Patterns and Trends in Continuous Glucose Monitoring Utilization Among Commercially Insured Individuals With Type 1 Diabetes: 2010–2013 to 2016–2019

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Prior studies suggest that only ~30% of patients with type 1 diabetes use continuous glucose monitoring (CGM), but most studies to date focused on children and young adults seen by endocrinologists or in academic centers. This study examined national trends in CGM utilization among commercially insured children and adults with type 1 diabetes. Overall, CGM utilization was 20.12% in 2010–2013 and 49.78% in 2016–2019, reflecting a 2.5-fold increase in utilization within a period of <10 years. Identifying populations with low CGM use is a necessary first step in developing targeted interventions to increase CGM uptake.

KEY POINTS

- Roughly half (49.78%) of the individuals in our sample of commercially insured individuals with type 1 diabetes used continuous glucose monitoring from 2016 to 2019.
- This represents a 2.5-fold increase in utilization within <10 years.
- Utilization was highest in those who were aged 0–12 years, were female, had health maintenance organization insurance, and were living in urban areas.

Continuous glucose monitoring (CGM) systems are a mainstay of disease management in type 1 diabetes. Since 2016, the American Diabetes Association's (ADA's) *Standards of Care in Diabetes* have broadly recommended the use of CGM for individuals with type 1 diabetes. These recommendations are based on randomized controlled trials that demonstrate the safety and efficacy of the devices. Compared with users who self-monitored their glucose with fingerstick blood glucose monitoring (BGM), CGM users had more time spent within the glycemic target range and lower A1C levels (1–5). CGM users, compared with nonusers, also had a significantly lower risk of hypoglycemia-related admission to an emergency room or hospital and a reduced risk of all-cause hospitalization (6). CGM users also benefit from measurable quality-of-life improvements (7). Importantly, these benefits have been demonstrated regardless of patients' previous daily frequency of BGM (8). CGM use is also associated with lower overall health care costs, likely through improved glycemic control, which prevents some instances of acute glycemic events and their associated health care expenditures and limits future costs of long-term complications of poor glycemic control (9,10).

Despite the established body of evidence and ADA recommendations, CGM uptake in individuals with type 1 diabetes has been slow. A number of studies in children and young adults have indicated increasing rates of CGM utilization in recent years, but estimates of utilization in adults with type 1 diabetes remain scarce in comparison (11,12). Several single-site observational studies have reported CGM use in adults with type 1

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diabetes to be as low as 8–17% (13,14). The T1D Exchange reported rates as high as 38%, but it is important to note that these patients are all receiving care from endocrinology practices and therefore may not be representative of the larger national population (15).

In addition to studies documenting suboptimal CGM uptake in real-world practice, a number of studies in children and one study in adults have documented substantial variation in CGM utilization by race/ethnicity, although little attention has been paid to other sociodemographic and clinical factors that are associated with utilization (11,13–17). To address this gap, we undertook a study to examine national trends in CGM utilization among commercially insured children and adults with type 1 diabetes in two distinct study periods: 2010–2013 and 2016–2019. These time periods coincide with the time frames before and after modification of the ADA guidelines to increase support for CGM use in the broad population of patients with type 1 diabetes. The time periods were also selected to align and allow for comparison with findings from the T1D Exchange.

Research Design and Methods

Data Source

Data were derived from the Merative MarketScan Research database. This database contains information on nearly 30 million individuals and captures data across the full continuum of care. For this analysis, we used the Commercial Claims and Encounters database, which includes information from employees and their dependents who are enrolled in employer-sponsored health plans. Data include de-identified patient-level data on enrollment, demographics, and clinical utilization across inpatient, outpatient, and prescription drug services. Data were extracted from two distinct study periods (1 January 2010 to 31 December 2013 and 1 January 2016 to 31 December 2019) to describe rates of CGM utilization within each period and compare changes in utilization over time.

Analytic Sample

The study population included all enrollees aged 0–64 years with ≥365 days of continuous medical and pharmacy coverage and ≥1 claim with an *International Classification of Diseases*, 9th revision (ICD-9) or 10th revision (ICD-10), diagnosis code indicating type 1 diabetes (i.e., ICD-9 codes 250.x1 or 250.x3 and ICD-10 code E.10). The index date for enrollees was defined as the date of their first type 1 diabetes–related claim within the study period (2010–2013 or 2016–2019). Enrollees remained in follow-up until the first occurrence of one of the following: initiation of CGM, gap in coverage >365 days, or the end of the study period (31 December 2013 or 31 December 2019).

Ascertainment of CGM Use

CGM use was ascertained in pharmacy and medical claims using National Drug Codes (NDCs), Current Procedural Terminology (CPT) codes, and Healthcare Common Procedure Coding system II (HCPCS II) claim identifiers (Supplementary Table S1). NDCs and HCPCS II codes map to the specific CGM devices available on the market during the study period, whereas CPT codes apply broadly to services provided during an encounter related to CGM start-up/training or interpretation. Patients had to have had two or more CGM claims to be classified as CGM users. Because this is a claims database, NDCs from our study correspond to prescriptions filled (as opposed to prescriptions sent). Eligible claims were flagged as "pharmacy" (NDC) or "medical" (HCPCS II or CPT).

Identification of Covariates

Demographic information on age, sex, insurance type, and residence in a rural versus urban area was collected from beneficiary enrollment files. Insurance type was categorized as health maintenance organization (HMO), preferred provider organization (PPO), or other (consumer-directed health plan, exclusive provider organization, high-deductible health plan, and point-of-service plans). Residence in rural versus urban area was based on classification of enrollees' five-digit zip code as a metropolitan or micropolitan statistical area (urban) versus not living in a county with a metropolitan or micropolitan statistical area coding (rural) (18). Diagnosis codes from inpatient and outpatient claims were used to ascertain the presence of existing diabetes-related complications that are included in the calculation of the adapted Diabetes Complication Severity Index (aDCSI). Initially described in 2009, the Diabetes Complication Severity Index uses claims and laboratory data to predict the long-term effects of diabetes on seven prominent body systems: ocular, renal, neurological, cerebrovascular, cardiovascular, peripheral vascular, and metabolic (Supplementary Table S2) (19). The adapted DCSI (aDCSI) is calculated solely using claims data and is validated with both ICD-9 and ICD-10 diagnostic codes to predict future hospitalizations,

near-future mortality, and overall health care utilization in type 1 and type 2 diabetes (20,21). For each individual in our cohort, the presence or absence of each complication was identified using diagnoses from the index date through the end of follow-up (as described above). We calculated aDCSI as the sum of the seven complications listed above. Prior occurrence of severe hypoglycemia (ICD-9 codes 251.0, 251.1, or 251.2 and ICD-10 codes E11.641 or E11.649) or diabetic ketoacidosis (DKA; ICD-9 code 250.1x or ICD-10 code E10.1) was ascertained via diagnosis codes from the emergency department or inpatient setting.

Statistical Analyses

We conducted cross-sectional comparisons of demographic and clinical information on the study populations from 2010–2013 and 2016–2019. Continuous variables are reported as mean ± SD and categorical variables are reported as frequency and percentage in each category. Cross-sectional comparisons of CGM use in the 2010–2013 and 2016–2019 study periods were conducted overall, as well as by key demographic and clinical characteristics. *t* Tests and χ^2 tests were used to compare continuous and categorical characteristics, respectively, across CGM use status within each time period. The mean difference in proportion of CGM use across the two study periods was compared and is presented, along with the corresponding 95% CI for the mean difference. A series of logistic regression models was used to assess the association between demographic variables and CGM utilization in each study period. Model 1 included only demographic variables, whereas model 2 additionally adjusted for prior acute diabetes complications (DKA and hypoglycemia) and the aDCSI. Analyses were performed in SAS, v. 9.4, statistical software (SAS Institute, Cary, NC). A two-sided *P* value <0.05 was considered statistically significant.

Results

A total of 210,275 commercially insured individuals with type 1 diabetes were included in our sample from the 2010–2013 study period and 131,406 from the 2016–2019 study period. Table 1 presents the distribution of age, sex, insurance type, and urban versus rural residence across the two study periods. In both periods, the distribution of age and sex was similar. PPO was the most common insurance type (62.35 and 53.71% for the study periods, respectively), and the majority of individuals lived in a metropolitan area (76.22 and 85.47%, respectively). The prevalence of DKA was

TABLE 1 Characteristics of Individuals With Type 1 Diabetes From the MarketScan Database Across Two Time Periods: 2010–2013 and 2016–2019

Demographic Characteristics	2010–2013 (*N* = 210,275)	2016–2019 (*N* = 131,406)
Age-group, years		
0–12	19,233 (9.15)	10,082 (7.67)
13–17	17,689 (8.41)	10,808 (8.22)
18–25	24,716 (11.75)	20,701 (15.75)
26–49	85,911 (40.86)	54,515 (41.49)
50–64	62,726 (29.83)	35,300 (26.86)
Sex		
Male	108,112 (51.65)	68,132 (50.07)
Female	101,190 (48.35)	62,720 (47.93)
Missing	973 (0.46)	554 (0.42)
Insurance type		
PPO	131,106 (62.35)	70,577 (53.71)
HMO	25,999 (12.36)	14,357 (10.93)
Other*	53,170 (25.29)	46,472 (35.37)
Patient residence		
Urban area	160,273 (76.22)	112,314 (85.47)
Rural area	50,002 (23.78)	19,092 (14.53)
Region of residence		
North central	48,832 (23.22)	29,081 (22.13)
Northeast	44,492 (21.16)	24,068 (18.32)
South	79,157 (37.64)	57,278 (43.59)
West	35,499 (16.88)	20,444 (15.56)
Unknown	2,295 (1.09)	535 (0.41)
Clinical characteristics		
Severe DKA	4,777 (2.27)	4,799 (3.65)
Severe hypoglycemia	2,006 (0.95)	970 (0.74)
Diabetes complications		
Ocular	10,090 (4.80)	10,742 (8.17)
Renal	4,016 (1.91)	4,964 (3.78)
Neurological	7,257 (3.45)	8,594 (6.54)
Cerebrovascular	890 (0.42)	860 (0.65)
Cardiovascular	3,051 (1.45)	4,064 (3.09)
Peripheral vascular	1,917 (0.91)	2,364 (1.80)
Metabolic	7,637 (3.63)	13,112 (9.98)
Sum of diabetes complications		
0	188,377 (89.59)	103,588 (78.83)
1	13,813 (6.57)	17,737 (13.5)
≥2	8,085 (3.84)	10,081 (7.67)
CGM utilization	42,302 (20.12)	65,411 (49.78)
CGM claim type		
Durable medical equipment	42,274 (99.93)	59,282 (90.63)
Pharmacy benefit†	28 (0.03)	6,129 (9.37)

Data are *n* (%). *Other insurance category includes consumer-directed health plan, exclusive provider organization, high-deductible health plan, and point-of-service plans. †If an individual had both claim types, the claim type was considered a pharmacy benefit claim.

higher in the 2016–2019 study period compared with the 2010–2013 study period (3.6 vs 2.27%, P <0.001). Ocular complications were the most prevalent complication among the participants in the 2010–2013 period (4.80%), whereas metabolic complications were the most prevalent in the 2016–2019 period (9.98%). In the 2010–2013 study period, nearly all CGM claims (99.93%) were filed as durable medical equipment claims, whereas in the 2016–2019 period, the percentage of CGM claims obtained as durable medical equipment was 90.63%, while 9.37% of claims were filled using pharmacy benefits.

Overall, CGM utilization was 20.12% (n = 42,302) in the 2010–2013 study period and 49.78% (n = 65,411) in the 2016–2019 study period (Figure 1). Within each study period, CGM use varied across age-groups. In 2010–2013, children (0–12 and 13–17 years) and older adults (50–64 years) had the lowest rates of CGM utilization and young (18–24 years) and middle-aged (25–49 years) adults had the highest utilization. By 2016–2019, these patterns had shifted such that the youngest age-group (0–12 years) had the highest rates of utilization, and the oldest age-group (50–64 years) had the lowest.

From the 2010–2013 to the 2016–2019 study period, CGM use increased by 29.66 percentage points (95% CI for difference: 29.34–29.98%, P <0.0001) (Table 2). While CGM utilization increased across all age-groups, the largest increase (51.65%) was observed in the 0–12 years age-group (95% CI 50.60–52.70%, P <0.0001). Use of CGM was more frequent in females than males in both study periods (P <0.001 for both), and the magnitude of the increase over time by sex was comparable (females 30.1%, males 29.24%). CGM use was higher among those living in urban areas compared with rural areas, and the magnitude of increase across study periods was similar (urban 29.25%, rural 29.84%). According to aDCSI scores, CGM use increased across all groups, with the highest increase among those with no complications (26.17%). However, even with this increase, CGM use in this group was considerably lower than among those with higher aDCSI scores.

In logistic regression models adjusted for demographics and disease severity, we evaluated the odds of CGM utilization by participants' characteristics separately in the two study periods (Table 3). For the 2010–2013 study period, in fully adjusted models, compared with the youngest age-group (0–12 years), those in the 18–25 years (odds ratio [OR] 1.16, 95% CI 1.09–1.22) and 26–49 years (OR 1.27, 95% CI 1.21–1.34) age-groups were significantly more likely to use CGM. Females (OR 1.18, 95% CI 1.15–1.21) and individuals with HMO insurance (OR 1.07, 95% CI 1.03–1.12) were more likely to use CGM than males and those with PPO insurance, respectively, while individuals living in rural areas were less likely than those living in urban areas to use CGM (OR 0.80, 95% CI 0.78–0.83).

Findings of the 2016–2019 period revealed a pattern similar to that of the previous period with one exception: age-groups. Using the youngest age-group (0–12 years) as the reference category, as age increased, the odds of CGM use decreased significantly, with those in the oldest age-group (50–64 years) having the lowest odds of CGM use (OR 0.24, 95% CI 0.23–0.25). Similar to the 2010–2013 study period, in 2016–2019, females and those with HMO insurance

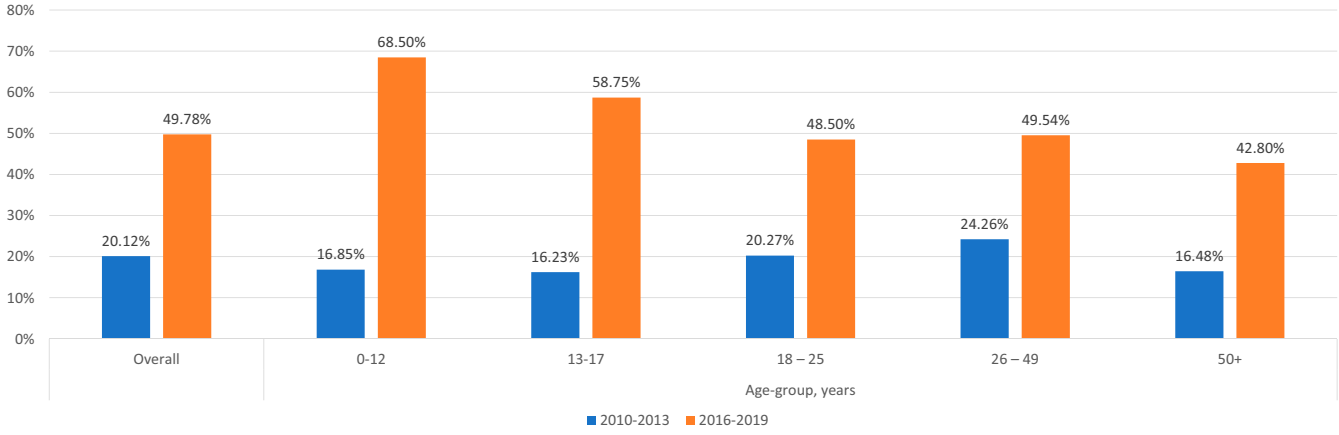

FIGURE 1 CGM utilization among individuals with type 1 diabetes enrolled in employer-sponsored health plans, overall and by age-group.

TABLE 2 Comparison of CGM Utilization Among Individuals With Type 1 Diabetes Across Subgroups Defined by Demographic and Clinical Characteristics Within and Across Study Periods (2010–2013 and 2016–2019)

	2010–2013		2016–2019		2016–2019 vs. 2010–2013, % (95% CI)
	With CGM, *n* (%)	*P*	With CGM, *n* (%)	*P*	
Overall	42,302 (20.12)	<0.0001	65,411 (49.78)	<0.0001	29.66 (29.34–29.98)
Demographic characteristics					
Age-group, years		<0.0001		<0.0001	
0–12	3,241 (16.85)		6,906 (68.50)		51.64 (50.6–52.7)
13–17	2,871 (16.23)		6,350 (58.75)		42.53 (41.48–43.58)
18–25	5,009 (20.27)		10,039 (48.50)		28.23 (27.42–29.04)
26–49	20,845 (24.26)		27,006 (49.54)		25.25 (24.78–25.73)
50–64	10,336 (16.48)		15,110 (42.80)		26.31 (25.74–26.89)
Sex		<0.0001		<0.0001	
Male	19,722 (18.24)		32,348 (47.48)		29.24 (28.8–29.68)
Female	22,390 (22.13)		32,765 (52.24)		30.11 (29.65–30.58)
Insurance type		0.0002		<0.0001	
PPO	26,082 (20.23)		35,016 (48.64)		28.41 (29.29–30.15)
HMO	5,463 (21.01)		7,793 (54.28)		33.27 (32.31–34.22)
Other*	10,757 (19.89)		22,602 (49.61)		29.72 (27.84–28.97)
Patient residence		<0.0001		<0.0001	
Urban	33,599 (20.96)		56,390 (50.21)		29.25 (28.89–29.6)
Rural	8,703 (17.41)		9,021 (47.25)		29.84 (29.06–30.63)
Clinical characteristics					
Severe DKA	4,216 (88.26)	<0.0001	4,422 (92.14)	<0.0001	3.89 (2.97–5.08)
Severe hypoglycemia	1,804 (89.93)	<0.0001	892 (91.96)	<0.0001	2.03 (−0.13 to 4.19)
Sum of diabetes complications		<0.0001		<0.0001	
0	22,888 (12.15)		39,695 (38.32)		26.17 (25.8–26.5)
1	12,254 (88.71)		16,415 (92.55)		3.84 (3.18–4.49)
≥2	7,160 (88.56)		9,301 (92.00)		3.70 (2.84–5.47)

*Other insurance category includes: consumer directed health plan, exclusive provider organization, high deductible health plan, and point-of-service plans.

were more likely to use CGM than males and individuals with PPO insurance, while those living in rural areas were less likely than those living in urban areas to use CGM.

Discussion

In this study of commercially insured individuals with type 1 diabetes, we observed a 2.5-fold increase in CGM utilization in less than a 10-year window (from 20.12% in 2010–2013 to 49.78% in 2016–2019). While an increasing trend was observed across all demographic groups studied, the magnitude of the increase and percentage of patients with CGM utilization in the most recent study period were highest among those aged 0–12 years compared with the other age-groups, females compared with males, those with HMO compared with PPO insurance coverage, and those living in urban compared with rural areas. These differences persisted in regression models adjusting for diabetes complications, which underscores the contribution of nonmedical risk factors to inequities in CGM use among people with type 1 diabetes, a group for whom CGM is recommended as the standard of care (22).

To our knowledge, our study is among the first to examine patterns of CGM use across a range of demographic characteristics in a large, geographically diverse population of patients with type 1 diabetes. The patterns of CGM utilization observed in our study are largely consistent with data from the T1D Exchange, a clinic-based registry of patients with type 1 diabetes from geographically diverse adult and pediatric endocrinology centers

TABLE 3 Logistic Regression Models Examining the Odds of CGM Utilization by Demographic and Clinical Characteristics of Commercially Insured Individuals in 2010–2013 and 2016–2019

	2010–2013		2016–2019	
	Model 1	Model 2	Model 1	Model 2
Age-group, years				
0–12	Ref	Ref	Ref	Ref
13–17	0.96 (0.91–1.02)	0.90 (0.84–0.96)	0.66 (0.62–0.70)	0.69 (0.65–0.73)
18–25	1.26 (1.20–1.33)	1.16 (1.09–1.22)	0.43 (0.41–0.46)	0.42 (0.40–0.45)
26–49	1.58 (1.52–1.65)	1.27 (1.21–1.34)	0.45 (0.43–0.47)	0.39 (0.37–0.41)
50–64	0.98 (0.94–1.02)	0.64 (0.61–0.67)	0.34 (0.33–0.36)	0.24 (0.23–0.25)
Sex				
Male	Ref	Ref	Ref	Ref
Female	1.28 (1.25–1.30)	1.18 (1.15–1.21)	1.22 (1.20–1.25)	1.20 (1.17–1.23)
Insurance type				
PPO	Ref	Ref	Ref	Ref
HMO	1.05 (1.01–1.08)	1.07 (1.03–1.12)	1.19 (1.15–1.24)	1.19 (1.14–1.24)
Other	1.03 (1.01–1.06)	1.02 (0.99–1.05)	0.96 (0.94–0.98)	0.96 (0.93–0.98)
Patient residence				
Urban area	Ref	Ref	Ref	Ref
Rural area	0.80 (0.78–0.82)	0.80 (0.78–0.83)	0.88 (0.85–0.91)	0.84 (0.81–0.87)

Data are odds ratio (95% CI). Model 1 simultaneously adjusts for all demographic variables (age-group, sex, insurance type, and location of patient residence). Model 2 additionally adjusts for prior acute diabetes complications (severe DKA and severe hypoglycemia) and aDCSI. Ref, reference category.

across the United States. The most recent report from the T1D Exchange (2016–2018) estimated that 30% of patients are using CGM, that CGM use has increased significantly over time (from 7% in 2010–2012 to 30% in 2016–2018), and that utilization is highest among children (51% in those <6 years of age) (11). Our study expands estimates of CGM utilization to a population of patients who are treated in both the endocrinology and primary care settings. This feature is significant because prior studies suggest that only 40% of patients with type 1 diabetes receive routine care from an endocrinologist (23) and that adherence to ADA clinical practice guidelines is significantly better in endocrinology clinics than in primary care clinics (24). In addition to the expansion of prior estimates to the primary care setting, our sample of patients with type 1 diabetes is more balanced in terms of the age distribution than patients in the T1D Exchange; using the most recent time period for both studies, 68% of the patients in our study (n = 89,815) were ≥26 years of age compared with 31% (n = 6,407) in the T1D Exchange.

Over the past few decades, life expectancy has increased substantially for people with type 1 diabetes (25). The increasing number of individuals with type 1 diabetes now living to old age raises important questions about how best to support healthy aging in this unique population with significant self-care demands. As in other studies, we found significantly lower CGM utilization among older versus younger adults. Because type 1 diabetes is typically diagnosed during childhood or adolescence and is a disease that requires lifelong monitoring and treatment, as patients' age, the average number of years they have spent managing their disease increases. Individuals who have spent more time managing day-to-day variations in blood glucose levels may not see the necessity of using advanced monitoring technology despite clinical trials demonstrating that improvements in time in range and reductions in hypoglycemia with CGM use are comparable in older adults to those observed in young adults (26). Diabetes providers may be hesitant to suggest CGM use in patients who have proven their self-efficacy with disease management. However, CGM use has been shown to increase time in range even when compared with individuals performing multiple fingerstick BGM measurements per day (27). CGM is also beneficial for its ability to detect acute or impending episodes of hypoglycemia, an issue that is especially prevalent in older adults (28). Ensuring that older adults with type 1 diabetes have adequate resources and support to enable successful diabetes self-management for as long as they are able is essential to helping this growing population as they age.

In our study, we found that females were significantly more likely than males to use CGM in both study

periods. There are several studies investigating the influence of sex on CGM use, but findings have been inconsistent. Although some studies have found no significant difference in CGM use by sex (14,20,29), others have reported that females are more likely than males to use CGM (30,31). Our study supports the latter, as we found that females had a higher rate of CGM usage in both study periods. Although there was a similar increase in CGM use in males and females across the two study periods (~30%), the persistent gap between the sexes indicates that sex may play a role in CGM usage. However, discrepancies across studies regarding patterns of CGM use by sex could be attributed to variations in study population, an area that requires further exploration in future studies.

Geographic disparities are an important driver in utilization of health care services. Individuals residing in rural areas often face barriers in accessing health care that can stem from limited provider availability and increased travel distance to receive care (32,33), lower socioeconomic status and higher poverty rates in rural residents than in their urban counterparts (34), and limited ability to use telehealth services because of inadequate broadband access (34). Our study found that CGM use increased in both urban and rural areas across the two study periods, but that CGM use was consistently lower in rural areas. Increasing access to CGM among individuals in rural areas is especially important in light of recent studies reporting that the incidence of type 1 diabetes is higher in rural areas in the United States (35) and that glycemic control is poorer among rural patients than among urban patients with type 1 diabetes (36).

Billing for CGM systems is unique in that claims can be processed and covered via medical or prescription insurance plans. This situation provides an opportunity for easier access through mail-order or retail pharmacies but also introduces potential confusion for both patients and providers regarding insurance billing and formulary preferences. In our study, the overwhelming majority of patients had CGM claims processed as durable medical equipment through their medical insurance plan, but, in the most recent study period, the percentage of patients utilizing prescription insurance to cover CGM as a pharmacy benefit was nearly 10%.

Despite this increase in claims for CGM as a pharmacy benefit, issues with insurance coverage and the inability to cover out-of-pocket fees remain significant barriers to uptake of CGM. In two large patient preference surveys, adults with type 1 diabetes most frequently cited "not covered by insurance" and "cost of supplies" as the reason for not initiating or for discontinuing CGM therapy (15). These barriers are exacerbated by the adoption of strict coverage criteria for people with type 1 diabetes, with some commercial insurance providers requiring documentation of four or more fingerstick BGM tests per day for CGM eligibility (37). Although CGM has been shown to be cost saving for insurance providers, CGM systems can come with a significant upfront cost for plan members, which may further limit their uptake (13). Minimizing cost- and insurance-related barriers to CGM utilization remains a priority for ensuring equitable access to diabetes technology.

Strengths and Limitations

This study has many strengths. It provides estimates of CGM utilization and trends in utilization over time among a large sample of patients with type 1 diabetes with employer-sponsored insurance. Individuals aged 0–64 years were included in our sample, which allowed us to provide estimates of CGM utilization in children as well as adults. The MarketScan database captures real-world health care data across the full continuum of care, integrating inpatient, outpatient, and emergency services and outpatient pharmaceutical data. This database is well established and provides a unique resource for examining health care patterns in a large sample across the United States (38–40). Because the data are claims-based, we were able to capture all encounters for each patient regardless of where the encounters occurred, as long as they were billed through the insurance provider. This extensive tracking at the enrollee level allowed for CGM use to be captured via CPT or HCPCS II codes, through encounters as well as through pharmacy claims for CGM prescriptions that were actually filled as opposed to using medications ordered as a proxy.

There were several limitations to our study as well. First, we did not include individuals covered by publicly funded insurers (i.e., Medicare or Medicaid), which limits the generalizability of our results. Future studies should explore variation of CGM utilization among Medicare and Medicaid beneficiaries to understand how patterns differ and whether the differences observed here hold in these other populations. Second, a number of key demographic factors (e.g., race/ethnicity and socioeconomic indicators) were not included in our dataset; thus, we were not able to compare CGM utilization by these subgroups. Another limitation was the use of diagnosis codes to identify individuals with type 1

diabetes. However, prior studies have validated the use of ICD-9 and ICD-10 codes to identify individuals with type 1 diabetes and have found the positive predictive value compared with chart review to be 96.5% (41,42). Finally, with the data available in the MarketScan database, we were unable to distinguish provider type (endocrinology vs. primary care), use of insulin pump, type of CGM system (intermittently scanned vs. real-time), or type of device used to collect CGM data (smartphone and app vs. a receiver). These data would have provided additional insights into some of the patterns of CGM use that we have presented here and should be explored in future studies.

Conclusion

In this large, geographically diverse sample of commercially insured individuals with type 1 diabetes, one in two individuals with type 1 diabetes in our sample (49.78%) used CGM during the 2016–2019 study period. This was a 2.5-fold increase in CGM utilization in less than a 10-year window (from 20.12% in 2010–2013 to 49.78% in 2016–2019). CGM utilization was highest among those aged 0–12 years compared with the other age-groups, females compared with males, those with HMO compared with PPO insurance, and those living in urban compared with rural areas. Widespread use of CGM could help people achieve better glycemic control and reduce complications associated with type 1 diabetes. Identifying populations with lower-than-expected utilization is a necessary first step in developing targeted interventions to increase CGM uptake and, ultimately, improve short- and long-term type 1 diabetes–related outcomes.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

M.E.L. and K.E.L. planned the study and acquired the data. M.E.L., K.E.L., O.A., and K.H. drafted the manuscript. M.E.L. and D.C.M. obtained funding. K.E.L. and K.H. performed statistical analyses, and M.E.L. advised on analyses. K.E.L., J.F., A.K.-N., and D.C.M. contributed to the study design. J.F., A.K.-N., and D.C.M. revised the manuscript. All authors approved the final manuscript for submission. M.E.L. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

PRIOR PRESENTATION

Findings from this study were presented at the American Diabetes Association's 82nd Scientific Sessions in New Orleans, LA, on 5 June 2022.

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