Continuous Glucose Monitoring in Adults with Diabetes in Clinical Practice: Increased Access and Education Needed

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BACKGROUND

Continuous glucose monitoring (CGM), which measures glucose levels in real time, has had an increased uptake in recent years.[1] While optimizing glucose control is critical to minimize the risk of diabetes complications, this must be balanced with the risk of severe hypoglycemia.[2] Guidelines recommend CGM in all patients with multiple daily doses of insulin, regardless of diabetes type,[3] though the evidence on CGM outside of randomized clinical trials (RCTs) is limited. Most evidence derives from small observational studies challenged by confounding associated with comparing CGM users to non-users.[4] As populations with diabetes in routine care greatly differ from the highly selected populations in RCTs, there may be differences in the safety and effectiveness of CGM in clinical practice. Using an ecological study design, selected to minimize the confounding expected in a non-randomized individual level study, we assessed temporal trends in CGM use and evaluated whether these correlate with trends in hypoglycemia and poor glycemic control in patients with type 1 diabetes (T1D) and type 2 diabetes (T2D).

METHODS

We conducted an ecological (i.e., population level) study using data from Optum's Clinformatics® Data Mart. For every six months of calendar time (01/01/2016–06/30/2021), we assembled 11 sequential cohorts of insulin users ≥18 years with T1D. Cohort entry was the first calendar date within each cohort. Individuals were required to have 1 inpatient or 2 outpatient T1D diagnoses, and no T2D history or non-insulin glucose-lowering drug use within the year before cohort entry. Patients could enter multiple cohorts if all criteria were met. Patients were followed from cohort entry until disenrollment, death, or a maximum of six months. Separate cohorts of patients with T2D were created using the same criteria as above, though for these cohorts, patients with a prior T1D diagnosis were excluded and use of non-insulin glucose lowering drugs was permitted. The prevalence of CGM, defined using CPT/HCPCS procedure codes, was calculated as the number of patients who used CGM divided by the number of patients in each cohort. Rates of severe hypoglycemia were defined using a validated algorithm of inpatient or emergency department hypoglycemia diagnoses,[5] with number of events divided by total person-years of follow-up. For the population subset with recorded HbA1c at baseline, we calculated the percentage of patients with poor glycemic control (average HbA1c ≥ 8.0%).

RESULTS

The number of patients with T1D or T2D increased from 2016–2021, from 7,873–13,861 and 115,224–206,889. CGM users with T1D were more likely to be female, use an insulin pump, and use bolus insulin, vs non-users (Table 1). CGM users with T2D were younger, more likely to be prescribed newer glucose-lowering drugs, and use both basal and bolus insulin, vs non-users.

The prevalence of CGM increased from 6.4–27.0% among patients with T1D. However, the rate of severe hypoglycemia slightly increased from 2016 (11.2/1000 person-years) to 2021 (18.9/1000 person-years, Fig. 1A). In patients with baseline HbA1c, CGM prevalence increased over time, which correlated to a decrease in the percentage of patients with poor glycemic control from 53.5% in 2016 to 40.8% in 2021 Fig. 1B). Stratifying by age, insulin type or receipt of diabetes education produced consistent results (data not shown).

CGM prevalence was low in patients with T2D (0.6–3.8%, Fig. 1C) and in the subset of patients with baseline HbA1c (0.7–4.0%, Fig. 1D). Given this, we were

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Table 1 Demographics and Baseline Characteristics of the Overall Cohort of Patients with Type 1 and Type 2 Diabetes Mellitus using Insulin and Stratified by CGM Use (Cohort Entry = January 1, 2021)

	Type 1 Diabetes Mellitus			**Type 2 Diabetes Mellitus**		
	Overall cohort (*n* = 13,861)	**CGM users (*n* = 3,732)**	**No use of CGM (*n* = 10,129)**	**Overall cohort (*n* = 206,889)**	**CGM users (*n* = 8,170)**	**No use of CGM (*n* = 198,719)**
Age						
Median (Q1, Q3)	40.0 (28.0, 54.0)	39.0 (28.0, 54.0)	40.0 (28.0, 54.0)	69.0 (61.0, 75.0)	67.0 (58.0, 73.0)	69.0 (61.0, 75.0)
18–44	8,218 (59.3)	2,216 (59.4)	6,002 (59.3)	7,519 (3.6)	420 (5.1)	7,099 (3.6)
45–64	4,133 (29.8)	1,107 (29.7)	3,026 (29.9)	62,165 (30.0)	3,047 (37.3)	59,118 (29.7)
65 +	1,510 (10.9)	409 (11.0)	1,101 (10.9)	137,205 (66.3)	4,703 (57.6)	132,502 (66.7)
Female Sex	6,042 (43.6)	1,805 (48.4)	4,237 (41.8)	105,919 (51.2)	4,143 (50.7)	101,776 (51.2)
Race/Ethnicity						
White	11,048 (79.7)	3,055 (81.9)	7,993 (78.9)	117,898 (57.0)	5,321 (65.1)	112,577 (56.7)
Asian	253 (1.8)	57 (1.5)	196 (1.9)	6,133 (3.0)	259 (3.2)	5,874 (3.0)
Black	811 (5.9)	188 (5.0)	623 (6.2)	34,008 (16.4)	1,087 (13.3)	32,921 (16.6)
Hispanic	814 (5.9)	189 (5.1)	625 (6.2)	34,458 (16.7)	1,034 (12.7)	33,424 (16.8)
Missing	935 (6.7)	243 (6.5)	692 (6.8)	14,392 (7.0)	469 (5.7)	13,923 (7.0)
Region						
Northeast	1,247 (9.0)	339 (9.1)	908 (9.0)	20,382 (9.9)	872 (10.7)	19,510 (9.8)
South	4,939 (35.6)	1,323 (35.5)	3,616 (35.7)	102,173 (49.4)	3,907 (47.8)	98,266 (49.4)
Midwest	4,594 (33.1)	1,264 (33.9)	3,330 (32.9)	43,540 (21.0)	2,046 (25.0)	41,494 (20.9)
West	3,081 (22.2)	806 (21.6)	2,275 (22.5)	40,794 (19.7)	1,345 (16.5)	39,449 (19.9)
Antidiabetic Medications						
Metformin	-	-	-	119,379 (57.7)	4,567 (55.9)	114,812 (57.8)
Second generation sulfonylureas	-	-	-	53,745 (26.0)	1,637 (20.0)	52,108 (26.2)
Thiazolidinediones	-	-	-	13,880 (6.7)	547 (6.7)	13,333 (6.7)
α-glucosidase inhibitors	-	-	-	800 (0.4)	24 (0.3)	776 (0.4)
Meglitinide	-	-	-	2,523 (1.2)	154 (1.9)	2,369 (1.2)
DPP-4 inhibitor	-	-	-	30,503 (14.7)	939 (11.5)	29,564 (14.9)
GLP-1 receptor agonist	-	-	-	54,830 (26.5)	3,633 (44.5)	51,197 (25.8)
SGLT-2 inhibitor	-	-	-	34,078 (16.5)	2,147 (26.3)	31,931 (16.1)
Insulin	13,861 (100)	3,732 (100)	10,129 (100)	206,889 (100)	8,170 (100)	198,719 (100)
Insulin Type*						
Basal insulin	629 (4.5)	86 (2.3)	543 (5.4)	117,756 (56.9)	2,423 (29.7)	115,333 (58.0)
Bolus insulin	7,093 (51.2)	2,349 (62.9)	4,744 (46.8)	10,688 (5.2)	1,093 (13.3)	9,595 (4.9)
Basal and bolus insulin	6,139 (44.3)	1,297 (34.8)	4,842 (47.8)	78,445 (37.9)	4,654 (57.0)	73,791 (37.1)
Insulin pump	4,720 (34.1)	1,618 (43.4)	3,102 (30.6)	530 (0.3)	162 (2.0)	368 (0.2)
Hypoglycemia	70 (0.5)	29 (0.8)	41 (0.4)	3,496 (1.7)	146 (1.8)	3,350 (1.7)
HbA1c level						
Median (Q1, Q3)	7.6 (6.8, 8.8)	7.4 (6.7, 8.5)	7.7 (6.9, 9.0)	8.2 (7.2, 9.7)	8.4 (7.4, 9.9)	8.1 (7.2, 9.7)
Missing	9,247 (66.7)	2,428 (65.1)	6,819 (67.3)	110,444 (53.4)	4,321 (52.9)	106,123 (53.4)
Any office visit	13,582 (98.0)	3,688 (98.8)	9,894 (97.7)	201,067 (97.2)	8,147 (99.7)	192,920 (97.1)
Endocrinologist or education	9,846 (71.0)	3,438 (92.1)	6,408 (63.3)	77,991 (37.7)	6,830 (83.6)	71,161 (35.8)

Abbreviations: *CGM,* continuous glucose monitoring; *DPP-4,* dipeptidyl peptidase-4; *GLP-1,* glucagon-like peptide-1; *SGLT-2,* sodium-glucose co-transporter 2; *Q,* quartile

Cells are counts (%) unless otherwise stated

*Measured in the six months on or before cohort entry

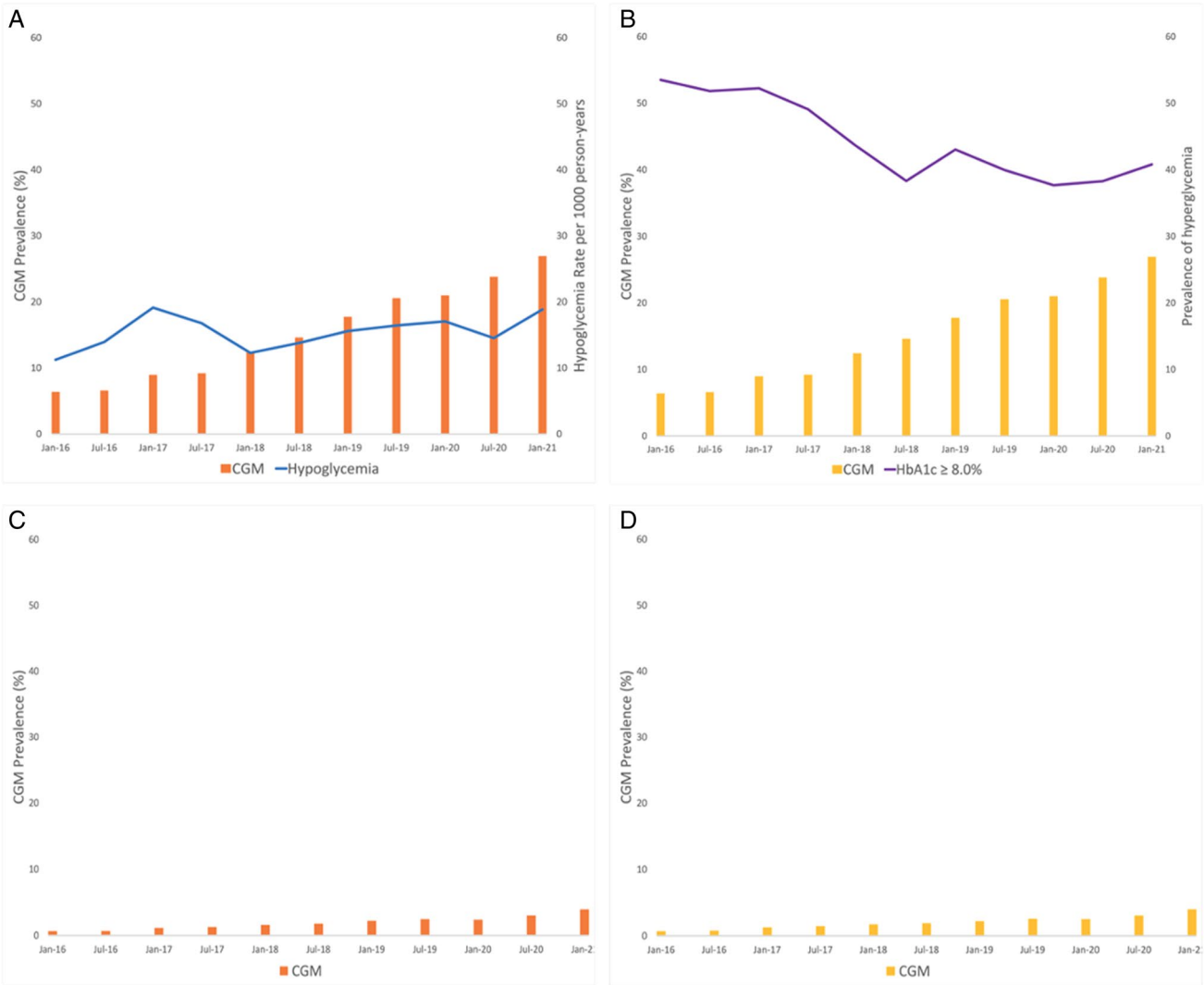

Figure 1 A Trends in use of CGM and rates of hypoglycemia in patients with type 1 diabetes mellitus B Trends in use of CGM and poor glycemic control in patients with type 1 diabetes mellitus and HbA1c test results at baseline C Trends in use of CGM in patients with type 2 diabetes mellitus D Trends in use of CGM l in patients with type 2 diabetes mellitus and HbA1c test results at baseline.

unable to assess the impact of CGM on hypoglycemia or poor glycemic control.

DISCUSSION

At the population level, increasing CGM prevalence in patients with T1D was associated with a reduction in the prevalence of poor glycemic control, but no reduction in the rate of severe hypoglycemia. Despite expanding guidelines,[3] the uptake of CGM in patients with T2D was low, precluding conclusions on study outcomes at an ecological level. RCTs have shown benefits of CGM on both hypoglycemia and hyperglycemia.[6,7] Potential explanations for our results may reside in the underlying differences between populations using CGM in clinical practice vs RCTs, low CGM uptake, and lack of targeted education on how to best operate CGM in routine care. This study was limited by its ecological nature. Future work should attempt to characterize CGM and associated clinical outcomes in subsets of patients who may most benefit from it, like frail older adults with diabetes.

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Declarations

Conflict of Interest *Dr. Abrahami is currently employed by Pfizer. Dr. Munshi has worked as a consultant for Sanofi and Lilly, unrelated to this work. Dr. Hernandez-Diaz reported receiving grants to her institution from Takeda for unrelated studies; personal fees from UCB and Roche outside the submitted work; and having served as an epidemiologist with the North America AED pregnancy registry, which is funded by multiple companies. Dr. Patorno is investigator of a research grant to the Brigham and Women's Hospital from Boehringer Ingelheim, not related to the topic of this work.*

Ethics *The study protocol was approved by the Brigham and Women's Hospital Institutional Review Board (Boston, US) and data use agreements were in place. All analyses were conducted using R version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) and the Aetion Evidence Platform version 4.48.*

Devin Abrahami, PhD[1]
Sonia Hernández-Díaz, MD, DrPH[2]
Medha N. Munshi, MD[3,4,5]
Elisabetta Patorno, MD, DrPH[1]

[1]Division of Pharmacoepidemiology and Pharmacoeconomics, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA;
[2]Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, MA, USA;
[3]Joslin Diabetes Center, United States, One Joslin Place, Boston, MA, USA;
[4]Harvard Medical School, Boston, MA, USA;
[5]Beth Israel Deaconess Medical Center, Boston, MA, USA

Corresponding Author: *Elisabetta Patorno, MD, DrPH; Division of Pharmacoepidemiology and Pharmacoeconomics, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA (e-mail: epatorno@bwh.harvard.edu).*

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