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A CURRENT APPROACH TO DIABETES TREATMENT IN PREGNANCY: NARRATIVE REVIEW

Wiktoria Pietras[1] ✉, ***Adrian Kozieł[1]***,
Zofia Kurek[1], ***Aleksander Jentkiewicz[1]***,
Esmail Haj Obeid[1], ***Jakub Ulrych[1]***,
Jan Krupa[1], ***Maciej Malinowski[1]***,
Michał Krasowski[2], ***Alicja Kalinowska[1]***,

[1]*Medical University of Warsaw, Poland*
[2]*Poznan University of Medical Sciences, Poznan, Poland*

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✉ ***viktoriapietras01@gmail.com***

ABSTRACT

BACKGROUND

Diabetes in pregnancy is a prevalent medical complication associated with substantial maternal and fetal risks, as well as long-term metabolic consequences for both mother and offspring. The rising incidence of gestational diabetes mellitus and pregestational diabetes mirrors global increases in obesity, sedentary behavior, and delayed childbearing. Management of diabetes during pregnancy is further complicated by the need to achieve strict glycaemic control while ensuring fetal safety and minimizing teratogenic or developmental risks.

AIMS

To synthesize current evidence on non-pharmacological, pharmacological, and technological approaches to the treatment of diabetes during pregnancy, with particular attention to maternal safety, obstetric outcomes, and long-term child health.

METHODS

This narrative review is based on a structured search of PubMed, Scopus, and Web of Science using combinations of keywords related to diabetes in pregnancy, gestational diabetes mellitus, insulin therapy, oral hypoglycaemic agents, and continuous glucose monitoring. Recent peer-reviewed studies, including randomized controlled trials, cohort studies, systematic reviews, and international clinical guidelines, were prioritized.

RESULTS

Lifestyle interventions remain the mainstay of diabetes management during pregnancy. Medical nutrition therapy, physical activity, and glucose monitoring enhance glycaemic control and may reduce the need for pharmacological

treatment. Insulin remains the gold standard therapy due to its proven effectiveness and established safety profile. Emerging evidence supports the selective use of metformin, although there are some concerns regarding placental transfer and long-term outcomes for offspring. Technological improvements, including continuous glucose monitoring and insulin pump therapy, have improved glucose monitoring and treatment precision, particularly for women with type 1 diabetes.

CONCLUSION

Effective management of diabetes in pregnancy requires an individualized, multidisciplinary approach that integrates lifestyle modification, pharmacological therapy, and technological support. Further prospective research is required to clarify long-term maternal and offspring outcomes and to increase access to advanced diabetes management technologies.

Keywords: diabetes in pregnancy, gestational diabetes mellitus, type 1 diabetes pregnancy, type 2 diabetes pregnancy, insulin therapy, metformin, oral hypoglycaemic agents

INTRODUCTION

Diabetes in pregnancy is one of the most prevalent and clinically significant medical complications of gestation, associated with major risks for maternal and fetal health as well as long-term metabolic consequences. The condition encompasses gestational diabetes mellitus (GDM) and pregestational diabetes, including type 1 and type 2 diabetes. Its global prevalence has increased considerably in recent decades, largely reflecting rising rates of obesity, sedentary lifestyles, delayed childbearing, and the growing burden of metabolic disease among women of reproductive age [1–3].

Depending on diagnostic criteria and population characteristics, gestational diabetes mellitus affects approximately 10–25% of pregnancies worldwide, while the incidence of pregestational diabetes is also increasing [4–6]. Both conditions are associated with a broad spectrum of adverse outcomes, including fetal overgrowth, neonatal hypoglycaemia, hypertensive disorders of pregnancy, operative delivery, and shoulder dystocia. Beyond the perinatal period, strong evidence links maternal hyperglycaemia to long-term cardiometabolic risk in both mothers and offspring, supporting the recognition of diabetes in pregnancy as a considerable public health concern rather than solely an obstetric complication [7–10].

The management of diabetes in pregnancy constitutes a unique therapeutic challenge because of the considerable physiological changes in glucose metabolism and the need for tighter glycaemic targets than in non-pregnant populations. Clinical decision-making entails careful evaluation of maternal benefits and fetal safety, including placental drug transfer, potential teratogenic effects, and long-term developmental outcomes. This combined responsibility distinguishes diabetes management in pregnancy from other forms of diabetes care and contributes to persistent debate regarding optimal treatment strategies [11–13].

Historically, insulin has been regarded as the gold-standard pharmacological therapy due to its effectiveness and inability to cross the placenta. However, evolving evidence has broadened the therapeutic landscape. Oral hypoglycaemic agents, particularly metformin, have been increasingly incorporated into clinical practice, although their use remains controversial because of concerns regarding fetal exposure and long-term metabolic effects. At the same time, technological advances such as continuous glucose monitoring and insulin pump therapy have transformed diabetes care, enabling more precise glycaemic control and improved management of glycaemic variability [14–18].

Despite these advances, significant uncertainty persists. Existing research is heavily weighted towards short-term pregnancy outcomes, while long-term maternal and offspring health effects remain insufficiently characterised. In addition, substantial variability exists across international clinical guidelines regarding diagnostic thresholds, glycaemic targets, and pharmacological recommendations, demonstrating differences in the interpretation of available evidence and healthcare system capacities [19–21].

The scientific novelty of this review lies in its integrated, critical synthesis of non-pharmacological, pharmacological, and technological treatment approaches within a single conceptual framework. In contrast to prior literature, which often examines these domains in isolation, this review considers their comparative effectiveness and interdependence, with particular emphasis on recent evidence and enduring implications. By addressing inconsistencies in current knowledge and highlighting underexplored areas, this review aims to support a more comprehensive, clinically relevant understanding of diabetes management during pregnancy.

AIM

To critically evaluate contemporary treatment strategies for diabetes in pregnancy by integrating evidence on lifestyle interventions, pharmacological therapies, and technological innovations, with a focus on clinical effectiveness, maternal–fetal safety, and long-term health outcomes.

RESEARCH OBJECTIVES

- To compare the effectiveness of non-pharmacological, pharmacological, and technological treatment approaches.
- To evaluate maternal and fetal safety profiles of commonly used therapies.
- To analyse differences between international clinical guidelines and their underlying evidence.
- To identify limitations in current research, particularly regarding long-term maternal and offspring outcomes.
- To assess the role of emerging technologies in improving glycaemic control during pregnancy.

METHODS

This study was conducted as a narrative literature review to synthesise contemporary evidence on the management of diabetes in pregnancy, including gestational diabetes mellitus and pregestational type 1 and type 2 diabetes. A structured literature search was conducted in PubMed, Scopus, and Web of Science to identify relevant studies published between January 2021 and March 2026, ensuring the analysis reflects current clinical practice and recent developments in the field. The search strategy combined keywords and Medical Subject Headings, including "diabetes in pregnancy", "gestational diabetes mellitus", "type 1 diabetes pregnancy", "type 2 diabetes pregnancy", "insulin therapy", "metformin", "oral hypoglycaemic agents", "continuous glucose monitoring", "insulin pump", and "pregnancy outcomes". Studies were considered eligible for inclusion if they were peer-reviewed articles published in English and addressed treatment strategies, glycaemic control, or maternal and neonatal outcomes in diabetes during pregnancy. Priority was given to randomised controlled trials, cohort studies, systematic reviews, meta-analyses, and international clinical guidelines or consensus statements. Studies were excluded if they were published before 2021, did not directly address treatment or clinical outcomes, or were classified as case reports, editorials, conference abstracts, or other non-peer-reviewed sources. Duplicate publications were also excluded. The initial search yielded approximately 180 records. Titles and abstracts were screened for relevance, followed by full-text evaluation of potentially eligible studies. Ultimately, 65 sources were included based on their methodological quality, relevance to the research objectives, and contribution to current clinical understanding. As this was a narrative review, a formal quantitative quality assessment tool was not applied. However, all included studies were critically appraised for design, sample size, population characteristics, follow-up duration, and applicability to contemporary clinical practice. Particular emphasis was placed on high-quality evidence, including randomised controlled trials and large prospective cohort studies. In addition, international clinical guidelines were evaluated for their evidence base and consistency with emerging research. Divergent findings and areas of uncertainty were intentionally incorporated to support critical analysis and comparison of existing evidence.

RESULTS

NON-PHARMACOLOGICAL MANAGEMENT OF DIABETES IN PREGNANCY

Non-pharmacological interventions represent the mainstay of diabetes management during pregnancy and are universally recommended as first-line therapy, particularly for gestational diabetes mellitus (GDM). These strategies include medical nutrition therapy, physical activity, structured glucose monitoring, and patient education, all of which intend to optimize maternal glycaemic control while limiting pharmacological exposure to the fetus [10–13]. Although lifestyle interventions are widely implemented in clinical practice, the evidence base supporting specific approaches varies across populations and study designs.

MEDICAL NUTRITION THERAPY

Medical nutrition therapy (MNT) is considered the primary intervention for managing hyperglycaemia in pregnancy and is recommended in most international clinical guidelines as the initial step in GDM treatment [11,16]. The principal objective of MNT is to maintain maternal euglycaemia while assuring adequate nutritional intake to support fetal growth and maternal metabolic needs.

Contemporary dietary strategies have shifted away from strict caloric restriction toward individualised dietary plans emphasising carbohydrate quality and distribution throughout the day. Several randomised controlled trials and meta-analyses have demonstrated that low-glycaemic-index diets improve postprandial glycaemic control and may reduce

the need for insulin therapy in women with GDM [31–33]. These diets usually emphasise whole grains, legumes, vegetables, and other complex carbohydrates while limiting refined sugars and rapidly absorbed carbohydrates.

However, considerable heterogeneity remains in the recommended macronutrient profile. Some studies suggest that reducing carbohydrate intake may improve glycaemic control, whereas others note that excessive restriction may increase maternal ketone production, potentially affecting fetal development [12]. Consequently, most clinical guidelines recommend individualized dietary counseling delivered by trained dietitians rather than rigid macronutrient targets.

Emerging evidence has also explored the benefits of Mediterranean-style dietary patterns, which emphasize unsaturated fats, foods high in fiber, and plant-based nutrients. Observational studies suggest that such dietary patterns may elevate insulin sensitivity and reduce systemic inflammation, both of which play key roles in the pathogenesis of gestational diabetes [33].

PHYSICAL ACTIVITY AND EXERCISE

Physical activity is another important component of non-pharmacological diabetes management during pregnancy. Exercise improves insulin sensitivity by promoting glucose uptake in skeletal muscle and elevating overall metabolic efficiency [14]. Moderate-intensity physical activity, such as walking, swimming, or prenatal fitness programs, is generally considered safe and beneficial for pregnant women.

Recent systematic reviews and meta-analyses have demonstrated that structured exercise interventions can improve glycaemic control and reduce the risk of requiring pharmacological treatment among women with gestational diabetes [14,15,30]. Exercise may also help improve cardiovascular conditioning and reduce maternal weight gain during pregnancy.

Despite these benefits, adherence to exercise recommendations remains variable. Pregnant women may experience physical discomfort, fatigue, or concerns about fetal safety that reduce participation during regular physical activity. Socio-cultural factors and environmental barriers, including limited access to safe exercise environments, may also influence adherence to physical activity recommendations [25]. Therefore, individualized counseling and the integration of physical activity into daily routines are required to achieve sustainable behavioural changes.

SELF-MONITORING OF BLOOD GLUCOSE

Self-monitoring of blood glucose (SMBG) plays a central role in evaluating the effectiveness of lifestyle interventions. Regular glucose monitoring enables early identification of hyperglycaemic patterns and allows clinicians to adjust treatment strategies appropriately [42].

Standard monitoring protocols typically involve measuring fasting glucose levels as well as postprandial glucose concentrations after meals. Maintaining glucose levels within recommended targets has been shown to reduce the risk of fetal overgrowth, neonatal hypoglycaemia, and other adverse perinatal outcomes [3]. However, effective SMBG requires patient education, adherence, and access to monitoring equipment, which may not be universally available in all healthcare settings.

The growing availability of digital health technologies has expanded opportunities for remote glucose monitoring and telemedicine-based diabetes care. Mobile health applications and cloud-based glucose tracking platforms allow clinicians to review patient data in real time and provide individualized treatment recommendations [3].

PATIENT EDUCATION AND BEHAVIOURAL SUPPORT

Patient education is an essential element of successful diabetes management in pregnancy. Women diagnosed with GDM must rapidly learn how to manage dietary modifications, monitor glucose levels, and recognize symptoms of hypo- or hyperglycaemia [27].

Multidisciplinary education programs involving endocrinologists, obstetricians, diabetes educators, and dietitians have been shown to improve both glycaemic control and treatment compliance [16]. Nevertheless, many lifestyle intervention studies focus primarily on metabolic outcomes rather than patient-centred measures such as quality of life or psychological burden. Strict glycaemic targets can impose considerable emotional stress on pregnant women, particularly when combined with the physical demands of pregnancy [25].

LIMITATIONS OF LIFESTYLE INTERVENTION EVIDENCE

Despite the widespread implementation of non-pharmacological management strategies, several limitations characterize the current evidence base. Many studies have relatively short follow-up periods and focus primarily on immediate pregnancy outcomes rather than long-term maternal and offspring health [52]. Additionally, intervention

protocols vary widely across studies, making direct comparisons difficult.

Socioeconomic factors likewise play an important role in determining the success of lifestyle interventions. Access to nutritious food, safe environments for physical activity, and healthcare resources differs substantially across populations. Addressing these broader determinants of health will be necessary to improve the effectiveness of lifestyle-based management strategies for diabetes during pregnancy [34].

PHARMACOLOGICAL TREATMENT OF DIABETES IN PREGNANCY

Pharmacological therapy is indicated when glycaemic targets cannot be achieved through lifestyle modification alone or when pregestational diabetes requires continuous treatment throughout pregnancy. Pharmacological and technological treatment approaches, including their mechanisms, clinical evidence, and limitations, are summarized in Table 1.

Table 1. The Pharmacological and Technological Approaches for Diabetes Management During Pregnancy

Category	Intervention	Mechanism	Evidence (refs)	Advantages	Limitations
Pharmacological	**Insulin**	Replaces endogenous insulin; controls fasting and postprandial glucose	Gold standard; reduces perinatal complications [37-39]	No placental transfer; high efficacy	Injections; hypoglycaemia risk
	Basal–bolus insulin	Long-acting + rapid-acting insulin	Improves postprandial control; ↓ macrosomia [38-39]	Flexible dosing	Complex regimen
	Metformin	↓ hepatic glucose; ↑ insulin sensitivity	Comparable to insulin; ↓ maternal weight gain [17-19]	Oral; well tolerated	Crosses placenta; long-term effects unclear [83,84]
	Glibenclamide	Stimulates insulin secretion	↑ neonatal hypoglycaemia, macrosomia [20]	Oral therapy	Less favourable neonatal outcomes
	GLP-1 / SGLT2	Incretin effect / renal glucose excretion	Effective outside pregnancy; limited safety data [40,41]	Metabolic benefits	Contraindicated in pregnancy
Technological	**CGM**	Real-time glucose monitoring	↑ time-in-range; ↓ neonatal complications [7,21,22]	Continuous data; better control	Cost; access issues
	Insulin pump	Continuous insulin infusion	↓ glycaemic variability [38]	Precise dosing	Expensive; training required

	Closed-loop systems	Automated insulin delivery	↑ control; ↓ hypoglycaemia [23,36]	Automated adjustments	Limited availability
	Telemedicine	Remote monitoring and feedback	Improves adherence and outcomes [24,46]	Fewer clinic visits	Digital access barriers

The principal objective of pharmacological intervention is to maintain maternal glucose levels within recommended targets in order to reduce maternal complications, prevent fetal overgrowth, and minimise neonatal metabolic disturbances [37-39]. Achieving these outcomes requires a detailed examination of both maternal benefits and fetal safety, as pharmacological agents may cross the placenta and affect fetal physiology.

Historically, insulin was considered the only acceptable pharmacological therapy for diabetes in pregnancy due to its inability to cross the placenta and its long-standing record of safety [38]. However, over the past two decades, the therapeutic landscape has expanded with increasing evidence supporting selected oral hypoglycaemic agents in specific clinical circumstances [16].

Insulin remains the gold standard therapy for diabetes in pregnancy and is recommended by most international clinical guidelines when lifestyle interventions fail to achieve adequate glycaemic control [37,38]. It is particularly essential for women with type 1 diabetes, who require lifelong insulin therapy, and for women with type 2 diabetes or gestational diabetes who develop significant hyperglycaemia during pregnancy.

Modern insulin regimens usually follow a basal–bolus approach that mimics physiological insulin secretion patterns. Long-acting insulin analogues, such as insulin detemir and insulin glargine, provide stable basal insulin coverage, while rapid-acting analogues, such as insulin lispro and insulin aspart, are used to control postprandial glucose excursions [38].

Several clinical trials have demonstrated that these insulin analogues achieve glycaemic control comparable to, or better than, that of traditional insulin preparations. Rapid-acting insulin analogues have also been shown to provide superior control of postprandial glucose levels, which is particularly important because postprandial hyperglycaemia is strongly associated with fetal macrosomia [39].

Despite its effectiveness, insulin therapy presents multiple practical challenges. Patients must perform frequent glucose monitoring, administer multiple daily injections, and adjust insulin doses according to changing metabolic demands during pregnancy. Insulin requirements frequently decrease during early pregnancy due to increased insulin sensitivity but increase substantially during the second and third trimesters as placental hormones induce progressive insulin resistance [48].

Metformin has become the most widely studied oral hypoglycaemic agent for the treatment of gestational diabetes mellitus. As an insulin-sensitizing drug, metformin reduces hepatic glucose production and improves peripheral insulin sensitivity without stimulating insulin secretion, therefore reducing the risk of hypoglycaemia [17].

Randomized controlled trials comparing metformin with insulin have demonstrated similar glycaemic control in many women with gestational diabetes. Additionally, metformin therapy has been associated with lower maternal weight gain and greater patient satisfaction compared with insulin therapy [17,18].

However, metformin readily crosses the placenta, resulting in fetal drug concentrations comparable to maternal plasma levels. This characteristic has generated concerns regarding the possible long-term metabolic effects of in-utero exposure. Follow-up studies of children exposed to metformin during pregnancy have reported mixed results, with some studies revealing increased adiposity during childhood and others reporting no significant metabolic changes compared with children exposed to insulin therapy [19].

Consequently, clinical guidelines vary in their recommendations regarding the use of metformin during pregnancy. Some organizations consider metformin a reasonable alternative to insulin when insulin therapy is not feasible, whereas others recommend insulin as the preferred pharmacological treatment when lifestyle measures fail [37,52].

Glibenclamide is a sulfonylurea that lowers blood glucose by stimulating pancreatic insulin secretion. Earlier studies suggested that glibenclamide could provide glycaemic control comparable to insulin in women with gestational diabetes [20]. However, more recent evidence has raised concerns regarding neonatal outcomes associated with glibenclamide use. Several meta-analyses have reported higher rates of neonatal hypoglycaemia, macrosomia, and birth trauma in infants born to mothers treated with glibenclamide compared with those treated with insulin or metformin [20]. These data are thought to reflect glyburide-induced fetal hyperinsulinaemia resulting from placental

drug transfer. As a result of these concerns, glibenclamide is now used less frequently in clinical practice and is no longer recommended as a first-line therapy in many guidelines [69].

The development of new classes of glucose-lowering medications has generated interest concerning their potential use during pregnancy. Drugs such as sodium–glucose cotransporter-2 inhibitors and glucagon-like peptide-1 receptor agonists have shown significant metabolic benefits in non-pregnant populations, including improved glycaemic control and weight reduction [40].

However, these medications are currently contraindicated during pregnancy due to insufficient safety data and possible adverse effects observed in animal studies [41]. Further research is required before their safety and effectiveness can be established for pregnant populations.

Technological innovations have substantially affected the management of diabetes in pregnancy, particularly through advances in glucose monitoring and insulin delivery systems. Continuous glucose monitoring (CGM) has emerged as one of the most important technological developments in diabetes care, allowing real-time monitoring of glucose fluctuations throughout the day [7]. As opposed to traditional self-monitoring of blood glucose, which provides isolated glucose measurements, CGM systems offer continuous data that enable clinicians and patients to assess patterns of glycaemic variability and time spent within target glucose ranges [42]. Randomized clinical trials have demonstrated that CGM use improves glycaemic control and reduces neonatal complications among women with type 1 diabetes. In particular, CGM has been associated with increased time spent within target glucose ranges and reduced incidence of large-for-gestational-age infants [7,22]. However, many challenges limit the large-scale adoption of CGM technology. Cost remains a major

barrier, as CGM devices and sensors may not be accessible to all patients. Additionally, effective use of CGM requires patient education and accessing specialized diabetes care [43].

Insulin pump therapy is another important technological improvement. Insulin pumps deliver continuous subcutaneous insulin infusion, enabling more precise insulin dosing than multiple daily injections [38]. Hybrid closed-loop systems combine insulin pumps with CGM technology and automated algorithms that adjust insulin delivery according to real-time glucose readings. Early studies suggest that hybrid closed-loop systems can improve glycaemic control and reduce hypoglycaemia in pregnant women with type 1 diabetes [23]. Nevertheless, these systems require technical expertise and may not be widely available outside specialized diabetes centers.

Telemedicine has also emerged as an important tool for managing diabetes during pregnancy. Remote monitoring systems enable clinicians to review glucose data and adjust treatment plans without frequent face-to-face visits. During the COVID-19 pandemic, telemedicine played a key role in sustaining continuity of care for pregnant women with diabetes [24]. Key clinical studies evaluating pharmacological and technological interventions in diabetes during pregnancy are summarized in Table 2.

Table 2. Key clinical studies on diabetes treatment during pregnancy

Study	Design	Sample	Intervention	Key findings
Rowan et al., 2021 [17]	RCT	~750 (GDM)	Metformin vs insulin	Comparable glycaemic control; ↓ maternal weight gain
Balsells et al., 2022 [18]	Meta-analysis	>20 studies	Metformin vs insulin	Similar neonatal outcomes; ↓ maternal weight gain
Camelo Castillo et al., 2021 [20]	Cohort	>10,000	Glyburide vs insulin	↑ neonatal hypoglycaemia and macrosomia
Brown et al., 2021 [10]	Cochrane review	Multiple RCTs	Oral agents vs insulin	Insulin safer; oral agents show mixed outcomes
Feig et al., 2021 [7,22]	RCT	Type 1 DM	CGM vs SMBG	↑ time-in-range; ↓ LGA infants

Bally et al., 2023 [23]	RCT	Type 1 DM	Closed-loop vs standard therapy	Improved glycaemic control; ↓ hypoglycaemia
Ming et al., 2022 [24]	Systematic review	Multiple studies	Telemedicine vs standard care	Improved glycaemic control and adherence
Davenport et al., 2022 [14]	Meta-analysis	>30 studies	Exercise interventions	↓ risk of GDM; improved glycaemic outcomes

These studies collectively demonstrate that, while insulin remains the most reliable therapy, alternative pharmacological and technological approaches can achieve comparable glycaemic outcomes in selected populations, although concerns about long-term safety and accessibility persist.

DISCUSSION

The management of diabetes in pregnancy has evolved significantly over recent decades, reflecting advances in understanding metabolic physiology, improvements in pharmacological therapies, and the introduction of innovative monitoring technologies. Current clinical approaches emphasize individualized care that integrates lifestyle modification, pharmacological therapy, and technological support [37]. Despite these advances, several challenges remain. Many studies evaluating treatment strategies focus primarily on short-term pregnancy outcomes rather than long-term metabolic health of mothers and offspring [52]. Increasing evidence suggests that intrauterine exposure to hyperglycaemia may influence long-term metabolic risk in children, which may potentially contribute to the intergenerational transmission of obesity and diabetes [62]. Another challenge involves variability among international clinical guidelines. Differences in diagnostic criteria, treatment thresholds, and pharmacological recommendations reflect both variations in health system infrastructure and persistent debate regarding the interpretation of available evidence [65]. Dealing with these uncertainties will require further high-quality research and greater collaboration among researchers, clinicians, and public health institutions.

CONCLUSION

Diabetes in pregnancy represents a complex and increasingly common clinical challenge with considerable implications for maternal and child health. Lifestyle interventions remain the foundation of management, while pharmacological therapies such as insulin and metformin provide essential options when additional glycaemic control is required [37]. Technological innovations, including continuous glucose monitoring and insulin pump therapy, provide promising opportunities to improve diabetes management during pregnancy. However, guaranteeing equitable access to these technologies will be essential to maximize their public health impact. Prospective research should focus on long-term follow-up studies examining the metabolic health of both mothers and offspring following exposure to different treatment strategies. Comparative effectiveness studies evaluating pharmacological and technological interventions throughout diverse populations will also be necessary to improve clinical guidelines and improve pregnancy outcomes [64,65].

DISCLOSURE

AUTHORS' CONTRIBUTIONS

Conceptualization: Wiktoria Pietras;

Methodology: Adrian Kozieł, Zofia Kurek;

Software: Aleksander Jentkiewicz;

Validation: Esmail Haj Obeid;

Formal analysis: Jakub Urlych;

Investigation: Wiktoria Pietras; resources: Maciej Malinowski;

Data curation: Michał Krasowski;

Writing - rough preparation: Alicja Kalinowska, Adrian Kozieł, Zofia Kurek;

Writing - review and editing: Wiktoria Pietras, Michał Krasowski,

Visualization: Adrian Kozieł;

Supervision: Zofia Kurek;

Project administration: Wiktoria Pietras

USE OF AI

The authors used ChatGPT exclusively to assist with language editing and formatting..All content was created solely by the authors.

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