



Continuous Glucose Monitoring versus Self-Monitoring of Blood Glucose for Glycemic Control in Adolescents with Type 1 Diabetes: A Systematic Review

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ABSTRACT

Type 1 diabetes mellitus (T1D) is a chronic condition affecting children and adolescents, and inadequate glycemic control may increase the risk of acute and chronic complications and adversely affect quality of life. This systematic review aimed to synthesize evidence on the impact of adherence to blood glucose monitoring on glycemic control and to identify factors influencing monitoring adherence among children and adolescents with T1D. A systematic literature search was conducted in Scopus, PubMed, and ProQuest for studies published between 2021 and 2026. Study selection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review protocol was registered in PROSPERO (CRD420261403299). The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tool, and findings were synthesized narratively. Fifteen studies were included in the final review. The findings indicate that continuous glucose monitoring (CGM) is generally associated with improved glycemic control, including reductions in HbA1c, increased time in range, and reduced hypoglycemia in several study populations. Monitoring adherence was influenced by psychological factors, including diabetes-related distress and fear of glucose readings, as well as technological factors, family support, and healthcare-system factors. Overall, CGM may support glycemic management and monitoring adherence; however, its effectiveness depends on patient engagement, psychosocial support, access to technology, and appropriate clinical education. A multidisciplinary approach is therefore needed to optimize glucose-monitoring technologies and improve diabetes self-management among children and adolescents with T1D. These findings highlight importance of integrating technological, behavioral, and clinical support into diabetes care.

INTRODUCTION

Type 1 diabetes mellitus (T1D) is a chronic metabolic disorder that commonly develops during childhood and adolescence and requires lifelong insulin therapy and daily self-management. Adolescents with T1D face particular challenges in maintaining optimal glycemic

control because diabetes management must be integrated with school activities, social interactions, physical activity, and increasing independence in self-care. Inadequate glycemic control may increase the risk of acute complications, including hypoglycemia and diabetic ketoacidosis, as well as long-term diabetes-related complications and reduced quality of life (Madrigal et al., 2020). Therefore, achieving and maintaining appropriate glycemic control is an important component of diabetes management during adolescence. Glycemic control is commonly assessed using glycated hemoglobin (HbA1c), which reflects average blood glucose levels over approximately the previous 2–3 months (Mandeep et al., 2026). However, HbA1c alone does not capture daily glucose fluctuations or episodes of hypoglycemia and hyperglycemia. Time in range (TIR), together with measures of time below and above range, provides additional information about daily glycemic patterns and is increasingly used to complement HbA1c in the assessment of diabetes management (de Bock et al., 2022; Wallia & Seley, 2022). Achieving appropriate glycemic targets is important because both persistent hyperglycemia and hypoglycemia may adversely affect health and quality of life in children and adolescents with diabetes (de Bock et al., 2022).

Self-monitoring of blood glucose (SMBG) has traditionally been used to obtain information about blood glucose levels through capillary blood measurements. SMBG provides information that can support immediate treatment decisions, including insulin adjustment and the prevention or management of hypo- and hyperglycemia. Continuous glucose monitoring (CGM), in contrast, provides continuous or frequent glucose measurements and information about glucose trends, allowing users and healthcare professionals to identify changes in glucose levels in real time. Current clinical guidelines recommend CGM as an important component of diabetes management for children and adolescents who are able to use the technology safely (Wallia & Seley, 2022). CGM-derived measures, including TIR and time below and above range, can be used together with HbA1c to provide a more comprehensive assessment of glycemic control (de Bock et al., 2022; Wallia & Seley, 2022). Despite advances in glucose-monitoring technologies, consistent monitoring and effective use of monitoring data remain challenging for young people with T1D. Psychological and behavioral factors, including diabetes-related distress, fatigue associated with diabetes management, fear of glucose readings, and concerns about appearing different from peers, may influence engagement with diabetes monitoring (Arslan et al., 2025). In addition, family support, communication, health literacy, access to diabetes technology, cost, and healthcare-system factors may affect the ability of young people to use glucose-monitoring technologies effectively. Previous evidence has also indicated that disparities in access to diabetes technology may influence the achievement of glycemic targets among children and adolescents with diabetes (de Bock et al., 2022). Therefore, the benefits of glucose-monitoring technologies may depend not only on the technology itself but also on sustained use, education, behavioral support, and access to appropriate clinical care.

Although previous studies have evaluated SMBG and CGM in people with T1D, evidence regarding their comparative effects on glycemic outcomes in adolescents remains heterogeneous. Differences in study populations, intervention duration, baseline glycemic control, monitoring technologies, and healthcare settings may contribute to variation in reported outcomes. Recent studies have reported beneficial effects of CGM on glycemic control among adolescents and young adults with T1D, including improvements in HbA1c and other

glycemic measures (Miller et al., 2023a). However, variation in findings and differences in the characteristics of available studies indicate the need for a systematic synthesis of evidence focused on glucose-monitoring approaches in young people with T1D.

This systematic review aimed to evaluate the effects of continuous glucose monitoring compared with self-monitoring of blood glucose on glycemic outcomes among adolescents with type 1 diabetes mellitus, with particular attention to HbA1c, time in range, and hypoglycemia.

METHODS

Review Design and Eligibility Criteria

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The protocol was registered in PROSPERO (CRD420261403299).

Eligibility criteria were structured using the Population, Intervention, Comparison, Outcomes, and Study Design (PICOS) framework. The target population comprised adolescents with type 1 diabetes mellitus. Interventions included continuous glucose monitoring (CGM), self-monitoring of blood glucose (SMBG), or monitoring adherence. Comparators included standard care, SMBG, non-CGM use, or low adherence. Outcomes comprised glycated hemoglobin (HbA1c), time in range (TIR), hypoglycemia, diabetic ketoacidosis, and quality of life. Eligible studies used quantitative designs, were published between 2021 and 2026, and were written in English or Indonesian. Reviews, qualitative studies, and studies without relevant populations or glucose-monitoring outcomes were excluded. Protocol publications without outcome data were excluded from the final synthesis.

Search Strategy and Study Selection

A literature search was conducted in Scopus, PubMed, and ProQuest. Search terms were developed using Medical Subject Headings (MeSH) and combined with Boolean operators. The terms covered type 1 diabetes, glucose monitoring, adolescents, adherence, effectiveness, and glycemic control. Database-specific search strategies are presented in Table 1.

Table 1. Research Strategy

Basis Data	Strategi Pencarian	Studi (n)
Scopus	("Type 1 Diabetes Mellitus" OR T1DM OR "juvenile diabetes") AND ("Self-Monitoring of Blood Glucose" OR SMBG OR CGM OR "continuous glucose monitoring") AND (adolescent* OR youth OR teenager*) AND (adherence OR compliance) AND (HbA1c OR glycemic control)	52
Pubmed	("blood glucose" OR "glucose monitoring") AND ("adolescents" OR "teenagers" OR "youth") AND ("type 1 diabetes" OR "T1D" OR "insulin-dependent diabetes" OR "juvenile diabetes") AND ("effectiveness" OR "efficacy" OR "impact" OR "outcomes")	29
Proquest	("glucose" OR "monitoring") AND ("adolescents" OR "youth") AND ("diabetes mellitus type 1" OR "insulin-dependent diabetes")	17

Study selection involved duplicate removal, title and abstract screening, and full-text

eligibility assessment. Two reviewers independently assessed records against the eligibility criteria. Disagreements were resolved through discussion and consensus.

Data Extraction and Quality Assessment

Two reviewers independently extracted data using structured, standardized forms. Extracted information included author and publication year, country, study design, participant characteristics, study objectives, measurement instruments, and findings related to glucose monitoring. Discrepancies were resolved by consensus.

Methodological quality was independently assessed by two reviewers using the Joanna Briggs Institute (JBI) Critical Appraisal Tool according to study design. Scores were calculated from the number of criteria met. The review classified scores of $\geq 75\%$ as indicating low risk of bias and scores of 50–74% as indicating moderate risk of bias. Disagreements were resolved through discussion and consensus.

Data Synthesis

Findings were synthesized narratively because of heterogeneity in study designs, populations, and outcome measures. The synthesis compared patterns, similarities, and differences across studies and examined determinants of monitoring, including sociodemographic, psychological, cultural and religious, healthcare-system, and information-related factors. Studies providing relevant contextual information were considered in the discussion.

RESULTS

The search identified 98 records from Scopus ($n = 52$), PubMed ($n = 29$), and ProQuest ($n = 17$). The attached PRISMA diagram reports removal of four duplicates and five records marked as ineligible by automation tools, leaving 89 records for screening. Twenty-one records were excluded by title, and 68 reports were sought for retrieval. Twenty reports were recorded as not retrieved, leaving 48 for eligibility assessment. Thirty-three reports were subsequently excluded, resulting in 15 studies reported as included. The selection process is presented in Figure 1.

Study Characteristics

The characteristics of the 15 study records are summarized in Table 2, including study design, location, participants, intervention, comparator, intervention duration, and reported findings.

The records covered CGM, automated insulin delivery systems incorporating CGM, remote glucose monitoring, diabetes support systems, behavioral interventions, and adjunctive pharmacological therapies. Participants included young children, adolescents, young adults, and adults. Reported intervention or follow-up periods ranged from 48 hours to three years. Three records—DAYTime, TZP-T1D, and BANDIT—were protocol publications and therefore did not provide completed trial outcomes. Differences in population and intervention also indicated that not all records directly addressed CGM compared with SMBG in adolescents.

Methodological Quality

The reported JBI appraisal scores are presented in Table 3.

Table 3. Critical Appraisal with JBI

No	Author, Years	Study Design	JBI (%) critical Appraisal
1.	(Deshpande et al., 2024)	RCT	11/13 (84.6%)
2.	(Miller et al., 2023b)	RCT	12/13 (92.3%)
3.	(Bisio et al., 2022)	RCT	11/13 (84.6%)
4.	(Sinisterra et al., 2021)	RCT	13/13 (100%)
5.	(Group et al., 2022)	RCT	12/13 (92.3%)
6.	(Piloya-Were et al., 2026)	RCT	11/13 (84.6%)
7.	(Crossen et al., 2023)	RCT	11/13 (84.6%)
8.	(Zhou et al., 2025)	RCT	12/13 (92.3%)
9.	(Shapiro et al., 2022)	RCT	11/13 (84.6%)
10.	(Brown et al., 2021)	RCT	13/13 (100%)
11.	(Purcell, Natassia, et al., 2025)	RCT	11/13 (84.6%)
12.	(Mahmud et al., 2025)	RCT	12/13 (92.3%)
13.	(Jalilova et al., 2024)	RCT	12/13(92.3%)
14.	(Waibel et al., 2022)	RCT	13/13 (100%)
15.	(O'Donnell et al., 2021)	RCT	11/13 (84.6%)

Seven records scored 11/13 (84.6%), five scored 12/13 (92.3%), and three scored 13/13 (100%). However, all records were classified as randomized controlled trials despite the presence of protocols and other study designs. These scores therefore remain provisional pending verification of study classification and eligibility.

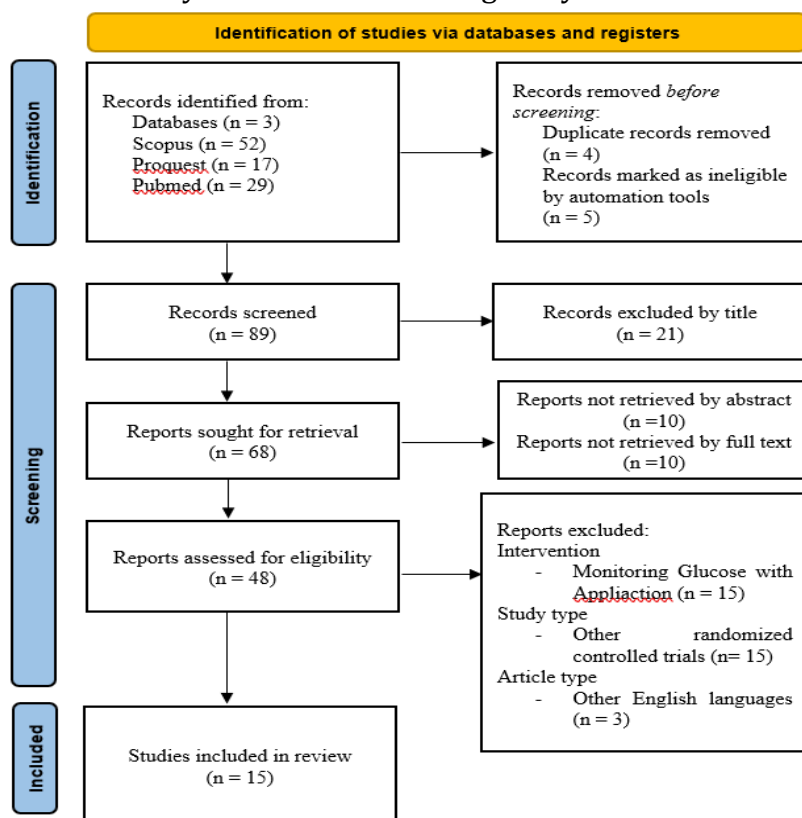
**Figure 1.** Prisma Flow Diagram

Table 2. Characteristics, Interventions, and Reported Findings of the Study Records

No	Title, Author, Years	Design	Country	Respondent	Intervention		Frequency and Period Intervention	Result
					Trial	Control		
1	Feasibility and Preliminary Safety of Smartphone-Based Automated Insulin Delivery in Adolescents and Children With Type 1 Diabetes (Deshpande et al., 2024)	RCT	USA	20 adolescents	Using AID (Automated Insulin Delivery)	Manual blood glucose monitoring.	Within 48 hours	The smartphone-based AID was feasible and safe in sequentially younger cohorts of adolescents and children
2	Continuous Glucose Monitoring Provides Durable Glycemic Benefit in Adolescents and Young Adults with Type 1 Diabetes: 12-Month Follow-Up Results (Miller et al., 2023b)	RCT	USA	153 adolescents and young adults aged 14 to <25 years	Using Continuous Glucose Monitoring (CGM) devices in conjunction with Blood Glucose Monitoring (BGM).	Using a CGM device only.	Use for 52 weeks.	This further evaluation of CGM supports the findings of the preceding RCT that use of CGM improves glycemic control and reduces hypoglycemia in adolescents and young adults with type 1 diabetes
3	Impact of a Novel Diabetes Support System on a Cohort of Individuals With Type 1 Diabetes Treated With Multiple Daily Injections: A Multicenter Randomized Study (Bisio et al., 2022)	RCT	New York	Adults and adolescent age >15 years	Using a CGM and a smart insulin pen	Use CGM only.	Use for 14 weeks.	Our DSS seems to be a feasible option for individuals using MDI, although the gly- cemic benefits associated with use need to be further investigated.

4	Patterns of Continuous Glucose Monitor Use in Young Children Throughout the First 18 Months Following Type 1 Diabetes Diagnosis (Sinisterra et al., 2021)	RCT	USA	Young children 1-6 years	Using CGM	Does not use CGM.	Used for 18 months.	Given the health benefits of CGM, further exploration of barriers to CGM use in families with public health insurance is needed
5	Positive Impact of the Bionic Pancreas on Diabetes Control in Youth 6–17 Years Old with Type 1 Diabetes: A Multicenter Randomized Trial (Group et al., 2022)	RCT	USA	165 youth	their personal standard care insulin delivery (SC group) plus real-time continuous glucose monitoring (CGM)	Not using CGM, and using traditional methods.	Use for 13 weeks.	In youth 6–17 years old with T1D, use of insulin-only configuration of BP improved HbA1c, TIR, and hyperglycemic metrics without increasing CGM-measured hypoglycemia compared with standard of care.
6	A Study Protocol for a Randomized, Controlled Trial: Improving Glucose Time-in-Range in Diabetes in African Youth (DAYTime)(Piloya-Were et al., 2026)	RCT	East Africa	144 participant	Received CGM treatment	Performing SBMG	For 6 months	Improving time in range (TIR) through continuous glucose monitoring (CGM) is crucial, as it can improve diabetes management and reduce complications
7	Remote glucose monitoring is feasible for patients and providers using a commercially available population health platform (Crossen et al., 2023)	RCT	California	Patients aged 1-20 years	People with T1D who use CGM	Patients with T1D do not use CGM	Three months of CGM use.	This study demonstrates the feasibility of RPM for patients with T1D using a commercially available population health platform, and suggests that RPM with clinician-initiated outreach may be

								particularly beneficial for patients with suboptimal glycemic control at entry.
8	Use of Freestyle Libre 2.0 in children with type 1 diabetes mellitus and elevated HbA1c: Extension phase results after a 12-week randomized controlled trial (Zhou et al., 2025)	RCT	Australia	66 participants children	Glycaemic outcomes with isCGM 2.0	Self-monitored blood glucose	Use of iSCGM for 24 weeks	After 24 weeks of using iSCGM 2.0, there was a sustained improvement in the frequency of hypoglycemia tests
9	Do baseline resilience profiles moderate the effects of a resilience-enhancing intervention for adolescents with type 1 diabetes (Shapiro et al., 2022)	RCT	Illinois	264 adolescents	Using CGM in diabetes management.	Diabetes management only.	Treatment provided over a three-year period.	Type 1 diabetes, adolescent, resilience, latent profile analysis, intervention
10	Multicenter Trial of a Tubeless, On-Body Automated Insulin Delivery System With Customizable Glycemic Targets in Pediatric and Adult Participants With Type 1 Diabetes (Brown et al., 2021)	RCT	California	235 participants	Interoperable glucose sensor (Dexcom G6; Dexcom, San Diego, CA), and a mobile app (Omnipod 5 app) on a locked-down Android phone.	Manual monitoring through monthly HbA1c lab tests.	The exercise was performed for five minutes a day for three months.	This tubeless automated insulin delivery system was safe and allowed participants to significantly improve HbA _{1c} levels and time in target glucose range with a very low occurrence of hypoglycemia.
11	Tirzepatide for the treatment of adults living with	RCT	Australia	60 participants aged 18-70	The use of CGM and weight management in	Just weight management.	Use for 32 weeks	Patients using CGM demonstrated improvement in

	concurrent type 1 diabetes and overweight or obesity (TZP-T1D): a double-blind, placebo-matched randomised controlled trial protocol (Purcell, Rodrigo, et al., 2025)			years	patients with T1D.			HbA _{1c} regardless of prior SMBG. Increased engagement with CGM likely promoted increased insulin boluses.
12	Adjunct-to-insulin therapy using SGLT2 inhibitors in youth with type 1 diabetes: a randomized controlled trial (Mahmud et al., 2025)	RCT	US	98 participants age 12-21 years	The use of CGM with SGLT2 inhibitor therapy.	Using SGLT2 inhibitor therapy.	22 weeks of use.	These data suggest that while youth with T2D have worse fluid cognition than youth with T1D, these differences are accounted for by differences in crystallized cognition (receptive language), central adiposity, and mental health.
13	The psychosocial outcomes of advanced hybrid closed-loop system in children and adolescents with type 1 diabetes (Jalilova et al., 2024)	RCT	US	60 children and adolescent	The use of CGM while taking psychological factors into account.	We do not use CGM. However, we take into account the psychological well-being of both pediatric and adult patients with T1D.	It was conducted over a period of six months.	In this large real-world pediatric exercise study, nocturnal hypoglycemia was higher on nights when average activity duration was higher.

14	Investigating the efficacy of baricitinib in new onset type 1 diabetes mellitus (BANDIT)—study protocol for a phase 2, randomized, placebo controlled trial (Waibel et al., 2022)	RCT	Australia	83 participants	Using CGM while taking self-efficacy into account.	Focusing only on self-efficacy.	The treatment was administered over a period of 48 weeks.	Geographic location presents a meaningful barrier to access to care for patients living with type 1 diabetes.
15	Pump It Up! A randomized clinical trial to optimize insulin pump self-management behaviors in adolescents with type 1 diabetes (O'Donnell et al., 2021)	RCT	US	130 participants	Focusing on glycemic control and improving self-management.	Just focus on self-management.	It was conducted over a two-month period.	The results show that the extended use of CLC-P at home until delivery is feasible. Inventory).

Glycemic Outcomes

Miller et al. reported sustained improvements in glycemic control and reduced hypoglycemia following CGM use in adolescents and young adults. The bionic pancreas study reported improvements in HbA1c, TIR, and hyperglycemic measures without increased CGM-measured hypoglycemia. Brown et al. reported improved HbA1c and time in the target glucose range with tubeless automated insulin delivery. The manuscript also described sustained improvement in hypoglycemia-related measures during the FreeStyle Libre 2.0 extension study.

Numerical outcome data were not consistently extracted across studies. Consequently, the available information did not support a reliable quantitative synthesis of HbA1c, TIR, hypoglycemia, hyperglycemia, or diabetic ketoacidosis.

Feasibility and Contextual Findings

Deshpande et al. reported the feasibility and preliminary safety of smartphone-based automated insulin delivery. Bisio et al. described a diabetes support system as feasible but indicated that its glycemic benefits required further investigation. Crossen et al. reported the feasibility of remote glucose monitoring with clinician-initiated outreach. Sinisterra et al. identified the need to further examine barriers to CGM use among families with public health insurance.

DISCUSSION

This systematic review evaluated glucose-monitoring approaches, particularly continuous glucose monitoring (CGM) compared with self-monitoring of blood glucose (SMBG), among young people with type 1 diabetes mellitus (T1D). The evidence suggests that CGM-based approaches may improve HbA1c and time in range (TIR), while providing information about hypoglycemia and hyperglycemia beyond that captured by HbA1c. Automated insulin delivery (AID) systems incorporating CGM also improved glycemic outcomes without increased CGM-measured hypoglycemia in some pediatric populations. However, differences in populations, interventions, follow-up periods, outcome definitions, and numerical reporting prevented reliable quantification of these effects. Clinical benefits also depended on sustained device use, engagement with glucose data, psychosocial factors, family support, and access to care.

These findings are consistent with previous evidence reporting improved HbA1c and CGM-derived outcomes in children and adolescents with T1D. Nevertheless, CGM, AID, and behavioral interventions must be distinguished. CGM provides glucose information, whereas AID combines monitoring with automated insulin delivery. Benefits observed in AID studies therefore cannot be attributed exclusively to CGM. Current ISPAD guidance recognizes both the role of CGM and its integration into glucose-responsive AID systems.

CGM may improve glycemic management by providing frequent measurements, trends, and alerts that support timely decisions about insulin administration, food intake, and physical activity. TIR, time below range, and time above range also capture glycemic patterns that HbA1c may not reflect. However, information alone does not ensure effective self-management. Young people and caregivers need education to interpret data and respond appropriately. Diabetes-

related distress, treatment burden, device visibility, and competing social and educational demands may affect sustained use. CGM implementation therefore requires individualized goals, shared decision-making, behavioral education, family support, and ongoing clinical follow-up.

Substantial heterogeneity limits direct comparison across studies. Participants differed in age, baseline HbA1c, diabetes duration, previous technology use, insulin-delivery method, adherence, and clinical support. Studies also evaluated different technologies, including CGM alone, AID, and hybrid closed-loop systems. Participants with poorer baseline control may show larger HbA1c improvements, whereas those with better control may benefit through increased TIR or reduced hypoglycemia. Accordingly, small changes in HbA1c should not be interpreted as an absence of benefit when other glycemic outcomes improve.

The findings support CGM use in appropriately selected children and adolescents with T1D who can use the technology safely. Device selection should reflect patient and family circumstances, preferences, and needs. Equitable implementation requires attention to cost, device availability, healthcare infrastructure, digital literacy, education, and trained clinical support. CGM should accompany comprehensive diabetes self-management education, including guidance on interpreting trends, responding to alerts, and avoiding excessive treatment responses.

The review addressed clinically relevant glycemic outcomes and psychosocial and contextual influences on technology use. Its protocol was registered in PROSPERO (CRD420261403299), and the review was intended to follow PRISMA 2020. However, heterogeneous evidence and incomplete numerical extraction prevented reliable meta-analysis. Protocols and studies outside the review question must be excluded, and the study characteristics, risk-of-bias assessment, and PRISMA diagram must be reconciled. The appraisal table also requires reconstruction to distinguish randomized trials from observational, feasibility, psychosocial, and protocol publications. Evidence certainty must remain cautiously interpreted until these issues are resolved.

Future research should directly compare CGM with SMBG in clearly defined adolescent populations using rigorous randomized controlled trials. Studies should standardize outcome definitions, report numerical glycemic and quality-of-life outcomes, document adherence and actual CGM wear time separately from treatment allocation, and use longer follow-up. Research should also examine socioeconomic conditions, technology access, family support, distress, health literacy, and healthcare-system factors, while distinguishing CGM effects from those of AID. Future reviews should apply explicit PICOS criteria, exclude ineligible publications, use design-appropriate appraisal tools, and standardize numerical extraction. When heterogeneity precludes meta-analysis, transparent narrative synthesis should describe the direction, consistency, and strength of the evidence.

CONCLUSION

The effectiveness of CGM is not universal and is greatly influenced by behavioral, social, and health care system factors. Variation in results between studies shows the importance of considering population heterogeneity, health literacy levels, family support, and access to

technology. Therefore, the implementation of CGM needs to be accompanied by comprehensive education and a multidisciplinary approach to ensure optimal utilization.

CGM has great potential to improve the quality of life of adolescents with type 1 diabetes mellitus, but its success depends on the integration of technology, clinical support, as well as behavioral-based interventions. Going forward, efforts are needed to improve accessibility, reduce the usage gap, and develop innovative strategies that can maximize the benefits of CGM in various population and health system contexts.

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