Perinatal Outcomes Associated with the Diagnosis of Gestational diabetes: systematic review and meta-analysis

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Abstract

Background and Aims

The objective of this study was to compare perinatal outcomes in pregnant women diagnosed with gestational diabetes using the one-step strategy proposed by the International Association of Diabetes and Pregnancy Study Groups (IADPSG), and the two-step, recommended by the American College of Obstetricians and Gynecologists.

Methods

A literature search was conducted from January 2014 to February 2019. Observational studies of pregnant women with a diagnostic for gestational diabetes were included, under the test proposed by the IADPSG and the two-step with the Carpenter-Coustan Criteria. Studies involving pre-pregnancy diabetics, multiple pregnancies, and pregnancies with fetal malformations were excluded. The outcomes studied were induction of labor and delivery, preterm delivery, fetal macrosomia, neonatal hypoglycemia, hyperbilirubinemia, low birth weight, and admission to the neonatal intensive care unit. Studies involving pre-pregnancy diabetics, multiple pregnancies, and pregnancies with fetal malformations were excluded.

Results

Eight studies were included with a population of 108,609 pregnant women. Statistical differences were obtained for the perinatal results of fetal macrosomia with a RR of 0.9 (95% CI 0.85 - 0.97; I2 0%), neonatal hypoglycemia with a RR of 1.1 (95% CI 1.01 - 1.40; I2 48.5%). Additional, maternal-perinatal outcomes were not statistically different.

Conclusion

This meta-analysis suggests that there are good results for neonatal macrosomia when the one-step diagnostic strategy was applied, while for neonatal hypoglycemia the risk was lower with the two-step method.

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Keywords: pregnancy, diabetes, diagnosis, outcomes, One-step approach, two-step approach.

Abbreviations: Diabetes Gestacional (DG), Carpenter and Coustan (CC), Federation of Gynecology and Obstetrics (FIGO) World Health Organization (WHO), International Association of Diabetes and Pregnancy Study Groups (IADPSG), International Prospective Register of Systematic Reviews (PROSPERO).

INTRODUCTION

Gestational diabetes (GD) is one of the most common maternal metabolic pathologies associated with adverse maternal and neonatal outcomes. The prevalence ranges of GD (from 7.5% to 25%) dependent on the geographical area and the diagnostic criteria used (1,2). The International Diabetes Federation reported that 75% to 90% of cases of hyperglycemia in pregnancy are due to GD, and one in seven pregnancies with GD results in complications (1).

Hispanics are at higher risk for developing GD. However, it is not clear if this risk corresponds only to Hispanics residing in Europe or the United States (3,4). In recent decades, a higher prevalence of GD has been found due to the increase in alterations in carbohydrate metabolism, obesity, and sedentary lifestyle (1,3).

Gestational diabetes increases the risk of maternal morbidity due to the greater probability of cesarean delivery, trauma to the vaginal canal, hypertensive states of pregnancy, and developing type 2 diabetes mellitus (5,6). Regarding perinatal morbidity, a higher percentage of fetal death, macrosomia, neonatal hypoglycemia, hypoxia, respiratory distress syndrome, admission to the intensive care unit, neonatal hyperbilirubinemia, shoulder dystocia, and others have been documented (2,7–10).

Early screening for gestational diabetes is important due to the multiple maternal-perinatal complications. However, the most effective prenatal screening test is not the same according to different scientific societies (11). More than 60 years ago, the diagnostic approach for DG was first described by O'Sullivan and Mahan (12). Later, Carpenter and Coustan (CC) modified the method, using as a first step a screening test with 50 g of glucose without requiring fasting. For altered results in this first test, a second test needs to be performed using a 100 g oral glucose tolerance test, requiring two altered values of four to be considered as positive (13). In 2010, a consensus of the International Association of Diabetes and Pregnancy (IADPSG) proposed a single step with the administration of a 75 g glucose load in pregnant

women with fasting for the previous eight hours and the new cut-off points for the diagnosis (6,14). The latter approach has lower cutoff limits and requires a single altered value of three to be considered positive for DG. This criterion was adopted after the results obtained in the Study of Hyperglycemia and Adverse Outcome in Pregnancy, which included more than 23,000 women from several countries and ethnicities. Thus, a direct relationship between adverse neonatal outcomes and high glucose concentration in the mother was demonstrated (9).

At present, there is still no consensus regarding the diagnostic criteria for GD. Some controversy has arisen because using the one-step approach was associated with increasing the DG prevalence. Studies reported an increase of 17% to 27% (2,15) even up to 31.3% (16) compared to the two-step method. Similarly, the one-step approach promotes greater use of medications, increased induction of labor, neonatal hypoglycemia, and more frequent testing to assess fetal well-being, with a direct impact on the cost of the health systems (11,17). Furthermore, there is debate about whether increasing the prevalence using the one-step diagnostic test is valid for all types of populations in terms of the objective of reducing maternal-perinatal morbidity, or on the contrary, it leads to more interventions and medicalization of healthy pregnancies (11,18,19).

The College of Obstetricians and Gynecologists (ACOG) has recommended the two-step approach (20). Also, this same diagnostic approach is preferred in countries like Canada (21). In some European countries and Australia, the one-step test with a 75 g glucose load has been used (22). This last recommendation is endorsed by the International Federation of Gynecology and Obstetrics (FIGO) (23) and the World Health Organization (WHO) (24).

As previously described, there is no agreement on whether either of the two diagnostic strategies improves maternal-perinatal outcomes. Therefore, the objective of this study was to compare the results, through a systematic review of the literature, of the maternal-perinatal outcomes in patients diagnosed with GD, where the one-step approach has been used as a diagnostic criterion, as proposed by the IADPSG, or the two-step Carpenter-Coustan cutoffs criterion.

MATERIALS AND METHODS

The present study is a systematic review of the literature where the obstetric and perinatal outcomes of gestational diabetic obstetric patients diagnosed according to the one-step or two-step criteria were explored. This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO), under protocol CRD42020215062. A literature search was conducted in Medline, ProQuest Central, ClinicIKey, JAMA Annual Reviews, Science Direct, SpringerLink, Taylor & Francis, and Scopus. The terms used for the search were: “gestational diabetes” “pregnancy outcomes” with the combination of “one step”, “two-step” “diagnosis”. Data sources were searched from January 2014 to February 2019. Studies in all languages and geographic location were incorporated.

Eligibility Criteria

Prospective and retrospective observational studies written in English were included. Studies with a population of pregnant women with a diagnostic test for GD were included, according to the definitions of a single step proposed by the IADPSG (a single 75 g glucose load at 24 and 28 weeks of gestation, fasting blood glucose level > 92 mg/dL, at the hour > 180 mg/dL, and at two hours >153 mg/dL), with an altered value to classify it as positive for GD (6); two steps with the Carpenter and Coustan criteria, screening with glycemia after administration of 50 g of glucose. A level greater than 130-140 mg/dL, for result positive, an Oral Glucose Tolerance Curve (OGTT) should be with a 100-g glucose load test, 1 h ≥ 180 mg/dL, 2 h ≥ 155 mg/dL, and 3 h ≥ 140 mg. A positive result for DG is given with two altered values (13).

The adverse and perinatal outcomes evaluated were the route of delivery, induction of labor, fetal macrosomia defined as fetal weight at birth greater than 4000 - 4500 g, hyperbilirubinemia, neonatal hypoglycemia, (as defined by the original study), admission to the neonatal intensive care unit, preterm delivery (below week 37), cesarean delivery, low birth weight (neonatal weight below 2500 g). Studies with pre-

pregnancy diabetic participation, multiple pregnancies, and pregnancies with fetal malformations, as well as studies with results in the diabetic population or with incomplete data were excluded from the review.

Strategies for information extraction

This systematic review and meta-analysis were conducted according to the Preferred Reporting Item for Systematic Reviews and Meta-Analysis PRISMA guidelines (25). Two review authors independently applied the selection criteria to the titles and abstracts. After the selection, the articles were read. Selection disagreements were resolved by consensus between two members of the research team.

All the studies were analyzed. Information on the author, year of publication, the country, number of participants, criteria used for the diagnosis of GD, and maternal-perinatal results were extracted. The results were evaluated in frequencies. In articles without frequencies, the calculation was based on the percentages reported and the relevant effect measures for the variables of interest to identify the association of perinatal results, using the different diagnostic criteria. The information was summarized in a pre-designed matrix in Microsoft Excel.

Statistical analysis of information

The relevant information of the data description is shown in Table 1. The grouped incidence of each outcome was obtained according to each diagnostic test, using a random-effects model according to that presented by Neyeloff JL et al (26). The effect estimate was expressed as relative risk (RR) using the Mantel-Haenszel fixed-effect model in the case of low heterogeneity. For the meta-analysis of each study, the relative risks were extracted for each outcome studied. Frequencies of the outcomes from the relative risk were calculated. Confidence intervals (CI) of 95% were presented for each relative risk. Clinical sources of heterogeneity between studies were explored. Statistical homogeneity was assessed by the statistic I^2. Values of zero indicated the absence of heterogeneity, while an I^2 less than 50% indicated acceptable homogeneity. Sensitivity analysis was performed for the

outcomes that presented heterogeneity greater than 50%. The software Stata v14 was used for the analysis.

Ethical Considerations

The present study is a review of the scientific literature and does not require approval by the ethics committee.

RESULTS

Evaluation of the quality of the evidence

The evaluation of the quality of the included studies was analyzed with the guidelines of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology initiative) (27) for analytical studies. All the analyzed studies had a score between 18 and 20. (Supplementary material table 1)

Characteristics of the studies

In the initial search, 2466 articles were obtained. The studies were excluded according to the selection criteria and without analysis of the results or duplicates. In total, 8 retrospective studies were evaluated (Figure 1), however nine cohorts were analyzed because the Pocobelli study included two different cohorts (28), with a total population of 108,609 pregnant women. The incidence of DG ranged between 8.3% and 35.5% in the studies that used one-step diagnostic criteria. In the studies where the two-step method was used, the incidence ranged between 2.5% and 21.6%. Regarding location, 50% of the studies were conducted in the United States, 26% in Taiwan, 12% in Canada, and 12% in Spain (Table 1).

Maternal outcomes

The maternal outcomes analyzed were induction of labor and cesarean delivery. The induction of labor was reported by four studies (2,28,29,31) which investigated this outcome. For the group of patients with a one-step diagnostic strategy, the incidence ranged from 15.7% to 46.4%, while for the CC group it was from 17.2% to 44.8%. A pooled analysis was performed and an incidence of 22.7% (95% CI 18.3 - 27.2) was found for the one-step diagnostic criterion. For the two-step it was 22.5% (95% CI:

18.7 - 26.2) with a RR 1.0 (95% CI 0.945 1.082; I^2 79.9%). A sensitivity analysis was performed excluding the Pocobelli studies (28) and Hung (29) that contributed more heterogeneity, obtaining a RR of 1.0 (IC 0.984 1.052; I^2 0%) (Figure 2a).

Seven studies analyzed the outcome of cesarean delivery (2,28–33). The incidence in the group of patients with the one-step diagnostic strategy ranged from 19.7% - 39.4%, while for the group in which the CC criterion was used it was 8.7% -37%. With the pooled analysis, an incidence of 27.2% was found for the one-step criterion (95% CI 22.6– 31.7), for the two-step group, the incidence was 27.1% (95% CI 23.5–30.7), with RR 0.99 (95% CI: 0.9 - 1.0; I^2 86.6%). After conducting the sensitivity analysis excluding the Pocobelli (28) and Duran (32) studies. It was obtained a RR of 1.06 (IC95%: 1.0-1.1) and an I^2 of 0% (Figure 2b).

Perinatal outcomes

Five studies evaluated fetal macrosomia as the perinatal outcome (2,28,30,32,34), Macrosomia as birth weight greater than 4500g was defined in a single study. The prevalence of macrosomia among the studies that used the one-step diagnostic test was 1.6% and 8.9%, while for the two-step diagnostic approach it ranged between 1.6% and 13%. When performing a pooled analysis for the one-step diagnostic criterion, an incidence of 4.9% (95% CI 2.1 - 7.7) was found and for the two-step criterion, the incidence was 5.6% (95% CI 2.6 - 8.5) with a RR of 0.9 (IC95% 0.8 - 0.9; I^2 0%) (Figure 3a).

Neonatal hypoglycemia

Six studies (28,30–34) referenced the neonatal hypoglycemia outcome. The incidence for the one-step group was between 0.5% and 8.5%, and for the two-step group 0.5% and 5.5%. When performing a pooled analysis, an incidence of 2.0% (95% CI 1.3 - 2.6) was identified for the one-step diagnostic criterion and 1.5% for the two-step diagnostic criterion (95% CI 9.5 - 2.1), with the RR found of 1.1 (IC 95% 1.0 - 1.4; I^2 48.5%) (Figure 3b).

Low weight at birth

Five articles (28,29,31,32,34) evaluated low weight at birth, the incidence for the group with the IADPSG diagnostic strategy ranged between 1.3% and 10%, for the two-step group 1.3% and 7.7%. For the pooled analysis, the incidence found was 5.8% (95% CI 3.5- 8.2) for the one-step diagnostic criterion and 6.3% for the two-step diagnostic criterion (95% CI 4.0 - 8.6) with a RR 0.9 (IC 95% 0.8 - 1.0; I^2 60%). Sensitivity analysis was performed excluding the study of Hungs (29), and a RR of 0.9 (IC 0.9 – 1.0; I^2 0%) was found (Supplementary material 2a).

Premature birth

Five studies (2,29,31,32,34) evaluated the association of preterm birth with diagnostic criteria. The incidence found for the diagnostic strategy proposed by IADPSG was between 5.7% and 9.3%, and for the two-step method, it fluctuated between 6.4% and 8.5%. When performing pooled analysis for the one-step diagnostic strategy, an incidence of 7.6% (95% CI 6.4 - 8.7) was found and for the two-step criterion of 7.3% (95% CI 6.6 - 8.0) with RR of 1.0 (IC95%: 0.9 - 1.0; I^2=0%) (Supplementary material 2b).

Admission to the intensive care unit

Seven studies (2,28–30,32–34) analyzed this perinatal result. For the two-step group, the incidence ranged between 0.6% and 10.5%, while for the group with the IADPSG diagnostic approach it ranged between 0.3% and 9.6%. For the pooled analysis according to the one-step criterion the incidence was 4.8% (95% CI 3.1-6.5) and for the two-step criterion 4.7% (95% CI 3.2 - 6.2) with a RR of 1.0 (IC95% 0.8 - 1.2; I^2=78.8%). A sensitivity analysis was performed excluding the studies by Palatnik (30), Duran (32), and Feldman (2); with this analysis, an RR of 1.0 was obtained (IC95% 0.9 - 1.1; I^2=0%) (Supplementary material 3a).

Hyperbilirubinemia

Four articles (2,30,33,34) reported hyperbilirubinemia. The incidence found was between 5.4% and 22.7% for the one-step diagnostic group and when the two-step diagnostic criterion was used, the incidence found was between 1.7% and 23.5%. The pooled analysis found incidence of 10.1% (IC95% 5.2 – 15) and 9.5% (IC95% 5.0 – 14) for the one and two steps respectively with an RR of 1.0 (IC95% 0.89-1.28; I^2=67%). After conducting sensitivity analysis the studies by Palatnik (30), Wu (33), and Lee (34) were excluded, the effect was unchanged (Supplementary material 3b). The maternal-perinatal results are summarized in Table 2.

DISCUSSION

GD is associated with multiple short- and long-term complications for the mother and the newborn. However, there is still debate regarding the most appropriate diagnostic strategy that manages to minimize the poor maternal-perinatal outcomes. This systematic review has assessed whether the one-step method, recommended by WHO (24) and by IADPSG (6), or the two-step one recommended by the ACOG (20), represents a lesser frequency of adverse maternal perinatal outcomes. The results found statistically significant differences in favor of the two-step strategy for the perinatal outcome of neonatal hypoglycemia and the outcome of fetal macrosomia. The results showed the benefit of the one-step diagnostic approach, however, as in this review, no differences were identified between these two diagnostic methods for the rest of the outcomes studied.

Macrosomia is one of the clinically relevant outcomes in pregnant women with GD since it is related to difficult labor, dystocia, birth trauma, and other adverse outcomes. In previous meta-analyses with the IADPSG diagnostic approach, lower incidences of macrosomia were found (35), similar to that reported in this work because less possibility of this perinatal outcome was identified with the one-step diagnostic approach (RR 0.9; IC95% 0.85 - 0.97; I^2 0%) (Figure 2). This is probably because this test increases the number of women with GD; including patients with milder glycemic alteration promotes more intervention and a stricter metabolic control that reduces the effect of maternal diabetes on fetal growth. On the other

hand, it is important to highlight that additional factors such as pre-pregnancy obesity and maternal weight gain, which are not stratified in the included studies, also influence this result (2,17,28,30,32,34,36).

An outcome of interest was that of neonatal hypoglycemia, whose incidence found in pregnant women with GD is 2.1% (37). In this study, a lower risk of hypoglycemia was detected with the two-step diagnostic strategy. (RR1.1; IC 95% 1.01 - 1.40; I^2 48.5%) (Figure 3), findings that disagree with another systematic review that reported a lower percentage of neonatal hypoglycemia 1.7% versus 4.5% in the group of pregnant women diagnosed with the IADPSG criteria in contrast to CC (35). This difference may be related to the type of design of the included studies, taking into account that in the work of Saccone et al (35). Clinical trials were analyzed and this work included analytical studies. Furthermore, the moderate heterogeneity found in the present review may partly explain the difference between these perinatal outcomes. However, according to our findings, the two-step strategy, according to the results of this meta-analysis, would confer less risk for the newborn regarding the presentation of hypoglycemia in the first hours of life. However, this variable may also be related to the treatment received by the mother for her diabetes and the glycemic control that she had during pregnancy.

It has been described that diabetic pregnant women have a greater probability of ending the pregnancy by cesarean section compared to healthy pregnant women (38). Ethridge et al found a similar cesarean delivery rate in pregnant women with GD diagnosed with the IADPSG method and with the two-step strategy (18). In this meta-analysis, when analyzing the risk of cesarean delivery, no statistical differences were found between the two diagnostic tests. However, two studies were found that increase heterogeneity (28,32). After excluding them, it was possible to identify some differences with a slight benefit for the diagnostic approach with the two-step method (RR 1.06; IC95%: 1.01-1.11).

For outcomes of preterm delivery, admission to the neonatal intensive care unit, small size for gestational age, and induction of labor (Figures 4 to 8) no differences were found between the two diagnostic tests. Similarly, an Australian study

evaluated the implications of adopting the diagnostic criteria proposed by IADPSG, and no reduction in macrosomia was found, but a slight decrease in neonatal hypoglycemia and admission to the ICU was observed with the one-step strategy. Additionally, these authors carried out cost-effectiveness analyses and showed an increase in hospital costs with the IADPSG diagnostic approach, due to a greater number of medical visits for follow-up, perhaps because of classifying low-risk women as DG(39). In contrast, the study by Saccone et al (35), where the one-step approach shows better results than the two-step approach concerning preterm delivery (3.7% vs 7.6% RR 0.49), neonatal hypoglycemia (1.7% vs 4.5%: RR 0.38), and cesarean delivery (16.3% vs 22%; RR 0.74). Similarly, in the publication by Hosseine et al (40), a significant association was reported between the two-step criteria and a higher frequency of cesarean delivery with a RR of 1.28 for the one-step group, versus a RR of 3.3 when the CC criteria were used. However, this review found an increased risk for gestational hypertension and admission to the neonatal ICU when GD was diagnosed with the one-step method. These differences in results are probably due to the size of the sample and the type of studies included in each of these systematic reviews. In the present meta-analysis, the small sample size of some studies may contribute to discrepancies with other publications.

On the other hand, it is important to know the population, to which the test is applied, taking into account that there are populations with a higher risk for GD compared to others. The Latin American population, for example, is considered to be at high risk for metabolic disorders such as GD and diabetes type 2 Mellitus (4,41). For this reason, with the one-step approach, the prevalence of the disease will increase; according to the IADPSG report, the prevalence of GD increases to 17.8% (6), In the case of countries with limited resources, it can lead to a greater burden on the system, the use of more laboratory tests and greater ultrasound follow-up of the fetus, as well as a generalization of treatment to non-ill patients. Martínez-Cruz et al (42) compared pregnant women without GD with pregnant women diagnosed with the IADPSG criteria not treated, finding no differences in terms of perinatal results, nor were there differences in the risk of adverse outcomes such as cesarean section, preterm delivery, and premature rupture of membranes. However, by identifying

more women with GD, a group with the potential risk of developing type 2 diabetes mellitus in the future would be classified. This is useful to guide long-term prevention strategies that focus on promoting a healthy lifestyle if we take into account the increase in obesity and metabolic syndrome in the world population.

This study shows the variable results between the different published works, due to the way of measuring maternal-perinatal outcomes and the diversity of diagnostic methods used. The variety of criteria in different regions even in the same country can complicate the interpretation and design of investigations in DG. This should motivate the generation of a universally accepted consensus to obtain similar diagnostic parameters in this endocrinopathy important for the pregnant women, showing superiority in the short and long term; for this, it is essential to perform intervention trials that demonstrate a clear benefit of proof over another. This work shows there are similar maternal-perinatal results with either of the two diagnostic strategies used; therefore, it would be independent to use one or the other test to the appearance of the neonatal complications evaluated.

The strength of this research is the inclusion of a variety of patients in terms of ethnic characteristics, which allows extrapolating the results to multiple populations. Additionally, adequate statistical analysis was performed, which improves the quality of our results. The main limitations of this meta-analysis are the heterogeneity of the studies found, which was reflected in the analysis, so its results should be interpreted in the light of statistical analysis and the possibility of publication bias. The relationship of maternal characteristics such as obesity, family history, metabolic control, and GD treatment with maternal-perinatal outcomes in pregnant women with GD was not investigated.

CONCLUSION

The findings of this meta-analysis indicate that the diagnosis of GD with the one-step or two-step diagnostic approach has similar perinatal results, except for hypoglycemia and neonatal macrosomia.

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Conflict of interest We declare that there is no financial or nonfinancial potential conflict of interest.

FIGURES

TABLES

FIGURES SUPPLEMENTARY MATERIAL

REFERENCES

1. Federación Internacional de Diabetes. Atlas de la Diabetes de la FID. Actualización. [Internet]. Atlas de la Diabetes de la FID. 2019. 1–169 p. Available from: http://www.idf.org/sites/default/files/Atlas-poster-2014_ES.pdf

2. Feldman RK, Tieu RS, Yasumura L. Gestational Diabetes Screening: The International Association of the Diabetes and Pregnancy Study Groups Compared With Carpenter-Coustan Screening. Obstet Gynecol [Internet]. 2016;127(1):10–7. Available from: https://insights.ovid.com/crossref?an=00006250-201601000-00004

3. Jenum AK, Richardsen KR, Berntsen S, Mørkrid K. Gestational diabetes, insulin resistance and physical activity in pregnancy in a multi-ethnic population – a public health perspective. Nor Epidemiol [Internet]. 2013;23(1). Available from: http://www.ntnu.no/ojs/index.php/norepid/article/view/1602

4. Chasan-Taber L, Fortner RT, Gollenberg A, Buonnaccorsi J, Dole N, Markenson G. A Prospective Cohort Study of Modifiable Risk Factors for Gestational Diabetes among Hispanic Women: Design and Baseline Characteristics. J Women's Heal [Internet]. 2010 Jan;19(1):117–24. Available from: http://www.liebertpub.com/doi/10.1089/jwh.2009.1416

5. Association AD. Introduction: Standards of Medical Care in Diabetes—2019. Diabetes Care [Internet]. 2019;42(Supplement 1):S1–2. Available from: https://care.diabetesjournals.org/content/42/Supplement_1/S1

6. Metzger BE. International Association of Diabetes and Pregnancy Study Groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. Diabetes Care. 2010;33(3):676–82.

7. Mirghani Dirar A, Doupis J. Gestational diabetes from A to Z. World J Diabetes. 2017;8(12):489–511.

8. Nayak PK, Mitra S, Sahoo JP, Daniel M, Mathew A, Padma A. Feto-maternal

outcomes in women with and without gestational diabetes mellitus according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG) diagnostic criteria. Diabetes Metab Syndr Clin Res Rev [Internet]. 2013;7(4):206–9. Available from: http://www.sciencedirect.com/science/article/pii/S1871402113001070

9. Leary J, Pettitt DJ, Jovanovič L. Gestational diabetes guidelines in a HAPO world [Internet]. Vol. 24, Best Practice and Research: Clinical Endocrinology and Metabolism. 2010. p. 673–85. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1521690X10000424

10. Waters TP, Dyer AR, Scholtens DM, Dooley SL, Herer E, Lowe LP, et al. Maternal and neonatal morbidity for women who would be added to the diagnosis of GDM using IADPSG criteria: A secondary analysis of the hyperglycemia and adverse pregnancy outcome study. Diabetes Care. 2016;39(12):2204–10.

11. Gupta Y, Kalra B, Baruah MP, Singla R, Kalra S. Updated guidelines on screening for gestational diabetes [Internet]. Vol. 7, International Journal of Women's Health. 2015. p. 539–50. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4445944/

12. O'sullivan, J B and, C M Maha. Criteria for the oral glucose tolerance test in pregnancy. Diabetes. 1964;13:278–85.

13. Carpenter MW, Coustan DR. Criteria for screening tests for gestational diabetes. Am J Obstet Gynecol [Internet]. 1982 Dec;144(7):768–73. Available from: https://linkinghub.elsevier.com/retrieve/pii/0002937882903490

14. Agarwal MM, Dhatt GS, Othman Y. Gestational diabetes: Differences between the current international diagnostic criteria and implications of switching to IADPSG. J Diabetes Complications [Internet]. 2015;29(4):544–9. Available from: files/38/S1056872715001026.html

15. Shahbazian H, Nouhjah S, Shahbazian N, Jahanfar S, Latifi SM, Aleali A, et

al. Gestational diabetes mellitus in an Iranian pregnant population using IADPSG criteria: Incidence, contributing factors and outcomes. Diabetes Metab Syndr Clin Res Rev. 2016;10(4):242–6.

16. March MI, Modest AM, Ralston SJ, Hacker MR, Gupta M, Brown FM. The effect of adopting the IADPSG screening guidelines on the risk profile and outcomes of the gestational diabetes population. J Matern Neonatal Med [Internet]. 2016 Aug 11;29(7):1141–5. Available from: http://www.tandfonline.com/doi/full/10.3109/14767058.2015.1038513

17. Scifres CM, Abebe KZ, Jones KA, Comer DM, Costacou T, Freiberg MS, et al. Gestational Diabetes Diagnostic Methods (GD2M) Pilot Randomized Trial. Matern Child Health J [Internet]. 2015 Aug 10;19(7):1472–80. Available from: http://link.springer.com/10.1007/s10995-014-1651-4

18. Ethridge JK, Catalano PM, Waters TP. Perinatal Outcomes Associated With the Diagnosis of Gestational Diabetes Made by The International Association of the Diabetes and Pregnancy Study Groups Criteria. Obstet Gynecol [Internet]. 2014 Aug 29;124(3):571–8. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4696546/

19. Ogunleye OK, Davidson KD, Gregg AR, Egerman RS. Perinatal outcomes after adopting 1- versus 2-step approach to diagnosing gestational diabetes. J Matern Neonatal Med [Internet]. 2017 Jan 17;30(2):186–90. Available from: https://www.tandfonline.com/doi/abs/10.3109/14767058.2016.1166201?journalCode=ijmf20

20. Committee on Practice Bulletins - Obstetrics. ACOG Practice Bulletin No. 190. Obstet Gynecol [Internet]. 2018 Feb;131(2):e49–64. Available from: http://journals.lww.com/00006250-201802000-00037

21. Feig DS, Berger H, Donovan L, Godbout A, Kader T, Keely E, et al. 2018 Clinical Practice Guidelines Diabetes and Pregnancy Diabetes Canada Clinical Practice Guidelines Expert Committee Pre-Existing Diabetes Preconception and During Pregnancy. Can J Diabetes [Internet].

2018;42:S255-282. Available from: https://doi.org/10.1016/j.jcjd.2017.10.038

22. RANZCOG. Diagnosis of gestational diabetes mellitus. In: Diabetes and Pregnancy. CRC Press; 2018. p. 110–8.

23. Hod M, Kapur A, Sacks DA, Hadar E, Agarwal M, Di Renzo GC, et al. The International Federation of Gynecology and Obstetrics (FIGO) Initiative on gestational diabetes mellitus: A pragmatic guide for diagnosis, management, and care #. Int J Gynecol Obstet [Internet]. 2015 Oct;131:S173–211. Available from: http://doi.wiley.com/10.1016/S0020-7292%2815%2930033-3

24. Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy: A World Health Organization Guideline. Diabetes Res Clin Pract [Internet]. 2014 Mar;103(3):341–63. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0168822713003549

25. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med [Internet]. 2009 Jul 21;6(7):e1000097. Available from: https://dx.plos.org/10.1371/journal.pmed.1000097

26. Neyeloff JL, Fuchs SC, Moreira LB. Meta-analyses and Forest plots using a microsoft excel spreadsheet: step-by-step guide focusing on descriptive data analysis. BMC Res Notes [Internet]. 2012 Dec 20;5(1):52. Available from: https://bmcresnotes.biomedcentral.com/articles/10.1186/1756-0500-5-52

27. Von Elm Erik, Altman Douglas G., Egger Matthias, Pocock Stuart J., Gotzsche Peter C. VJP. Declaración de la Iniciativa STROBE (Strengthening the Reporting of Observational studies in Epidemiology): directrices para la comunicación de estudios observacionales. Gac Sanit [Internet]. 2018;97(34):e11775. Available from: http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0213-91112008000200011&lng=es.

28. Pocobelli G, Yu O, Fuller S, Fraser JR, Wartko PD, Chen L, et al. One-Step Approach to Identifying Gestational Diabetes Mellitus. Obstet Gynecol

[Internet]. 2018 Oct 11;132(4):859–67. Available from: http://insights.ovid.com/crossref?an=00006250-201810000-00009

29. Hung T-H, Hsieh T-T. The Effects of Implementing the International Association of Diabetes and Pregnancy Study Groups Criteria for Diagnosing Gestational Diabetes on Maternal and Neonatal Outcomes. Sanchez-Margalet V, editor. PLoS One [Internet]. 2015 Mar 10;10(3):e0122261. Available from: https://dx.plos.org/10.1371/journal.pone.0122261

30. Palatnik A, Swanson K, Churchill T, Bilski A, Grobman WA, Miller ES. Association Between Type of Screening for Gestational Diabetes Mellitus and Cesarean Delivery. Obstet Gynecol [Internet]. 2017 Aug 16;130(3):539–44. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5569909/

31. Kong JM, Lim K, Thompson DM. Evaluation of the International Association of the Diabetes In Pregnancy Study Group new criteria: gestational diabetes project. Can J Diabetes [Internet]. 2015;39(2):128–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25523181

32. Duran A, Śaenz S, Torrejón MJ, Bordí U E, Del Valle L, Galindo M, et al. Introduction of IADPSG criteria for the screening and diagnosis of gestational diabetes mellitus results in improved pregnancy outcomes at a lower cost in a large cohort of pregnant women: The St. Carlos gestationaldiabetes study. Diabetes Care. 2014;37(9):2442–50.

33. Wu E, Nien F, Kuo C, Chen S, Chen K, Chuang L, et al. Diagnosis of more gestational diabetes lead to better pregnancy outcomes: Comparing the International Association of the Diabetes and Pregnancy Study Group criteria, and the Carpenter and Coustan criteria. J Diabetes Investig [Internet]. 2016 Aug 16;7(1):121–6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4718104/

34. Lee GT, Satyan MT, Grothusen JD, Drummond KM, Hagen G, Brown C, et al. A retrospective study comparing outcomes in a midwestern US population after introduction of IADPSG guidelines for gestational diabetes. J Matern

Neonatal Med [Internet]. 2017 Jan 2;32(1):67–72. Available from: https://www.tandfonline.com/doi/full/10.1080/14767058.2017.1371692

35. Saccone G, Caissutti C, Khalifeh A, Meltzer S, Scifres C, Simhan HN, et al. One step versus two step approach for gestational diabetes screening: systematic review and meta-analysis of the randomized trials. J Matern Neonatal Med [Internet]. 2019 May 3;32(9):1547–55. Available from: https://www.tandfonline.com/doi/full/10.1080/14767058.2017.1408068

36. Khalifeh A, Eckler R, Felder L, Saccone G, Caissutti C, Berghella V. One-step versus two-step diagnostic testing for gestational diabetes: a randomized controlled trial. J Matern Neonatal Med [Internet]. 2018 Feb 16;33(4):612–7. Available from: https://www.tandfonline.com/doi/full/10.1080/14767058.2018.1498480

37. HAPO Study Cooperative Research Group, Metzger BE LL et al. Hyperglycemia and Adverse Pregnancy Outcomes The HAPO Study Cooperative Research Group. 2008;1863–71.

38. Huhn EA, Massaro N, Streckeisen S, Manegold-Brauer G, Schoetzau A, Schulzke SM, et al. Fourfold increase in prevalence of gestational diabetes mellitus after adoption of the new International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria. J Perinat Med. 2017;45(3):359–66.

39. Cade TJ, Polyakov A, Brennecke SP. Implications of the introduction of new criteria for the diagnosis of gestational diabetes: A health outcome and cost of care analysis. BMJ Open. 2019;9(1):1–8.

40. Hosseini E, Janghorbani M. Systematic review and meta-analysis of diagnosing gestational diabetes mellitus with one-step or two-step approaches and associations with adverse pregnancy outcomes. Int J Gynecol Obstet [Internet]. 2018 Aug 10;143(2):137–44. Available from: http://doi.wiley.com/10.1002/ijgo.12644

41. Mukerji G, Kainth S, Pendrith C, Lowe J, Feig DS, Banerjee AT, et al.

Predictors of low diabetes risk perception in a multi-ethnic cohort of women with gestational diabetes mellitus. Diabet Med [Internet]. 2016 Oct;33(10):1437–44. Available from: http://doi.wiley.com/10.1111/dme.13009

42. Martínez-Cruz N, Rapisarda AMC, Soriano-Ortega KP, Arce-Sánchez L, Cianci A, Ortega-Gonzalez C, et al. Perinatal outcomes in Mexican women with untreated mild gestational diabetes mellitus diagnosed by the international association of diabetes and pregnancy study groups criteria. Diabetes, Metab Syndr Obes Targets Ther. 2019;12:2667–74.

Figure 1: PRISMA Flow chart of the study.

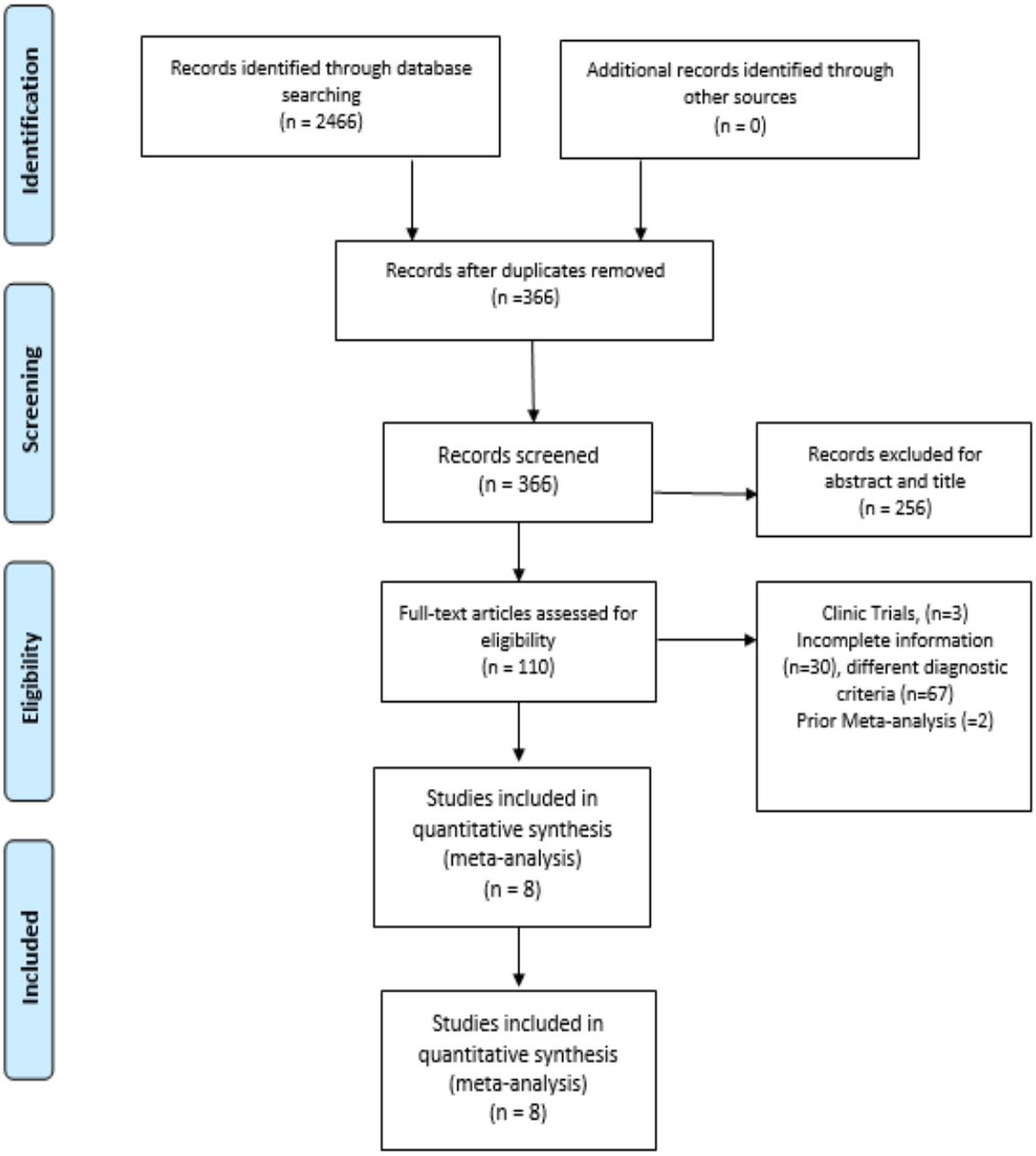

Figure 2: Forest plot displaying the result of 2a) Labor induction and 2b.) Cesarean birth.

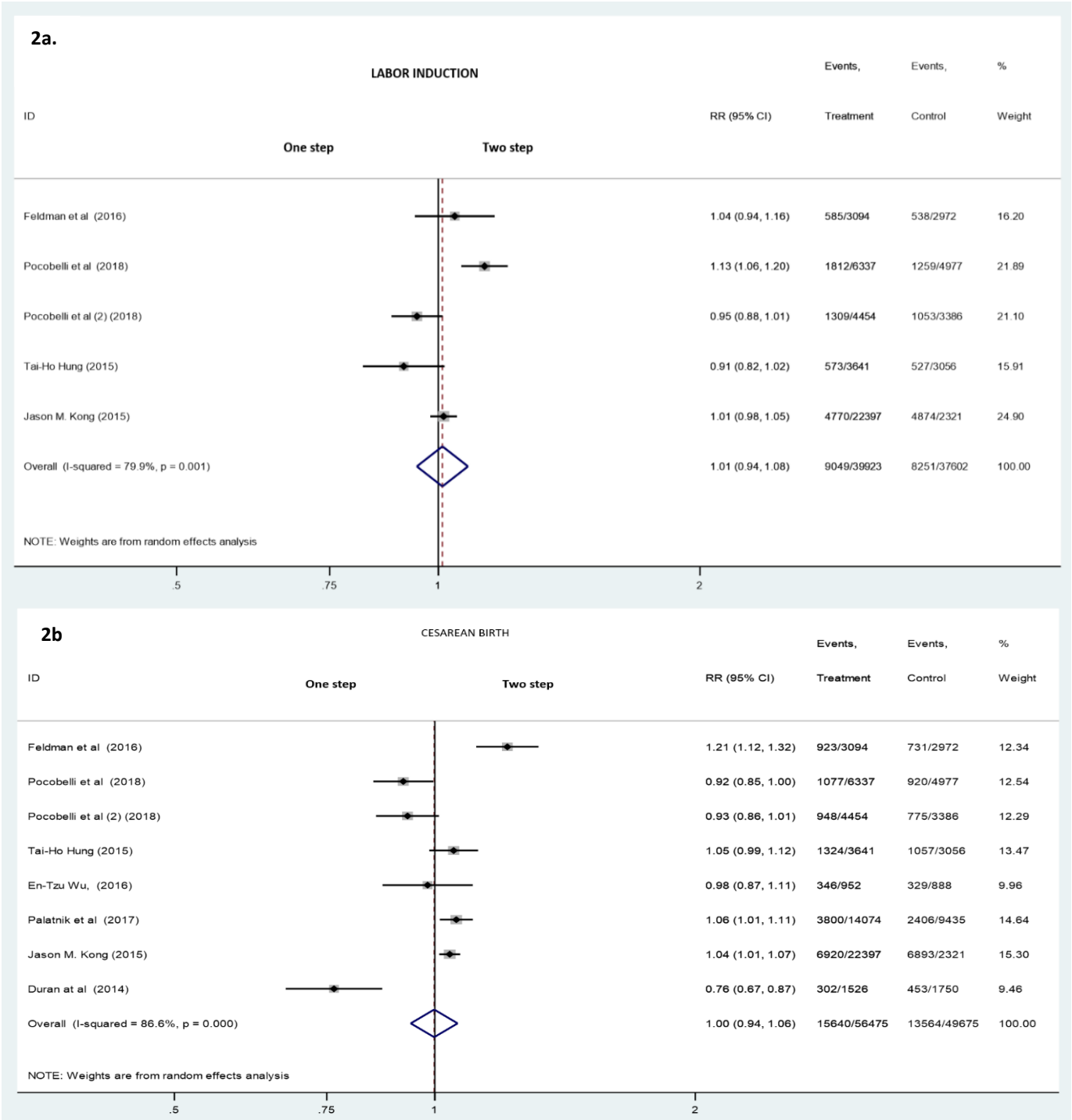

Figure 3: Forest plot displaying the result of 3a) Macrosomy and 3b) Hipoglicemy

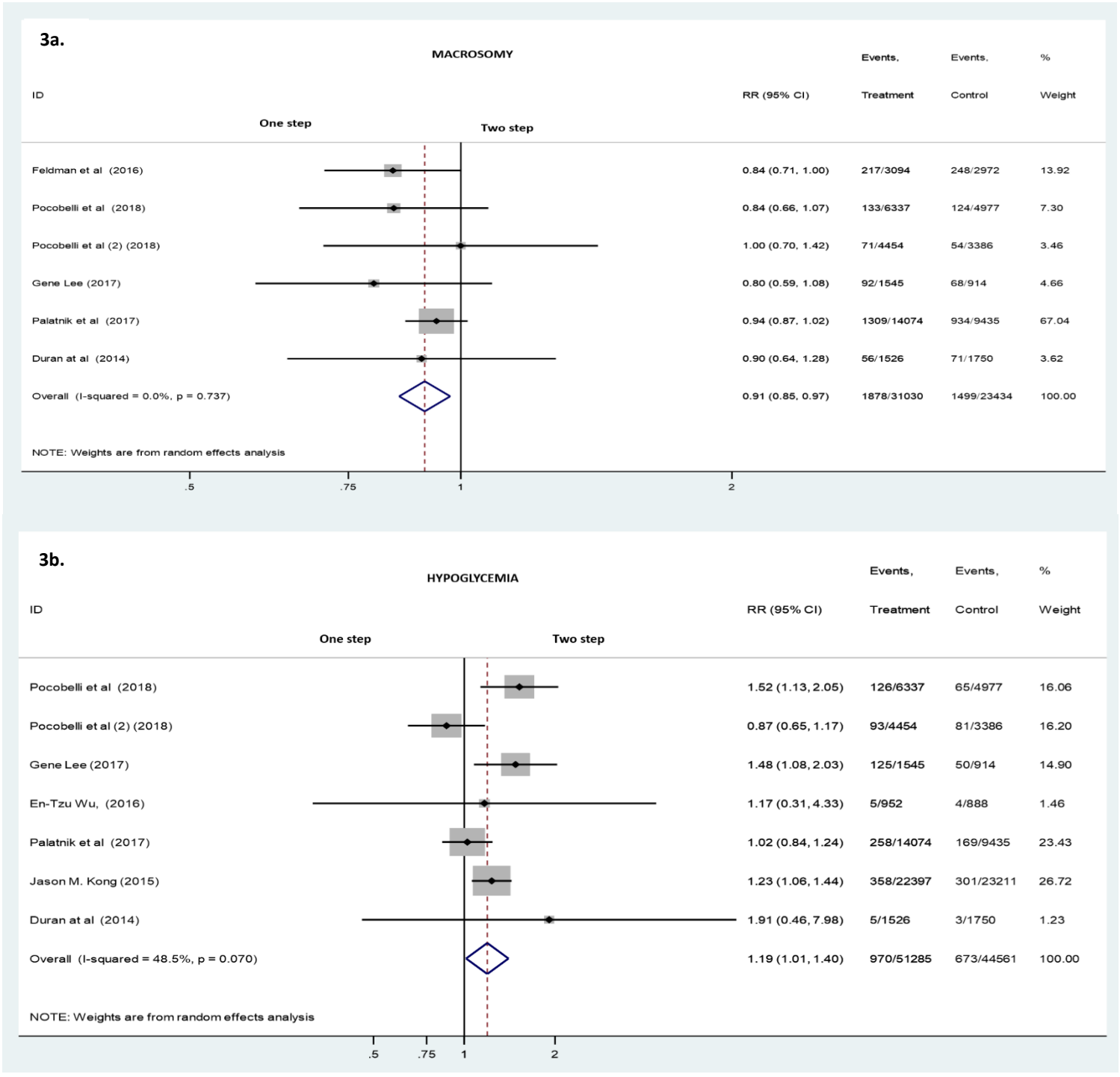

Table 1. Included Studies

Study/year	Country	Type of study	Diagnostic method	Number of participants	Incidence of diabetes % (n)
Feldman 2016(2)	United States	Retrospective	One step (IADPSG)	3094	27.4% (n=847)
			Two steps (CC)	2972	17% (n=513)
Pocobelli 2018(28)	United States	Retrospective	One step (IADPSG)	6337	11.4% (n=273)
			Two steps (CC)	4977	6.9% (n=343)
Pocobelli 2018(28)	United States	Retrospective	One step (IADPSG)	4554	11.3% (n=503)
			Two steps (CC)	3386	9.6% (n=325)
Hung T-H 2015(29)	Taiwan	Retrospective	One step (IADPSG)	3641	12,4% (n= 453)
			Two steps (CC)	3056	4.6% (n=141)
Gene Lee 2017(34)	United States	Retrospective	One step (IADPSG)	1545	21.6% (n=334)
			Two steps (CC)	914	7% (n=74)
En-Tzu Wu 2016(33)	Taiwan	Retrospective	One step (IADPSG)	952	7.4% (n=128)
			Two steps (CC)	888	2.6% (n=23)
Palatnik 2017(30)	United States	Retrospective	One step (IADPSG)	14074	8.3% (n=1167)
			Two steps (CC)	9435	9.6% (n=715)
Kong 2015(31)	Canada	Retrospective	One step (IADPSG)	22397	9% (n=2104)
			Two steps (CC)	23211	7.9% (n=1838)
Duran 2014(32)	Spain	Retrospective	One step (IADPSG)	1526	36% (n=542)
			Two steps (CC)	1750	10.6% (n=85)

Table 2. Perinatal Outcomes

Outcome	One step	Two-step	Effect	Sensitivity Analysis
Induction of labor	22.7% (IC 95% 18.3 -.27.2)	22.5% (IC 95%: 18.7 – 26.2)	RR 1.0 (IC 95% 0.945 1.082; I^2 79.9%)	RR 1.0 (IC 0.984 1.052; I^2 0%)
Cesarean birth	27.2% (IC 95% 22.6– 31.7)	27.1% (IC 95% 23.5–30.7)	RR 0.99 (IC95%: 0.93 - 1.06; I^2 86.6%)	
Macrosomy	4.9% (IC 95% 2.1 - 7.7)	5.6%, (IC 95% 2.6 – 8.5)	RR 0.9 (IC95% 0.85 - 0.97; I^2 0%)	
Hypoglicemia	2.0% (IC 95% 1.3 - 2.6)	1.5% (IC 95% 9.5 – 2.1)	RR 1.1 (IC 95% 1.01 - 1.40; I^2 48,5%)	
Low birth weight	5.8% (IC 95% 3.5- 8.2)	6.3% (IC 95% 4.0 – 8.6)	RR 0.9 (IC 95% 0.85 - 1.05; I^2 60%)	RR 0.9 (IC0.94 – 1.05; I^2 0%)
Preterm labor	7.6% (IC 95% 6.4 – 8.7)	7.3% (IC 95% 6.6 – 8.0)	RR 1.0 (IC95%: 0.94 - 1.06; I^2=0%).	
Admission to ICU	4.8% (IC 95% 3.1- 6.5)	4.7% (IC95% 3.2 – 6.2)	RR 1.0 (IC95% 0.89 - 1.28; I^2=78.8%)	RR de 1.0 (IC95% 0.93 - 1.14; I^2=0%)
Hyperbilirubinemia	10.1% (IC95% 5.2 – 15)	9.5% (IC95% 5.0 – 14)	RR 1.0 (IC95% 0.89- 1.28; I^2=67%)	

TABLES SUPPLEMENTARY MATERIAL

Table 1 STROBE score of included studies

Study	Country	Type of study	STROBE
Feldman 2016	United States	Retrospective	Título y resumen: 1 Introducción: 2 Metodologìa:7 Resultados: 4 Discusión: 4
Pocobelli 2018	United States	Retrospective	Título y resumen: 1 Introducciòn:2 Metodología: 8 Resultados: 4 Discusion:4
Hung T-H 2015	Taiwan	Retrospective	Título y resumen: 1 Introducciòn:2 Metodologìa:7 Resultados :4 Discusión: 4
Gene Lee 2017	United States	Retrospective	Título y resumen: 1 Introducción: 2Metodologìa:8 Resultados: 4 Discusión: 4
En-Tzu Wu 2016	Taiwan	Retrospective	Título y resumen: 1 Introducciòn:2 Metodologìa:7 Resultados :4 Discusión: 4
Palatnik 2017	United States	Retrospective	Título y resumen: 1 Introducciòn:2 Metodologìa:7 Resultados :4 Discusion:4
Kong 2015	Canada	Retrospective	Título y resumen: 1 Introducciòn:2 Metodologìa:8 Resultados: 4 Discusión: 4
Duran 2014	Spain	Retrospective	Título y resumen: 1 Introducciòn:2 Metodologìa:8 Resultados: 4 Discusión: 5

Figure 2. Supplementary material Forest Plot 2a) Low weight at birth - 2b) Preterm Delivery

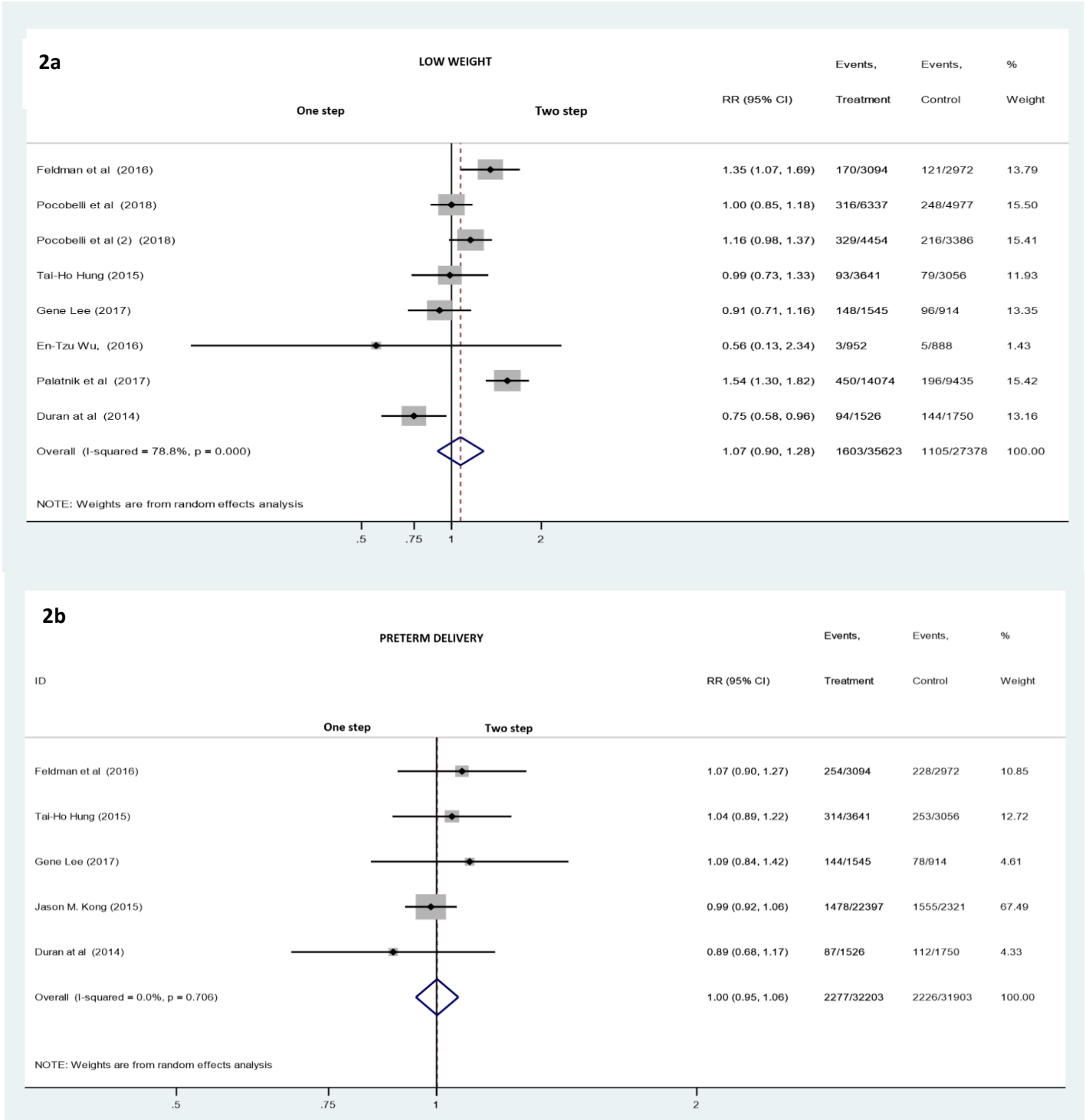

Figure 3. Supplementary material: Forest plot 3a) Admission to the intensive care unit

3b) Hyperbilirubinemia