0.36)	0.440
	T2D (n = 65)	T2D (n = 68)	T2D (n = 25)	T2D (n = 22)		
HbA1c, mean ± SD, %	8.53 ± 1.04	8.59 ± 1.37	7.83 ± 0.96	8.35 ± 1.34	–0.46 (–0.78 to -0.15)	0.005

CGM — continuous glucose monitoring; CI — confidence interval; HbA1c — glycated hemoglobin; SD — standard deviation; T1/2D — type 1/2 diabetes

Table 3. Recommended Changes in Diabetes Regimens and Advice in the CGM and Control Groups

Recommendations	CGM group	Control group
Pharmacological		
Add or change the dose of OHA	7 (7.8%)	2 (2.2%)
Add GLP1 RA	4 (4.4%)	0 (0%)
Change the insulin regimen or insulin type	12 (13.3%)	0 (0%)
Adjust the dose of insulin	49 (54.4%)	8 (8.9%)
No change in DM regimen	28 (31.1%)	0 (0%)
Non-pharmacological		
Correct matching of insulin doses to CHO	12 (13.3%)	0 (0%)
Hypoglycemic management	5 (5.6%)	1 (1.1%)
Dietary advice (CHO type and portion or meal times)	54 (60.0%)	9 (10%)
Exercise management	3 (3.3%)	1 (1.1%)

Data are n (%)
CGM — continuous glucose monitoring; CHO — carbohydrate; DM — diabetes mellitus; GLP-1 RA — glucagon-like peptide-1 receptor agonist; OHA — oral hypoglycemic agent

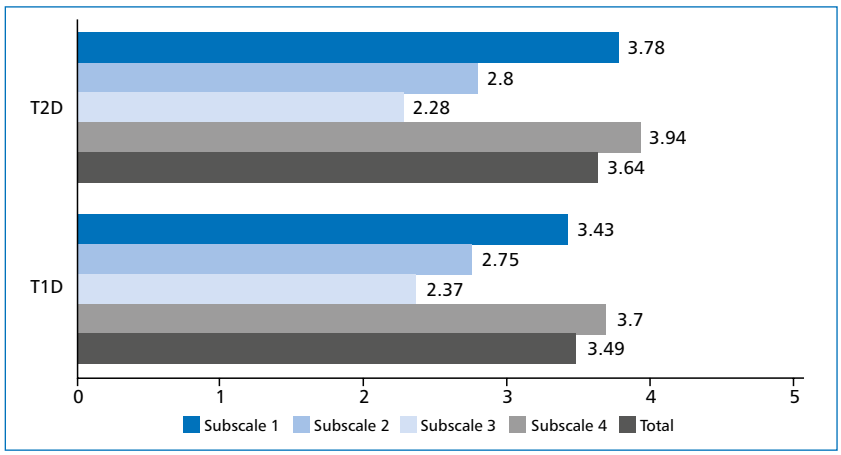

Figure 3. Mean Scores from Glucose Monitoring System Satisfaction GMSS Survey
Subscale 1: openness; subscale 2: emotional burden; subscale 3: behavioral burden; subscale 4: trust (T1D) or worthwhileness (T2D); total: total satisfaction

with T1D or T2D in the outpatient clinic. Our study population comprised patients with relatively long duration of diabetes, on multiple insulin injections, and with a mean baseline HbA1c of 8.41%. They were the typical patients with diabetes who had more complex diabetes regimens with suboptimal control managed

Table 4. Responses of Patients with Type 1 Diabetes to the Glucose Monitoring System (GMSS) User Satisfaction Survey_

		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
1	Helps me feel more satisfied with how things are going with my diabetes	2 (9.5%)	0	4 (19.0%)	10 (47.6%)	5 (23.8%)
2	Makes me think about diabetes more than I want to	0	0	6 (28.6%)	9 (42.9%)	6 (28.6%)
3	Takes too much time to use	2 (9.5%)	9 (42.9%)	6 (28.6%)	2 (9.5%)	2 (9.5%)
4	Doesn't seem to be as accurate as I would like it to be	5 (23.8%)	7 (33.3%)	7 (33.3%)	1 (4.8%)	1 (4.8%)
5	Makes me worry a lot	4 (19%)	7 (33.3%)	5 (23.8%)	2 (9.5%)	3 (14.3%)
6	Is too much of a hassle to use	1 (4.8%)	15 (71.4%)	1 (4.8%)	2 (9.5%)	2 (9.5%)
7	Gives me numbers that I don't entirely trust	2 (9.5%)	11 (52.4%)	5 (23.8%)	1(4.8%)	2 (9.5%)
8	Helps me feel less restricted by diabetes	1 (4.8%)	6 (28.6%)	4 (19.0%)	8 (38.1%)	2 (9.5%)
9	Makes me feel more frustrated with my diabetes	4 (19%)	11 (52.4%)	4 (19%)	2 (9.5%)	0
10	Helps me be more spontaneous in my life	0	6 (28.6%)	3 (14.3%)	10 (47.6%)	2 (9.5%)
11	Causes too many skin irritations or bruises	4 (19%)	10 (47.6%)	5 (23.8%)	1 (4.8%)	1 (4.8%)
12	Often gives me results that don't make sense	7 (33.3%)	9 (42.9%)	3 (14.3%)	1 (4.8%)	1 (4.8%)
13	Makes me feel more down and depressed	9 (42.9%)	5 (23.8%)	3 (14.3%)	3 (14.3%)	1 (4.8%)
14	Helps me be more open to new experiences in life	1 (4.8%)	2 (9.5%)	7 (33.3%)	10 (47.6%)	1 (4.8%)
15	Is too painful to use	8 (38.1%)	9 (42.9%)	1 (4.8%)	1 (4.8%)	2 (9.5%)

Data are n (%)

under the secondary care setting in Hong Kong. The relatively high cost of CGM devices has made their frequent and long-term use more reluctant for people in the public healthcare system. We believed that education and support by professional healthcare providers given to people with diabetes would provide the optimal benefit of CGM use. We also believed that a food diary would not only facilitate professionals to guide medical therapy, but also aid the CGM users to gain a greater understanding of how diet and lifestyle would impact glucose levels. As illustrated in this study, a 10–14 days CGM with professional support led to a significant mean HbA1c decline from 8.41% at baseline to 7.77% at follow-up between 12–20 weeks in the CGM group (adjusted group difference, –0.40%).

It is to emphasize that CGM itself is not a treatment tool, but a tool for making therapeutic adjustments in clinical practice. In our study, CGM report paired with the logbook led to 68.9% of additional pharmacological adjustment after reading by the endocrinologists. Sixty percent of patients received dietary advice and 13.3% received advice on the correct matching of insulin dose with carbohydrates. It is believed that these therapeutic interventions and lifestyle modifications led to greater improvement in glycemic control. Though not measured in the study, patients' self-modification of behavior based on CGM glucose feedback could also have contributed to the improvement in glycemic control. Other studies on short-term professional CGM demonstrated that it helped people with diabetes to improve glycemic control via lifestyle improvement without treatment modification in primary care and secondary care [14, 15].

Earlier studies on CGM in outpatient clinics have shown variable results in people with diabetes. The randomized control trial MITRE Study did not result in improvement in HbA1c level with the use of a 3-day professional CGM 3 times over 12 weeks compared to the control group in insulin-treated diabetes [16]. Another study showed that the use of a 3-day professional CGM in an outpatient clinic resulted in HbA1c reduction in the non-insulin treated but not the insulin-treated subgroup [17].

A more recent pilot multicentered randomized control trial demonstrated that professional CGM improved HbA1c in insulin-treated type 2 diabetes patients managed in primary or secondary care settings [18]. HbA1c was reduced by 0.44% from baseline of 8.6% in the group with SMBG + 4 sensors, which was significantly

Table 5. Responses of Patients with Type 2 Diabetes to the Glucose Monitoring System (GMSS) User Satisfaction Survey

		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
1	Helps me feel more satisfied with how things are going with my diabetes	1 (1.7%)	0	5 (8.5%)	33 (55.9%)	20 (33.9%)
2	Makes me think about diabetes more than I want to	1 (1.7%)	2 (3.4%)	3 (5.1%)	40 (67.8%)	13 (22%)
3	Takes too much time to use	7 (11.9%)	22 (37.3%)	19 (32.2%)	9 (15.3%)	2 (3.4%)
4	Helps me and my doctor to know how much of my diabetes medications to take	0	0	8 (13.6%)	31 (52.5%)	20 (33.9%)
5	Makes me worry a lot	11 (18.6%)	18 (30.5%)	18 (30.5%)	9 (15.3%)	3 (5.1%)
6	Is too much of a hassle to use	10 (16.9%)	31 (52.5%)	12 (20.3%)	4 (6.8%)	2 (3.4%)
7	Gives me information that I don't find very useful	8 (13.6%)	32 (54.2%)	12 (20.3%)	6 (10.2%)	1 (1.7%)
8	Helps me feel less restricted by diabetes	3 (5.1%)	8 (13.6%)	21 (35.6%)	23 (39%)	4 (6.8%)
9	Makes me feel more frustrated with my diabetes	7 (11.9%)	31 (52.5%)	14 (23.7%)	5 (8.5%)	2 (3.4%)
10	Helps me be more spontaneous in my life	0	6 (10.2%)	16 (27.1%)	27 (45.8%)	10 (16.9%)
11	Causes too many skin irritations or bruises	15 (25.4%)	26 (44.1%)	12 (20.3%)	5 (8.5%)	1 (1.7%)
12	Helps me understand how food and activity affect me	0	4 (6.8%)	9 (15.3%)	32 (54.2%)	14 (23.7%)
13	Makes me feel more down and depressed	12 (20.3%)	30 (50.8%)	13 (22.0%)	3 (5.1%)	1 (1.7%)
14	Helps me be more open to new experiences in life	0	0	17 (28.8%)	30 (50.8%)	12 (20.3%)
15	Is too painful to use	16 (27.1%)	28 (47.5%)	11 (18.6%)	3 (5.1%)	1 (1.7%)

Data are n (%)

lower than in the SMBG group. This finding was similar to our retrospective cohort study.

In a recent large retrospective cohort study that also analyzed personal rtCGM initiated by physicians in both T1D and T2D insulin-treated patients, similar to our study design, there was a significantly greater HbA1c reduction among CGM users than non-CGM users [19]. The mean HbA1c declined from baseline 8.17% to 7.76% at 12 months (difference of –0.41%) among CGM users, compared with a decline from 8.28% to 8.19% (difference of –0.09%) among non-CGM users. In our study, there was significant glycemic improvement in T2D patients with a mean HbA1c decrease from 8.53% at baseline to 7.83% in the CGM group (adjusted group difference, –0.46%). The reduction in HbA1c was not significant in patients with T1D. This could be related to the small sample size.

In contrast to our T1D population with a mean age of 51 years and a mean duration of diabetes of 19 years, a recently published trial demonstrated early use of CGM within the first year of T1D diagnosis was associated with long-term improvement in HbA1c [20]. On the other hand, in older T1D adults aged > 60 years, CGM resulted in a small but lower risk of hypoglycemia compared with SMBG in a randomized control trial [21].

There are several limitations of this study. It is a retrospective study design, and data were collected retrospectively. The sample size was small, especially for T1D. It was a single center study, while clinical practice may differ in different centers. CGM users were selected by physicians, and propensity score matching for the control group was performed to minimize selection bias. It only included insulin-treated diabetes and the effect on non-insulin-treated T2D was not known in this study. An additional multi-center study with a large prospective sample including both insulin-treated and non-insulin-treated diabetes would be needed to clarify the effects of CGM in an outpatient setting in Hong Kong.

Conclusions

Our study demonstrated that a 10 to 14-day CGM with professional support is beneficial in improving glucose control for people with diabetes treated with insulin in an outpatient clinic. CGM represents a useful tool for doctors to optimize and personalize diabetes management in clinical practice.

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Conflicts of interest

None declared.

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