

# Compliance and barriers to self-monitoring of blood glucose in patients with gestational diabetes mellitus: A systematic review

**Sumanta Saha**

Department of Public Health, University of Queensland, Brisbane, Australia

**Address for correspondence:**

Dr. Sumanta Saha, University of Queensland, Brisbane, Australia.

E-mail: sumanta.saha@uq.net.au

## ABSTRACT

**Objective:** This study intends to understand the barriers to self-monitoring of blood glucose (SMBG) in gestational diabetes mellitus (GDM) patients. In addition, it also aims to know the factors that influence the compliance with SMBG-testing among GDM patients.

**Methods:** The study primarily comprised a search of various databases (PubMed, EMBASE, SCOPUS, PsycINFO, PROQUEST, and CINAHL). Research papers published between March 2010 and June 2018 were searched for this review. Article types considered for this review were observational studies, experimental studies, and systemic reviews with or without meta-analysis. Using a set of eligibility criteria; initially, the papers were scrutinized by reviewing the abstracts, following which a full-text review of the selected papers was undertaken. Finally, a critical appraisal and an overall qualitative assessment of these studies were done.

**Results:** Literature search identified 25 papers, excluding the duplicates. Six studies (two qualitative and four quasi-experimental) that matched the eligibility criteria of this study were reviewed. The barriers of SMBG in GDM patients were non-prescription of SMBG by the health-care providers, poor perception and fear of SMBG, and family history of Type 2 diabetes. Use of smartphone technology and SMBG-education improved the compliance to SMBG testing. However, most of the quasi-experimental studies did not have a pre- and post-intervention comparison of their results or comparison of their findings with any control group. Moreover, the way of determining compliance among three of these studies was not identical. Similarly, among the qualitative studies, one study does not have a clear mention of the language in which the interviews were conducted, whereas the other qualitative study does not state, if the English language translation of the verbatim transcripts was validated or not. Only one study mentioned the diagnostic criteria used to diagnose GDM.

**Conclusion:** The recent evidence to the barriers of SMBG and the factors that influence the compliance of SMBG is weak and not generalizable. Moreover, there is a scarcity of literature that addresses the context.

**Keywords:** SMBG, Compliance, Barrier, Gestational, Diabetes

**WEBSITE:** ijhs.org.sa

**ISSN:** 1658-3639

**PUBLISHER:** Qassim University

## Introduction

Gestational diabetes mellitus (GDM) is a common medical complication of pregnancy that can adversely affect the health of both the mother (hypertension, increased chances of cesarean section, hydramnios, preeclampsia, etc.) and the fetus (restriction of fetal growth, macrosomia, hyperbilirubinemia, hypoglycemia, and shoulder dystocia).<sup>[1-3]</sup> GDM is characterized by hyperglycemia that is diagnosed for the 1<sup>st</sup> time in pregnancy (in the absence of any pre-existing Type-1 or type-2 diabetes).<sup>[3,4]</sup> The hyperglycemic situation

in GDM is temporary and generally normalizes once the pregnancy is over.<sup>[5,6]</sup>

Self-monitoring of blood glucose (SMBG) is often recommended as a part of GDM management.<sup>[7-9]</sup> SMBG is performed by putting a drop of blood (obtained by puncturing the skin of the tip of the finger using a needle) on a strip which is then read using a glucose reading meter.<sup>[10]</sup>

Despite the emphasis on SMBG-testing as a treatment component of GDM,<sup>[7-9]</sup> much is not known about its barriers

and compliance among the GDM patients. Most studies related to the barriers and compliance of SMBG-testing are primarily based on Type 1 and Type 2 diabetes patients.<sup>[10-14]</sup>

Therefore, to appreciate the existing evidence (and its rigor) of the barriers of SMBG and the factors that determine the compliance to SMBG in GDM patients, this systemic review was done.

In this study, the terms adherence and compliance are used interchangeably due to their similar type of meaning.<sup>[15-17]</sup>

## Methods

This systemic review does not have a pre-published protocol. This study made every possible attempt to adhere strictly to the PRISMA reporting system to report its findings.<sup>[18]</sup>

Eligibility criteria: Inclusion criteria: (1) Studies that assessed the barriers to SMBG-testing and/or the factors attributing to the compliance of SMBG-testing in GDM patients (2) studies that were conducted and published between March 2010 and June 2018, (3) studies of following types were included in the study – qualitative studies, observational studies, experimental studies, and systemic review with or without meta-analysis (that include studies conducted and published in March 2010 or later), and (4) articles that are available in English language only.

### Exclusion criteria

(1) Studies that included Type-1 diabetes and/or Type-2 diabetes patients along with GDM patients as their study population were excluded from the study.

Following databases were searched for the purpose of this study – PubMed, EMBASE, SCOPUS, PsycINFO, PROQUEST, and CINAHL. The search was restricted to all articles published between March 2010 and June 2018. The last date of the search was on June 30, 2018. None of the authors of the studies included in this paper were contacted.

Following search terms were used for the database search – (“adherence” odds ratio [OR] “perception” OR “barrier” OR “compliance OR “behavior”) AND (“SMBG” OR “self-monitoring”) AND (“GDM” OR “gestational diabetes”).

Besides, the above-mentioned database search hand search was done in the bibliography of the articles included in this article. An additional search (using the search terms mentioned above) was also done in the internet search engine – “Google” (<https://www.google.com/>). Furthermore, the search was also extended to the PROSPERO website (<https://www.crd.york.ac.uk/prosperto/>)<sup>[19]</sup> to identify any currently ongoing protocols that might also be reviewing similar outcomes like this study.

The rationale for choosing the papers published after March 2010 is discussed here. The diagnosis of GDM had

been chaotic globally due to the use of different diagnostic criteria (to diagnose GDM) in different countries.<sup>[5,20]</sup> In March 2010, The International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria for the diagnosis of GDM became available<sup>[20,21]</sup> which was endorsed by the World Health Organization and various countries across the globe.<sup>[20-22]</sup> Therefore, in view of this wide consensus for the IADPSG (2010) guideline for GDM diagnosis,<sup>[20-22]</sup> the studies conducted and published in March 2010 and onward were screened for inclusion in this paper.

Following procedure was used to screen and select the studies for reviewing. At first, the abstract of all the articles found during the search was read. Next, the papers that appeared to meet the eligibility criteria of this study (through abstract review) were selected for a full-paper review. In addition, full papers were reviewed when an inclusion or exclusion decision was not possible by reading the abstract alone.

During the full-text reading (of the sorted papers), all articles that matched this study’s eligibility criteria were included in this review (for data extraction and analysis). The entire work for this paper (from the planning of this study to database search, data extraction, data analysis, and the write-up) was conducted by the author independently (single author).

Data collected from each of the studies primarily included – the surname of first author, the year of publication, the country where the study was conducted, the study design, the study population, the barriers of SMBG, the factors determining the compliance to SMBG, and the diagnostic criteria used to diagnose GDM.

Following study design related information were extracted from each study – the study type, interventions (SMBG-related) if any, frequency, and duration of such intervention, if there was any comparison or control group, the assessed outcome, the data collection method, information about the conflict of interest, and funding related information. The study population relevant information that were extracted was – the sample description, the sample size, any dropouts, the gestational age of the study participants, the age range of the study participants, the mean age of the study sample, the sampling procedure, and the inclusion and exclusion criteria of the study (in relevance to this study’s objectives).

Risk of bias of the individual studies was assessed using the 4<sup>th</sup> Edition of Joanna Briggs Institute (JBI) Reviewer’s Manual.<sup>[23]</sup>

Results obtained from the studies reviewed in this paper were analyzed qualitatively, as a meta-analysis was not possible (due to lack of comparable data).<sup>[18]</sup> Any bias in the reported outcome of the individual papers (included in this systemic review) was assessed by matching the aims’ of these studies against their reported results.<sup>[18]</sup>

All illustrations (tables and diagrams) are placed at the end of this paper (after the references).

## Results

In total, 42 papers were identified using the above-described literature search. There were 17 duplicates which were manually screened and excluded. After excluding the duplicates, 25 studies were screened by reading the abstracts (against the eligibility criteria of this study) and 12 studies were selected for full paper review. Finally, six papers were rejected, and the remaining six papers<sup>[24-29]</sup> were accepted for this review [Diagram 1]. Inclusion and exclusion of the studies were strictly based on the eligibility criteria mentioned above.

Data extracted from the selected studies in this review have been depicted in a summary table [Table 1]. Out of the six

papers, four were quasi-experimental studies<sup>[26-29]</sup> and two were qualitative studies.<sup>[24,25]</sup>

The risk of bias of the selected studies was assessed using the respective JBI tools available for these types of studies.<sup>[30,31]</sup> The critical appraisal depicted that the qualitative studies [Table 2] were of good quality.<sup>[24,25]</sup> On the other hand, the critical appraisal of the quasi-experimental studies<sup>[26-29]</sup> revealed that only one study<sup>[29]</sup> had a relatively good study design, methodology, and analysis [Table 3].<sup>[26-28]</sup> It is the only quasi-experimental study<sup>[29]</sup> that compared its finding with a control group. None of the quasi-experimental studies<sup>[26-29]</sup> did any pre- and post-intervention comparison of their findings.

The qualitative studies reviewed in this study identified some of the potential barriers of SMBG in GDM patients. The study conducted in China ( $n = 17$ ) identified the poor understanding of SMBG-testing among GDM patients and lack

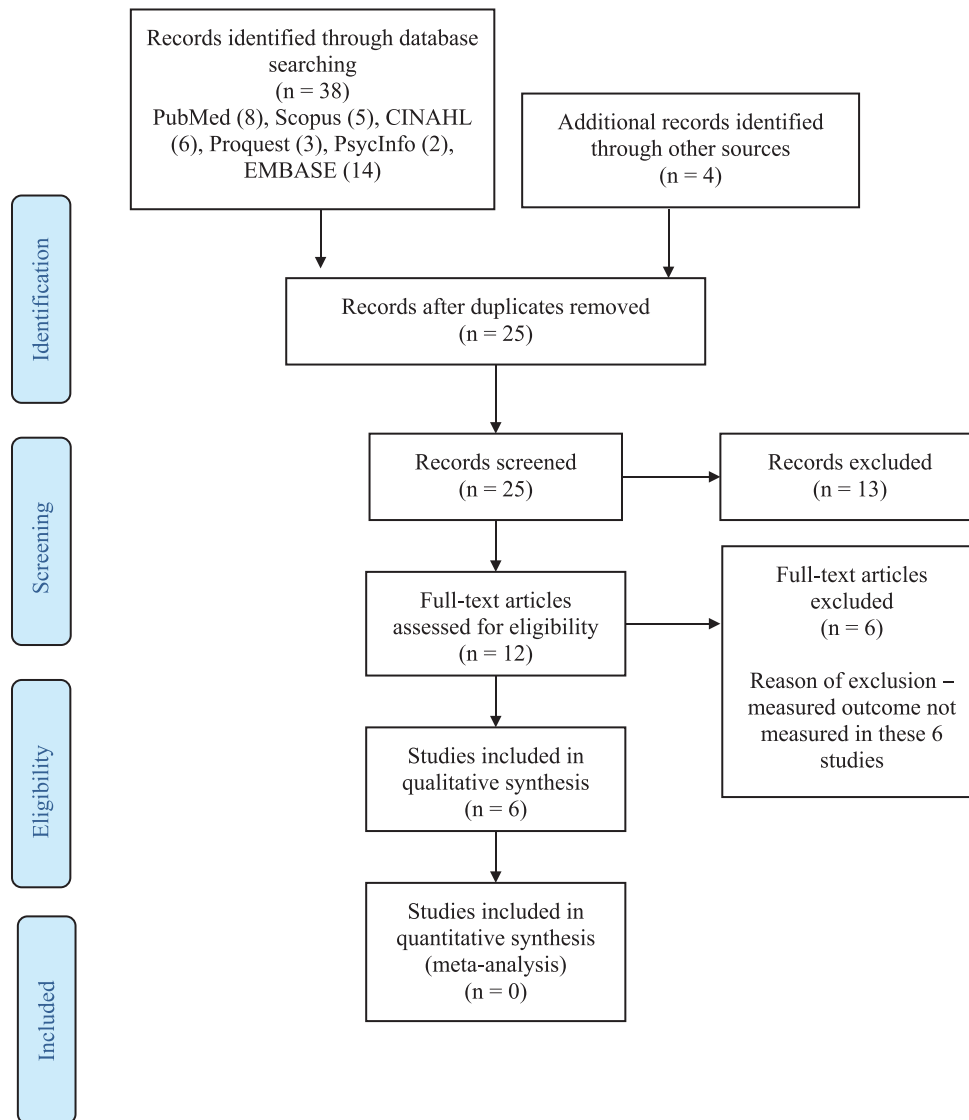


Diagram 1: PRISMA 2009 flow diagram<sup>[18]</sup>

**Table 1:** Summary table

Author, year, and country	Design	Study population	Outcome/results
China <sup>[25]</sup>	Qualitative study Outcome assessed – self-health care among GDM patients Data collection method – semi-structured interviews content analysis Conflict of interest- declared Funding information - provided	Description of the sample – GDM patients Gestational age: Between 34 and 38 weeks of pregnancy Total sample size- 17 Dropouts – N/A Age range of participants – between 21 and 37 years Mean age of participants – not clear Sample recruitment process: Purposive sampling Inclusion: Mandarin Chinese speaking GDM affected females aged 16 years or more at a gestational age between 34 and 38 weeks who were living in a rural area Exclusion: Not clear	SMBG not practiced because the health care provider did not recommend. Understanding about SMBG was poor. GDM diagnostic criteria used: Not mentioned
Thailand <sup>[24]</sup>	Qualitative study Outcome assessed – perception and experience of living with SMBG of GDM patients Data collection method – semi-structured interview followed by an in-depth interview Conflict of interest – declared Funding information – provided	Description of sample – GDM patients Gestational age: Between 24 and 30 weeks of gestation Total sample size – 30 Dropouts – 0 Age range of participants – not clear Mean age of participants – 32.5 years Sample recruitment process: Not clear Inclusion: Not clear except GDM patients Exclusion: Not clear	GDM patients faced fear and worry about performing SMBG. GDM diagnostic criteria used: Not mentioned
UK <sup>[27]</sup>	Quasi-experimental study Method – Intervention – participants were advised to do SMBG and record blood glucose values using a smartphone-based system Intervention frequency-6 timed per day (minimum 18 readings a week was considered optimum) Duration of intervention – until delivery No comparison groups Exposure – to smartphone devices to record SMBG values Outcome assessed – compliance to SMBG Data collection – methods/ tools – electronically to a website Conflict of interest- declared Funding information – provided	Description of sample – GDM patients included in the second phase of the study were not on insulin or metformin (similar participant characteristics were unclear for those recruited in the first phase). Gestational age – not clear Total sample size –104 (included in study 54 and dropouts 2) Age range of participants – no mention Mean age of participants – no mention Sample recruitment process: all women who attended the diabetes-maternity clinic (in 2 <sup>nd</sup> phase) Analysis or comments about the power: Not available Inclusion criteria: Not clear except that GDM patients and not on insulin or metformin were included in the 2 <sup>nd</sup> phase of the study Exclusion criteria: Not clear	Use of smartphone devices to record SMBG values resulted in good compliance to SMBG was observed in 85% (46 out of 54) of participants who did the minimum weekly blood glucose recordings. Compliance phase wise: Beta phase – 6/6 participants (100%), 2 <sup>nd</sup> phase 40/48 participants (83%) GDM diagnostic criteria used: No mention
Brazil <sup>[28]</sup>	Quasi-experimental study Intervention – SMBG education Intervention frequency – once only after being diagnosed of GDM Duration of intervention – N/A Outcome assessed –SMBG-related adherence and barrier information obtained after 3 days of the intervention Data collection – over the phone using a questionnaire Conflict of interest- no mention Funding information – no mention	Description of sample – GDM patients Gestational age: Not clear Total sample size – 135 (122 participated) Dropouts – 13 Age range of participants – no mention Mean age of participants – no mention Sample recruitment process: Not clear Analysis or comments about the power: No mention Inclusion – GDM dx in the current pregnancy, participation interested in the intervention program, consenting participants Exclusion – those participants not contactable by phone	SMBG education resulted in good SMBG adherence (97.5% practices SMBG) 19% perceived SMBG as an extremely uncomfortable thing to do 17.2% perceived the lancet of the needle and the time of conducting the SMBG as barriers GDM diagnostic criteria used: not clear No mention about the validity and reliability of the questionnaire used

(Contd...)

**Table 1:** (Continued)

Author, year, and country	Design	Study population	Outcome/results
France <sup>[26]</sup>	Quasi-experimental study Intervention- SMBG Intervention frequency- just before meals and 2 h post meal Duration of intervention – 1–2 weeks Outcome assessed – compliance to pre- and post-prandial SMBG Data collection – methods/tools- calculating the percentage of recommended SMBG tests performed (those performing a minimum 80% of both pre- and post-prandial tests were considered compliance) Conflict of interest- declared Funding information – provided	Description of the sample – French-speaking newly diagnosed GDM patients Gestational age: Not clear Total sample size – 94 Dropouts – 3 Age range of participants – not clear Mean age of participants – 33.2±5.1 Sample recruitment process: Not clear Analysis or comments about the power: Not clear Inclusion: French-speaking females with understanding about SMBG and pre- and post-prandial glucose targets Exclusion: Not clear	Non-compliance to SMBG was independently associated with family history of type 2 diabetes in first degree relatives (OR=0.38, 95% CI 0.15–0.98), (P=0.044) GDM diagnostic criteria used: The IADPSG criteria used to make the diagnosis
Spain <sup>[29]</sup>	Quasi-experimental study Intervention- SMBG along with mobile-based reminders for SMBG 4 times a day Intervention frequency – 4 times per day, every day (twice a week if good blood glucose report for a month) Duration of intervention – 9 months (GDM participants used the mobile technology for maximum 3 months) Outcome assessed – SMBG compliance Data collection – methods/tools – compliance was determined by dividing recommended SMBG frequency in duration by the frequency of SMBG performed by the GDM patients in a particular duration Conflict of interest – declare Funding information – provided	Description of the sample – GDM patients with or without hypertension Gestational age: not clear Total sample size – 20 Dropouts – 1 Age range – not clear Mean age – 35.2±3.9 Gender- females Sample recruitment process: not clear Analysis or comments about the power: Not clear Inclusion: GDM patients with or without hypertension (details of the inclusion criteria not clear) Exclusion: not clear	Patient reminder based mobile technology helped to increase compliance than the participant in the control group who did not receive such electronic reminders (t- statistics 2.166, P=0.0312) Mean and standard deviation of compliance intervention group (1.01±0.10) or control group was (0.87±0.28) GDM diagnostic criteria used: Not clear

GDM: Gestational diabetes mellitus, SMBG: Self-monitoring of blood glucose

of SMBG-recommendation by the health-care providers as the barriers to perform SMBG,<sup>[25]</sup> whereas the study conducted in Thailand ( $n = 30$ ) found fear and worry about performing an SMBG-test as a barrier.<sup>[24]</sup>

The results of the quasi-experimental studies reveal the following finding. Cosson *et al.*<sup>[26]</sup> ( $n = 94$ ) reported that poor compliance to SMBG ( $n = 35$ , 38%) was independently associated with family history of Type-2 diabetes in first-degree relatives (OR = 0.38, 95% confidence interval [CI] 0.15–0.98),  $P = 0.044$ ).<sup>[26]</sup> The study further identified that French ethnicity and having medical insurance (for the impoverished patients) were also associated with non-compliance to SMBG in GDM patients (however, the OR and CI were not reported for these findings).<sup>[26]</sup> The study by Peleg *et al.*<sup>[29]</sup> unveiled that compliance to SMBG-testing improved by the use of smartphone-based reminders in the participants of the intervention group (t-statistics 2.166,  $P = 0.0312$ ).<sup>[29]</sup>

The remaining quasi-experimental studies measured the compliance to SMBG testing among GDM patients in percentages.<sup>[27,28]</sup> The study by Mackillop *et al.* ( $n=104$ ) found that the use of a smartphone to record blood glucose readings resulted in good SMBG-testing compliance.<sup>[27]</sup> Almost 85% of the participants (46 out of 54) of this study did the test as per the

research team's pre-determined optimum SMBG frequency,<sup>[27]</sup> whereas the Sousa *et al.* study<sup>[28]</sup> ( $n = 135$ ) reported 97.5% of the study participants (119 of 122) to be compliant to the SMBG recommendations. The study also found that about 17% of the GDM patients (21/122) perceived the lancet of the needle (to obtain blood for SMBG) and the time of conducting the SMBG-test as the barriers to SMBG.<sup>[28]</sup>

A forest plot or meta-analysis was not considered as a part of this systemic review, as the studies included for this review were not comparable (being a combination of qualitative and quantitative) and the quantitative ones<sup>[26-29]</sup> were also quite a few in number.<sup>[18]</sup>

Overall, the results obtained from the reviewed studies lacked rigor and external validity. The strength and weaknesses of these studies are enumerated in the successive paragraphs.

Study design and study methodology-wise out of the three quasi-experimental studies that reported good compliance to SMBG-testing,<sup>[27-29]</sup> the evidence is stronger only for the Peleg *et al.* study<sup>[29]</sup> since it used a control group to compare its finding (along with an appropriate statistical test). However, the methodology of calculating the compliance to the SMBG-testing was different among these three studies and hence not comparable.<sup>[27-29]</sup>

**Table 2: Qualitative studies<sup>[31]</sup>**

Study author, year	Is there congruity between the stated philosophical perspective and the research methodology?	Is there congruity between the research methodology and the methods used to collect data?	Is there congruity between the research methodology and the representation and analysis of data?	Is there congruity between the research methodology and the interpretation of results?	Is there a statement locating the researcher culturally or theoretically?	Is the influence of the researcher on the research, and vice-versa, addressed?	Are participants and their voices, adequately represented?	Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?
[24]	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes
[25]	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes

Answers: Yes, No, Unclear, or Not/Applicable (NA)

**Table 3: Quasi-experimental studies<sup>[30]</sup>**

Study author, year	Is it clear in the study what is the “cause” and what is the “effect” (i.e., there is no confusion about which variable comes first)?	Were the participants included in any comparisons similar to those in any other comparisons?	Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Were there multiple measurements of the outcome both pre and post the intervention/exposure?	Was there a control group?	Were follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Were the outcomes of participants included in any comparisons measured in the same way?	Were outcomes measured in a reliable way?	Was an appropriate statistical analysis used?
[28]	Yes	No	No	No	No	Yes	NA	Unclear	Yes
[29]	Yes	Yes	Yes	No	Yes	Yes	Yes	Unclear	Yes
[27]	Yes	No	No	No	No	Yes	NA	Unclear	Unclear
[26]	Yes	No	No	No	No	Yes	Unclear	Unclear	Yes

Answers: Yes, No, Unclear, or Not/Applicable (NA)

Both of the qualitative studies<sup>[24,25]</sup> and two of the quasi-experimental studies<sup>[26,28]</sup> addressed the barriers to SMBG testing (mentioned above). However, the evidence is perhaps weakened due to the following reasons. Several components that are not clear in the qualitative studies are – the influence of researchers on the study population,<sup>[24,25]</sup> how the cultural or theoretical beliefs of the researchers were related to their study,<sup>[24,25]</sup> the language in which the interviews were conducted,<sup>[24]</sup> and the quality and validity assessment of the English language translations of the verbatim transcripts.<sup>[25]</sup> Whereas the hazy areas of the quasi-experimental studies<sup>[26,28]</sup> that dealt with SMBG-barriers were – absence of a control group or a pre-intervention finding to compare with the post-intervention findings,<sup>[26,28]</sup> the measurement methods of barriers to SMBG-testing in GDM patients were not consistent among the two studies,<sup>[26,28]</sup> and lack of validity-related information of the questionnaire used in one of these studies (to understand the barriers of SMBG in GDM patients).<sup>[28]</sup>

None of the studies except Cosson *et al.*<sup>[26]</sup> utilized any diagnostic criteria to define GDM in their study population.

Overall, the studies<sup>[24-29]</sup> measured or analyzed what they intended to measure or analyze.

The additional search in the PROSPERO website (<https://www.crd.york.ac.uk/prosperto/>)<sup>[19]</sup> (as of June 30, 2018) identified a Cochrane protocol that is in “review ongoing” status.<sup>[32]</sup> This study is currently assessing adherence to SMBG-testing in GDM patients as a secondary outcome in randomized control trials, quasi-randomized control trails, and cluster-randomized control trials.<sup>[32]</sup> However, if the barriers to SMBG-testing among GDM patients are going to be reviewed or not in this Cochrane review is not clear.<sup>[32]</sup>

None of the hand searched literature matched the eligibility criteria of this review, hence not included.

## Discussion

The literature review conducted in this study identified a severe shortage of studies that have tried to understand the barriers and compliance to SMBG in GDM patients. There are several shortfalls of the existing literature which are discoursed here. Overall, the study population-related description such as the previous history of GDM, the gestational age at which the study participants were recruited, the obstetric history (the gravida and parity), and age range of participants was not available throughout these studies consistently. Study population characteristics such as previous history of GDM, gravida, and parity-related information were available in only one of the studies done by Youngwanichsetha and Phumdoung.<sup>[24]</sup> Only two studies (the qualitative ones) mentioned the gestational age of their study population.<sup>[24,25]</sup> The age range of the study participants was available for only one study,<sup>[25]</sup> and only three out of the six studies provided a mean age.<sup>[24,26,29]</sup> Exclusion

criteria were not clearly stated in most studies.<sup>[24-27,29]</sup> This lack of basic study population defining features made comparison across these studies difficult.

Study population-related confusion was also witnessed in one study, between its two phases.<sup>[27]</sup> In the first phase, a pilot testing of the role of mobile technology in SMBG compliance was done.<sup>[27]</sup> Based on the feedback from the participants of the pilot test necessary changes was made to the mobile technology and was re-tested in GDM patients for SMBG compliance in the second phase.<sup>[27]</sup> The reporting of the result was unclear because it reported compliance (85%, i.e. 46 out of 54) based on all participants of both phases of the study although the mobile technology in the second phase (upgraded) was not same as the first phase.<sup>[27]</sup> The comparison between the two phases was complicated further as the info about what medications the participants were on while in the study was only available for those enrolled in the second phase (who were not treated with insulin or metformin).<sup>[27]</sup> Nevertheless, a separate group wise frequencies for the compliance was available in the study.<sup>[27]</sup>

Regarding the quasi-experimental studies,<sup>[26,28,29]</sup> sampling-related information such as sampling method and sample size calculation was grossly unavailable. The study by Mackillop *et al.*<sup>[27]</sup> was an exception in this regard. It recruited all women who attended the diabetes-maternity clinic (in the second phase).<sup>[27]</sup> However, the calculation of power or factors that might have strengthened or compromised the statistical power was not available for any of these non-randomized experimental studies.<sup>[24,26-29]</sup> Lack of power related information made it difficult to comment on the strength of the evidence produced from the studies.

Then, regarding the confounders, none of the four quasi-experimental studies,<sup>[26-29]</sup> except one,<sup>[26]</sup> considered for adjusting the confounders. It was also not clear if any other methods such as randomization or matching were used by the quasi-experimental studies<sup>[26-29]</sup> to decrease any bias due to confounding. The effects of an intervention are generally at risk of confounding and efforts should be made to identify and control them to avoid undue bias.<sup>[33]</sup> Confounding can be controlled by stratification, adjusting, matching, randomization, etc.<sup>[33]</sup>

Next, quasi-experimental studies are considered to be of better rigor and quality when they include a pre- and post-intervention comparison and/or a comparison with a control group, rather than without such comparisons.<sup>[34]</sup> None of the quasi-experimental studies<sup>[26-29]</sup> included in this review mentioned a pre- and post-comparison of their findings. Out of the four quasi-experimental studies,<sup>[26-29]</sup> only one study<sup>[29]</sup> compared its findings with a control group. Therefore, in regard to comparability of the results, the studies are relatively weak.

Comparability of the four quasi-experimental studies<sup>[26-29]</sup> weakened further since the method of assessing compliance

among these studies<sup>[26-29]</sup> was not consistent. Cosson *et al.*<sup>[26]</sup> considered participants to be compliant with SMBG when at least 80% of the total (pre- and post-prandial) SMBG tests were done,<sup>[26]</sup> whereas, Peleg *et al.*<sup>[29]</sup> measured the compliance by dividing the recommended number of SMBG over a time period by the number of SMBG tests done during that period.<sup>[29]</sup> On the other hand, the study by Mackillop *et al.*<sup>[27]</sup> ensured compliance when 18 SMBG tests were done per week. In Sousa *et al.* study,<sup>[28]</sup> the compliance determination method was not clear.<sup>[28]</sup>

The causes of non-compliance to SMBG among the GDM patients were studied in the Cosson *et al.* study.<sup>[26]</sup> However, only for one cause of non-compliance (the family history of Type 2 diabetes in first-degree relatives) (OR = 0.38, 95% CI 0.15–0.98,  $P = 0.044$ ) an OR and CI were available, for assessing the strength of association.<sup>[26]</sup> Other causes of non-compliance identified by this study (not-belonging to French ethnicity ( $n = 28$ ,  $P = 0.048$ ) and having medical insurance dedicated for the impoverished ( $n = 9$ , 26%,  $P = 0.033$ )<sup>[26]</sup> were difficult to interpret because the results were reported in statistical significance (p-value) only (for the respective variables) with no clear mention about the strength of association (like the OR) and the precision of such association (e.g., the 95% CI).<sup>[26,35]</sup>

None of the quasi-experimental studies<sup>[26-29]</sup> have a clear mention of the raters and inter- and intra-rater reliability about the cause and effect relationship derived statistically.<sup>[30]</sup>

Although the qualitative studies<sup>[24,25]</sup> were of good quality (fulfilling most of the critical appraisal criteria [Table 2]), certain issues question the overall rigor of these studies. Only one of the two qualitative studies clearly mentioned its sampling method (purposive).<sup>[25]</sup> The interview transcripts in Ge *et al.*<sup>[25]</sup> study were translated from Mandarin Chinese language to the English language; however, information about the translation quality and its validity is not clearly depicted.<sup>[25]</sup> In the other qualitative study, interviewers were in contact with the participants for a substantial duration – it is not clear from the study if such engagement anyhow affected (biased) the participant responses and if anything was done to address it.<sup>[24]</sup>

Information regarding the GDM diagnostic criteria used to identify GDM patients was available only for one study.<sup>[26]</sup> It used the IADPSG criteria<sup>[21]</sup> to diagnose GDM.<sup>[26]</sup>

Conflict of interest and funding related declaration were available for all studies except the study by Sousa *et al.*<sup>[28]</sup> None of the authors of the studies<sup>[24-29]</sup> incorporated in this review were contacted.

### Limitations of this study

This study was based on a literature search of a relatively short time span, less than a decade (from March 2010 to June

2018), which might have compromised the scope of reviewing a larger number of studies.

### Conclusion

To understand the barriers to SMBG and the factors that determine the compliance of SMBG among GDM patients, this systemic review was conducted. This review included relevant articles published between March 2010 and June 2018. There were few studies (six only) that met the eligibility criteria of this review. The studies reviewed in this paper reported the following barriers of SMBG in GDM patients – lack of SMBG-testing recommendation by health-care providers, poor concept, fear, and anxiety about SMBG-testing, and family history of Type 2 diabetes.<sup>[24-26,28]</sup> The compliance to SMBG-testing in GDM patients improved with the use of education (SMBG related) and technology (smartphone and mobile-based).<sup>[27-29]</sup> However, these results are not comparable across the studies. Moreover, the results are not generalizable due to the respective weaknesses of the studies discussed in this paper. Therefore, based on this review, the current evidence regarding SMBG related barriers and compliance in GDM patients are labeled as weak and inadequate (for an external validity). Henceforth, further research is required on this topic.

### Funding

No funding in any form was available for this study.

### Conflict of interest Statement

There are no conflicts of interest.

### References

1. Buchanan TA, Xiang AH, Page KA. Gestational diabetes mellitus: Risks and management during and after pregnancy. *Nat Rev Endocrinol* 2012;8:639-49.
2. Langer O, Yogev Y, Most O, Xenakis EM. Gestational diabetes: The consequences of not treating. *Am J Obstet Gynecol* 2005;192:989-97.
3. Kim C, Ferrara A. *Gestational Diabetes During and After Pregnancy*. Dordrecht, New York: Springer; 2010.
4. American Diabetes Association. Standards of Medical Care in Diabetes-2017. Vol. 40; 2017. Available from: [http://www.care.diabetesjournals.org/content/diacare/suppl/2016/12/15/40\\_Supplement\\_1.DC1/DC\\_40\\_S1\\_final.pdf](http://www.care.diabetesjournals.org/content/diacare/suppl/2016/12/15/40_Supplement_1.DC1/DC_40_S1_final.pdf). [Last accessed on 2018 Jul 5].
5. Agarwal MM. Gestational diabetes mellitus: An update on the current international diagnostic criteria. *World J Diabetes* 2015;6:782. Available from: <http://www.wjgnet.com/1948-9358/full/v6/i6/782.htm>. [Last accessed on 2018 Jun 19].
6. Brown J, Alwan NA, West J, Brown S, McKinlay CJ, Farrar D, *et al.* Lifestyle interventions for the treatment of women with gestational diabetes. *Cochrane Database Syst Rev* 2017;5:CD011970.
7. NICE. Diabetes in Pregnancy: Management from Preconception to the Postnatal Period|Guidance and Guidelines|NICE; 2015. Available from: <https://www.nice.org.uk/guidance/ng3/chapter/1->

- Recommendations#gestational-diabetes-2. [Last accessed on 2018 Jul 01].
8. Blumer I, Hadar E, Hadden DR, Jovanović L, Mestman JH, Murad MH, *et al*. Diabetes and pregnancy: An endocrine society clinical practice guideline. *J Clin Endocrinol Metab* 2013;98:4227-49.
  9. American Diabetes Association. 13. Management of Diabetes in Pregnancy. *Diabetes Care* 2017;40 Suppl 1:S114-S119. Available from: [http://www.care.diabetesjournals.org/content/40/Supplement\\_1/S114](http://www.care.diabetesjournals.org/content/40/Supplement_1/S114). [Last accessed on 2018 Jul 1].
  10. Clar C, Barnard K, Cummins E, Royle P, Waugh N, Aberdeen Health Technology Assessment Group. Self-monitoring of blood glucose in Type 2 diabetes: Systematic review. *Health Technol Assess Winch Engl* 2010;14:1-140.
  11. Tan MY, Magarey JM, Chee SS, Lee LF, Tan MH. A brief structured education programme enhances self-care practices and improves glycaemic control in Malaysians with poorly controlled diabetes. *Health Educ Res* 2011;26:896-907. Available from: <https://www.academic.oup.com/her/article/26/5/896/633732>. [Last accessed on 2018 Jul 4].
  12. Ong WM, Chua SS, Ng CJ. Barriers and facilitators to self-monitoring of blood glucose in people with Type 2 diabetes using insulin: A qualitative study. *Patient Prefer Adherence* 2014;8:237-46. Available from: <https://www.dovepress.com/barriers-and-facilitators-to-self-monitoring-of-blood-glucose-in-peopl-peer-reviewed-article-PPA>. [Last accessed on 2018 Jul 4].
  13. Choi JH, Park CY, Cha BS, Kim IJ, Park TS, Park JY, *et al*. Perception of clinicians and diabetic patients on the importance of postprandial glucose control and diabetes education status: A cross sectional survey. *Diabetes Metab J* 2012;36:120-7.
  14. Nyomba BL, Berard L, Murphy LJ. The cost of self-monitoring of blood glucose is an important factor limiting glycemic control in diabetic patients. *Diabetes Care* 2002;25:1244-45.
  15. Aronson JK. Compliance, concordance, adherence. *Br J Clin Pharmacol* 2007;63:383-4.
  16. Alpert JS. Compliance/adherence to physician-advised diagnostic and therapeutic strategies. *Am J Med* 2014;127:685-6. Available from: <http://www.linkinohub.elsevier.com/retrieve/pii/S000293431400237X>. [Last accessed on 2018 Jun 30].
  17. Chatterjee JS. From compliance to concordance in diabetes. *J Med Ethics* 2006;32:507-10.
  18. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, *et al*. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Med* 2009;6:e1000100. Available from: <http://www.dx.plos.org/10.1371/journal.pmed.1000100>. [Last accessed on 2018 Jun 28].
  19. University of York. International Prospective Register of Systematic Reviews. PROSPERO. Available from: <https://www.crd.york.ac.uk/PROSPERO>. [Last accessed on 2018 Jul 01]
  20. McIntyre HD, Colagiuri S, Roglic G, Hod M. Diagnosis of GDM: A suggested consensus. *Best Pract Res Clin Obstet Gynaecol* 2015;29:194-205. Available from: <http://www.linkinohub.elsevier.com/retrieve/pii/S1521693414001709>. [Last accessed on 2018 Jun 19].
  21. International Association of Diabetes and Pregnancy Study Groups Consensus Panel. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care* 2010;33:676-82. Available from: <http://www.care.diabetesjournals.org/cgi/doi/10.2337/dc09-1848>. [Last accessed on 2018 Jun 19].
  22. World Health Organization. Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy: A World Health Organization Guideline. *Diabetes Res Clin Pract* 2014;103:341-63. Available from: <http://www.linkinohub.elsevier.com/retrieve/pii/S0168822713003549>. [Last accessed on 2018 Jun 19].
  23. Aromataris E, Munn Z. Joanna Briggs Institute Reviewer's Manual; 2017. Available from: <https://www.reviewersmanual.joannabriggs.org>. [Last accessed on 2018 Jul 01].
  24. Youngwanichsetha S, Phumdoung S. Lived experience of blood glucose self-monitoring among pregnant women with gestational diabetes mellitus: A phenomenological research. *J Clin Nurs* 2017;26:2915-21.
  25. Ge L, Wikby K, Rask M. Is gestational diabetes a severe illness? Exploring beliefs and self-care behaviour among women with gestational diabetes living in a rural area of the south east of China. *Aust J Rural Health* 2016;24:378-84.
  26. Cosson E, Baz B, Gary F, Pharisien I, Nguyen MT, Sandre-Banon D, *et al*. Poor reliability and poor adherence to self-monitoring of blood glucose are common in women with gestational diabetes mellitus and may be associated with poor pregnancy outcomes. *Diabetes Care* 2017;40:1181-6.
  27. Mackillop L, Loerup L, Bartlett K, Farmer A, Gibson OJ, Hirst JE, *et al*. Development of a real-time smartphone solution for the management of women with or at high risk of gestational diabetes. *J Diabetes Sci Technol* 2014;8:1105-14.
  28. Sousa AM da S, Fiuza D, Mikami FC, Abrão KC, Francisco RP, Zugaib M. Evaluation of information retention and adherence to treatment in patients with gestational diabetes mellitus after multidisciplinary group. *Rev Assoc Médica Bras* 2016;62:212-7. Available from: [http://www.scielo.br/scielo.php?script=sci\\_arttext&pid=S0104-42302016000300212&lng=en&tlng=en](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-42302016000300212&lng=en&tlng=en). [Last accessed on 2018 Jun 23].
  29. Peleg M, Shahar Y, Quaglini S, Broens T, Budasu R, Fung N, *et al*. Assessment of a personalized and distributed patient guidance system. *Int J Med Inf* 2017;101:108-30.
  30. Tufanaru C, Campbell J, Hopp L. Systematic Reviews of Effectiveness. Ch. 3. Joanna Briggs Institute Reviewer's Manual Joanna Briggs Institute; 2017. Available from: <https://www.reviewersmanual.joannabriggs.org>. [Last accessed on 2018 Jul 04].
  31. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. *Int J Evid Based Healthc* 2015;13:179-87.
  32. Gill M, Nguyen TM, Bain E, Crowther C, Middleton P. Home Versus Hospital glucose Monitoring for Gestational Diabetes During Pregnancy [Cochrane Protocol]. PROSPERO; 2015. Available from: [http://www.crd.york.ac.uk/PROSPERO/display\\_record.php?ID=CRD42015018972](http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42015018972). [Last accessed on 2018 Jun 26].
  33. Jager KJ, Zoccali C, MacLeod A, Dekker FW. Confounding: What it is and how to deal with it. *Kidney Int* 2008;73:256-60. Available from: <http://www.sciencedirect.com/science/article/pii/S0085253815529748>. [Last accessed on 2018 Aug 10].
  34. Harris AD, McGregor JC, Perencevich EN, Furuno JP, Zhu J, Peterson DE, *et al*. The use and interpretation of quasi-experimental studies in medical informatics. *J Am Med Inform Assoc JAMIA* 2006;13:16-23.
  35. Szumilas M. Explaining odds ratios. *J Can Acad Child Adolesc Psychiatry* 2010;19:227-9.