Review Article

Type 2 Diabetes Mellitus and Pregnancy: A Systematic Review

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ABSTRACT

Objective

To evaluate maternal and fetal outcomes in pregnancies with T2DM analyzing pharmacological treatments, lifestyle modifications, and postpartum care to identify effective interventions for managing complications and improving maternal and neonatal health outcomes.

Materials and Methods

A systematic review was conducted following PRISMA guidelines to synthesize evidence on Type 2 Diabetes Mellitus and pregnancy outcomes, complications, and management strategies. Comprehensive database searches (PubMed, Cochrane, DOAJ) using targeted keywords identified 5,068 records, narrowed to 17 highly relevant studies.

Results and Discussion

A systematic review of 17 studies, including 6 RCTs, explored maternal and fetal outcomes in pregnancies complicated by Type 2 Diabetes Mellitus and Gestational Diabetes Mellitus. Interventions included glycemic control (fasting glucose: 70-95 mg/dL, postprandial: 100-140 mg/dL), metformin, insulin therapy, and lifestyle modifications like physical activity and dietary counseling. Maternal complications included pre-eclampsia (2-48%), gestational hypertension (8–21%), and excessive gestational weight gain. Fetal outcomes appeared with elevated threats of macrosomia (13%), preterm delivery (up to 85%), and neonatal hypoglycemia despite the fact that metformin decreased the chances of macrosomia and weight gain. Interventions done after delivery such as OGTT and weight control prevented the development of T2DM. ***Conclusion:*** The study provided evidence that Type 2 diabetes has repercussions on the results of pregnancy stressing on the need to control glycemia, the use of drugs, measures at the level of lifestyle and at the level of the postpartum period.

Keywords

gestational diabetes; type 2 diabetes mellitus; diabetes management; maternal-fetal outcomes; pregnancy complications.

INTRODUCTION

The rising prevalence of Type 2 Diabetes Mellitus (T2DM) during pregnancy poses a critical global public health challenge. In 2021, over 16% of live births were affected by maternal diabetes, with gestational diabetes mellitus (GDM) as the predominant form [1]. The escalating global burden of GDM is driven by increasing obesity rates, sedentary lifestyles, and advanced maternal age, which exacerbate insulin resistance and glucose metabolism impairments during pregnancy [2]. With 30-50% of pregestational diabetes cases among women of reproductive age linked to T2DM, urgent strategies are needed to mitigate associated complications, including miscarriage, preeclampsia, and adverse neonatal outcomes[3]. Understanding these global trends and their implications is essential for developing targeted interventions that can mitigate the adverse effects of diabetes in pregnancy, ultimately improving maternal and neonatal health outcomes worldwide.

T2DM was classified historically as "non-insulin dependent diabetes mellitus" and it results in

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hyperglycemia due to insulin resistance and relative deficiency [4]. T2DM has spread across the world and has grown into a public health disaster, which is mainly due to a rise in obesity, people being sedentary and unhealthier eating habits [5]. At the same time, Childbearing among the female patients already suffering from T2DM has now become a serious clinical problem, affecting the health of offspring from the global and maternal health perspective [6].

Pregnancy is characterized by altering metabolic states, beginning with enhanced insulin sensitivity that progresses into insulin resistance. This can worsen already existing glycemic impairment among T2DM women. Maternal hyperglycemia, especially pregestational DM bears the risks of both the adverse obstetric, perinatal, and even long-term outcomes. Understanding such interplay is essential for providing appropriate care and minimizing the risks [7].

The increasing prevalence of ovarian hypertrophy, advanced maternal age, and evolving population screening criteria contribute to the global rise in T2DM during pregnancy. Estimates indicate that hyperglycemia complicates approximately 16.9% of pregnancies globally, translating to about 21.4 million cases annually out of 127.1 million pregnancies. However, the methodology used to calculate this indicator requires clarification to ensure transparency and reliability. According to the IDF, 15.5% of pregnancies worldwide are affected by GDM, with 12.8% attributed to GDM and 1.3% involving pre-diagnosed diabetes. Accurate, standardized methods are essential for understanding and addressing these trends effectively [8]. It is evident that the prevalence of T2DM during pregnancy is increasing at a rate as evidenced by a 90% increase in cases between the years 1998 and 2013 in Scotland for instance. A similar picture can be noted in Ontario, Canada, which demonstrates a variance from 0.7% in 1996 to 1.5% in 2010 for preexisting diabetes in pregnancy [9]. In the Southeast Asian region, Thai (24.7%), Singaporean (23.5%) and Malaysian (22.5%) women with GDM have higher GDM rates compared to other regions [10]. According to a recent report, GDM was discovered in 35% of women in Bangladesh, this is substantially above previous estimations [11]. As per various estimates, total global estimates show estimates of standard deviation of 5.4% in Europe, 10.1% in eastern and south eastern Asia, as well as 13.6% in Africa [12].

The pattern of T2DM is on the rise among women in pregnancy especially in the regions of developing countries and regions that are classified as middle income due to urbanization, poor dietary changes and limited of access to quality healthcare services [13]. It especially occurs in racial groups that are at risk of diabetes such as South Asians, African Americans, Hispanics, and Indigenous people signifying the need for focused strategies and interventions [14].

Pregnancy is characterized by a variety of metabolic changes which in this case are for the benefit of the fetus. In the first trimester, it is noted that the mother's insulin sensitivity rises such enabling increased glucose utilization but in the late pregnancy, hormones like hPL, progesterone, and cortisol promote insulin resistance which in turn makes the body mobilize fats and increase the amounts of glucose produced by the liver so as to support the growing fetus [15, 16].

In patients with T2DM, insulin sensitivity and beta cell function are often reflected in the measures of the overall glycemic control. Although the normalization of blood glucose level in the first three months of pregnancy decreases the risk of malformations and miscarriage, hyperglycemic events at full term pregnancy have been shown to be associated with various fetal complications as well. Therefore, blood glucose management during pregnancy ought to be fairly rigorous [17].

The increasing obesity among mothers that develops into T2DM, while complicates victims by presenting risks such as miscarriage, still births, preeclampsia, as well as increases the number of deliveries through cesarean. Macrosomia in fetuses and trauma at birth has a higher chance of occurring at women suffering with T2DM, hence proper glucose control in such patients is critical in order to minimize the chances of the two [18, 19].

Women with T2DM have more chances of complications such as pregnancy-induced hypertension, preterm birth, infections, and having to deliver via cesarean section. Expecting mothers suffering from hyperglycemia prior to conceiving are likely to give birth to children affected with congenital malformations, whereas those with severe cases are likely to encounter macrosomia, shoulder dystocia and diabetes in their newborns. It has also been observed that these infants might even develop metabolic disorders at a later stage [20].

It is difficult for people who are pregnant and have active type 2 diabetes due to hormones secreted by pituitary

adenomas to manage their other co morbidities. This discussion emphasises the necessity of custom-made healthcare interventions that would help to correct such hormonal dissociations and their consequences [21, 22].

Considering the risks involved, the first step to pregnancy, even in women diagnosed with T2DM, is to start with the detailed assessment to control the blood glucose levels and monitoring [23]. Some reports indicate that it is indeed possible to achieve the glycemic targets and as a consequence, reduce the incidence congenital malformations and even maternal mortality during childbirth [24]. Guidance in this setting should stress the ability to control the levels of blood glucose, usage of contraceptives more effectively and the evaluation of the complications of diabetes, including retinopathy and cardiovascular pathology [25].

The management of T2DM in the reproductive stage encompasses diet therapy, exercise, pharmacological agents, and surveillance to attain normal blood glucose and avoid complications. The postpartum phase is of paramount importance as it helps in mitigating health issues related to both the mother and the baby [26] . Furthermore, now having diabetes in a pregnancy increases the likelihood of having diabetes in the next pregnancies, hence diabetes management continues to be critical [27].

The metabolic advantages of breastfeeding such as better glucose response and a lower tendency of developing obesity in childhood makes it beneficial for both mother and child. For this reason, it is in the best interest of women with T2DM to be motivated and assisted in executing breastfeeding tasks [28]. Although healthcare professionals have improved their ability to manage T2DM during pregnancy, many important aspects of this condition remain unknown, including the best treatment options, the progression of the disease, and how to manage it long-term. Future work should seek to find potential indicators of complications' development, assess the security and effectiveness of new drugs, and create precise strategies for those in danger [29].

Moreover, while studies highlight regional disparities in GDM and T2DM prevalence, few delve into the sociocultural, economic, and genetic factors underlying these variations. For instance, Southeast Asia and Africa report higher prevalence rates than Europe, yet the drivers behind these disparities remain unclear. This study seeks to address these unresolved issues by identifying the gaps in glycemic management practices, exploring the influence of diverse treatment strategies on maternal and fetal outcomes, and providing evidence-based recommendations to optimize care for women with T2DM during pregnancy.

The study objectives are to investigate maternal and fetal outcomes in pregnancies burdened with T2DM under different treatments including pharmacological therapy, lifestyle adjustment and care after child bearing. It also sought to determine the methods for proper glycemic control, evaluate maternal complications such as preeclampsia, and assess fetal outcomes, while moreover assessing the post-partum measures aimed at prevention of the advancement of T2DM and broadening of results.

METHODS AND MATERIALS

Study Design

This systematic literature review was done as per PRISMA guidelines which demonstrate that the work is consistent, measurable, and repeatable. The aim was to integrate contemporary findings regarding the association of T2DM with pregnancy, specifically addressing its outcomes, experiences, and management.

Search Strategy

In this systematic review, the process of identifying and selecting studies is shown graphically in Figure 1. In the beginning, 5,068 records were found as a result of thorough database searching, using the keywords. ("Type 2 Diabetes" OR "T2D") AND ("pregnancy" OR "pregnant women") AND ("outcomes" OR "complications" OR "management"). This search spanned three major databases: PubMed (3,568 records), Cochrane (969 records), and DOAJ (531 records). Together, these three databases provide a balanced and comprehensive coverage of peer-reviewed, biomedical, clinical, and open-access research, ensuring the inclusion of high-quality and diverse sources relevant to the topic. Scopus was not included in this review primarily due to its broader multidisciplinary focus, which may include studies less directly relevant to T2DM and pregnancy. Future research could consider including Scopus to potentially capture additional studies from allied fields.

During the screening phase, records were filtered based on publication years (2022-2024), narrowing the results to 1,229 records. Applying an open access filter further refined the records to 727. After a detailed

title and abstract review, 644 records were deemed relevant. Following eligibility assessment, 83 records were closely evaluated, and 17 highly relevant studies were included. This systematic and rigorous process ensured the selection of the most recent and pertinent research addressing T2D and pregnancy, focusing on outcomes, complications, and management strategies, while adhering to PRISMA guidelines.

The selection of studies followed PRISMA guidelines, with two reviewers independently screening studies for inclusion. Inter-observer agreement yielded a Cohen's kappa value of 0.82, reflecting strong consistency. Quality was assessed using the RoB 2; CASP; NOS and AMSTAR 2, achieving a kappa value of 0.78. High-quality studies ensured accuracy, minimizing bias, and strengthening result validity.

Inclusion and Exclusion

The Inclusion criteria for the systematic review include the investigation published from 2022 to 2024 on the topic relationship between T2D and pregnancy with respect to the outcomes, the complications, and the management thereof. This timeframe was chosen to ensure that the review captures the most recent evidence on the relationship between T2D and pregnancy, reflecting the latest developments in clinical understanding, management, and outcomes in this field. This also helps to ensure the review's relevance and timeliness, taking into account any changes in guidelines, treatments, or research trends. Only open-access English studies were included.

Eligible study designs included randomized controlled trials (RCTs) (These studies are the gold standard for minimizing bias and establishing causality), observational studies (These provide insights into real-world outcomes of T2D patients during pregnancy), systematic reviews, meta-analyses (These provide an aggregated analysis of existing evidence, enhancing the reliability of findings), and narrative reviews (These were included to offer a comprehensive overview of the current knowledge base, especially where specific studies may not have sufficient data on their own.). Studies were excluded if they did not address T2D in pregnancy, focused on unrelated conditions, were non-English publications, lacked full-text availability, or were abstracts, editorials, conference proceedings and studies with duplicate data or irrelevant titles and abstracts to ensure relevance, consistency, and comprehensive data analysis.

Quality Assessment

Table 1 displays the risk of bias and quality assessment of the studies that were included in the review according to the different groups of study designs. For RCTs, the Cochrane Risk of Bias (RoB 2) tool was utilized. This tool assesses risk of bias across five domains. Scores for the RCTs ranged between 8-9 out of 10, suggesting that these studies generally demonstrated moderate to high quality, with a minimal risk of bias in most cases. In the case of NLRs, the CASP (Critical Appraisal Skills Programme) checklist was applied. This tool focuses on several domains including the study's design, sampling methods, measurement reliability, and the analysis and reporting of results. Scores of 7-8 out of 10 were achieved, indicating a moderate to high level of quality. However, while these studies showed reasonable methodological rigor, some limitations such as potential confounding variables and biases due to the non-randomized nature of the studies were noted.

For observational and cross-sectional studies, the Newcastle-Ottawa Scale (NOS) was used to assess the selection of participants, the comparability of groups, and the assessment of outcomes. Scores ranged from 7-8 out of 9, indicating that these studies were of moderate to high quality. Despite this, some observational studies had limitations regarding sample representativeness, which could affect the generalizability of the findings.

For systematic reviews and meta-analyses, the AMSTAR 2 tool was applied. This tool evaluates the methodological quality of systematic reviews based on criteria such as the comprehensive nature of the search strategy, the risk of bias assessment, and the transparency in reporting the review process. Systematic reviews scored between 8-9, while meta-analyses achieved scores of 9 out of 11, indicating high quality in these reviews. However, some systematic reviews encountered limitations in terms of study selection, heterogeneity, and the inclusion of grey literature, which could potentially affect the robustness of the findings.

To summarise, the studies that were included in the review were able to display a significant amount of methodological rigor which adds weight to the conclusions that have been made regarding the review.

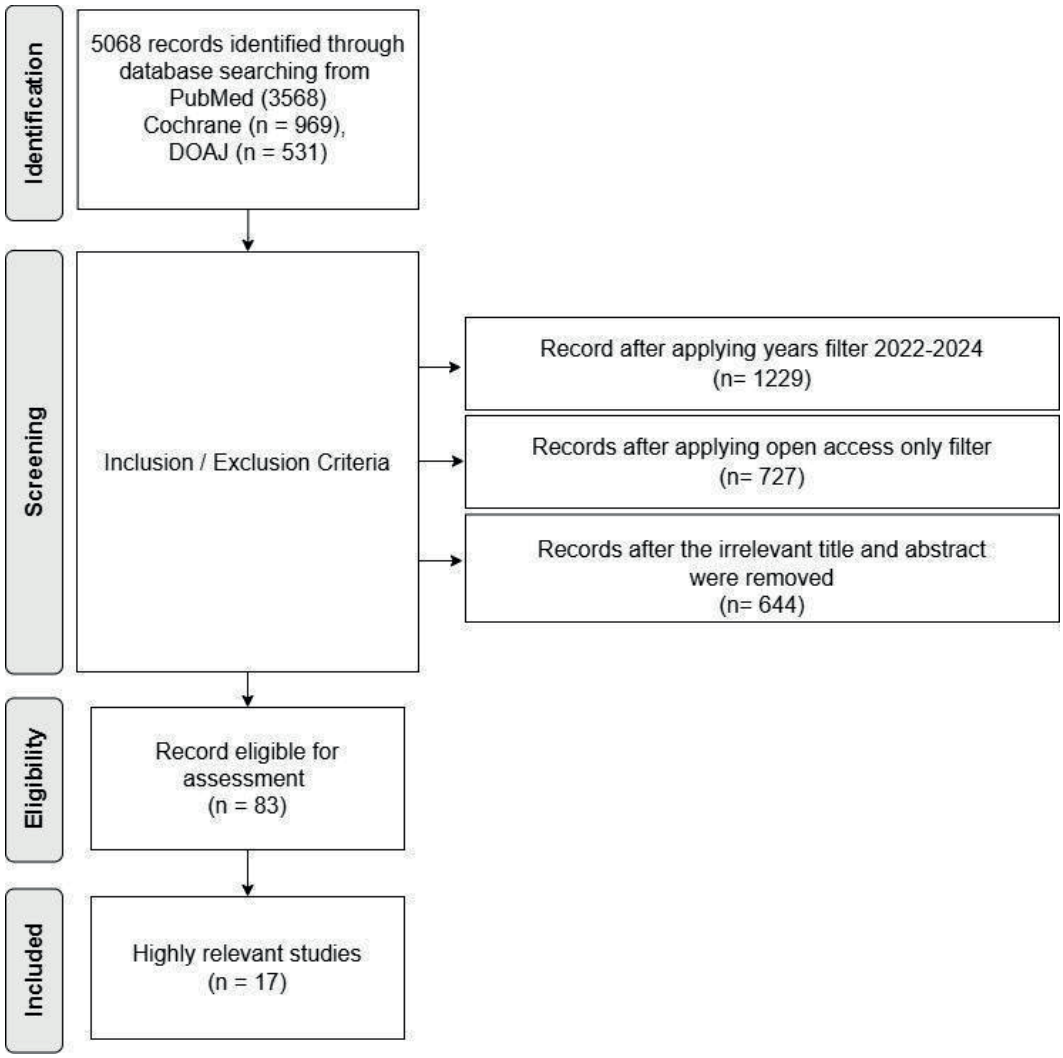

Figure 1. PRISMA Flow Diagram

Table 1. Quality and risk of bias Assessment studies.

Study Design	Studies	Tool	Quality Score	Quality Level
Randomized Controlled Trials (RCTs)	Taylor et al. 2022 [30], Yland et al. 2024 [31], Fu et al. 2022 [32], Patel et al. 2024 [33], Feig et al. 2022 [34], Nørgaard et al. 2023 [35]	RoB 2	8-9/10	Moderate to High
Narrative Literature Reviews (NLR)	Raets et al. 2023 [36], Adam et al. 2023 [37], Kristensen et al. 2022 [38], Piotrowska et al. 2023 [39]	CASP	7-8/10	Moderate to High
Observational Studies	Tryggestad et al. 2023 [40], Coetzee et al. 2023 [41]	NOS	7-8/9	Moderate to High
Cross-Sectional Studies	Milenkovic et al. 2023 [42], Sahrakorpi et al. 2022 [43]	NOS	7-8/9	Moderate to High
Systematic Reviews	Kabir et al. 2024 [44], Gunabalasingam et al. 2024 [45]	AMSTAR 2	8-9/11	High
Meta-Analysis	Clement et al. 2024 [46]	AMSTAR 2	9/11	High

Note: RoB 2: Cochrane Risk of Bias tool for RCTs; CASP: Critical Appraisal Skills Programme for Narrative Literature Reviews; NOS: Newcastle-Ottawa Scale for Observational and Cross-Sectional Studies; AMSTAR 2: A Measurement Tool to Assess Systematic Reviews 2 for Reviews.

Ethical Clearance:

As this is a systematic review of previously published studies, ethical approval was not required.

RESULTS

A total of 17 studies were included in this review, encompassing a diverse range of study designs, populations, and geographical regions, as shown in Table 2 of these, 6 studies were randomized controlled trials, highlighting the robust evidence they provide. Other designs included 4 narrative reviews, 2 systematic reviews, 2 observational studies, 2 cross-sectional studies, and 1 meta-analysis. The studies were conducted across various countries, including Australia, the US, Canada, Denmark, Belgium, South Africa, Finland, and the UK, with some studies utilizing global or multi-country datasets. Sample sizes ranged from 28 participants [38] to 2,983 participants [31]. Maternal age varied significantly, from as young as 20.5 ± 3.2 years [40] to 39 years [43], representing both younger and older populations at risk of diabetes-related complications.

Table 2. Study Characteristics

Author's Year	Country	Study Design	Sample Size	Age (Mean ± SD)
Taylor et al. 2022 [30]	Australia	RCT	76	36 ± 5 years
Yland et al. 2024 [31]	US	RCT	2983	32 years
Fu et al. 2022 [32]	Canada	RCT	460	-
Patel et al. 2024 [33]	US	RCT	831	-
Feig et al. 2022 [34]	Canada	RCT	502	34.9 ± 4.8 years
Nørgaard et al. 2023 [35]	Denmark	RCT	216	-
Raets et al. 2023 [36]	Belgium	Narrative Review	119	-
Adam et al. 2023 [37]	Global data	Narrative Review	-	-
Kristensen et al. 2022 [38]	UK	Narrative Review	28	-
Piotrowska et al. 2023 [39]	Poland	Narrative Review	14	-
Tryggestad et al. 2023 [40]	USA	Observational	407	20.5 ± 3.2 years
Coetzee et al. 2023 [41]	South Africa.	Observational	47	27 years.
Milenkovic et al. 2023 [42]	Canada	Cross-sectional	79	-
Sahrakorpi et al. 2022 [43]	Finland	Cross-sectional	204	39 years
Kabir et al. 2024 [44]	Ireland	Systematic Review	8	-
Gunabalasingam et al. 2024 [45]	UK	Systematic Review	12	18-45
Clement et al. 2024 [46]	UK	Meta-Analysis	47	33.6 years

Table 3 outlines the interventions and management strategies employed across these studies. Glycemic control was achieved through multitarget approaches combining insulin therapy, glucose monitoring, and lifestyle interventions in studies like [36], where recommended fasting and postprandial glucose targets were 70-95 mg/dL and 100–140 mg/dL, respectively. Pharmacological interventions, such as metformin monotherapy or in combination with insulin, were commonly employed [31, 32, 46]. Faster-acting insulins, such aspart [35], were evaluated for enhanced glycemic control. Lifestyle modifications, including dietary counseling, structured physical activity 30 minutes of daily moderate exercise and postpartum interventions like weight management and breastfeeding, were emphasized in several studies [30, 36, 43]. Innovative programs such as eHealth platforms and postpartum tai chi qigong [31] demonstrated promising results. Behavioral interventions [38] focused on oral health education, while postpartum interventions [37, 42] stressed the importance of oral OGTT, HbA1c monitoring, and weight tracking to prevent progression to T2DM.

Table 3. Interventions and Management Strategies in the Included Studies

Intervention Type	Glycemic Control Method	Pharmacological Treatment	Lifestyle Modifications	Studies
*Multitarget Approach	Insulin therapy, glucose monitoring, fasting 70–95 mg/dL, postprandial 100–140 mg/dL	Insulin preferred; metformin and glyburide safe; antihypertensives (methyldopa, labetalol, nifedipine); low-dose aspirin	Dietary counseling, PA (30 min daily), weight management	36
**Pharmacological	HbA1c targets during pregnancy; fasting and postprandial glucose monitoring	Insulin therapy (4.5%), metformin (44%) Metformin (monotherapy or combination), insulin therapy (74%)	Structured PA, dietary programs, weight gain management	31-34, 40, 46
Specialized Insulin Protocols	HbA1c monitoring	Faster-acting insulin aspart, insulin required in 94%, metformin in some cases	Adherence to insulin regimens	35, 41
***Lifestyle Modifications	Insulin therapy, glucose monitoring, HbA1c monitoring	Metformin (monotherapy or combination), insulin therapy, insulin detemir, NPH insulin, DHA supplementation	Dietary counseling, PA (30 min daily), weight management, structured PA, postpartum diet, PA, breastfeeding, weight reduction, aerobic exercise, eHealth program, postpartum tai chi qigong	30, 36, 37, 39, 40, 42, 43, 45
****Behavioral Interventions	Focus on oral health and behavioral interventions	-	Behavioral changes through education, oral hygiene training, and tool use	38
Postpartum Interventions	OGTT post-delivery, HbA1c assessments, weight tracking	Metformin for preventing type 2 diabetes progression, insulin during pregnancy	Postpartum diet, PA, breastfeeding, weight reduction	37

*(Glycemic Control, Diet, Weight Management, and Education); **(Metformin ± Insulin); ***(Dietary Counseling, PA, and Weight Management); ****(Educational or Psychologically Informed)

Maternal Outcomes

Table 4 highlights the breakdown of maternal outcomes. Description of results is given under subsections.

Pre-eclampsia

Pre-eclampsia was a prevalent complication, with incidence rates ranging from 2% to 48% across studies. Specifically, 20% of diabetes pregnancies and 17.1% of T2DM pregnancies were affected by pre-eclampsia. Metformin was associated with a reduction in pre-eclampsia rates, particularly in T2DM pregnancies. However, severe cases, such as those complicated by diabetic ketoacidosis (DKA), showed significantly elevated rates of 36%. Additionally, 13.7%-14.9% of cases were identified in preterm pregnancies, indicating a major risk factor for GDM [33, 36, 37, 40, 41, 44-46].

C-section Rate

C-section rates were higher in GDM and T2DM pregnancies, with particularly high rates in DKA cases (57%). This increase in C-section rates was primarily attributed to chronic hypertension and nephropathy in these pregnancies. Notably, the use of metformin did not significantly alter the C-section rates but was considered effective in managing other pregnancy complications [31, 34, 37, 41].

Gestational Hypertension

Gestational hypertension was another common comorbidity in pregnancies with T2DM and GDM, with baseline rates ranging from 8% to 21% across studies. Metformin was effective in reducing these rates, particularly in T2DM pregnancies. In severe cases, such as DKA, the incidence of gestational hypertension was 21% indicating the heightened risk in complicated pregnancies [30, 39, 41, 45, 46].

Maternal Weight Gain

Excessive maternal weight gain was closely linked to

adverse outcomes, including postpartum diabetes and macrosomia. Several studies showed that metformin and physical activity interventions effectively limited excessive weight gain, with 72% of participants achieving weight reduction. The classification of maternal weight gain into excessive, appropriate, or restricted highlighted that 68% of DKA pregnancies were classified as obese, further emphasizing the importance of managing weight gain in these high-risk pregnancies [30, 32, 36, 37, 39, 41, 45].

Table 4. Maternal Outcomes in Pregnancy with Type 2 Diabetes.

Outcome	Findings	Studies
Pre-eclampsia	20% in diabetes; 17.1% in T2D; 2-48% incidence; major GDM risk factor; metformin reduces; 13.7%-14.9% in preterm; 36% in DKA.	33, 36, 37, 40, 41, 44-46
C-Section Rate	Higher in GDM; similar rates with metformin; higher in chronic hypertension/ nephropathy; 57% in DKA cases.	31, 34, 37, 41
Gestational Hypertension	17.1% in T2D; reduction with metformin; comorbidity with GDM; 8-17% baseline; 21% in DKA cases.	30, 39, 41, 45, 46
Maternal Weight Gain	Limit weight gain; excessive linked to postpartum diabetes; reduced with metformin; physical activity critical; 72% weight reduction; classified as excessive/ appropriate/restricted; 68% obesity in DKA.	30, 32, 36, 37, 39, 41, 45

Fetal Outcomes

Table 5 highlights the breakdown of fetal outcomes. Description of results is given under subsections.

Macrosomia

Macrosomia was a frequent complication in diabetic pregnancies, particularly in poorly controlled GDM and T2DM pregnancies, with rates of up to 13% in T2DM pregnancies. Metformin use was associated with a reduction in macrosomia rates but was less effective in cases with excessive gestational weight gain (GWG). Poor glycemic control and excessive GWG contributed to an increased risk of macrosomia, with rates as high as 3% in some studies [32, 34, 37, 39, 41, 45, 46].

Preterm Birth

Preterm birth rates were significantly higher in diabetic pregnancies, with a reported 4-fold increase compared to non-diabetic pregnancies. In T2DM pregnancies, the rates were as high as 34.9%, while severe DKA cases had a dramatic increase to 85%. Additionally, restricted GWG further increased the risk of preterm births, indicating the significant role of weight management in preventing early delivery [31, 32, 34, 36, 37, 41, 45, 46].

Low Birth Weight (LBW)

LBW and particularly small-for-gestational-age (SGA) infants were notable concerns in metformin-treated pregnancies, with 12.9% of SGA infants born to metformin-treated mothers compared to 6.6% in placebo-treated groups. Furthermore, restricted GWG was linked to an increased incidence of low birth weight, emphasizing the importance of maintaining appropriate weight gain throughout pregnancy to optimize fetal outcomes [31, 32, 34, 45].

Neonatal Hypoglycemia

Neonatal hypoglycemia was a common complication in diabetic pregnancies, but the use of metformin significantly reduced its incidence compared to placebo. Although neonatal hypoglycemia was noted in various subsets, the reduction with metformin highlighted the importance of effective glycemic control in preventing neonatal complications [31, 33, 36, 37, 39, 45].

Fetal Distress and Mortality

Severe cases of diabetic ketoacidosis resulted in high fetal mortality, with estimates of 28%. Additionally, fetal distress was frequently noted in these severe cases, underlining the critical need for proper glycemic control throughout pregnancy to minimize fetal complications [41].

Table 5. Fetal Outcomes in Pregnancy with Type 2 Diabetes

Outcome	Findings	Studies
Macrosomia	13% in T2D; common in GDM; reduced with metformin; increased with poor GDM control/excessive GWG; 3%.	32, 34, 37, 39, 41, 45, 46
Preterm Birth	4x higher in diabetes; 34.9% in T2D; linked to GDM; 46%-48% with metformin; higher with restricted GWG; 85%.	31, 32, 34, 36, 37, 41, 45, 46
Low Birth Weight	Higher SGA in metformin-treated (12.9% vs. 6.6%); increased with restricted GWG.	31, 32, 34, 45
Neonatal Hypoglycemia	Common in diabetes/GDM; reduced with metformin; similar rates in MOMPOD; not subset-specific.	31, 33, 36, 37, 39, 45
Fetal Distress	High fetal mortality (28%); severe outcomes noted.	41

DISCUSSION

The current systematic literature review included studies of many types such as: randomized controlled trials, systematic reviews, observational and cross-sectional studies that produced quality and varied evidence. Sample sizes were very different, as per the few mentioned above, size of participants ranged between 28 and 2983, hence both narrow and broad reached. The birth mothers ranged in age from early 20s to late 30s years of age showing the extent of exposure of T2DM across the childbearing ages. The geographical scope of the studies which included high-resource countries and low-resource countries provides insights on the variations in the Care and outcomes of diabetes in pregnancy in various parts of the world. The results of the study show the undersupply of focused interventions and policies tailored to the specific populations, while promoting uniform care measures, which are necessary to meet the peculiarities of diabetic pregnancies around the world. A review which reported the analysis of 22 studies that evaluated pregnancy management among women suffering from T2DM in relation to pregnant women suffering from T1DM [47]. Some of the other reviews concentrated on cohort studies, especially examining the effects of GDM on the evolution of T2DM after childbirth. A particular review of this nature reviewed 28 studies and overall incidence of T2DM in women with a history of GDM was noted [48]. Moreover, a systematic review involving T2DM and T1DM pregnancies proved a strong dataset for the purpose of analysis. It was based on 3743 citations and comprised 156 studies involving 756,061 maternities out of which 50 studies had a low or moderate risk of bias [49, 50]. A different systematic review on the incidence of GDM converting to T2DM mentioned the overall risk ranges of between 2.6% and over 70%. Such variations in outcome appear to reflect differences in sizes of sample, durations of follow-up, and study populations [51].

The current SLR emphasized that the management of T2DM in pregnancy requires comprehensive interventions combining glycemic control, pharmacological treatments, and lifestyle modifications. Multitarget approaches, integrating insulin therapy, glucose monitoring, and structured lifestyle interventions, were identified as the most effective strategies for optimizing maternal and fetal outcomes. There was efficacy in the usage of metformin in the management of macrosomia and weight gain. Nonetheless, treatment came with challenges as it was also associated with a higher risk of delivering small-for-gestational-age infants. Other methods such as change in eating patterns, physical activity, or even the use of eHealth programs was very helpful in bettering one's weight and blood glucose.

Interventions like oral glucose tolerance test (OGTT) and breastfeeding that are done after one is at term were also very important in reducing the chances of T2DM developing but brought this idea that the treatment was always tailored and often multi-faceted As a cohort of one hundred thirty five pregestational diabetic patients-73 of them were T1DM and the other 62 were T2DM aged around 29 & 33 with a 5 & 6 year age gap respectively undergoing a constant insulin therapy throughout their pregnancy. The results indicated on the other hand that T1DM bears a higher tendency on the development of macrosomia due to the weight that one gains during gestation whereas T2DM had an excessive risk on spontaneous abortions the primary reason being pregestational BMI and maternal weight at early stage of pregnancy [52, 53]. Many of the reviews examined the development transition from GDM to T2DM, emphasizing that GDM females are at a higher risk, up to 10 times increased, of getting T2DM in future [54, 55]. Moreover, a review of T1DM and T2DM pregnancies in women indicates that, while the glycemic control during pregnancy may be better in T2DM cases, the perinatal problems, including preeclampsia and premature birth, are still worrying in both populations respectively [56]. Another study emphasized that strict glycemic management during pregnancy would help lessen the likelihood of suffering from preeclampsia and preterm delivery, which are common among women with T2DM. The combination of nutrition education and organized exercise was observed to enhance glycemic control and prevent excessive weight gain quite effectively [57]. In addition, regular exercise was suggested to reduce blood glucose and stop undue weight gain, thus reinforcing its contribution as a core measure in the treatment of T2DM during the course of pregnancy [58].

Findings from current SLR on maternal outcomes emphasize the difficulty of treating T2DM during pregnancy. Pre-eclampsia was reported to be a common problem, with some cases reporting a prevalence of up to 48% in badly managed cases. Metformin was found to have some effectiveness in lowering the

risk of gestational hypertension and pre-eclampsia. Uncontrolled GWG was also pointed out as one of the major complications during the pregnancy that causes an increasing risk of diabetes postpartum and higher rates of c-section. Combining lifestyle changes with drugs like metformin was successful in mitigating excessive GWG and controlling blood sugar levels during the pregnancy phase. These results stress the importance of early intervention, regular blood sugar checks, and thorough postpartum follow up for diabetic women. It is worthy to note that meta-analysis data also indicate that the incidence of pre-eclampsia in women with T2DM is lower than in those with T1DM. The estimated risk ratios for pre-eclampsia among women who enter pregnancy with T2DM is around 0.76 (95% CI: 0.68-0.85) suggesting a decreased risk for this condition amongst T2DM women as compared to those with T1DM [59]. Women with T2DM had a lower probability of undergoing C-section compared to those with T1DM (OR = 0.80) [60]. Although there are scarce data on maternal weight gain during pregnancy in retrospectively studied pregnant women with T2DM, there is enough literature in the systematic reviews that shows the importance of control of GWG for this group of women as it impacts both obesity and diabetes complication risks. It is indicated throughout the literature that optimal glycemic control is one of the measures to prevent excess weight gain and its consequences during the course of pregnancy [61].

The current SLR findings on fetal outcomes highlight the significant challenges associated with T2DM in pregnancy. Macrosomia and preterm birth were prevalent in poorly controlled pregnancies, with preterm birth rates reaching as high as 85% in severe cases such as diabetic ketoacidosis (DKA). While metformin effectively reduced the risk of macrosomia and improved glycemic variability, it was related with increased rates of SGA infants, necessitating careful consideration of its risk-benefit balance. Neonatal hypoglycemia, a major concern in women with a history of T2DM, was reduced after metformin therapy. There are severe complications like cadaveric fetal head, high fetal death rate in cases of diabetic ketoacidosis and so far, so there is a great need for early term detection, control of hyperglycemia and care in order to achieve good results in the child. Macrosomia which is defined as birth weight greater than 4000 grams is still a major area of concern in a woman who has diabetes during pregnancy. Women with T2DM are reported to have higher chances of having LGA babies (2.79 odd ratio), as compared to non-diabetic pregnancies which shows the risk chances are also high [62, 63]. Between pregnancies with and without diabetes, preterm birth, which has been defined as the time of delivery being <37 gestational weeks, also differed. However, T2DM women showed reduced probability of having a preterm delivery than T1DM women with a meta-analysis indicating that the risk ratio stands at 0.69 for T2DM pregnancies as compared to T1DM [64]. Neonatal hypoglycemia was a recurrent and significant metabolic complication, which was noted particularly in the newborns of mothers with T2DM. This is due to the exposure of the fetus to high levels of maternal blood glucose which leads to the overproduction of insulin by the newborn [65, 66]. Regardless of these problems, there is enough evidence to state that pregnancies complicated with T2DM were associated with even a higher perinatal mortality rate than pregnancies with T1DM which had a reported relative risk 1.26 [55].

These findings imply that T2DM pregnancies do not have as many risk factors as T1DM when it comes to getting pregnant, for example, pre-eclampsia and preterm births, but there are still potential threats to fetal health and viability and therefore need to be controlled and managed comprehensively.

Limitations of the study

The systematic evaluation offers a new perspective on the treatment of T2DM in pregnant women, however, there are various limitations that must first be outlined. The results for the studies combined were found to have considerable diversity in relation to sample population, sample size, and geographic location which could impact the applicability of the result. In addition, most studies were not able to follow up with patients for over an extended period which limited their analysis on the impact of interventions such as metformin and insulin on maternal and fetal health. Moreover, since the review was restricted to English language papers publications only, some studies which would have been relevant though not in the English language were not included. But this helps to limit biases and ensures that as few non-universal observations were made as possible while allowing for better clarity of the comparisons that were made.

CONCLUSION

The systematic literature review emphasizes the critical role of T2DM in pregnancy outcomes and stresses the need for proper management to enhance the health status of both the mother and the fetus. The review merged evidence from clinical trials, observational studies, and reviews, providing a comprehensive overview of issues and management approaches targeting T2DM during pregnancy.

The studies consistently reported maternal issues, including pre-eclampsia, gestational hypertension, and excessive gestational weight gain. Notably, pre-eclampsia, a significant risk factor in T2DM pregnancies, had an incidence ranging from 2% to 48%, primarily derived from studies conducted across diverse geographic regions. Metformin was moderately effective in decreasing this risk. Gestational hypertension, another frequent comorbidity, showed baseline figures of 8% to 21% based on multi-regional studies, underlining the importance of early treatment. Excessive gestational weight gain was positively linked with postpartum diabetes and other adverse pregnancy outcomes. However, weight loss strategies, including dietary changes and metformin, were beneficial in mitigating these risks.

Fetal outcomes like macrosomia, prematurity, LBW, and neonatal hypoglycemia were significant issues in diabetic pregnancies. Metformin demonstrated moderate effectiveness in preventing macrosomia and neonatal hypoglycemia but was related with an increased incidence of SGA infants. The pronounced rate of preterm births in diabetic women further underscores the critical need for controlling blood glucose levels and managing obesity to enhance pregnancy outcomes.

The results emphasize the importance of ongoing research and optimization of therapeutic management to support better outcomes for affected mothers and children. Achieving better clinical outcomes requires a combination of drug treatments like insulin and metformin, lifestyle changes, including diet and physical activity, and maternal care. Adequate screening and surveillance efforts after delivery should aim to reduce the likelihood of women and their children developing type 2 diabetes mellitus and related conditions. Additionally, advancing research and clinical practices remains paramount to optimizing management protocols and improving care for women with T2DM during pregnancy.

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Conflict of Interest

The authors declare no conflict of interest related to this study.

Authors' Contributions

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