Evidence for improved glucose metrics and perinatal outcomes with continuous glucose monitoring compared to self-monitoring in diabetes during pregnancy

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OBJECTIVE: Continuous glucose monitoring is recommended for pregnant women with type 1 diabetes, due to associations with decreased hemoglobin A1c and large for gestational age. However, its benefit in type 2 diabetes and gestational diabetes is not established. This systematic review and meta-analysis compared usage of continuous glucose monitoring to self-monitoring of blood glucose both across and within diabetes in pregnancy and determined which glucose metrics are associated with perinatal outcomes, to potentially inform treatment targets in diabetes in pregnancy.

DATA SOURCES: We searched Medline, Embase, CENTRAL, CINAHL, and Scopus, from January 2003 to August 2024.

STUDY ELIGIBILITY CRITERIA: Randomized controlled trials and quasi-experimental studies comparing continuous glucose monitoring with self-monitoring of blood glucose in diabetes in pregnancy were included.

STUDY APPRAISAL AND SYNTHESIS METHODS: Randomized controlled trials and quasi-experimental studies were analyzed separately. Data were extracted on continuous glucose monitoring metrics, hemoglobin A1c, rates of cesarean delivery, large for gestational age, small for gestational age, neonatal hypoglycemia, and neonatal intensive care unit admission, summarized as mean differences or odds ratios with 95% confidence intervals and 95% prediction intervals. Prespecified subgroup analyses were undertaken by diabetes in pregnancy subtype, including duration of continuous glucose monitoring use (continuous vs intermittent) for large for gestational age. Certainty of evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluations framework.

RESULTS: Across diabetes in pregnancy, continuous glucose monitoring (vs self-monitoring of blood glucose) decreased hemoglobin A1c (mean difference, −0.22% [95% confidence interval, −0.37, −0.08]) (7 randomized controlled trials, moderate-certainty evidence). Within diabetes in pregnancy, continuous glucose monitoring use (vs self-monitoring of blood glucose) showed similar but stronger benefits in both type 1 diabetes when used throughout pregnancy (hemoglobin A1c mean difference, −0.18% [95% confidence interval, −0.36, 0.00]; large for gestational age odds ratio, 0.51 [0.28, 0.90]) (1 randomized controlled trial, high-certainty evidence), and gestational diabetes when used intermittently (hemoglobin A1c mean difference, −0.18 [95% confidence interval, −0.33, −0.02]) (5 randomized controlled trials, moderate-certainty evidence) and large for gestational age (odds ratio, 0.46 [0.26, 0.81]) (1 quasi-experimental study, low-certainty evidence), with insufficient data for continuous glucose monitoring benefit in type 2 diabetes. Increased pregnancy %time-in-range (type 1 diabetes) and decreased mean sensor glucose (type 1 diabetes/gestational diabetes) were associated with decreased large for gestational age.

CONCLUSION: Usage of continuous glucose monitoring (vs self-monitoring of blood glucose) reduces hemoglobin A1c and possibly large for gestational age across diabetes in pregnancy. Greatest benefit was evidenced in type 1 diabetes, followed by gestational diabetes, although continuous glucose monitoring duration differed. Mean sensor glucose and pregnancy %time-in-range are important continuous glucose monitoring metrics for reducing large for gestational age.

Key words: continuous glucose monitoring (CGM), gestational diabetes (GDM), large-for-gestational age (LGA), meta-analysis, systematic review, type 1 diabetes (T1D) in pregnancy, type 2 diabetes (T2D) in pregnancy

Introduction

Diabetes in pregnancy (DIP), encompassing pregestational diabetes (type 1 diabetes [T1D], type 2 diabetes [T2D]) and gestational diabetes (GDM), complicates>21 million (17%) live births globally each year.[1] DIP is associated with greater risk of pregnancy complications, including stillbirth, congenital malformations, large for gestational age (LGA), and preeclampsia, related to maternal hyperglycemia.[2,3] Long-term DIP leads to greater risk of obesity, T2D, and cardiovascular disease in both mother and offspring.[2] Despite improvements in DIP management, perinatal complications have not normalized to background population frequencies.[3] Optimizing management of maternal hyperglycemia is essential to reduce intergenerational complications of DIP.[4]

Self-monitoring of blood glucose (SMBG) in DIP currently represents standard care to guide glucose management.[5,6] Fasting and either 1-hour or 2-hour postprandial SMBG is usually recommended, although SMBG treatment targets vary internationally.[2] A recent meta-analysis of SMBG as a component of GDM management reported less preeclampsia (risk ratio [RR], 0.61 [95% confidence intervals [CIs], 0.46, 0.81]),

AJOG at a Glance

Why was this study conducted?

To provide a comprehensive systematic review and meta-analysis of the benefits of continuous glucose monitoring (CGM) on maternal glucose and perinatal outcomes across and within diabetes in pregnancy (DIP) and determine glucose metrics associations with perinatal outcomes, to inform treatment targets in DIP.

Key findings

Within DIP, usage of CGM compared to self-monitoring reduces hemoglobin A1c and large for gestational age (LGA).

Increased pregnancy %time-in-range (3.5 to 7.8 mmol/L [63 to 140 mg/dL]) for type 1 diabetes (T1D) and decreased mean sensor glucose for T1D and gestational diabetes (GDM) are associated with decreased LGA.

What does this add to what is known?

Benefits of CGM may extend beyond T1D to GDM.

Targeting mean sensor glucose (T1D/GDM) and pregnancy %time-in-range (T1D) are important for reducing LGA.

LGA (RR, 0.58 [0.46, 0.72]), and macrosomia (RR, 0.44 [0.34, 0.57]) compared to facility-based (clinic) glucose monitoring (moderate-certainty evidence).[7]

The Continuous glucose monitoring in pregnant women with type 1 diabetes (CONCEPTT) randomized controlled trial (RCT)[8] demonstrated the benefit of real-time continuous glucose monitoring (rt-CGM) use throughout pregnancy, providing 24-hour interstitial glucose data. The addition of continuous glucose monitoring (CGM) compared to SMBG lowered third trimester maternal hemoglobin A1c (HbA1c) by (mean difference [MD], 0.19% [95% CI, -0.34, -0.03]) translating into significantly less LGA (odds ratio [OR], 0.51 [95% CI, 0.28, 0.90]), neonatal hypoglycemia (OR, 0.45 [0.22, 0.89]), and >24-hour admissions to the neonatal intensive care unit (NICU) (OR, 0.48 [0.26, 0.86]).[8] International guidelines now recommend CGM in women with T1D preconception and during pregnancy.[5,6] Subsequent real-world CGM uptake has been significant, with a UK national audit from 2021 to 2022 showing that 95% of pregnant women with T1D were using CGM.[9] In the United States, registry data showed CGM use increased from 20.6% to 30.0% from 2015 to 2018.[10] Notably, sociodemographic disparities in access were prevalent, with women who do not use CGM at the greatest risk of adverse pregnancy outcomes.[10]

Despite increasing interest in the use of CGM in T2D and GDM, it is uncertain whether similar benefits in pregnancy outcomes are seen. It is also unclear which CGM metrics and thresholds currently recommended outside of pregnancy (eg, %time-in-range, mean sensor glucose [SG], glucose variability)[11] best predict pregnancy complications across DIP.

The aim of this systematic review and meta-analysis was to determine the benefit of CGM vs SMBG in the management of DIP, including CGM metric associations with perinatal outcomes, to potentially inform DIP treatment targets.

Methods

Information sources and search strategy

This systematic review and meta-analysis was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist (Supplemental Table 1). The protocol was registered with the International Prospective Register of Systematic Reviews (CRD42023426645).

Systematic literature searches were performed in Medline, Embase, CENTRAL, CINAHL, and Scopus for relevant studies published between January 2003 and August 2024 (Supplemental Table 2). The search was restricted to RCTs and quasi-experimental studies (intervention studies where participants are not randomized to their assigned groups) in humans comparing outcomes

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All data supporting the findings of this study are available within the paper and its Supplemental Information.

PROSPERO Registration: CRD42023426645, June 3, 2023 (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=426645).

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for CGM vs SMBG both across and within DIP (T1D, T2D and GDM). Key words for pregnancy, type of diabetes, CGM, and SMBG were used. There were no language restrictions.

Study selection

Eligible publications met the following criteria: participants were pregnant with T1D, T2D, or GDM; used CGM continuously, intermittently, or once; SMBG comparator group; reported maternal glycemia and/or perinatal outcomes; and RCT or quasi-experimental study design.

Studies were excluded if participants were not pregnant (eg, prepregnancy), no comparator SMBG group, non-RCTs or nonquasi-experimental studies, where only an abstract was available, or conducted in the in-patient setting.

Data extraction

Study and participant characteristics were independently extracted by J.B. and A.S. with conflicts resolved by T.L.H. using Covidence (Veritas Health, Innovation, Melbourne, Australia). Data extracted included cohort characteristics (country, enrollment years, study design, and sample size), participant characteristics (age, body mass index [BMI], and type of diabetes), CGM data (type, brand, and duration used), and outcomes: maternal glycemia (HbA1c) and perinatal outcomes (gestational weight gain [GWG], preeclampsia, cesarean delivery, preterm birth, congenital malformations, birthweight, LGA, small for gestational age [SGA], macrosomia, respiratory distress syndrome, hypoglycemia, hyperbilirubinemia, NICU admission, stillbirth, and neonatal death). Additionally, CGM metric (Supplemental Box 1) associations with perinatal outcomes were extracted.

Assessment of risk of bias

Risk of bias for each study was assessed using modified Joanna Briggs Institute tools for RCTs[12] and quasi-experimental studies[13] (Supplemental Questions 1 and 2). Studies were considered low quality with ≥3 poor quality metrics. Certainty of evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluations framework,[14] rated as high, moderate, low, and very low (Supplemental Tables 5 and 6).

Data synthesis and analysis

RCT and quasi-experimental studies were analyzed separately, with RCT data reported as primary analysis and quasi-experimental data as supporting evidence. Summary measures of effect for CGM vs SMBG across DIP were presented as weighted MD with 95% CI and 95% prediction intervals (PIs) (estimate of the range of possible effect for future studies) for continuous outcomes (third trimester HbA1c) and weighted OR with 95% CI and 95% PI for categorical outcomes (cesarean delivery, LGA, SGA, neonatal hypoglycemia, and NICU admission) using the Dersimonian and Laird random effects model accounting for within-study and between-study variance. Prespecified subgroup analyses were undertaken by DIP subtype (T1D, T2D, GDM, or mixed DIP), with duration of CGM use (continuous vs intermittent) additionally undertaken for LGA. Heterogeneity was assessed using Cochran's Q test and I^2 statistics; considered present if $I^2>75$. Review Manager web (version 8.17.0) was used for meta-analyses and to calculate effect measures, and presented in forest plots.

Results

Study selection

Figure 1 outlines the study selection process. Characteristics of 18 studies (14 RCTs and 4 quasi-experimental studies) representing 2630 participants are summarized in Table. Two CONCEPTT subanalyses[17,18] were not included in the primary RCT analyses, but did examine associations between CGM metric and perinatal outcomes.

Study characteristics

Study sample size ranged from 40 to 340 participants conducted across 17 countries, most frequently China,[19,25,27,31,32] Italy,[8,21] Poland,[15,26] Spain,[8,16] and the United States.[8,28] Five studies reported mixed DIP results[20–24] with 2 also reporting selected outcomes by DIP subtype.[22,24] Participant BMI was reported in 17 studies, with mean or median BMI in the normal range (18.5 to 24.9 kg/m^2) in 6 studies,[15,16,25–27,32] overweight range (25.0 to 29.9 kg/m^2) in 9 studies,[8,19–24,29,33] and obesity class I range (30.0 to 34.9 kg/m^2) in 2 studies.[28,30]

Three types of CGM were used: rt-CGM (6 studies),[8,15,22,25,28,30] intermittently scanned CGM (5 studies),[16,19,21,26,27] and retrospective CGM (6 studies).[23,24,29,31–33] One study used a mixture of rt-CGM and intermittently scanned CGM.[20] Duration of CGM use varied from 48 hours (1 study)[33] to entire pregnancy (5 studies).[8,15,16,20,21] Seven studies used CGM intermittently,[22–25,29,31,32] and 6 studies used CGM at a single time point in pregnancy, ranging from 48 hours to 4 weeks duration.[19,26–28,30,33]

Antihyperglycemic medication use varied (Table). Of 10 studies[24–27,29–34] including participants with GDM, 1 study included only Class-A1 (diet and exercise–treated) GDM,[27] 2 studies included only Class-A2 (insulin-treated) GDM,[24,29] 6 studies included both (insulin when required),[25,26,28,30–32] and 1 study included insulin or metformin when required.[33]

Risk of bias assessment

Of 14 RCTs, 4 were classified as high quality[8,22,24,26] and 10 as medium quality[19,21,23,25,27–31,33] (Supplemental Table 3). Of 4 quasi-experimental studies, 3 were classified as medium quality,[15,16,32] with the remaining low-quality study excluded from meta-analysis[20] (Supplemental Table 4). The most frequent domain ranked low for RCTs and quasi-experimental studies (43% and 75%, respectively) related to statistical conclusion validity (not powered for measured outcomes and no true intention-to-treat analysis) (Supplemental Figures 1 and 2).

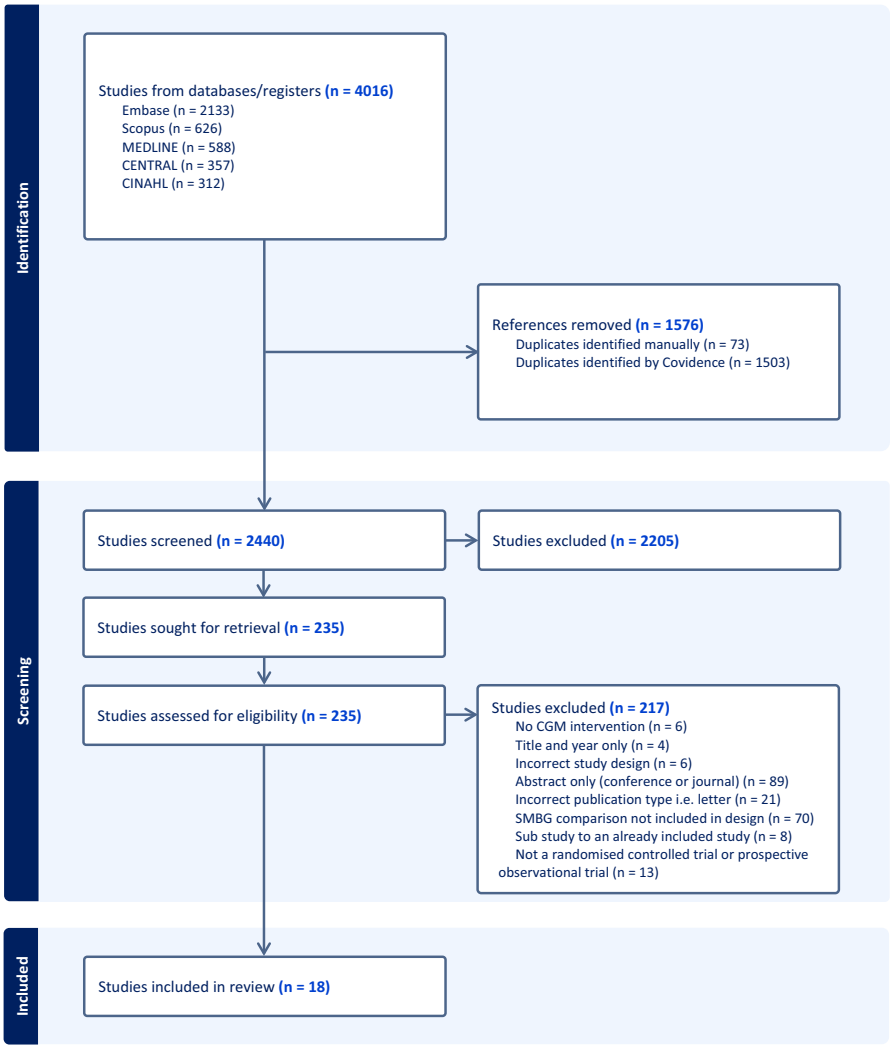
Synthesis of results

Maternal hemoglobin A1c

Across diabetes in pregnancy

Seven RCTs[8,23,25,28–31] and 1 quasi-experimental study[15] assessed the effect of CGM vs SMBG on third trimester

FIGURE 1
PRISMA flow diagram of literature search



PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

HbA1c. Meta-analysis of RCTs showed CGM (vs SMBG) was associated with lower third trimester HbA1c across DIP (n=683; MD, −0.22% [95% CI, −0.37, −0.08] [95% PI, −0.56, 0.12]) (some heterogeneity present, I^2=71%) (moderate-certainty evidence) (Figure 2). Quasi-experimental data demonstrated similar benefit on third trimester HbA1c for CGM use (low-certainty evidence) (Supplemental Figure 7).

Within diabetes in pregnancy

T1D: Of 5 studies[8,15,16,22,24] reporting on HbA1c, 1 RCT[8] and 1 quasi-experimental study[15] reported data that could be used to calculate effect measures. Based on the CONCEPTT RCT,[8] CGM (vs SMBG) was associated with lower third trimester HbA1c (n=187; MD, −0.18% [−0.36, 0.00]) (Figure 2) (high-certainty evidence), supported by quasi-experimental data[15] (n=194; MD, −0.30% [−0.52, −0.08]) (low-certainty evidence).

T2D: Of 2 studies[22,24] reporting on third trimester HbA1c, no differences were found between CGM and SMBG (Supplemental Table 8).

Mixed DIP: Of RCTs (4—mixed T1D, T2D[20—23]; 1—mixed T1D, T2D, GDM[24]) reporting on third trimester HbA1c, a single RCT could be used to calculate effect measures, with CGM (vs SMBG) associated with decreased third trimester HbA1c (n=71; MD, −0.60% [−0.91, −0.29]) (Figure 2).

GDM: Of 7 RCTs[24—26,28—31] reporting on third trimester HbA1c, 5[25,28—31] were meta-analyzed. CGM (vs SMBG) reduced third trimester HbA1c (n=425; MD, −0.18% [−0.33, −0.02] [95% PI: −0.50, 0.14]) (some heterogeneity present, I^2=68%) (Figure 2) (moderate-certainty evidence).

Continuous glucose monitoring metrics

Across diabetes in pregnancy

Eight RCTs and[8,21,25,28—31,35] 4 quasi-experimental studies[15,16,20,32] reported on CGM glucose metrics,

TABLE
Study characteristics of studies included in the systematic review

Study|year	Country|enrollment years	Study design	Type of diabetes	Sample size	CGM type	CGM brand|device name	CGM duration|timeframe	Antihyperglycemic medication	Main outcome reported
Cypryk[15]|2023	Poland|2013—2017	Quasi-experimental	T1D	Total: 262; CGM: 130; Comparator: 132	rt-CGM	Medtronic Minimed|Paradigm REAL-time 722[a], Paradigm Veo[a]	Entire pregnancy+6 wk	CSII	HbA1c (T1—T3)
Perea[16]|2022	Spain	Quasi-experimental	T1D	Total: 300; CGM: 132; Comparator: 168	is-CGM	Abbott|Freestyle Libre, Freestyle Libre 2	14 (8.9—20) wk to delivery	MDI	LGA[b]
Feig[8,17,18]|2017	Canada, England, Ireland, Italy, Scotland, Spain, USA|2013—2016	RCT	T1D	Total: 215; CGM: 108; Comparator: 107	rt-CGM[c]	Medtronic|Guardian REAL-time, MiniMed Minilink	10.5 (2.2) wk to delivery	CSII or MDI	HbA1c change T1—T2 and T2—T3[b]
Li[19]|2021	China|2016—2018	RCT	T2D	Total: 124; CGM: 64; Comparator: 60	is-CGM	Abbott|Freestyle Libre	14 d|12—14 wk	MDI	GA and urinary ketones
Toft[20]|2022	Norway|2016—2018	Quasi-experimental	T1D & T2D	Total: 40 (T1D: 26, T2D: 13, MODY: 1); CGM: 20 (T1D: 19, T2D: 1); Comparator: 20 (T1D: 7, T2D: 12, MODY: 1)	rt-CGM (& 1 is-CGM)	Various	T1 to delivery	CSII or MDI and/or Metformin	GA and CGM metrics across gestation
Tumminia[21]|2021	Italy|2018—2019	RCT	T1D & T2D	Total: 40 (T1D: 34, T2D: 6); CGM: 21 (T1D: 19; T2D: 2); Comparator: 19 (T1D: 15; T2D: 4)	is-CGM[a]	NR	4—8 wk to delivery	CSII or MDI	HbA1c change[b]
Secher[22]|2013	Denmark|2009—2011	RCT	T1D & T2D	Total: 154 (T1D: 123, T2D: 31); CGM: 79 (T1D: 63, T2D: 16); Comparator: 75 (T1D: 60; T2D: 15)	rt-CGM	Medtronic Minimed|Guardian REAL-time	6 d|8, 12, 21, 27, 33 wk, encouraged continual use	CSII or MDI	LGA[b]
Murphy[23]|2008	UK|2003—2006	RCT	T1D & T2D	Total: 71 (T1D: 46, T2D: 25); CGM: 38 (T1D: 28; T2D: 10); Comparator: 33 (T1D: 18, T2D: 15)	Retrospective CGM	Medtronic Minimed|Gold	5—7 d|intervals of 4—6 wk between 8 and 32 wk	CSII or MDI	HbA1c (T2—T3) every 4-wk differences

(continued)

TABLE
Study characteristics of studies included in the systematic review *(continued)*

Study|year	Country|enrollment years	Study design	Type of diabetes	Sample size	CGM type	CGM brand|device name	CGM duration|timeframe	Antihyperglycemic medication	Main outcome reported
Voormolen[24]|2018	Netherlands, Belgium|2011–2015	RCT	T1D, T2D, & GDM	Total: 300 (T1D: 106, T2D: 81 GDM: 108) CGM: 147 (T1D: 50, T2D: 40, GDM: 54); Comparator: 153 (T1D: 56, T2D: 41, GDM: 54)	Retrospective CGM	Medtronic|iPro2	5–7 d|Every 6 wk from randomization	CSII or MDI (Class A2 GDM)	Macrosomia (defined as >90% percentile, LGA)[b]
Lai[25]|2023	China|2019–2021	RCT	GDM	Total: 154; CGM: 77; Comparator: 77	rt-CGM[c]	Medtronic|specific model NR	3 d|0, 4, 8 wk post randomization	Insulin as required (CGM: 16.1% vs SMBG: 12.9%)	TIRp after 8 wk[b]
Majewska[26]|2023	Poland|2020–2022	RCT	GDM	Total: 100; CGM: 50; Comparator: 50	is-CGM	Abbott|Freestyle Libre 1	4 wk|once at 27 (26–28) wk	Insulin as required (CGM: 30.6% vs SMBG: 32.0%)	Mean fasting and postprandial glycemia[b]
Zhang[27]|2021	China|2019–2020	RCT	GDM	Total: 110; CGM: 55; Comparator: 55	is-CGM	Abbott|specific model NR	14 d	Class A1 GDM	GWG, maternal hypoglycemia, compliance, and health behavior
Lane[28]|2019	USA|2017–2018	RCT	GDM	Total: 40; CGM: 20; Comparator: 20	rt-CGM[c]	Medtronic MiniMed|530G system	4 wk|once at 27.2 (8.5) wk	Insulin as required (CGM: 36.4% vs SMBG: 50.0%)	Mean sensor glucose[b]
Paramasivam[29]|2018	Malaysia|2013–2015	RCT	GDM	Total: 57; CGM: 32; Comparator: 25	Retrospective CGM	Medtronic|iPro2 Enlite	6 d|28, 32, 36 wk	Class A2 GDM	HbA1c change (28–37 wk)[b]
Alfadhli[30]|2016	Saudi Arabia|2011–2014	RCT	GDM	Total: 130; CGM: 68; Comparator: 62	rt-CGM	Medtronic Minimed|Guardian REAL-time	3–7 d, 66.8 (2.3) h|once at 26 (5) wks	Insulin as required (CGM: 11.4% vs SMBG: 11.2%)	Maternal glycemia, pregnancy outcomes
Wei[31]|2016	China|2011–2012	RCT	GDM	Total: 120; CGM: 58; Comparator: 62	Retrospective CGM	Medtronic Minimed|Gold	24–28 or 28–36 wk|48–72 h on weekdays	Insulin as required (CGM: 31.3% vs SMBG: 12.7%)	GWG
Yu[32]|2014	China|2011–2012	Quasi-experimental	GDM	Total: 340; CGM: 150; Comparator: 190	Retrospective CGM[c]	Medtronic Minimed	72 h, 66.8 (2.3)/wk for 5 wk|1, 5 post randomization	Insulin as required (CGM: 27.9% vs SMBG: 12.2%)	CGM metrics; rates of preeclampsia, cesarean, composite neonatal

(continued)

TABLE
Study characteristics of studies included in the systematic review *(continued)*

Study|year	Country|enrollment years	Study design	Type of diabetes	Sample size	CGM type	CGM brand |device name	CGM duration |timeframe	Antihyperglycemic medication	Main outcome reported
Kestila[33]|2007	Finland	RCT	GDM	Total: 73; CGM: 36; Comparator: 37	Retrospective CGM	Medtronic Minimed	47.4 (2.5) h|once at W28.7 (2.5) wk	Insulin/metformin as required (CGM: 30.6% vs SMBG: 8.0%)	Need for pharmacotherapy

Studies categorized by type of DIP and by year of publication. Class A1: diet and exercise—managed GDM; Class A2: insulin-managed GDM.

CGM, continuous glucose monitor; *CSII*, continuous subcutaneous insulin infusion; *GA*, glycated albumin; *GDM*, gestational diabetes; *GWG*, gestational weight gain; *HbA1c*, hemoglobin A1c; *is-CGM*, intermittently scanned continuous glucose monitor; *LGA*, large for gestational age; *MDI*, multiple daily injections; *MODY*, maturity-onset diabetes of the young; *NR*, not reported; *RCT*, randomized controlled trial; *rt-CGM*, real-time continuous glucose monitor; *SMBG*, self-monitoring of blood glucose; *T1D*, type 1 diabetes; *T2D*, type 2 diabetes; *T*, trimester; *TIRp*, time in range for pregnancy (3.5 to 7.8 mmol/L [63 to 140 mg/dL]).

[a] Used an unblinded CGM in the control group during measured time points; [b] Powered for main outcome reported and number achieved. References [17,18] are subanalyses to the CONCEPTT RCT which have been included for data on CGM metrics; [c] Used a blinded CGM in the control group during measured time points.

including the 2 CONCEPTT subanalyses.[17,18]

Within diabetes in pregnancy

T1D: Of 5[8,15–18] studies reporting on CGM glucose metrics, 1 CONCEPTT subanalysis and 2 quasi-experimental designs[15,16] demonstrated associations between glucose metrics and LGA. One quasi-experimental study using first trimester CGM reported increased pregnancy %time-in-range (%TIRp) and decreased mean SG were both associated with decreased LGA.[15] CONCEPTT subanalyses showed first trimester increased %TIRp and decreased pregnancy %time-above-range (%TARp); second trimester increased %TIRp, pregnancy %time-below-range (%TBRp), decreased %TARp (also reported by Perea et al[16]), mean SG (day and overnight), coefficient of variation, and standard deviation (SD); and third trimester increased %TIRp, % TBRp, decreased %TARp, and mean SG (overall and overnight) were all associated with reduced LGA (Supplemental Table 7).

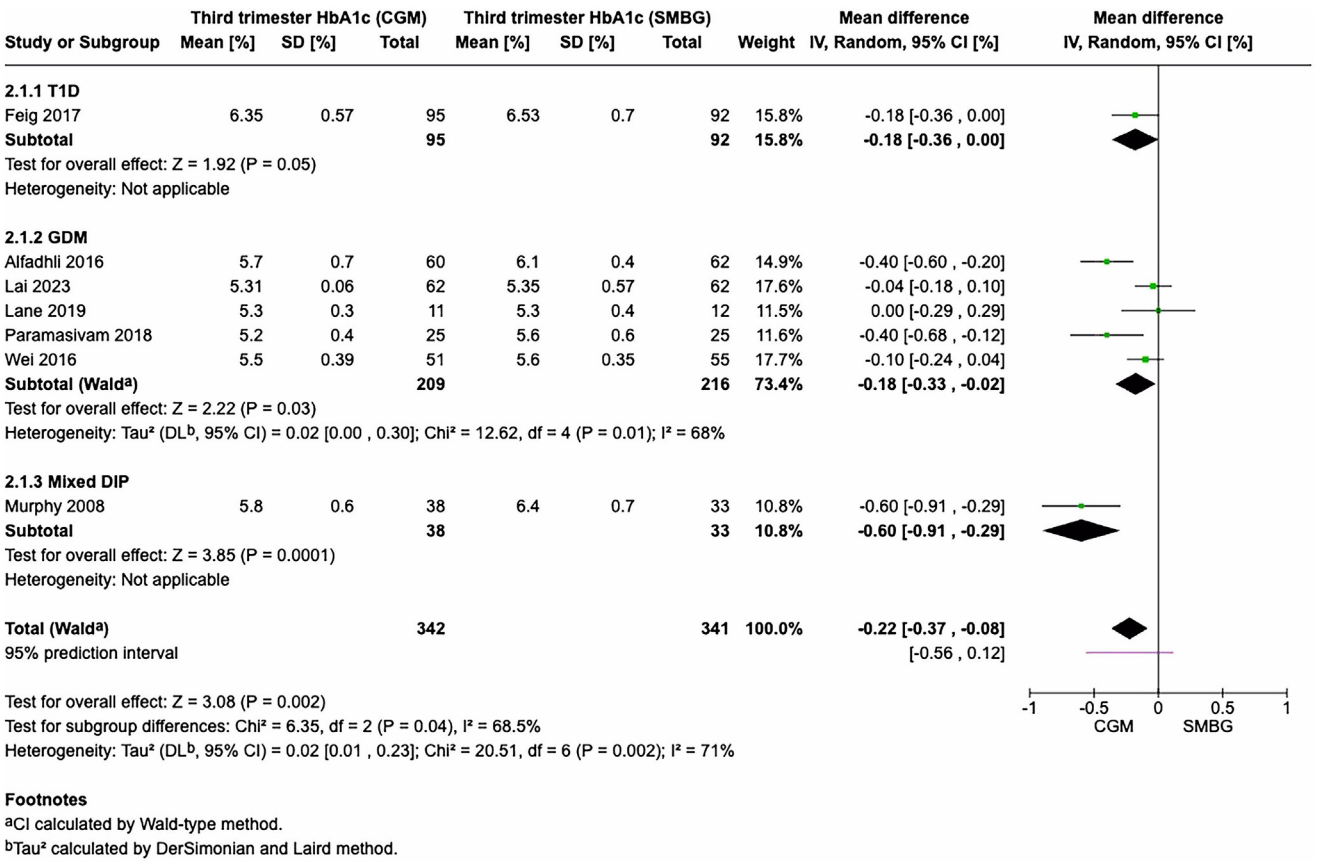
Two studies assessed other perinatal outcomes: increased first trimester % TBRp was associated with less preterm birth,[16] while first and second trimester TBRp<4% were associated with an increased risk of preeclampsia and neonatal hypoglycemia, respectively[17] (Supplemental Table 7).

T2D: One RCT[19] reported 2 weeks of CGM use at 12 to 14 weeks' gestation resulted in improvements in %TIRp and %TARp, but this study did not assess perinatal outcomes (Supplemental Table 8).

Mixed DIP: Of studies[20,21] reporting on glucose metrics, 1 RCT[21] showed increased first trimester %TBRp and reduced second trimester %TBRp with CGM, but this was not associated with improvements in any reported perinatal outcomes (Supplemental Table 9).

GDM: Of 6 studies reporting on CGM glucose metrics,[25,28–32] 3 (2 RCTs[25,28]; 1 quasi-experimental study[32]) compared metrics for both CGM and SMBG (using a masked CGM system) and 3 RCTs reported metrics for the CGM group only.[29–31] Two RCTs reporting on %TIRp showed no association between higher %TIRp and improved outcomes[25,28]:

FIGURE 2
Forest plot for third trimester hemoglobin A1c



CGM vs SMBG weighted MD (95% CI) and 95% PI for third trimester HbA1c. Overall DIP results graded with moderate-certainty evidence due to small sample sizes. Results also categorized by type of DIP (T1D, GDM, and mixed DIP). T1D graded with high-certainty evidence. GDM graded with moderate-certainty due to small sample sizes.

CGM, continuous glucose monitor; *CI*, confidence interval; *DIP*, diabetes in pregnancy; *GDM*, gestational diabetes; *HbA1c*, hemoglobin A1c; *MD*, mean difference; *PI*, prediction interval; *SMBG*, self-monitoring of blood glucose; *T1D*, type 1 diabetes.

1 demonstrated improved rates of recommended GWG and lower birthweight with CGM use[25] despite no difference in %TIRp between CGM and SMBG, while the other showed no difference in %TIRp nor perinatal outcomes between CGM and SMBG.[28] A large quasi-experimental study[32] demonstrated less preeclampsia, preterm birth, primary cesarean, birthweight, LGA, macrosomia, neonatal hypoglycemia, hyperbilirubinemia, and respiratory distress syndrome with CGM use, associated with a reduction in %TARp, %time-below-range, SD, and mean amplitude of glycemic excursions (MAGE), but did not report on %TIRp. Furthermore, this study demonstrated a positive association between higher second trimester mean SG and LGA (OR, 1.61 [95% CI, 1.17, 2.21]), higher second trimester mean SG and MAGE and respiratory distress syndrome (ORs 2.31 [1.05, 5.09] and 1.73 [1.04, 2.90], respectively), and between higher third trimester MAGE and macrosomia (OR, 1.9 [1.19, 3.04]), neonatal hypoglycemia (OR, 1.63 [1.07, 2.48]), and preeclampsia (OR, 3.66 [2.16, 6.20]) (Supplemental Table 10).

Of 3 RCTs reporting on metrics only in the CGM group, CGM was associated with greater %TIRp and less %TARp in third trimester[29]; and lower mean SG and SD over a 4-day period,[30] but this did not translate into improved perinatal outcomes. While less excessive GWG was observed with CGM in 1 study,[31] no specific second or third trimester metric associations were observed (Supplemental Table 10).

Maternal outcomes

Across diabetes in pregnancy

Fifteen studies (12 RCTs[8,21–26,28–31,33]; 3 quasi-experimental studies[15,16,32]) reporting on cesarean delivery across DIP were meta-analyzed. RCT data showed CGM (vs SMBG) did not reduce cesarean delivery (n=1354; OR, 0.88 [95% CI, 0.70, 1.11] [95% PI, 0.70, 1.11]) (low heterogeneity, I^2=0%) (low-certainty evidence) (Supplemental Figure 3). Meta-analysis of quasi-experimental studies showed similar findings (n=881; OR, 0.91 [0.53, 1.54]) for CGM vs SMBG (some heterogeneity present, I^2=71%)

(low-certainty evidence) (Supplemental Figure 7).

Within diabetes in pregnancy

T1D: Four studies (2 RCTs[8,22]; 2 quasi-experimental studies[15,16]) reporting on cesarean delivery were meta-analyzed. Two RCTs demonstrated CGM (vs SMBG) was associated with reduced cesarean delivery (n=325; OR, 0.61 [0.39, 0.97]) (low heterogeneity, I^2=0%) (moderate-certainty evidence) (Supplemental Figure 3). In contrast, quasi-experimental evidence showed CGM (vs SMBG) was not associated with reduced cesarean delivery (n=545; OR, 1.15 [0.70, 1.87]) (low heterogeneity, I^2=42%) (low-certainty evidence) (Supplemental Figure 7).

T2D: Based on 1 RCT,[22] CGM vs SMBG was not associated with less cesarean delivery (n=31; OR, 1.50 [0.36, 6.23]) (low-certainty evidence) (Supplemental Figure 3).

Mixed DIP: Of studies reporting on cesarean delivery,[20–24] 3 RCTs were meta-analyzed (2—T1D, T2D[21,23]; 1—T1D, T2D, GDM[24]). CGM (vs SMBG) was not associated with reduced cesarean delivery (n=401; OR, 1.09 [0.69, 1.70]) (low heterogeneity, I^2=0%) (Supplemental Figure 3).

GDM: Seven RCTs[25,26,28–31,33] and 1 quasi-experimental study[32] reported on cesarean deliveries. RCT meta-analysis showed that CGM (vs SMBG) was not associated with reduced cesarean delivery (n=597; OR, 0.93 [0.67, 1.29] [95% PI, 0.67, 1.29]) (low heterogeneity, I^2=0%) (low-certainty evidence) (Supplemental Figure 3). In contrast, based on 1 quasi-experimental study,[32] CGM (vs SMBG) demonstrated reduced cesarean delivery (n=336; OR, 0.61 [0.39, 0.95]) (low-certainty evidence) (Supplemental Figure 7).

Neonatal outcomes

Across diabetes in pregnancy

Fourteen studies (11 RCTs[8,21–26,28–31]; 3 quasi-experimental studies[15,16,32]) reporting on LGA rates were meta-analyzed. Across DIP, RCT meta-analysis showed CGM vs SMBG did not reduce LGA (n=1157; OR, 0.82 [0.59, 1.13] [95% PI, 0.43, 1.56]) (low heterogeneity, I^2=25%) (low-certainty evidence) (Figure 3). There was no difference in SGA (9 studies[8,21,23–26,28,30,31]; n=1075; OR, 1.24 [0.70, 2.19] [95% PI, 0.70, 2.19]), neonatal hypoglycemia (11 studies[8,21–26,29–31,33]; n=1320; OR, 0.82 [0.62, 1.09] [95% PI, 0.62, 1.09]), or NICU admissions (9 studies[8,23–25,28–31,33]; n=1059; OR, 0.95 [0.63 to 1.43] [95% PI, 0.42, 2.13]) (Supplemental Figures 4–6) (low-certainty evidence).

In contrast, quasi-experimental data did not support the above LGA finding, with CGM (vs SMBG) associated with reduced LGA (3 studies[15,16,32]; n=868; OR, 0.67 [0.47, 0.96]) (low heterogeneity, I^2=24%). However, similarly to RCT findings, quasi-experimental data found CGM (vs SMBG) had no effect on SGA (2 studies[16,32]; n=624; OR, 1.00 [0.16, 6.41]), neonatal hypoglycemia (2 studies[16,32]; n=619; OR, 0.78 [0.18, 3.38]), and NICU admissions (1 study[15]; n=230; OR, 0.57 [0.25, 1.31]) (Supplemental Figure 7) (very low to low-certainty evidence).

Within diabetes in pregnancy

T1D: Five studies (3 RCTs[8,22,24]; 2 quasi-experimental studies[15,16]) reporting on LGA were meta-analyzed. RCT evidence showed CGM (vs SMBG) overall (ie, combining studies evaluating intermittent use and for pregnancy duration) was not associated with decreased LGA (3 studies[8,22,24]; n=427; OR, 1.04 [0.47, 2.30]). Importantly, however, based on the single CONCEPTT RCT,[8] benefit for LGA was seen when CGM was used for pregnancy duration (n=200; OR, 0.51 [0.28, 0.90]) (Figure 3) (high-certainty evidence). Additionally, meta-analysis of 2 RCTs[8,22] showed CGM vs SMBG was associated with reduced neonatal hypoglycemia (n=317; OR, 0.56 [0.34, 0.93]) (low heterogeneity, I^2=0) (Supplemental Figure 5); and based on the single CONCEPTT RCT,[8] less NICU admissions (n=200; OR, 0.49 [0.27, 0.89]) (high-certainty evidence) (Supplemental Figure 6). No impact of CGM vs SMBG was seen on SGA (1 RCT,[8] n=200; OR, 1.00 [0.14, 7.24]) (moderate-certainty evidence) (Supplemental Figure 4).

In contrast, quasi-experimental data showed no CGM (vs SMBG) benefit on LGA (2 studies[15,16]; n=900; OR, 0.80 [0.55, 1.16]), SGA (1 study[16]; n=292; OR, 0.36 [0.07, 1.74]), neonatal hypoglycemia (1 study[16]; n=286; OR, 1.60 [0.92; 2.78]), and NICU admissions (1 study[15]; n=230; OR, 0.57 [0.25, 1.31]) (low-certainty evidence) (Supplemental Figure 7).

T2D: Meta-analysis of 2 RCTs[22,24] reporting on LGA showed no difference with CGM (vs SMBG) (n=109; OR, 0.77 [0.34, 1.77]) (low heterogeneity, I^2=0) (low-certainty evidence) (Figure 3).

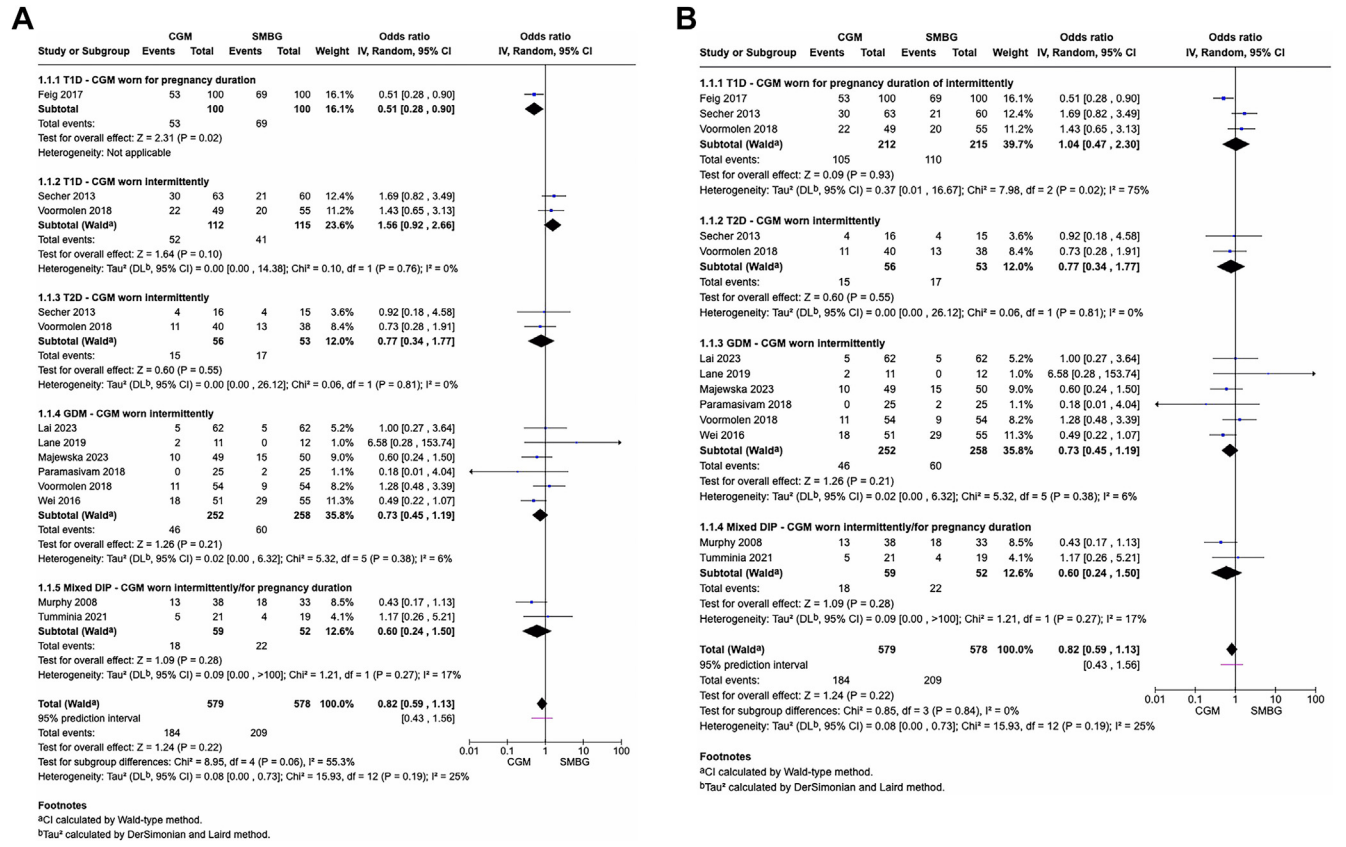
Mixed DIP: RCT meta-analyses revealed no difference with CGM vs SMBG for LGA (2 RCTs[21,23]; n=111; OR, 0.60 [0.24 to 1.50]), neonatal hypoglycemia (3 RCTs[21,23,24]; n=401; OR, 1.05 [0.68, 1.62]), or NICU admission (2 RCTs[23,24]; n=361; OR, 1.06 [0.64, 1.77]) (Figure 3, Supplemental Figures 5 and 6).

GDM: Meta-analysis of 6[24–26,28,29,31] RCTs showed CGM (vs SMBG) was not associated with reduced LGA (n=510; OR, 0.73 [0.45, 1.19] [95% PI, 0.41, 1.30], low heterogeneity, I^2=6%) (Figure 3). This differed from quasi-experimental data derived from a single study,[32] where CGM (vs SMBG) was associated with significantly reduced LGA (n=332; OR, 0.46 [95% CI, 0.26, 0.81]), albeit based on low-certainty evidence (Supplemental Figure 7).

RCT meta-analysis showed no benefit for CGM on SGA (5 RCTs[25,26,28,30,31]; n=474; OR, 1.49 [0.73, 3.03] [95% PI, 0.73, 3.03], low heterogeneity, I^2=0%), NICU admissions (6 RCTs[25,28–31,33]; n=498; OR, 1.12 [0.63 to 1.99] [95% PI, 0.45, 2.78], low heterogeneity, I^2=26%), or neonatal hypoglycemia (6 RCTs[25,26,29–31,33]; n=574; OR, 0.77 [0.44 to 1.36] [95% PI, 0.44, 1.36], low heterogeneity, I^2=0%) (low-certainty evidence). In contrast to RCT evidence, quasi-experimental data derived from 1 study[32] for CGM (vs SMBG) showed benefit for neonatal hypoglycemia (n=332; OR, 0.36 [0.16, 0.81]) based on low-certainty evidence (Supplemental Figures 4–7).

A single quasi-experimental study[32] reported on GDM subgroups, specifically women treated with diet and exercise alone

FIGURE 3
Forest plots for large for gestational age infants



CGM vs SMBG weighted OR (95% CI) and 95% PI for LGA rates: (**A**) demonstrates effect size in T1D subgrouped by length CGM is used and (**B**) demonstrates effect size in T1D combining CGM used for pregnancy duration and intermittently. Overall, DIP results graded with low-certainty evidence due to small sample sizes. T1D (CGM worn for pregnancy duration) graded with high-certainty evidence. T2D and GDM (CGM worn short-term/intermittently) graded with low-certainty evidence due to small sample sizes and large CI crossing the line of no effect. Two studies[23,24] defined macrosomia as >90th percentile for gestational age, and were therefore included in the LGA meta-analysis.

CGM, continuous glucose monitor; *CI*, confidence interval; *DIP*, diabetes in pregnancy; *GDM*, gestational diabetes; *LGA*, large for gestational age; *OR*, odds ratio; *PI*, prediction interval; *SMBG*, self-monitoring of blood glucose; *T1D*, type 1 diabetes; *T2D*, type 2 diabetes.

(Class-A1 GDM, N=272), and with insulin (Class-A2 GDM, N=64). While no descriptive analyses were performed, similar rates of pregnancy complications between Class-A1 and Class-A2 CGM groups were observed. There was no significant difference in pregnancy outcomes between CGM and SMBG in women with Class-A2 GDM. In contrast, for women with Class-A1 GDM, CGM use was associated with fewer pregnancy complications including primary cesarean, preterm delivery, macrosomia, LGA, and neonatal hypoglycemia. Overall, CGM use was associated with higher rates of insulin treatment vs SMBG, presumably due to the additional glucose data provided by CGM.

Comment

Principal findings

Our large systematic review and meta-analysis of 18 studies, consisting of 2630 women with DIP, demonstrated moderate-certainty evidence of CGM benefit as a management tool compared to SMBG across DIP, associated with a 0.22% mean HbA1c reduction. Evidence was stronger for CGM use within DIP subgroups, with high-certainty evidence of benefit in T1D when used for the pregnancy duration only, lowering mean HbA1c by 0.18%,[8] supported by quasi-experimental evidence (0.30% HbA1c reduction),[15] as well as for lowering LGA by 49%[8] and NICU admissions by 51%.[8] In GDM, based on moderate-certainty RCT evidence, intermittent and short-term CGM use was associated with a similar 0.18% reduction in HbA1c. Moreover, low-certainty quasi-experimental evidence[32] suggested this improvement in maternal glycemia in GDM translated into a 54% and 64% reduction in LGA and neonatal hypoglycemia, respectively. Data were insufficient for conclusions in T2D pregnancies.

Comparison with existing literature

Given the rapid advances in CGM technology in DIP, our review provides a comprehensive current evidence base for the benefits of CGM use both across and within DIP, including T1D, T2D, and GDM. The single previous systematic review and meta-analysis of CGM across DIP (n=1358) showed a small beneficial effect of CGM use (vs SMBG) on HbA1c, cesarean delivery, and birthweight, based on only very low to low-certainty evidence, without analysis within DIP subgroups.[36] In contrast, an earlier Cochrane review found that CGM use (vs SMBG) was associated only with a decreased risk of hypertensive disorders of pregnancy (2 RCTs, n=384) (RR, 0.58 [95% CI, 0.39, 0.85]) in women with preexisting diabetes, again based on low-certainty evidence.[37] While the CONCEPTT RCT was included in the aforementioned review, importantly, authors did not differentiate between T1D and T2D, or by CGM duration, which presumably accounted for the observed lack of benefit for CGM on LGA given our findings that continuous, but not intermittent, CGM use was associated with less LGA in T1D in pregnancy.

There have been 2 previous systematic reviews of CGM (vs SMBG) in GDM. A 2017 Cochrane review reported less GWG (MD, −1.26 kg [−2.28, −0.24], 2 studies, n=179), based on very low-certainty evidence,[38] while a more recent review comprising 6 studies (n=482) found similar benefits on GWG (MD, −1.17 kg [−2.15, −0.19]), lower HbA1c (MD, −0.22% [−0.42, −0.03]), and birthweight (MD, −116.26 g [−224.70, −7.81]).[39] Consistent with previous reviews of CGM in T2D,[40] a lack of RCT data precluded assessment of the impact of CGM on glycemic management or perinatal outcomes, although studies are currently underway (ISRCTN12804317).

We also sought to determine CGM glucose metrics that best corresponded with pregnancy outcomes and DIP-specific CGM metric thresholds. Our analysis in T1D in pregnancy found a 49% reduction in LGA (1 RCT, OR, 0.51 [0.28, 0.90]), associated with increased %TIRp, from both the first[18] and the second trimester.[15,16,18] Given the mean %TIRp±SD for risk of LGA vs non-LGA for the CONCEPTT study[18] was 62.6±11.8% vs 67.6±11.8% in the third trimester, and for the quasi-experimental Cypryk et al study[15] 67.9±9.4% vs 73.0±11.3% in the overall pregnancy, respectively, our findings largely support the currently recommended %TIRp >70%.[11,41] In contrast, 2 RCTs in GDM showed no differences in third trimester %TIRp nor rates of LGA with the use of CGM compared to SMBG.[25,28] Notably, this was despite achieving far higher mean %TIRp than in CONCEPTT (CONCEPTT mean third trimester %TIRp 68%,[8] compared to 88.8%[28] and 100%[25] in the GDM studies). While higher %TIRp in GDM (and presumably T2D) can be achieved, it may be that tighter %TIRp range and early uninterrupted CGM use are required for additional benefit on perinatal outcomes beyond that achieved with SMBG; all key questions for further research. It may also be that the additional glucose benefits achieved by CGM compared to SMBG outside of T1D pregnancies are not as determinative for perinatal outcomes, with a relatively greater impact of maternal obesity or sociocultural factors, especially for T2D in pregnancy.[3]

We also found evidence to support the association between mean SG and LGA in both T1D and GDM. The CONCEPTT subanalysis showed lower mean SG (as well as SD and coefficient of variation) from 24 weeks' gestation was associated with decreased LGA,[18] consistent with Cypryk et al demonstrating an association between lower mean SG across pregnancy and lower LGA risk.[15] Similarly in GDM, Yu et al reported a positive association between higher mean SG and risk of LGA.[32] These RCT subanalysis and quasi-experimental findings are consistent with noninterventional observational cohort studies exploring associations between CGM metrics and perinatal outcomes in women with GDM.[42−44] Two smaller GDM cohort studies evaluating short-term CGM use in the third trimester[42,44] demonstrated that higher overall and overnight mean SG were strongly associated with greater LGA and birthweight percentile, respectively. A larger cohort study in 1302 Chinese women with GDM found that %TARp and overnight, daytime, and daily SG based on 14 days of CGM use at a mean 26 weeks' gestation were all similarly associated with a composite adverse pregnancy outcome (preterm birth, LGA, fetal distress, premature rupture of membranes, and NICU admission).[43] In addition, %TIRp; %TARp; area under the curve; MAGE; and overnight, daytime, and daily SG were positively associated, while %TBRp was inversely associated, with LGA.[43] While the authors proposed potential metric thresholds of 2.5% time-above-range and daily SG of 4.8 mmol/L (86.5 mg/dL) to identify those at a greater risk of any adverse pregnancy outcome in their cohort, mean daily SG was low even in women at the highest risk of perinatal complications (lowest vs highest absolute risks for any adverse pregnancy outcome: daily SG 4.4 to 4.7 mmol/L [79.3 to 84.7 mg/dL] vs 5.8 to 6.1 mmol/L [104.5 to 109.9 mg/dL], respectively, and for LGA: daily SG 3.3 to 3.9 mmol/L [59.5 to 70.3 mg/dL] vs 6.4 to 6.9 mmol/L [115.3 to 124.3 mg/dL], respectively).

Furthermore, the Glucose Levels Across Maternity prospective observational study (N=937)[45] showed increased mean±SD SG (6.4±0.8 vs 5.8±0.4 mmol/L [115±14 vs 104±7 mg/dL]), SD (1.2±0.3 vs 1.0±0.2 mmol/L [22±5 vs 18±4 mg/dL]), and decreased %TIRp (84±17 vs 94±4) and consistently higher mean daytime and overnight SG from 13 to 14 weeks' gestation in 58 women (8% of the total cohort) who were subsequently diagnosed with GDM.[46] Overall, second trimester percent time >7.8 mmol/L (140 mg/dL) best predicted GDM at 24 to 28 weeks' gestation, with an area under the receiver operating characteristic curve of 0.81.[35,47] LGA and hypertensive disorders of pregnancy were associated with higher mean glucose levels (5.7±0.5 mmol/L [102±9 mg/dL] vs 5.6±0.4 mmol/L [100±8 mg/dL], P=0.01 and 5.7±0.4 mmol/L [103±8 mg/dL] vs 5.5±0.4 mmol/L [99±8 mg/dL], P<0.001, respectively) and more time

>7.8 mmol/L (140 mg/dL) (median 3.9% vs 2.8%, $P=0.006$ and 3.5% vs 2.8%, $P<0.001$, respectively) throughout pregnancy, irrespective of GDM diagnosis.[47] However, consistent with low mean SG observed even in the higher risk groups in the Chinese cohort study, the absolute difference in mean SG in Glucose Levels Across Maternity was only 2 to 4 mg/dL between those with and without these perinatal complications.[47] Considered together with our present findings, whereby reported %TIRp reflects overall management success at reducing hyperglycemia yet is still not associated with reduction in LGA, these observational data in non-T1D populations, highlighting their lower mean SG, as well as continuous associations between CGM glucose metrics and perinatal complications similar to that observed for the oral glucose tolerance test,[48,49] underscore the current difficulty with defining specific CGM metric treatment targets in non-T1D populations.

Strengths and limitations

Strengths of this systematic review and meta-analysis include that it is the largest and most comprehensive assessment of CGM use compared to SMBG in DIP. Analysis across and within DIP, including T1D, T2D, and GDM, as well as by duration of CGM use, provides important insights into the comparative benefits of CGM use across the spectrum of hyperglycemia in pregnancy. The evaluation of the relationship between specific CGM metrics and pregnancy outcomes also provides important clinical insight into the practical utility of CGM, identifying both %TIRp and mean SG as key metrics in the management of DIP, as well as highlighting differences relating to %TIRp targets and associations with LGA in T1D compared to GDM and T2D.

This review has several limitations, mostly related to heterogeneity of CGM use across the included studies, with significant variation in type, duration, and timing of use. Only studies in T1D used CGM for the duration of pregnancy. The similar benefits found for intermittent CGM in GDM and continuous CGM in T1D contrast with the lack of benefit on perinatal outcomes for intermittent CGM in T1D. These discordant findings may reflect the lower quality, quasi-experimental evidence for CGM in GDM. However, we note that the quasi-experimental study by Yu et al[32] remains the largest intervention study evaluating intermittent CGM use vs SMBG in GDM, to analyze CGM metric associations with perinatal outcomes. Indeed, the number and size of studies for each type of DIP were also limited, with a lack of data for T2D especially. Accordingly, the level of evidence (Grading of Recommendations, Assessment, Development, and Evaluations) to support our conclusions for T2D and GDM ranged from very low to moderate. Finally, although out of scope for this review, we note the critical role of automatic insulin delivery closed-loop systems in T1D in providing additional improvements to HbA1c and %TIRp throughout pregnancy beyond that achieved with CGM alone.[50]

Research implications

In T1D (high-certainty) and GDM (moderate-certainty), CGM use reduces HbA1c (RCT evidence), and mean SG and %TIRp (T1D only) are associated primarily with a decreased risk of LGA (RCT subanalysis and quasi-experimental evidence). This review highlights the need for high-quality RCTs evaluating earlier, tighter %TIRp and mean SG targets and greater %TIRp to confirm our findings of greater improvement in perinatal outcomes

GLOSSARY

Mixed diabetes in pregnancy (mixed DIP). Term has been used to describe studies that have not analyzed study outcomes of interest by type of diabetes in pregnancy. For example, analyzing combined type 1 diabetes in pregnancy and type 2 diabetes in pregnancy results.

Real-time continuous glucose monitoring (rt-CGM). CGM system providing 24-hour interstitial glucose data and prespecified range alarms in real time for individuals to respond to.

Intermittently scanned CGM (is-CGM). CGM system providing 24-hour interstitial glucose data through regular scanning of sensor to obtain data for individuals to respond to.

Retrospective CGM. CGM systems that collect and store 24-hour interstitial glucose data to be downloaded and reviewed by a healthcare professional for lifestyle and pharmacotherapy adjustments. Not seen in real time by the person wearing the device.

Pregnancy %time-in-range (%TIRp). Time spent in recommended glucose range for pregnancy (3.5 mmol/L to 7.8 mmol/L [63 mg/dL to 140 mg/dL]).

Pregnancy %time-below-range (%TBRp). Time spent below the recommended glucose range for pregnancy (<3.5 mmol/L [63 mg/dL]).

Pregnancy %time-above-range (%TARp). Time spent above the recommended glucose range for pregnancy (>7.8 mmol/L [140 mg/dL]).

Mean sensor glucose (mean SG). Average glucose across a 24-hour period.

Standard deviation (SD). A measure of glycemic variation that measures the spread of glucose readings around the mean.

Coefficient of variance (CV). A measure of glycemic variability calculated as SD of sensor glucose divided during a period of time divided by the mean SG during the same period of time.

Mean amplitude of glucose excursions (MAGE). A measure of glycemic variation that measures the average of all glycemic excursions exceeding the SD of blood glucose obtained in a 24-hour period.

with CGM beyond that achieved with SMBG both across and within DIP. Current evidence in GDM suggests stronger associations between mean (especially overnight) SG and perinatal outcomes (interventional and non-interventional studies) and higher time-above-range (noninterventional studies). Establishing CGM treatment targets in non-T1D populations remains unclear given lower overall mean glucose and tight glucose ranges between those with and without complications, and the continuous associations between CGM glucose metrics and perinatal complications observed in noninterventional pregnancy cohorts. Ongoing studies including RCTs of CGM use in T2D and GDM (PRegnancy Outcomes using continuous glucose monitoring TEChnology in pregnant women with early-onset Type 2 diabetes RCT [ISRCTN12804317][51] and the Continuous glucose monitoring for women with gestational diabetes: an RCT: the CORDELIA RCT),[52] as well as observational studies (Maternal glucose in pregnancy [MAGIC][53] and Glycemic Observation and Metabolic Outcomes in Mothers and Offspring),[54] alongside health economic analyses, will provide important insights into the role of CGM use in the management of both T2D and GDM, and in the prediction of GDM and perinatal complications more broadly.

Conclusion

While evidence is lacking to support usage of CGM in T2D, the use of CGM in T1D and GDM is associated with decrea sed third trimester HbA1c, and reduced mean SG and greater %TIRp (T1D) are most strongly associated with a decrease in LGA. ■

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