REVIEW

Effect of Prenatal Care on Perinatal Outcomes of Pregnant Women with Diabetes Mellitus: A Systematic Review

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Objective: to evaluate the effect of prenatal care (PC) on perinatal outcomes of pregnant women with diabetes mellitus (DM). **Methods**: systematic review developed according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines and conducted through the population, intervention, control, and outcomes (PICO) strategy. Clinical trials and observational studies were selected, with adult pregnant women, single-fetus pregnancy, diagnosis of DM, or gestational DM and who had received PC and/or nutritional therapy (NT). The search was carried out in PubMed, Scopus, and BIREME databases. The quality of the studies was evaluated using the tools of the National Heart, Lung and Blood Institute–National Institutes of Health (NHLBI-NIH). **Results**: We identified 5972 records, of which 15 (n=47 420 pregnant women) met the eligibility criteria. The most recurrent outcomes were glycemic control (14 studies; n=9096 participants), hypertensive disorders of pregnancy (2; n=39 282), prematurity (6; n=40 163), large for gestational age newborns (4; n=1556), fetal macrosomia (birth weight >4kg) (6; n=2980) and intensive care unit admission (4; n=2022). **Conclusions**: The findings suggest that PC interferes with the perinatal outcome, being able to reduce the risks of complications associated with this comorbidity through early intervention, especially when the NT is an integral part of this assistance.

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INTRODUCTION

Diabetes mellitus (DM) is a public health problem of increasing magnitude among adults in developed and developing countries. Due to the increase in prevalence among women of reproductive age, and in parallel with the increase in obesity in this population, an increase in the prevalence of DM diagnosed before or during pregnancy has been observed [1-3].

Hyperglycemia in pregnancy (HIP) is the most common metabolic disorder in pregnancy [3,4]. In 2021, an estimated 16.7% (about 21.1 million) of live births to mothers aged between 20 and 49 years were affected by this condition. Among this prevalence, 80.3% resulted from gestational diabetes mellitus (GDM), 10.6% resulted from DM diagnosed before pregnancy and 9.1% due to overt DM, diagnosed primarily during pregnancy [4].

To protect the health of pregnant women and their newborns from the negative effects of HIP, prenatal care (PC) has been recognized as an essential factor, as it allows timely interventions on possible complications [5-8] commonly associated with this condition, such as lack of glycemic control [9,10] and the birth of macrosomic or large for gestational age (LGA) newborns [11-13]. Therefore, prenatal health care is crucial to maximize the potential for a healthy life of both the mother and the fetus and the inadequacy of this assistance has been related to higher rates of maternal and infant morbidity and mortality [8,14,15].

The World Health Organization (WHO) [8] has been reviewing PC strategies, recommending that all women and their newborns receive quality care during the pregnancy-puerperal cycle, including specialized and multidisciplinary follow-up. Among the strategies reviewed, there is the expansion of the consultation calendar for pregnant women at usual risk to a minimum of eight PC appointments throughout pregnancy, starting in the first trimester [8]. In addition, it is recommended for cases of DM prior to pregnancy, that this multi-professional follow-up is carried out before or as early as possible until the levels of glycated hemoglobin (HbA1c) are optimized for pregnancy, ideally 6.0%, with the objective of reducing the risk of preeclampsia, congenital anomalies, macrosomia, and preterm birth [16].

Related studies point to specialized nutritional therapy (NT) initiated concomitantly with the initiation of PC as an important tool in the control of HIP, bringing potential benefits to maternal-fetal health [17-19]. NT may be effective in reducing pregnancy complications (preeclampsia, excessive weight gain, need for insulin therapy, prematurity) and neonatal complications (neonatal hypoglycemia and macrosomia) in addition to the adequacy of glycemic control, which is the main factor that impacts the perinatal outcome [16,20-22].

In this context, the objective of this study was to systematically review the literature evaluating the effect of PC on the perinatal outcomes of pregnant women with DM. This is particularly relevant regarding the benefits of this care to the health of the mother and the fetus both in the short and in the long term.

METHODS

Study Design and Protocol Registration

This study employed a systematic review design and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, and it was registered in the international prospective register of systematic reviews (PROSPERO CRD 42020147826) [23].

Search Strategy and Data Sources

The search was carried out in PubMed, Scopus, and BIREME databases in July 2022. A conceptual mapping of the study variables was elaborated based on the items of the PICO strategy for the elaboration of search keys containing the most recurrent terms in each database. After this step, the terms contained in the DeCS (Health Descriptors) for the Portuguese terms and the MeSH (Medical Subject Headings) for the English terms were considered for the research as descriptors, in addition to the application of the Boolean operators "OR" and "AND" to integration between terms and keys. There was no delimitation of the period of publication of the studies for the search. The final keys are described in Box 1.

Eligibility

The population, intervention, control, and outcomes (PICO) strategy was used to define the question and variables to be analyzed. The study question defined was: What is the effect of PC on the perinatal outcome of pregnant women with DM? The population (P) consisted of pregnant women with GDM or DM before pregnancy; the intervention (I) studied was PC, with specialized guidance and appointments in groups or individuals by various health professionals, including the nutritionist; control (C) consisted of pregnant women who received usual PC without NT and the outcomes (O) analyzed were hypertensive disorders of pregnancy (HDP), glycemic control, prematurity, hospitalization in the neonatal intensive care unit (NICU), macrosomia (birth weight >4kg) and LGA newborns.

As for the characteristics of PC mentioned by the studies, the most recurrent were related to the number of appointments, frequency, adherence, participation of a multidisciplinary team, and treatment of DM.

For the selection of publications, the following

Box 1. Search strategies used in the PubMed, Scopus, and BIREME electronic databases.

PubMed[a]	
Search P	(gestation[Mesh] OR gestation[tiab] OR Pregnancy[Mesh] OR pregnancy*[tiab] OR pregnant women[tiab]); (Diabetes Mellitus, Type2[Mesh] OR Diabetes Mellitus, Noninsulin-Dependent[tiab] OR Diabetes Mellitus[tiab] OR Diabetes Mellitus, Type1[Mesh] OR Diabetes Mellitus, Insulin-Dependent, 1[tiab] OR Type 1 Diabetes[tiab] OR Diabetes,Gestational[Mesh] OR Diabetes,Gestational[tiab] OR Gestational Diabetes Mellitus[tiab] OR Pregnancy in Diabetes[Mesh] OR Pregnancy in Diabetes[tiab]);
Search I	(Prenatalcare[Mesh] OR prenatalcare[tiab] OR Care, Prenatal[tiab] OR Maternal Health Services[tiab] OR Therapy, Nutrition[tiab] OR PrenatalNutrition[Mesh] OR PrenatalNutritional[tiab] OR Nutritional Physiology, Prenatal[tiab]).
Final advanced search (inclusion of the AND operator between the three braces)	(gestation[Mesh] OR gestation[tiab] OR Pregnancy[Mesh] OR pregnancy*[tiab] OR pregnant women[tiab]) AND (Diabetes Mellitus, Type2[Mesh] OR Diabetes Mellitus, Noninsulin-Dependent[tiab] OR Diabetes Mellitus[tiab] OR Diabetes Mellitus, Type1[Mesh] OR Diabetes Mellitus, Insulin-Dependent, 1[tiab] OR Type 1 Diabetes[tiab] OR Diabetes,Gestational[Mesh] OR Diabetes,Gestational[tiab] OR Gestational Diabetes Mellitus[tiab] OR Pregnancy in Diabetes[Mesh] OR Pregnancy in Diabetes[tiab]) AND (Prenatalcare[Mesh] OR prenatalcare[tiab] OR Care, Prenatal[tiab] OR Maternal Health Services[tiab] OR Therapy, Nutrition[tiab] OR PrenatalNutrition[Mesh] OR PrenatalNutritional[tiab] OR Nutritional Physiology, Prenatal[tiab]).
Scopus[b]	
Search P and I	(TITLE-ABS-KEY ("Diabetes,Gestational") OR TITLE-ABS-KEY ("Gestational Diabetes Mellitus") OR TITLE-ABS-KEY ("Diabetes Mellitus, Type2") OR TITLE-ABS-KEY (Diabetes Mellitus") AND TITLE-ABS-KEY (pregnant*) OR TITLE-ABS-KEY (pregnancy*) OR TITLE-ABS-KEY ("pregnant women")); (TITLE-ABS-KEY (prenatalcare) OR TITLE-ABS-KEY ("Prenatal Care") OR TITLE-ABS-KEY ("Care, Prenatal") OR TITLE-ABS-KEY ("Maternal Health Services") OR TITLE-ABS-KEY ("Therapy, Nutrition") OR TITLE-ABS-KEY ("prenatal nutrition") OR TITLE-ABS-KEY ("prenatal nutritional") OR TITLE-ABS-KEY ("nutrition phisiology, Prenatal"))
Advanced search (inclusion of the AND operator between the three braces)	(TITLE-ABS-KEY ("Diabetes,Gestational") OR TITLE-ABS-KEY ("Gestational Diabetes Mellitus") OR TITLE-ABS-KEY ("Diabetes Mellitus, Type2") OR TITLE-ABS-KEY (Diabetes Mellitus") AND TITLE-ABS-KEY (pregnant*) OR TITLE-ABS-KEY (pregnancy*) OR TITLE-ABS-KEY ("pregnant women")) AND (TITLE-ABS-KEY (prenatalcare) OR TITLE-ABS-KEY ("Prenatal Care") OR TITLE-ABS-KEY ("Care, Prenatal") OR TITLE-ABS-KEY ("Maternal Health Services") OR TITLE-ABS-KEY ("Therapy, Nutrition") OR TITLE-ABS-KEY ("prenatal nutrition") OR TITLE-ABS-KEY ("prenatal nutritional") OR TITLE-ABS-KEY ("nutrition physiology, Prenatal"))
Refinement of results	Application of filters: keyword; prenatalcare; pregnancy; pregnant Woman. Concomitant button selection "limit to".
BIREME[c]	
Search P and I	Mesh term "prenatalcare in Diabetes" Applied filters: "prenatal care" and "types of study".

[a] Updated in 07/12/2022; [b] Updated in 07/13/2022; [c] Updated in 07/15/2022; P: population; I: intervention.

inclusion criteria were adopted: controlled and/or randomized clinical trials (RCTs), observational studies (cross-sectional, retrospective, and prospective cohort) and studies referring to adult pregnant women, single-fetus pregnancy, diagnosis of DM or GDM who have received PC and/or NT, and who had information on the effect of these criteria on perinatal outcomes. Only publications in Portuguese, English, and Spanish were selected. Studies were grouped according to the highest recurrence of outcomes.

Selection of Studies and Data Extraction

After the search, all references were imported into a reference manager (EndNote®) and publications indexed in more than one database (duplicates) were removed. After removing duplicates, 5079 records were analyzed for the application of eligibility criteria described in

above section *Elegibility* from the reading of titles and abstracts, which resulted in the exclusion of 5028 records that did not meet the eligibility criteria. After this step, 51 studies were read in their entirety, and the inclusion criteria were applied. Subsequently, 15 manuscripts remained for final analysis, as described in Figure 1. Data extraction from the included studies for final analysis was performed using a Microsoft Excel® spreadsheet. The entire process of search and selection of studies was carried out by two researchers independently and when there was disagreement, a third researcher reviewed the entire process.

Assessment of Study Quality and Risk of Bias

The quality of the studies included from the perspective of risk of bias was assessed using the "Quality Assessment of Controlled Intervention Studies" tool for intervention studies and the "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies" for observational and cohort studies, both from the National Heart, Lung and Blood Institute—National Institutes of Health (NIH). Such tools can be accessed for free through the official link (https://www.nhlbi.nih.gov/) and include 14 study quality questions, with "yes," "no," and "not reported or not applicable." Based on these responses, the studies were classified as "Good," "Fair," or "Poor," considering a study "good" if it obtained eight or more "yes" responses. The ratings of these tools are not based on summary scores but qualitative judgment. This evaluation was carried out by two researchers independently and whenever there was inconsistency, a third researcher contributed to a resolution.

RESULTS

Search Results

Initially, 5972 records were selected through electronic searches in the PubMed (n=2224), BIREME (n=2536), and Scopus (n=1212) databases. There were 893 duplicate references, which were removed from the analysis, resulting in 5079 records. From this number, 5028 references were excluded from the reading of titles and abstracts because they were considered irrelevant to the scope of this review, for not meeting the eligibility criteria, such as population and outcomes of interest, resulting in 51 studies, which were read in full. Thirty-six studies were excluded and reasons described in the flow diagram (Figure 1). So, we included a total of 15 studies, totaling 47 420 evaluated pregnant women.

Characteristics of Included Studies

Table 1 presents general information about the studies included in this systematic review, such as year of publication, type of study, population studied, among others. Table 2 presents a summary of the main findings of the studies, including PC characteristics, when these were mentioned, in addition to the presence of statistical adjustments.

Of all the studies included, four studies detailed the characteristics of PC [15,24-26], including information about the participation of a multidisciplinary team, gestational age at onset, number and frequency of appointments, adherence to the proposed program, information about insulin therapy and other adopted therapies, guidelines for home blood glucose monitoring, self-care and lifestyle changes for pregnant women.

NT as part of PC was considered in nine [6,9,10,15,18,25-28] of the 15 included studies. Of these, only the study by Silva et al. [26] reported an average of five appointments with the nutritionist.

Overall, there was a high variation in the sample size (n=45 to n=38 224) and the mean age of the participants ranged from 22 to 35 years (Table 2).

As for the statistical analyses, 10 studies mentioned variable adjustments and possible confounding factors from multivariate logistic regressions [6,11,15,25-29,31,32] (Table 2).

Regarding the quality of the studies analyzed from the perspective of risk of bias, it was observed that most studies met the criterion classification with a "good" result, both the two clinical trials included and nine of the 13 observational studies included. The questions that most received "no" as an answer were associated with the methodology of the studies regarding the blinding of researchers and participants, as well as information on adherence to the interventions applied and categorization of exposure variables. The summary of the results of this analysis is shown in Table 3.

The most recurrent perinatal outcomes were glycemic control, HDP, especially preeclampsia, prematurity, LGA newborns, fetal macrosomia, and NICU admission.

Glycemic Control

Fourteen of 15 studies evaluated glycemic control (n=9096) [6,9-11,15,18,24-28,30-32]. Of these, six studies considered the oral glucose tolerance test (OGTT) as a tool to assess glycemic control, measured in fasting, 1h, and 2h postprandial with 75g of glucose [9,11,18,24,31,32].

Two considered fasting and 2h postprandial glucose (15,28). Landon et al. [27] evaluated glycemic control through fasting, 1h, 2h, and 3h postprandial glycemia with a 100g glucose load. Huynh et al. [6] evaluated glycemic control from 2h postprandial blood glucose with a 75g glucose load. In the study by Silva et al. [26] glycemic control was assessed through fasting and 1h postprandial glucose with 75g glucose. In the study by Pylypjuk et al.
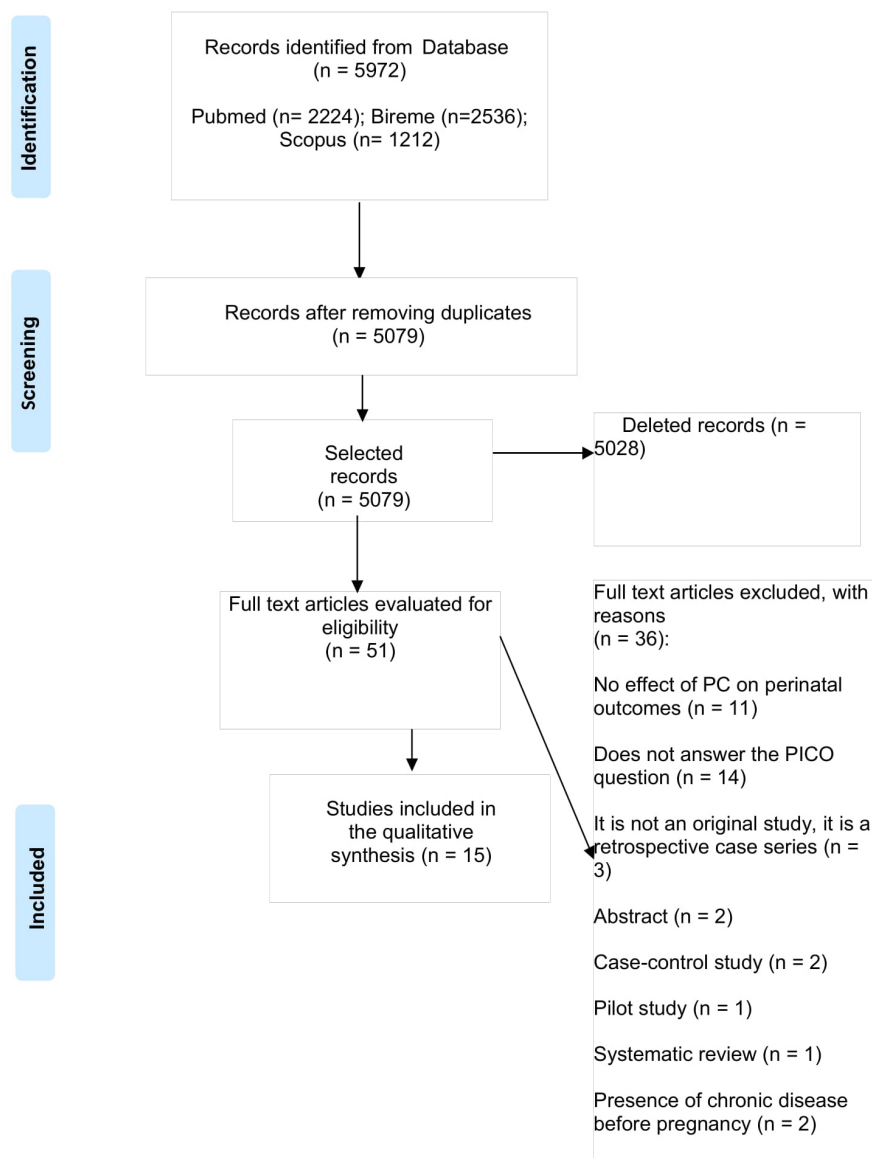
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┌─────────────────────────────────┐
│ Records identified from Database │
│           (n = 5972)            │
│                                  │
│ Pubmed (n= 2224); Bireme (n=2536);│
│        Scopus (n= 1212)         │
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│ Records after removing duplicates│
│           (n = 5079)            │
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│  Selected    │────────▶│ Deleted records (n =  │
│  records     │         │ 5028)                 │
│ (n = 5079)   │         └──────────────────────┘
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Identification

Screening

Included

Full text articles evaluated for eligibility
(n = 51)

Studies included in the qualitative synthesis (n = 15)

Full text articles excluded, with reasons
(n = 36):

No effect of PC on perinatal outcomes (n = 11)

Does not answer the PICO question (n = 14)

It is not an original study, it is a retrospective case series (n = 3)

Abstract (n = 2)

Case-control study (n = 2)

Pilot study (n = 1)

Systematic review (n = 1)

Presence of chronic disease before pregnancy (n = 2)

Figure 1. **Flow diagram**.

[30] HbA1c was used to assess glycemic control. Sunjaya and Sunjaya [10] evaluated glycemic control through HbA1c and fasting and 2h postprandial glucose. In the study by Carter et al. [25] glycemic control was assessed through fasting glucose and HbA1c. In general, adequate glycemic control was observed after PC, especially in studies that applied NT as part of this assistance (n=9).

HDP

HDP were evaluated in two studies (n=39 282) [27,29]. In Landon et al. [27], gestational hypertension was defined as a systolic blood pressure >140 mm/Hg and diastolic blood pressure >90 mm/Hg measured on two occasions at least 4 hours apart, or a change in blood pressure that was subsequently treated with medication. Preeclampsia was defined as an elevation in blood pressure (according to the definition of gestational hypertension) associated with proteinuria (>300mg of protein in a 24-hour urine collection) or abnormal blood levels of liver enzymes (aspartate aminotransferase level ≥70U/L) or thrombocytopenia (platelet count <100,000 per cubic millimeter).This study [27] found lower rates of gestational hypertension and preeclampsia in the group that received specialized NT and self-monitoring of capillary blood glucose when compared to the control group. Similarly, Allen et al. [29] observed lower rates of preeclampsia in the group that started PC in the first trimester when compared to the groups that did not

Table 1. General Information About Studies Included in this Systematic Review

	Total number of studies (n=15)	
	n	%
Study type		
Prospective cohort	1	06.66
Retrospective cohort	8	53.33
Cross-sectional	4	26.66
RCT	2	13.33
Publication year		
2016-2021	12	80.00
2005-2015	3	20.00
Continents and Countries		
Asia (Indonesia, Japan, China)	4	26.66
Europe (Ireland)	1	06.66
Africa (Ethiopia)	1	06.66
America (USA, Brazil, Canada)	9	60.00
Population studied		
Women with GDM	9	60.00
Women with DM and GMD, comparing these groups	4	26.66
Women with Type 2 Diabetes Mellitus (T2DM)	2	13.33
Overall study quality		
Poor	0	0
Fair	4	26.66
Good	11	73.33

RCT: randomized clinical trial

receive PC or that started PC only in the third trimester of pregnancy. Despite this, Allen et al. [29] do not describe the diagnostic criteria used to classify preeclampsia, nor the characteristics of the PC provided.

Prematurity

Prematurity was evaluated in six studies (n=40 118) [10,24,25,27,29,32] and of these, only three associated it with PC (n=39 461) [25,27,29]. Carter et al. [25] observed 59% less probability of premature birth among women who received 15 or more PC appointments when compared to those who received eight or more appointments. Landon et al. [27] observed a higher proportion of prematurity among the control group when compared to the intervention group that received NT as part of PC (11.6% versus 9.4%) (p=0.27). Allen et al. [29] observed higher rates of preterm birth in the group that started PC in the third trimester when compared to women who started in the first or second trimester. In all these studies, prematurity was considered as birth before 37 weeks of gestation.

LGA and Fetal Macrosomia

The birth of LGA newborns was evaluated in four studies (n=1556) [11,25,27,32] however only two were associated with PC (n=1137) [25,27]. Carter et al. [25] did not observe statistical differences between the groups. Landon et al. [27]) observed a higher proportion of birth weight LGA among the control group when compared to the intervention group that received NT as part of the PC (14.5% versus 7.1%) (p<0.001). In all of these studies, the classification was based on birth weight values above the 90th percentile.

Fetal macrosomia was assessed in six studies (n=2022) [10,11,18,27,30,32]. Of these, two demonstrated an association with PC (n=1446) [18,27]. Shi et al. [18] observed a higher proportion of macrosomia in the group that performed PC without the participation of specialized NT (27.62% versus 9.77%; p<0.001). Landon et al. [27] observed a higher percentage among the control group when compared to the intervention group that received NT as part of the PC (14.3% versus 5.9%) (p<0.001).

Table 2. Summarization of Results and Main Outcomes of Studies

Ref	Country	Population	n (total sample and study groups)	Design	Objective	Average age (SD)	PC characteristics according to study groups	Main results/outcomes analyzed	Statistical adjustments
[24]	China	GDM Pregnant women, 18-45 years old, gestational age <31 weeks diagnosed with GDM.	309 - Control (n= 162); - Intervention (n= 147)	RCT (multicentric)	To investigate whether health education and lifestyle changes through telemarketing are more effective than traditional PC in controlling blood glucose in women with GDM.	31.07 (±4.34)	Control group: Guidance on GDM addressing self-care, home monitoring of capillary blood glucose, glucose target, and lifestyle (exercise and diet). - Guidance of anthropometric (weight) and clinical (blood pressure) markers. - Frequency of consultations: 1 every 2 weeks, after the GDM diagnosis. - Drug intervention, when blood glucose was not controlled. Intervention group: Distance guidance on home monitoring of capillary blood glucose, lifestyle, and self-care. - Weekly interaction between patients and the multidisciplinary team by application. - Frequency of teleservice: Weekly - Discussions of articles and fundamentals about GDM on weekends by the group.	The glycemic qualification rate of the intervention group was higher than that of the control group at 3-time points, whereas in Group I (23-24 weeks of gestation) at T3 (54.8% vs. 83.3%) and Group II (25-26 weeks of gestation) at T3 (62.5% vs. 80.0%) and T7 (75.0% vs. 100%) Mean birth outcomes (type of delivery, premature birth of membranes, labor and birth, baby weight at birth postpartum): none of these outcomes were significantly different between the study groups.	No information about the adjustment of variables in statistical analyses.
[27]	USA	Pregnant women between 24 and 31 weeks with mild GDM (fasting glucose < 95 mg/dL [5.3 mmol per liter] in OGTT 100 g glucose	958 - Control group (n= 473) - Intervention group (n= 485)	RCT (multicentric)	To determine whether treating women with GDM reduces perinatal and obstetric complications.	Intervention group: 29.2 ± 5.7 Control group: 28.9 ± 5.6	Control group (C): usual PC Intervention group (I): dietary intervention, blood glucose self-monitoring, and insulin therapy (if needed).	Significant reductions with the intervention care compared to usual care (I vs. C): - mean birth weight (3302 "(I)" vs. 3408 "(C)" g); neonatal fat mass (427 "(I)" vs. 464 "(C)" g; p = 0.003), birth weight>4kg (5.9% "(I)" vs. 14.3% "(C)"; RR: 0.41; p < 0.001), shoulder dystocia (1.5% "(I)" vs. 4.0% "(C)"; RR: 0.37; p = 0.02) and cesarean delivery (26.9% "(I)" vs. 33.8% "(C)"; RR: 0.79; p= 0.02), preeclampsia and gestational hypertension (combined rates for the two conditions), 8.6% "(I)" vs. 13.6% "(C)"; RR:0.63; p= 0.01).	Adjustment for initial reported alcohol consumption for primary outcome analysis (perinatal and neonatal)
[30]	Canada	Pregnant women with DM 2 diagnosed before age 18 or at the time of pregnancy	112 Classification by pre-pregnancy BMI: - Low weight: <18.5 kg/m² (1.8%) - Eutrophy: 18.5-24.9 kg/m² (23.2%) - Overweight: 25-29.9 kg/m² (35.7%) - Obesity level I: 30-34.9 kg/m² (18.8%) - Obesity level II: 35-39.9 kg/m² (16.9%) - Obesity level III: 40 kg/m² (3.6%)	Longitudinal (prospective cohort)	To describe perinatal outcomes of pregnancies in type 2 DM women	22 (19-25.5)	- Semi-annual monitoring by the research team of patients' ongoing engagement with the healthcare system. - Provision of prenatal care assistance to remote communities, but without descriptions regarding the characterization of care and frequency	- The median HbA1c in the first quarter was 9.3% (78mmol/mol) higher than the other quarters, considered above the current recommended HbA1c level of ≤7.0% (53mmol/mol) - The majority of women became pregnant with overweight (35.7%) or obesity (39.6%) pre-pregnancy BMI and there was an increase to 73% of women classified as obese at the time of delivery. - The mean pregnancy weight gain was 13.3 kg, which is considered above that recommended for overweight or obese pregnant women. - 41% cesarean, mean birth weight was 3.524g. - 5.4% of newborns were classified as having macrosomia at birth (>90th percentile).	No information about the adjustment of variables in statistical analyses.

Ref	Country	Population	Sample / Classification	Study design	Objective	Intervention	Age	Results	Statistical adjustment
[32]	Ireland	Pregnant women with GDM	303 Classification by maternal BMI (n= 303); <18.5 kg/m²: (1.0%) ≥ 18.5–<25.0 kg/m² (32.8%) ≥ 25.0–< 30 kg/m² (30.1%) ≥ 30–< 35 kg/m² (20.3%) ≥ 35 kg/m² (15.9%)	Observational (retrospective cohort)	Determine the influence of obesity and glucose intolerance on neonatal hypoglycemia and birth weight above the 90th percentile (LGA)	- NICU and appointments with doctors and healthcare professionals in the hospital. - No detailed description of the PC and its periodicity.	Median = 33.6 (29.8–37.7)	- Newborns of mothers with BMI ≥ 30 kg/m² were more prone to neonatal hypoglycemia when compared to BMI < 30 kg/m² 24 (9.2%) vs. 23 (8.8%), p=0.016) with a significantly higher odds ratio for neonatal hypoglycemia at 2.10 (IC 95% 1.10 – 4,00), p=0.023. - LGA newborn was not associated with or predicted by plasma glucose curve (PG-AUC) nor obesity; however, multiparous women had 2.8 times (CI 95% 1.14 – 6.78, p=0.024) more probability of having a LGA newborn.	Logistic regression with adjustments for pre-pregnancy BMI, plasma glucose area under the curve, maternal age, high parity, family history of DM, and insulin resistance status.
[9]	Japan	Pregnant women with GDM	41 GDM group -> GDM (n=23): patients who did not improve oral glucose tolerance GDM group -> NGT (n=18): patients who improved	Observational (retrospective cohort)	To assess whether there was an improvement in glucose tolerance in pregnant women with GDM under nutritional guidelines and meal planning.	- nutritional monitoring - home blood glucose monitoring - Insulin therapy: in cases where good glycemic control was not achieved after 2 weeks of diet.	32.4 (± 4.1) - GDM group -> GDM) 29.6 (± 4,0) - GDM group ->NGT	- GDM group -> NGT: OGTT improved from mid-pregnancy after adequate nutritional therapy. - NGT did not require insulin therapy, while 39.1% (GDM -> GDM group) required insulin therapy. -Appearance of T2DM postpartum: (5.6% vs. 39.1% in GDM -> NGT vs. GDM -> GDM, p=0.03) - Primiparity was a predictive factor for improved glucose tolerance in the GDM group -> NGT	No information about the adjustment of variables in statistical analyses.
[18]	China	Pregnant women with GDM	488 - Non-MNT group (n=181) - MNT group (n=307)	Observational (retrospective cohort)	To verify the association between nutritional therapy and the risk of T2DM in pregnant women with GDM	-Non-MNT group: without detailed follow-up information. -MNT group: individualized guidelines for GDM carried out by nutritionists including detailed nutritional assessment, and guidelines on physical exercise.	31.6 (± 4.3) – did not receive specialized nutritional therapy 32.0 (± 4.3) –specialized nutritional therapy	Fasting blood glucose and 2h postprandial glucose at 28 weeks (5.68 mmol/L), 32 weeks (5.37 mmol/L), and 36 weeks (5.29 mmol/L), as well as intrapartum (5.29 mmol/L) were lower in the MNT group than in the non-MNT group with: 9.95 mmol/L (28 weeks), 7.68 mmol/L (32 weeks), 7.70 mmol/L (36 weeks) and 7.71 mmol/L (intrapartum). Both groups had p < 0.001; - Weight gain and adverse event rates during pregnancy were lower in the MNT group compared to the non-MNT group (all p < 0.05). - 92.2% of participants in the MNT group had a normal OGTT result, and the rate of exclusive breastfeeding within 4 months of delivery was 54.4% in the MNT group; both were superior to the non-MNT group (66.3%, p<0.001; 29.3%, p <0.05).	No information about the adjustment of variables in statistical analyses.
[28]	USA	Pregnant women with GDM diagnosed before 33 weeks of gestation	4001 According to pre-pregnancy BMI: - Eutrophy 18.5 a 24.9 kg/m² (n=1609) - Overweight 25 a 29.9 kg/m² (n= 1141) Obesity>30kg/m² (n= 1251)	Observational (retrospective cohort)	To investigate the relationship between pre-pregnancy weight, type of treatment (diet or insulin), glycemic control, and pregnancy outcome.	- diet for diabetes -insulin therapy for cases that did not reach the glycemic target after two weeks of diet (fasting glucose ≤95mg/dL and 1h postprandial ≤140mg/dL).	28.1 (± 6) - Eutrophy 29.6 (± 6) - Overweight 29.7 (± 6) - Obesity	- Women with obesity pre-pregnancy BMI who achieved glycemic target (mean blood glucose <100mg/dL; fasting blood glucose between 60 and 90mg/dL; 2h postprandial<120mg/dL), had results comparable to eutrophy and overweight women only treated with insulin. - Women with GDM who failed to achieve established levels of glycemic control (66%) had significantly greater adverse pregnancy outcomes in all 3 groups. - Obese women well controlled with insulin: significantly lower adverse outcome than diet-treated subjects (p = 0.005).	Multiple logistic regression. Confounding factors - demographics and clinical that potentially affect fetal morbidity. Adjusted variables – LGA, parity, previous macrosomia, mean blood glucose, pregnancy weight gain, Obesity, treatment modality and disease severity (fasting plasma and OGTT).

Ref	Country	Population	Sample (n)	Study design	Objective	Data	Intervention	Results	Adjustments
[15]	USA	Pregnant women with DM before pregnancy and GDM	942 - DM before pregnancy (n = 443) - GDM (n= 499)	Observational (retrospective cohort)	To determine whether there is an association between adherence to prenatal care and NICU admission or stillbirth and adverse perinatal outcomes in women with DM and GDM	Previous DM: 1° quartile – 29.1±6.8 Between 2° and 4° quartile 31.4 ± 6.3 GDM: 1°quartile – 30.4 ± 6.3 Between 2° and 4° quartile 30.1 ± 6.0	Prenatal care in the Diabetes in Pregnancy Program (guidance from doctors, nurses and nutritionists specializing in Diabetes) for both groups	- Neonates of women with DM and lower adherence had higher rates of NICU admission or stillbirth (55% versus 39%; p = 0.003). - Women in the lowest adherence quartile were more likely to be admitted to the NICU: 1.61 [CI 1.03-2.5]; p = 0.035). - Those with lower adherence had worse glycemic monitoring and more hospitalizations.	OR adjustments were performed using multivariable logistic regression, but without detailing the variables and potential confounding factors that were evaluated.
[6]	USA	Pregnant women with GDM	292 -Received PC for 18 months before the pregnancy diabetes clinic (pre-DMC) (n=118) - Received PC at a clinic specializing in diabetes in pregnancy (post-DMC) (n=174)	Observational (retrospective cohort)	To assess whether antenatal care in specialist diabetes in pregnancy program improves persuasiveness with the 2h 75g oral glucose tolerance test (2h OGTT) in women with GDM	Completed 2hr OGTT: 33.0 ± 5.1 Non completion 2hr OGTT: 32.7 ± 5.5	- Pre-DMC group: routine prenatal care - Post-DMC group: individualized, specialized and multi-professional follow-up consisting of guidance from nutritionists, nurses, social workers, doctors and diabetes educators.	- The 2h postprandial OGTT was requested more frequently in the post-DMC group in the postpartum period compared to the pre-DMC group (90.0 vs. 53.0%; OR 5.91 [CI 95%3.06 - 11.39]; p<0.0001). - The 2h postprandial OGTT completion rates were 49.2% post-DMC and 25.0% pre-DMC; OR 2.90 [95% CI 1.34 - 6.27]; p = 0.007). - Women who received post-DMC antenatal care were 2.98 times more likely to complete the 2h postprandial OGTT compared to those who received pre-DMC care (OR 2.98 [1.34, 6.62], p=0.007).	Adjustment for potential confounders: history of polycystic ovary syndrome and BMI at last prenatal visit.
[25]	USA	Pregnant women with type 2 DM and GDM	179 - ≤8 prenatal consultations (n=83) - ≥ 15 prenatal consultations (n=96)	Observational (retrospective cohort)	To investigate the association between the number of prenatal consultations and pregnancy outcomes in women with GDM and type 2 DM	- ≤8 consultations: 29.50 ± 5.99 - ≥ 15 consultations: 28.65 ± 5.67	Prenatal care: A prenatal visit was defined as any appointment scheduled with a midwifery professional (doctor or nurse) in an outpatient setting during pregnancy. - At the start of treatment, patients received diabetes education and nutritional counseling.	- Mean HbA1c at delivery was significantly better in the group that received the most consultations. 6.4% (46 mmol/mol) vs. 6.9% (52mmol/mol) (p = 0.01). - LGA baby births: were similar between groups with more consultations (28%) compared with fewer consultations (18%) ([ORa] 1.69; CI 95% 0.81-3.54). - Need for admission to the NICU: the group with more than 15 consultations was 85% less likely (ORa 0.15; 95%CI - Need for admission to the NICU: the group with more than 15 consultations was 85% less likely (ORa 0.15; 95%CI 0.04–0.53) and 59% less likely to have preterm delivery (ORa 0.41; CI 95% 0.21–0.80).	Adjustments for confounders (on the effect of gestational age on delivery and NICU admission and prematurity): African-American race, nulliparity, and Obesity defined as BMI ≥30kg/m².

Ref	Country	Population	Sample / Groups	Study design	Objective	Age	Prenatal care description	Main results	Adjustments
[29]	USA	Pregnant women with type 2 DM	38324 Classification of groups according to the beginning of prenatal care: - 1st trimester (n= 33502) - 3rd trimester (n= 810) - no PC (n= 275)	Observational (retrospective cohort)	To determine whether PC affects perinatal outcomes in pregnant women with type 2 DM.	Not analyzed on average. Only classified as older or younger than 35 years	There is no description of prenatal care	- Intrauterine fetal death: higher risk in those who did not undergo prenatal care (11.3% vs 0.9% of those who started in the 1st trimester) and 6.2% of those who started in the 2nd trimester (p<0.0001). - Preterm delivery: rate increased in late presentation (29.4% at delivery vs 21.0% in 1st trimester and 27.6% in 2nd trimester; p = 0.004). - Rates of intrauterine fetal death and preterm delivery were still statistically significant with an ORa of 11.37 (95% CI: 6.10-21.16; p<0.0001) and 1.55 (95% CI: 1.03-2.32; p=0.034), respectively. - Preeclampsia: higher proportion in the group without CP (16.9% compared to 8.17% in the group that started CP in The 1st trimester and 11.13% in the group that started in the 3rd trimester p<0.0001).	Regression adjusted for parity, maternal age, maternal race/ethnicity, maternal education, type of insurance (public/private), and chronic hypertension
[10]	Indonesia	Pregnant women with GDM and DM	45 individuals were grouped based on therapy: - Nutritional therapy only (MNT) (n= 16) - Insulin group combined with MNT (n= 25) - Oral antidiabetic group combined with MNT (n = 4)	Observational (cross-sectional)	To assess the glycemic profile and outcomes of pregnant women with GDM and DM based on their methods of therapy and review current guidelines on the management of diabetes in pregnancy.	30.69 (± 4.3)	- Recommendations and prescription of nutritional therapy for all patients. - Medical guidance and prescription of insulin therapy or oral antidiabetics. - There was no detailing and characterization of the PC, as well as its periodicity.	- Worse glycemic control in patients using oral antidiabetic drugs after MNT (random blood glucose 216.75 mg/dL, fasting glucose 175.75 mg/dL and HbA1c 7.15% (54mmol/mol). - A higher proportion of fetal deaths (50%) was found in the oral antidiabetic group, with 12% occurring in patients using MNT and 6.3% occurring in insulin users. - The mean gestational age at delivery was 37.0 (±3.5) weeks. - 33% of patients had preterm birth.	No information about adjustment of variables in statistical analyses
[31]	Ethiopia	Pregnant women	1027 GDM diagnosis: - Normal (n = 896) - GDM (n = 131)	Observational (cross-sectional)	To determine the prevalence of GDM and associated factors among PC women in public health units	27.22 (± 5.2)	- Assistance for all groups in prenatal care in public health units. - There were no details about the characterization of prenatal care or its periodicity.	- Normal glucose level was more common among women with a high level of physical activity (33.4% vs 17.6%) and adequate dietary diversity (51.5% vs 27.5%) than women with GDM. Prevalence of GDM of 12.8% (95% CI: 10.7–14.8%); 118 (90%) of them were diagnosed with regular OGTT and the remaining 13 (10%) at the end of the OGTT. - Pregnant women with inadequate dietary diversity had twice the GDM than their counterparts.	ORa adjustments for maternal age, marital status, educational level, employment status, arm circumference, systolic and diastolic blood pressure, anemia, physical activity level, dietary diversity status, family history of DM, parity, history of macrosomic baby, history of abortion, history of stillbirth in previous pregnancy, GDM, and prenatal depression.
[26]	Brazil	Pregnant women with GDM	283 Pre-pregnancy BMI classification (n=278) Low weight (n= 6) Normal (n= 77) Overweight (n= 116) Obesity (n= 79)	Observational (cross-sectional)	To evaluate the predictive factors of birth weight of children of women with GDM.	31.2 (± 5.8)	- The pregnant women received 5 to 6 consultations with the nutritionist, in addition to prenatal consultations.	- Gain of 1 kg of weight during pregnancy in the 1st and 3rd trimesters increased birth weight by 21 g (p = 0.01) and 27 g (p = 0.03), respectively. - birth weight were pre-pregnancy BMI (β = 17.16, p = 0.02; 95%CI 2.62-31.69) and 3rd trimester postprandial blood glucose (β = 4.14, p=0.008; 95%CI 1.09-7.20), in the model adjusted for GA at delivery (β= 194.68, p<0.001; 95%CI 146.79-242.58).	Adjustments for 2nd trimester gestational weight gain, number of prenatal visits, 1st trimester fasting glucose, adjusted for gestational age at delivery

| [11] | Brazil | Pregnant women with GDM | 116 Classification according to pre-pregnancy BMI: - Normal (n=32) - Overweight (n=35) - Obesity (n=49) | To characterize pregnant women with GDM and identify factors associated with the occurrence of LGA newborns | Obser-vational (cross-sec-tional) | 32.7 (± 6.4) | All received PC, however there are no details about it. | The variables associated with LGA after multivariate analysis were: Pre-preg-nancy obesity (OR 11.6; 95% CI: 1.40–95.9; p = 0.023), previous macro-somia (OR 34.7; 95% CI: 4 .08–295.3; p < 0.001), high fasting glucose in the 3rd trimester (OR 2.67; 95% CI: 1.01–7.12; p = 0.048) and combined change in OGTT (post-dextrose fasting) (OR: 3.53; CI 95 %: 1.17–10.6; p = 0.024). Lower weight gain reduced the risk for LGA (OR¼ 0.04; 95% CI: 0.01–0.32; p < 0.001). | Adjustments for pre-pregnancy BMI, previous macrosomia, weight gain categories, mean 3rd trimester fasting glucose, OGTT changes |

Abbreviations: SD – standard deviation; RCT - randomized clinic trial; CI - confidence interval; PC - prenatal care; pre-pregnancy BMI – Pre-pregnancy body mass; GDM – Gestational Diabetes Mellitus; T2DM – Type 2 Diabetes Mellitus; GDM group -> GDM – group that did not normalize blood glucose in mid-pregnancy and required insulin therapy; GDM group ->NGT - group that normalized blood glucose in mid-gestation with adequate nutritional therapy; OGTT – oral glucose tolerance test; HbA1c – glycated hemoglobin; ; NICU - neonatal intensive care unit; LGA – large for gestational age; OR – odds ratio; ORa – odds ratio adjusted; IC 95% - confidence interval of 95%. MNT– medical nutritional therapy; MNT group0 - received specialized nutritional therapy; Non-MNT group – did not received specialized nutritional therapy; RR – relative risk.

Hospitalization of the Newborn in a NICU

The admission of newborns to the NICU was evaluated in four studies (n=2382) [15,25,27,32] being associated with PC in three of them (n=2079) [15,25,27]. Sperling et al. [15] observed that women in the lowest quartile of PC adherence were more likely to be admitted to the NICU when compared to those in the highest quartiles. Carter et al. [25] reported an 85% lower proportion of NICU admissions among pregnant women who received 15 or more appointments when compared to pregnant women who received eight or more appointments from PC. Landon et al. [27] observed a higher proportion among the control group when compared to the intervention group that received NT as part of PC (11.6% versus 9.0%) (p=0.19).

DISCUSSION

Most of the included studies were performed in the US. However, those focused on NT were carried out in Southeast Asia and Brazil. The recent interest in the subject is remarkable, given that more than 80% of studies were published after 2015, which may be associated with the increasing prevalence of HIP cases in recent years as a consequence of rapid urbanization, epidemiological transition and nutrition, a global epidemic of obesity, and the change of diagnostic criteria for GDM [4].

The number of RCTs is considerably lower when compared to the observational studies included in this review. The sample size and the proper use of control groups are positive characteristics found in all original research/intervention studies. Another issue that can be considered homogeneous among the studies is the type of HIP considered, most often resulting from GDM.

The scope of the original studies follows the trend in the literature regarding PC for medium- and high-risk pregnant women, which focuses mainly on the assessment of the impact of actions based on the multidisciplinarity of this care, including medical doctors, nurses, psychologists, nutritionists, among other health professionals, making the assistance complete, effective, and efficient [8,20].

Of the 15 studies included, only four detailed the characteristics of the PC provided, such as the number of appointments, adherence to care and quality assessment, and important information that makes up the planning of actions for this care.

Methodologically, the improvement in the quality of PC strategies is noticeable over time, with studies gradually incorporating more robust instruments in recent years, such as quality indices of this care [33], which allows for more specific interventions. Nevertheless, these data as well as instruments to assess adherence to the care provided were not mentioned in the included studies,

Table 3. Summary of Study Quality Assessment Results and Risk of Bias

NHLBI Quality Assessment of Controlled Intervention Studies		
Criteria	Tian et al., 2021	Landon et al., 2009
1. Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?	Yes	Yes
2. Was the method of randomization adequate (ie, use of randomly generated assignment)?	Yes	Yes
3. Was the treatment allocation concealed (so that assignments could not be predicted)?	NR	NR
4. Were study participants and providers blinded to treatment group assignment?	NR	CD
5. Were the people assessing the outcomes blinded to the participants' group assignments?	NR	NR
6. Were the groups similar at baseline on important characteristics that could affect outcomes (eg, demographics, risk factors, co-morbid conditions)?	Yes	Yes
7. Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?	Yes	Yes
8. Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower?	Yes	Yes
9. Was there high adherence to the intervention protocols for each treatment group?	NR	NR
10. Were other interventions avoided or similar in the groups (eg, similar background treatments)?	Yes	Yes
11. Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	Yes	Yes
12. Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?	Yes	Yes
13. Were outcomes reported or subgroups analyzed prespecified (ie, identified before analyses were conducted)?	Yes	Yes
14. Were all randomized participants analyzed in the group to which they were originally assigned, ie, did they use an intention-to-treat analysis?	NR	Yes
Quality rating:	Good	Good

Available at: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. *CD: cannot determine; NA: not applicable; NR: not reported

Table 3, Part 2: NHLBI Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

Criteria	[30]	[32]	[9]	[18]	[28]	[15]	[6]	[25]	[29]	[10]	[31]	[26]	[11]
1. Was the research question or objective in this paper clearly stated?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the study population clearly specified and defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the participation rate of eligible persons at least 50%?	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	Yes	Yes	No	No	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Was a sample size justification, power description, or variance and effect estimates provided?	No	No	NR	No	NR	Yes	Yes	No	No	No	Yes	Yes	No
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	No	No	NA	No
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (eg, categories of exposure, or exposure measured as continuous variable)?	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
10. Was the exposure(s) assessed more than once over time?	Yes	No	Yes	No	NR	No	Yes	No	Yes	No	NA	Yes	No
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	No	Yes	CD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12. Were the outcome assessors blinded to the exposure status of participants?	Yes	NR	NR	NR	No	No	No	No	No	No	No	No	No
13. Was loss to follow-up after baseline 20% or less?	CD	NR	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relations between exposure(s) and outcome(s)?	No	Yes	NR	NR	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Quality rating	Fair	Good	Fair	Fair	Good	Good	Good	Good	Good	Fair	Good	Good	Good

Available at: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tool. *CD: cannot determine; NA: not applicable; NR: not reported.

which can be considered a negative point. Another point considered negative is the scarcity of studies on pregnant women with DM prior to pregnancy, which points to the need for new studies on this population in view of the complexity and severity of perinatal complications associated with this population [15,25,29,30,34].

One positive point to be highlighted, which is broadly related to the methodological quality of the studies, is the performance of statistical adjustments that allow more reliable results when analyzing the interference of possible confounding variables.

Most studies considered the NT as part of the PC, however, there was no detail of this follow-up regarding the number of appointments, gestational age at the beginning, participation of pregnant women in collective appointments, adherence and nutritional guidance methods applied, indicating the need of studies that address these variables.

It is worth noting the importance of this follow-up for pregnant women with HIP, which includes a complete and detailed nutritional assessment, considering sociodemographic, obstetric, clinical, anthropometric, and dietary aspects that guarantee the quality of care provided. The main goals of NT are based on the adequacy of nutritional needs to promote adequate fetal growth, adequacy of gestational weight gain, and glycemic control [9,16].

Glycemic control was assessed in most studies. Achieving goals in individuals with DM is a potential challenge and, therefore, the main objective of PC for pregnant women with DM, as the HIP is directly related to the development of obstetric and neonatal complications [16,34,35].

Horie et al. [9] retrospectively evaluated whether glucose intolerance in women diagnosed with GDM before the 20th week of gestational age improved in mid-pregnancy after adequate NT and found that the group of pregnant women who received this follow-up showed normalization of blood glucose values in the OGTT performed after two weeks of diet and did not evolve with the need for insulin therapy. These data point to the importance of early nutritional care in achieving adequate glycemic control in pregnant women with an early diagnosis of GDM. The sooner care begins, the greater the chances of adequacy.

Sunjaya and Sunjaya [10] analyzed pregnant women with DM and GDM and grouped the participants into three groups according to the therapy applied, one group received only NT, another associated insulin therapy and NT, and one group received oral antidiabetic drugs and NT. The findings showed worse glycemic control in addition to a higher percentage of fetal deaths in the oral antidiabetic treatment group when compared to the other groups. Within this context of insulin use,

a systematic review [36] found higher proportions of macrosomia, LGA, NICU admission, preterm birth, and other complications in the groups that used insulin when compared to those that did not. These results reinforce the importance of NT as essential care in the prevention of fetal morbidity and mortality, adequacy of glycemic control and a possible delay in the use of insulin for pregnant women with HIP due to GDM [36,37].

Shi et al. [18] also observed adequacy of glycemic control, lower rates of macrosomia, higher rates of breastfeeding and lower risk of developing Type 2 Diabetes Mellitus (T2DM) in the postpartum period in pregnant women with GDM who received NT when compared to those who did not highlight the importance of this specialized care and aimed at reducing timely treatable complications.

Within this context, Allen et al. [29] in a retrospective cohort aimed to investigate the association of PC with adverse perinatal outcomes in pregnant women with T2DM and classified the cohort according to the onset of PC by gestational trimester. Among the results presented, it is noteworthy that even after statistical adjustments, pregnant women who started PC in the third trimester had a higher risk of prematurity and intrauterine fetal death, when compared to pregnant women who started PC in the first or second trimester of pregnancy, the which indicates and corroborates the recommendation and essentiality of starting this care in the first trimester [8,20].

In addition to early PC, the number of appointments for this care deserves attention, as it can determine the organization of a calendar to be followed, enabling the adequacy of care for the different stages of pregnancy [8].

Carter et al. [25] aimed to associate the number of PC appointments with pregnancy outcomes in pregnant women with DM and GDM, according to percentiles of the number of appointments. Those with a percentile ≥ 75 were compared with those with a percentile ≤ 25, 15 and eight visits, respectively. Mean HbA1c at delivery was significantly lower in pregnant women with more than 15 visits. In addition, the group that had more appointments had a lower risk of hospitalization of newborns in the NICU, births of LGA newborns, and prematurity when compared to the group that had fewer appointments, which points to the need to establish an ideal number of PC appointments for pregnant women with the HIP. The greater number of appointments may be associated with improved outcomes due to the association with early, continuous, and periodic monitoring of clinical and laboratory variables [7,25].

There is no specific recommendation for the number of PC visits for high-risk pregnant women. Carter et al. [25] indicate that a number greater than the eight recommended by the WHO [8] would result in better perinatal outcomes, given the magnitude and complexity

of medium- and high-risk pregnancies, it is believed that the greater the number of appointments, the greater the possibility early detection and timely treatment of possible complications [7,8,20].

The occurrence of preeclampsia and gestational hypertension, complications commonly associated with DM in pregnancy [13,38], was evaluated as an outcome in two studies [27,29].

Insulin resistance, a characteristic commonly present in women with HIP due to GDM, may be associated with the development of preeclampsia [38,39]. The Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study showed a continuous linear association between OGTT results and preeclampsia rates [40]. Such findings reinforce the importance of NT and the precocity of PC in preventing this outcome, which can cause complications to the health of the maternal-fetal binomial and is considered the main cause of maternal mortality worldwide [41].

Regarding adherence to PC, only one study associated it with neonatal outcomes [15]. Among women with DM, those classified in the lowest adherence quartiles had higher rates of hospitalization of their newborns in the NICU when compared to pregnant women in the highest quartiles. Related to this, pregnant women with low adherence also had poor glycemic control, higher rates of complications during pregnancy and postpartum, as well as hospitalizations. It shows that the better the adherence of pregnant women to PC, the better the results of pregnancy [8].

Wong et al. [42] studied the impact of PC adherence on pregnancy outcomes among women with GDM. The lowest adherence to the PC was defined as absence from at least two appointments. Those who met this criterion had higher proportions of uncontrolled glycemic control, macrosomia, and a tendency to increase admission of newborns to the NICU. Within this context, all efforts on the part of the multidisciplinary team are valid to adapt the treatment to the patient's situation, making the care individualized and contributing to the improvement of adherence [8].

The most recurrent neonatal outcomes were macrosomia, LGA newborn, need for NICU admission, and prematurity. These outcomes can increase hospitalization rates and, consequently, expenses in the health sector, as the longer the hospitalization time, the greater the need for treatment supplies, impacting the global economy on a large scale [3,4,15]. Within this context, treating pregnant women with HIP becomes a challenge for health services, and PC can directly contribute to the reduction of these expenses, based on early and specialized care that allows timely detection and intervention of these and other complications, favoring the perinatal outcome of these pregnant women.

Fetal macrosomia is an adverse outcome commonly associated with HIP because of the high rate of placental transfer and is associated with complications for the maternal-fetal binomial, such as cesarean delivery, postpartum hemorrhage, shoulder dystocia, and need for admission to the NICU [43-45], in addition to the increased risk of chronic non-communicable diseases in adulthood caused by epigenetic changes and contributing to the intergenerational perpetuation of the disease if birth weight is not controlled [12,46,47].

A RCTs with pregnant women with 958 pregnant women with GDM [27] showed a lower proportion of fetal macrosomia, mean birth weight, and cesarean delivery in the intervention group compared to the control group. The difference between the groups was the participation of the nutritionist in the intervention group, which reinforces the importance of early nutritional care and concomitant with the onset of PC in reducing this common outcome in pregnancies with the HIP.

Limitations of this study are the scarcity of detailed information about PC and NT, such as the number of appointments, gestational age at the beginning of the follow-up, instruments that assess the quality and adherence of PC, the place of performance, whether public or private institution, RCTs and studies with women with DM prior to pregnancy. However, this is the first systematic review devoted to systematically present available data regarding the effect of PC on the perinatal outcomes of pregnant women with DM and it contributed to the identification of gaps that still exist in research involving the topic.

CONCLUSION

The findings show that PC directly interferes with the perinatal outcome of pregnant women with HIP, through timely and early intervention carried out by a multidisciplinary team, including specialized NT, which can be considered beneficial for the adequacy of glycemic control as well as a reduction in the occurrence of HDP and fetal macrosomia. Therefore, it is essential to carry out studies that allow organizing and systematizing the PC of these pregnant women, enabling more effective specific actions during this period with the objective of reducing unfavorable outcomes for the maternal-fetal binomial.

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