Systematic Reviews on the Prevention of Adverse Pregnancy Outcomes Related to Maternal Obesity to Improve Evidence-Based Counselling

Systematische Übersichtsarbeiten über die Verbesserung der evidenzbasierteren Beratung zur Prävention von mütterlichen adipositasbezogenen ungünstigen Schwangerschaftsausgängen

OPEN ACCESS

Authors
Susann Behnam[1,2,3], Birgit Arabin[1]

Affiliations
1 Clara Angela Foundation Witten und Berlin, Witten, Germany
2 Philipps University Marburg, Marburg, Germany
3 Dr. Horst Schmidt Hospital, Wiesbaden, Germany

Keywords
maternal obesity, gestational diabetes, health literacy, evidence-based medicine, counselling

Schlüsselwörter
mütterliche Adipositas, Gestationsdiabetes, Gesundheitskompetenz, evidenzbasierte Medizin, Beratung

received 3.2.2024
accepted after revision 13.3.2024

Bibliography
Geburtsh Frauenheilk 2024; 84: 564–572
DOI 10.1055/a-2295-1725
ISSN 0016-5751

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

Correspondence
Susann Behnam, MD
Clara Angela Foundation
Koenigsallee 36
14193 Berlin, Germany
subehnam@gmail.com

ABSTRACT

Background
Health professionals and their patients should understand the importance of evidence. In the case of gestational diabetes mellitus, which is often associated with an abnormally high body mass index, the immediate and long-term outcome of women and their offspring depends in part on advice and implementation of lifestyle changes before, during and after pregnancy.

Methods
Up to September 2023, MEDLINE, CENTRAL, and WEB OF SCIENCE were used to identify systematic reviews and meta-analyses on the prevention of gestational diabetes. The ROBIS and AMSTAR criteria were analyzed for all systematic reviews.

Results
A total of 36 systematic reviews were identified. Dietary interventions, physical activity or a combined approach all reduced adverse pregnancy outcomes such as gestational diabetes, pregnancy-induced hypertension and related morbidities. Within the randomized controlled trials included in the 36 systematic reviews, the type, intensity and frequency of interventions varied widely. The primary outcomes, reporting and methodological quality of the 36 systematic reviews and meta-analyses also varied.

The meta-analysis with the highest ROBIS and AMSTAR-2 scores was selected to design an icon array based on a fact box simulating 100 patients.

Conclusions
We propose a methodology for selecting the best evidence and transforming it into a format that illustrates the benefits and harms in a way that can be understood by lay patients, even if they cannot read. This model can be applied to counselling for expectant mothers in low and high-income

countries, regardless of socioeconomic status, provided that women have access to appropriately trained healthcare providers.

ZUSAMMENFASSUNG

Hintergrund
Die Bedeutung von Evidenz sollte medizinische Fachkräften und ihren Patientinnen klar sein. Bei Gestationsdiabetes mellitus, der oft mit einem ungewöhnlich hohen Body-Mass-Index assoziiert ist, hängen sowohl die direkten Schwangerschaftsausgänge als auch die Langzeitergebnisse der Frauen und Kinder teilweise von der Beratung und den Lebensstiländerungen während und nach der Schwangerschaft ab.

Methoden
Bis September 2023 wurden Recherchen in MEDLINE, CENTRAL und WEB OF SCIENCE zur Identifizierung von systematischen Übersichtsarbeiten und Metaanalysen zur Prävention von Gestationsdiabetes durchgeführt. Alle systematischen Übersichtsarbeiten wurden anhand der ROBIS- und AMSTAR-Kriterien analysiert.

Ergebnisse
Es wurden insgesamt 36 systematische Übersichtsarbeiten identifiziert. Ernährungsinterventionen, körperliche Aktivitäten oder eine Kombination beider Herangehensweisen konnten ungünstige Schwangerschaftsausgänge wie z. B. Gestationsdiabetes, schwangerschaftsinduzierte Hypertonie und die damit zusammenhängende Morbidität senken. In den randomisierten kontrollierten Studien, die in den 36 systematischen Übersichtsarbeiten eingeschlossen wurden, gab es starke Unterschiede in der Art, der Intensität und der Häufigkeit der Intervention. Die primären Endpunkte, die Berichterstattung und die methodologische Qualität der 36 systematischen Übersichtsarbeiten und Metaanalysen variierten ebenfalls stark.

Es wurde die Metaanalyse mit den höchsten ROBIS- und AMSTAR-2-Punktzahlen ausgewählt, um eine Reihe von Symbolen basierend auf einer 100 Patientinnen simulierenden Faktenbox zu entwerfen.

Schlussfolgerungen
Es wird hier eine Methode vorgeschlagen, mit der die beste Evidenz ausgewählt und in ein Format überführt werden kann, das die Vorteile und Schäden so veranschaulicht, dass sie von Patientinnen ohne medizinische Vorbildung verstanden werden können, selbst wenn diese Frauen nicht lesen können. Dieses Modell kann bei der Beratung werdender Mütter in Ländern mit niedrigem und hohem Einkommen eingesetzt werden, unabhängig vom sozioökonomischen Status der Frauen, sofern sie Zugang zu entsprechend ausgebildeten Gesundheitsdienstleistern haben.

Introduction

Gestational diabetes mellitus (GDM) is defined as glucose intolerance first diagnosed in pregnancy [1]. In 2020, the pooled global prevalence of GDM was 14% with a range of 13.97% to 14.04%, whereby high-income countries had the highest standardized prevalence of GDM [2]. GDM is associated with elevated immediate risks for pre-eclampsia, perinatal mortality, preterm delivery, fetal macrosomia, shoulder dystocia or cesarean delivery [3]. Metzger et al. reported on abnormal maternal postpartum glucose tolerance requiring continuous follow-up of all women with GDM [4]. During the life course of these women, increased hyperinsulinemia, dyslipidemia, type-2 diabetes mellitus (DM), hypertension, and cardiovascular disease (CVD) were described [5]. Glucose resistance appears earlier in obese women due to pre-existing impaired insulin resistance. Overweight, obesity and excessive gestational weight gain (GWG) [6] are all associated with increased risks of GDM. First-trimester algorithms allow an individualized prediction with a sensitivity of up to 80% [7, 8, 9, 10] pointing towards pre-existing risk profiles that lower the threshold for the disease [11, 12, 13]. The risk of developing overt diabetes mellitus after a pregnancy with GDM increases with age resulting in a cumulative 15-year risk of 25% [14].

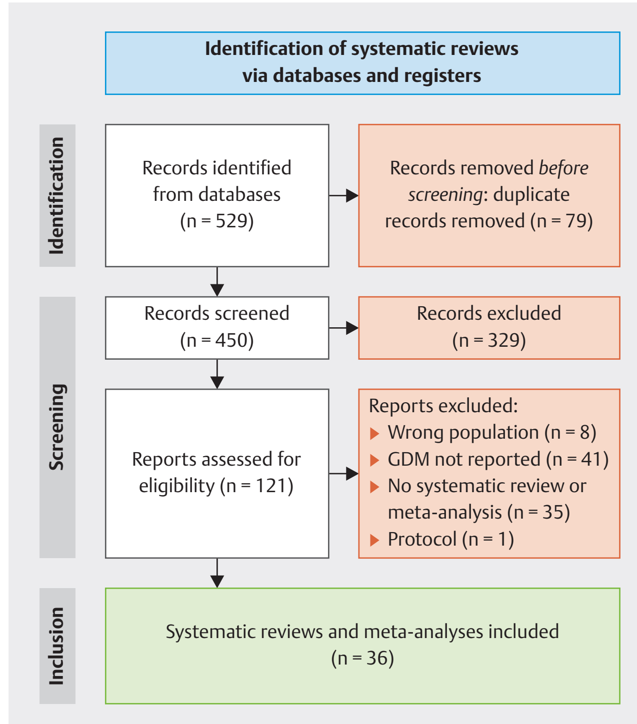
Barker et al. postulated that the global incidence of GDM depends on a mismatch between the pre-and postnatal environment [15] explaining the increasing prevalence in regions with previously low rates of GDM. There is a U-shaped relation between low (Odds ratio [OR] 2.15, 95% Confidence Interval [CI] 1.29–3.50) and high birth weight (OR: 1.97, 95% CI: 1.12–3.45) and subsequent GDM in females [16]. Prenatal famine exposure and fetal growth restriction (FGR) were associated with impaired glucose tolerance, proinsulin and insulin secretion in adulthood [17, 18, 19]. In addition, GDM associated with fetal macrosomia increases the risk of childhood obesity [20]. Gestational diabetes and gestational hypertension both significantly increase the odds of childhood overweight with a high maternal BMI being the main driver for this association [21]. Ultrasound measurements have shown that fetal overgrowth already starts at 20 weeks of gestation and remains until adulthood [22]. Hypertriglyceridemia was diagnosed in 14/68 children (21%) before puberty [23]. At the age of 11 years, the risk for metabolic syndrome is 3.6-fold higher [24]. As adults, the risks of insulin resistance and metabolic syndrome [23, 25], CVD, insulin-dependent DM and early mortality [18] are increased.

The rising global rates of overweight, obesity, GDM and type 2 DM require urgent consideration by policymakers and awareness of physicians and future parents. Therefore, healthcare providers should translate the evidence into formats recognizable for lay people. In other fields of medicine, it has been shown that fact boxes and icon arrays can enable patients to make informed decisions [26, 27] recognizing benefits and harms [28, 29, 30] and to understand the evidence independently of the opinion of their healthcare providers [31]. In this umbrella review, we evaluated current systematic reviews (SRs) and meta-analyses to reduce GDM and present a framework for counselling.

Material and Methods

A literature search was conducted up to September 2023 using MEDLINE, Web of Science and the Cochrane Library on the prevention of GDM using the following search terms: pregnancy, overweight, obesity, weight gain, diabetes, GDM, perinatal mortality, systematic reviews and meta-analyses. Data on primary and secondary outcomes, participant characteristics, intervention details, frequency and compliance were collected using a standardized Excel spreadsheet (▶ **Fig. 1**).

To extract the best evidence we analyzed the reporting and methodological quality of the publications. In the second step, the evidence with the highest ROBIS and AMSTAR-2 rating was selected to design a fact box with a corresponding icon array for those who are less familiar with a tabular format. Fact boxes contain a description of the reference class, a comparison of at least two groups, the effects in absolute numbers, and a summary of benefits and harms by relating the data to a group of 100 or 1000 participants [32]. Their development follows the evidence-based medicine models of Sackett et al. [33].



▶ **Fig. 1** Flow chart illustrating the process of identification and selection of relevant systematic reviews and meta-analyses. n = numbers

Results

Defining the occurrence of GDM as a primary outcome we identified 36 meta-analyses and systematic reviews whereby the following interventions were investigated:

- 8/36 with *only dietary counselling* [34, 35, 36, 37, 38, 39, 40, 41],
- 16/36 with *supervised exercise programs* [42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57],
- 6/36 with combined dietary and physical exercise interventions [58, 59, 60, 61, 62, 63],
- 6/36 whereby only *dietary, respectively exercise interventions were compared with a combination of both* [64, 65, 66, 67, 68, 69].

All of the participants included in the trial had been tested against groups receiving standard care. Only 9/36 studies used macrosomia or large for gestational age (LGA) as a primary or secondary outcome, 6/36 investigated perinatal mortality, and 2/36 NICU admission. In 27/36 publications all maternal BMI categories were considered, whereby two provided subgroup analyses for different BMI categories: 8 SRs exclusively concentrated on pregnant women with overweight and obesity [34, 59], only 2/36 on normal weight women. As several RCTs were cited within several SRs, summing patients would have induced bias. Therefore, instead of aggregating patient numbers, we categorized lifestyle interventions as follows:

1. Among 8/36 SRs investigating *only dietary advice* one SR including women with a BMI > 25 kg/m^2 reported that the intervention significantly reduced GDM. This was in accordance with a sub-analysis of women with the same BMI class within another publication [36].
   Two meta-analyses specified the type of diet showing that a plant-based approach, respectively a Mediterranean diet significantly reduced GDM [40, 41]. One SR investigating a low-glycemic index diet found a decreased rate of LGA children [39]. Other significant outcome variables were a reduction of maternal weight gain (5/8 SRs), pregnancy-induced hypertension (PIH) (2/8 SRs), fasting and postprandial glucose and post-partum weight retention (both in 1/8 SRs).
2. Among 20/36 SRs investigating *physical activity and exercise* programs during pregnancy 13/20 found a significant reduction of GDM. A further SR reports that two RCTs showed a successful intervention in preventing GDM in contrast to eight RCTs with no statistical significance [54]. Exercise interventions were also able to reduce the incidence of preeclampsia, respectively PIH in 3/20 SRs [46, 52, 53]; 7/20 SRs showed a significant reduction of GWG in exercising mothers and 2/20 a significant reduction of LGA infants.
3. Among 6/36 SRs investigating the implementation of *both physical exercise* *and* *diet,* 2/6 found a significant reduction of GDM when the interventions started early and 4/6 described a significant reduction of maternal GWG during pregnancy.

4. Out of the 6/36 SRs comparing diet, exercise alone and a combination of both, two SRs showed a significant reduction of GDM in all three intervention arms [65, 68]. One SR indicated a benefit of only exercise, whereas another suggested a benefit of a singular diet or singular exercise in contrast to a combined approach which was not successful [64, 66]; 2/6 SRs did not prove a significant effect on GDM by any intervention although all three intervention types were successful in limiting GWG or PIH [67, 69].

All 36 SRs were analyzed according to ROBIS and AMSTAR criteria to determine the quality of the reviews. The overall risk of bias according to the ROBIS tool ranged from low in 12 reviews to high in 13 reviews with additionally 11 reviews showing an unclear risk. The overall confidence, rated using the ASTAR 2 criteria, was low, respectively critically low in six, 22 SRs, whereas six SRs had a moderate level of confidence. Only two SRs fulfilled all criteria of being a high-quality review [38, 60]. Therefore, we chose one of the latter for our counselling model.

▶ **Fig. 2** illustrates that dietary counselling in pregnant women had no significant impact on the prevention of GDM, although there was a trend to reduce GDM. Nevertheless, the model explains that 10/100 pregnant women without, but only 3/100 women with nutritional counselling developed PIH. This can easily be translated that in about 7/100 women PIH could be prevented (▶ **Fig. 2**).

Calculations were based on the absolute number of the control groups.

Dietary interventions

Apart from the general information of the icon array, the information for patients can be specified: The detailed components of women's diets influence GDM risks [70]. Consumption of sugar-sweetened drinks, potatoes [71], animal fat and cholesterol [72], high glycemic load and low-cereal fiber diets [73] are associated with an increased risk for GDM. Alternatively, a high-fiber diet [73], a plant-based diet [40], a Mediterranean diet [41], intake of vegetables, a substitution of red meat for poultry, fish, or legumes [74] and of potatoes by vegetables [71] and adherence to "healthful" dietary patterns [75] are also associated with a lower risk of GDM.

Physical exercise

There are large differences in the proportion of women performing regular exercise before and during pregnancy. In Norway, the rate before pregnancy was 46.4% but declined to 28% and 20% at 17 and 30 gestational weeks respectively [76]. Studies in Denmark [77], the USA [78] and Brazil [79] showed a more pronounced reduction in physical activity even in uncomplicated pregnancies whereby activity positively correlated with income. Most women do not meet recommendations for physical activity [79]. The meta-analyses varied in reporting and analyzing details of the interventions. Seven meta-analyses performed detailed subgroup analyses indicating that an early initiation, high intensity and frequent performances were essential for a successful intervention [46, 47, 48, 53, 54, 66, 67]. Women should be motivated to accumulate at least 600 MET (metabolic equivalent of task) minutes of supervised moderate-intensity training which equals e.g. 140 min of brisk walking, water aerobics, stationary cycling or resistance training per week [46, 47]. Other authors emphasize the benefit of low-intensity mind-body exercises such as yoga or pilates [49]. Only 6/20 SRs considered the participant's compliance [46, 47, 50, 51, 64, 67]. Six meta-analyses reported details of the interventions without considering them for separate subgroup analyses [41, 50, 51, 55, 56, 69].

Combined counselling

Similarly, the overall and differential effects of combined diet and physical activity during pregnancy varied by the pattern, timing and prevalence of exercise or diet.

Pharmacological interventions

Although we did not systematically include pharmacological SRs, some SRs about lifestyle compared the interventions with patients where medication was administered. In general, metformin in obese women was involved [80], myo-inositol [64, 81] and probiotics [64, 82]. Pregnant women should not use metformin to prevent GDM or poor pregnancy outcomes in obese non-diabetic women. In contrast, in women who are already diagnosed with GDM, metformin reduces PIH as compared with other treatments or placebo [83]. Four RCTs on antenatal supplementation with myo-inositol during pregnancy showed a potential benefit to reduce GDM, whereas a network meta-analysis summarized that inositol supplementation did not significantly alter GDM risk. There were no differences in PIH, macrosomia or perinatal mortality when compared with controls. Up to now, only one RCT within our investigated SRs showed a decrease in GDM when women used probiotics [82].

Discussion and Conclusion

Several RCTs have shown that fact boxes and icon arrays are effective tools for informing laypeople. They can improve the understanding of statistical data and of benefits and harms. Although we already suggested the use of fact boxes, albeit not in combination with icon arrays [84, 85], unfortunately, these tools have not yet been integrated into maternal-fetal medicine. Fact boxes and icon arrays could supplement the state-of-the-art within guidelines for parents who must make decisions for or against screening tools, invasive procedures, medical treatments or the place of birth and support women in their decisions not biased by false incentives [86].

The strength of this umbrella review is to evoke awareness towards the increasing number and various quality of retrospective SRs and meta-analyses. Shennan et al. indirectly criticized a lack of consistent primary evidence and the heterogeneity in so-called network meta-analyses in different populations and healthcare systems [87]. Similarly, Prior characterized meta-analyses with a selection bias due to absent or delayed registration of the protocol or non-consistent outcome as "p-hacking" [88]. Another potential error is to apply Cochrane tools for RCTs which contain an item of *blinding participants and health care providers*. This item is of limited

Nutritional counseling

for gestational diabetes prevention

HARDING CENTER FOR RISK LITERACY

Numbers are averages for pregnant women who either received nutritional counseling or did not before a blood sugar test (glucose tolerance test) was carried out.

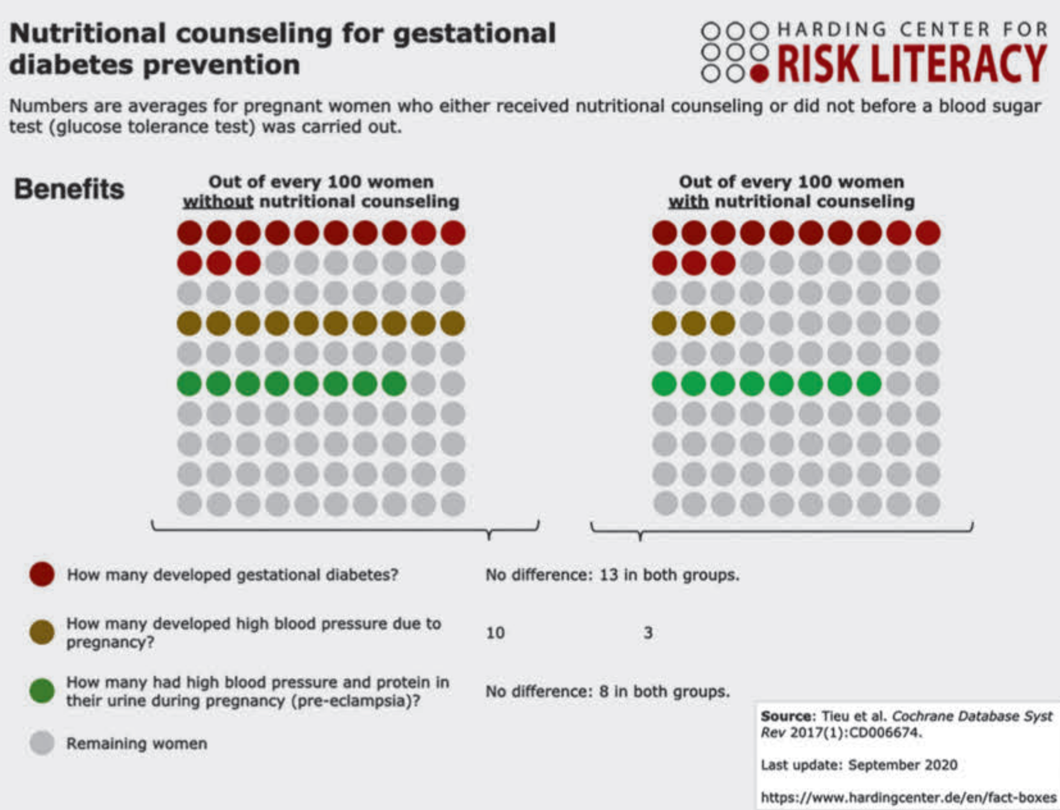
	Out of every 100 women without nutritional counseling	Out of every 100 women with nutritional counseling
Benefits		
How many developed gestational diabetes?	No difference: 13 in both groups	
How many developed high blood pressure due to pregnancy?	10	3
How many had high blood pressure and protein in the urine during pregnancy (pre-eclampsia)?	No difference: 8 in both groups	
Harms		
How many had a cesarean section?	No difference: 30 in both groups	
How many had severe injuries in the genital area (severe perineal tears)?	No difference: 1 in both groups	

Short summary: Nutritional counseling was not able to prevent gestational diabetes and pre-eclampsia. However, about 7 out of 100 women with nutritional counseling suffered from high blood pressure caused by their pregnancy less often. Differences regarding cesarean sections and perineal tears could not be observed.

Source: Tieu et al. *Cochrane Database Syst Rev* 2017(1):CD006674.

Last Update: September 2020

https://www.hardingcenter.de/en/fact-boxes



▸ **Fig. 2** Fact box combined with an icon array designed to communicate the main benefits and harms of nutritional counselling for pregnant women to prevent gestational diabetes based on the Cochrane Review by Tieu et al. [38] (Source: Creation by C. Ellermann on behalf of Harding Center for Risk Literacy based on data by Tieu et al. 2017 [38]).

value for lifestyle interventions since neither counselling of health care specialists nor women following lifestyle interventions can be blinded [89].

Limitations of this umbrella review are that among all retrospective SRs, only 2/36 were designed as an individual participant data meta-analysis [36, 63]. Not all studies applied a sensitivity analysis. In addition, it has not yet been shown that fact boxes improve the understanding of parents-to-be and the dialogue between pregnant patients and their healthcare providers as demonstrated for other fields [90, 91]. Therefore, we are currently examining the acceptance in different social and patient groups.

We consciously concentrated on lifestyle interventions because, during pregnancy, women play an active part in the health outcomes of themselves and their offspring. Pregnant women are more sensitive to advice and particularly often in contact with the medical system.

In the future, *prospective* meta-analyses and Delphi procedures as already performed for GDM [92] may avoid weaknesses of retrospective SRs and improve the sources for counselling.

Ideally, interventions should be continued after birth and similarly, long-term outcomes of mothers and their children should be evaluated. As preconceptional BMI is associated with an increase in pregnancy complications, it is recommended to control and possibly reduce body weight before pregnancy [93]. An intergenerational approach to address childhood adiposity should start preconceptionally and continue until early childhood or even puberty [94]. Improved health literacy obtained during pregnancy may help mothers maintain a healthier lifestyle and improve the health of their offspring. Increased awareness and compliance towards evidence-based counselling may hopefully improve compliance and outcomes of mothers and their offspring.

In the meantime, editorial boards should critically analyze the "tsunamis" of SRs and meta-analyses, so that only the best evidence is translated into patient counselling. It is often difficult to retrospectively determine how the interventions were integrated into the daily routine. To motivate patients intellectual models may be helpful, but possibly it is even more important that health care providers show empathy with their patients which cannot be analyzed from studies.

Specified practices to increase health literacy of pregnant women in low and high-income countries and different socioeconomic populations should become part of medical education and would possibly reduce costs and increase satisfaction and the health of societies as in the "Triple Aim" model [95]. Our proposals may be a small step to interrupt vicious circles of the obesity epidemic.

Contributors' Statement

SB performed the literature search, analyzed the quality of the systematic reviews applying ROBIS and AMSTAR criteria and wrote the manuscript. BA designed the manuscript and essentially contributed to the writing. All authors have studied and revised the manuscript.

Acknowledgement

We thank Christin Ellermann and Mirjam Jenny for designing the fact box and icon array. Furthermore, we thank Prof. Gerd Gigerenzer and Dr. Jens Stupin for their inspiration and support.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Wiener K. Identifying gestational diabetes mellitus and the effect of different diagnostic criteria. J Obstet Gynaecol 2001; 21: 158–159. doi:10.1080/01443610020026083

[2] Wang H, Li N, Chivese T et al. IDF Diabetes Atlas: Estimation of Global and Regional Gestational Diabetes Mellitus Prevalence for 2021 by International Association of Diabetes in Pregnancy Study Group's Criteria. Diabetes Res Clin Pract 2022; 183: 109050. doi:10.1016/j.diabres.2021.109050

[3] Ye W, Luo C, Huang J et al. Gestational diabetes mellitus and adverse pregnancy outcomes: systematic review and meta-analysis. BMJ 2022; 377: e067946. doi:10.1136/bmj-2021-067946

[4] Metzger BE, Bybee DE, Freinkel N et al. Gestational diabetes mellitus. Correlations between the phenotypic and genotypic characteristics of the mother and abnormal glucose tolerance during the first year postpartum. Diabetes 1985; 34 (Suppl 2): 111–115. doi:10.2337/diab.34.2.s111

[5] Arabin B, Baschat AA. Pregnancy: An Underutilized Window of Opportunity to Improve Long-term Maternal and Infant Health-An Appeal for Continuous Family Care and Interdisciplinary Communication. Front Pediatr 2017; 5: 69. doi:10.3389/fped.2017.00069

[6] Rasmussen KM, Abrams B, Bodnar LM et al. Recommendations for weight gain during pregnancy in the context of the obesity epidemic. Obstet Gynecol 2010; 116: 1191–1195. doi:10.1097/AOG.0b013e3181f60da7

[7] Cuckle HS. Screening for pre-eclampsia–lessons from aneuploidy screening. Placenta 2011; 32: S42–S48. doi:10.1016/j.placenta.2010.07.015

[8] Gabbay-Benziv R, Doyle LE, Blitzer M et al. First trimester prediction of maternal glycemic status. J Perinat Med 2015; 43: 283–289. doi:10.1515/jpm-2014-0149

[9] Gabbay-Benziv R, Oliveira N, Baschat AA. Optimal first trimester preeclampsia prediction: a comparison of multimarker algorithm, risk profiles and their sequential application. Prenat Diagn 2016; 36: 34–39. doi:10.1002/pd.4707

[10] Nanda S, Savvidou M, Syngelaki A et al. Prediction of gestational diabetes mellitus by maternal factors and biomarkers at 11 to 13 weeks. Prenat Diagn 2011; 31: 135–141. doi:10.1002/pd.2636

[11] Fleming N, Ng N, Osborne C et al. Adolescent pregnancy outcomes in the province of Ontario: a cohort study. J Obstet Gynaecol Can 2013; 35: 234–245. doi:10.1016/S1701-2163(15)30995-6

[12] Rich-Edwards JW, McElrath TF, Karumanchi SA et al. Breathing life into the lifecourse approach: pregnancy history and cardiovascular disease in women. Hypertension 2010; 56: 331–334. doi:10.1161/HYPERTENSIONAHA.110.156810

[13] Sattar N, Greer IA. Pregnancy complications and maternal cardiovascular risk: opportunities for intervention and screening? BMJ 2002; 325: 157–160. doi:10.1136/bmj.325.7356.157

[14] Ashwal E, Hadar E, Hod M. Diabetes in low-resourced countries. Best Pract Res Clin Obstet Gynaecol 2015; 29: 91–101. doi:10.1016/j.bpobgyn.2014.05.009

[15] Barker DJ, Osmond C, Golding J et al. Growth in utero, blood pressure in childhood and adult life, and mortality from cardiovascular disease. BMJ 1989; 298: 564–567. doi:10.1136/bmj.298.6673.564

[16] Claesson R, Aberg A, Marsál K. Abnormal fetal growth is associated with gestational diabetes mellitus later in life: population-based register study. Acta Obstet Gynecol Scand 2007; 86: 652–656. doi:10.1080/00016340701207682

[17] de Rooij SR, Painter RC, Phillips DIW et al. Impaired insulin secretion after prenatal exposure to the Dutch famine. Diabetes Care 2006; 29: 1897–1901. doi:10.2337/dc06-0460

[18] Persson B, Pschera H, Binder C et al. Decreased beta-cell function in women with previous small for gestational age infants. Horm Metab Res 1993; 25: 170–174. doi:10.1055/s-2007-1002070

[19] Roseboom T, de Rooij S, Painter R. The Dutch famine and its long-term consequences for adult health. Early Hum Dev 2006; 82: 485–491. doi:10.1016/j.earlhumdev.2006.07.001

[20] Simmons R. Perinatal programming of obesity. Exp Gerontol 2005; 40: 863–866. doi:10.1016/j.exger.2005.09.007

[21] Patro Golab B, Santos S, Voerman E et al. Influence of maternal obesity on the association between common pregnancy complications and risk of childhood obesity: an individual participant data meta-analysis. Lancet Child Adolesc Health 2018; 2: 812–821. doi:10.1016/S2352-4642(18)30273-6

[22] Li M, Hinkle SN, Grantz KL et al. Glycaemic status during pregnancy and longitudinal measures of fetal growth in a multi-racial US population: a prospective cohort study. Lancet Diabetes Endocrinol 2020; 8: 292–300. doi:10.1016/S2213-8587(20)30024-3

[23] Keely EJ, Malcolm JC, Hadjiyannakis S et al. Prevalence of metabolic markers of insulin resistance in offspring of gestational diabetes pregnancies. Pediatr Diabetes 2008; 9: 53–59. doi:10.1111/j.1399-5448.2007.00258.x

[24] Boney CM, Verma A, Tucker R et al. Metabolic syndrome in childhood: association with birth weight, maternal obesity, and gestational diabetes mellitus. Pediatrics 2005; 115: e290–e296. doi:10.1542/peds.2004-1808

[25] Dabelea D, Knowler WC, Pettitt DJ. Effect of diabetes in pregnancy on offspring: follow-up research in the Pima Indians. J Matern Fetal Med 2000; 9: 83–88. doi:10.1002/(SICI)1520-6661(200001/02)9:183::AID-MFM173.0.CO;2-O

[26] Marteau TM, Dormandy E, Michie S. A measure of informed choice. Health Expect 2001; 4: 99–108. doi:10.1046/j.1369-6513.2001.00140.x

[27] Schwartz LM, Woloshin S, Welch HG. The drug facts box: providing consumers with simple tabular data on drug benefit and harm. Med Decis Making 2007; 27: 655–662. doi:10.1177/0272989X07306786

[28] Woloshin S, Schwartz LM. Communicating data about the benefits and harms of treatment: a randomized trial. Ann Intern Med 2011; 155: 87–96. doi:10.7326/0003-4819-155-2-201107190-00004

[29] [Petrova D, Garcia-Retamero R, Cokely ET. Understanding the Harms and Benefits of Cancer Screening: A Model of Factors That Shape Informed Decision Making. Med Decis Making 2015; 35: 847–858. doi:10.1177/0272989X15587676

[30] Sullivan HW, O'Donoghue AC, Aikin KJ. Communicating Benefit and Risk Information in Direct-to-Consumer Print Advertisements: A Randomized Study. Ther Innov Regul Sci 2015; 49: 493–502. doi:10.1177/2168479015572370

[31] Gigerenzer G. Full disclosure about cancer screening. BMJ 2016; 352: h6967. doi:10.1136/bmj.h6967

[32] McDowell M, Rebitschek FG, Gigerenzer G et al. A simple tool for communicating the benefits and harms of health interventions: A guide for creating a fact box. MDM Policy Pract 2016; 1: 2381468316665365. doi:10.1177/2381468316665365

[33] Sackett DL, Rosenberg WM, Gray JA et al. Evidence based medicine: what it is and what it isn't. BMJ 1996; 312: 71–72. doi:10.1136/bmj.312.7023.71

[34] Lamminpää R, Vehviläinen-Julkunen K, Schwab U. A systematic review of dietary interventions for gestational weight gain and gestational diabetes in overweight and obese pregnant women. Eur J Nutr 2018; 57: 1721–1736. doi:10.1007/s00394-017-1567-z

[35] O'Brien CM, Grivell RM, Dodd JM. Systematic review of antenatal dietary and lifestyle interventions in women with a normal body mass index. Acta Obstet Gynecol Scand 2016; 95: 259–269. doi:10.1111/aogs.12829

[36] Rogozinska E, Chamillard M, Hitman GA et al. Nutritional manipulation for the primary prevention of gestational diabetes mellitus: a meta-analysis of randomised studies. PloS One 2015; 10: e0115526. doi:10.1371/journal.pone.0115526

[37] Tanentsapf I, Heitmann BL, Adegboye AR. Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. BMC Pregnancy Childbirth 2011; 11: 81. doi:10.1186/1471-2393-11-81

[38] Tieu J, Shepherd E, Middleton P et al. Dietary advice interventions in pregnancy for preventing gestational diabetes mellitus. Cochrane Database Syst Rev 2017(1): CD006674. doi:10.1002/14651858.CD006674.pub3

[39] Zhang R, Han S, Chen GC et al. Effects of low-glycemic-index diets in pregnancy on maternal and newborn outcomes in pregnant women: a meta-analysis of randomized controlled trials. Eur J Nutr 2018; 57: 167–177. doi:10.1007/s00394-016-1306-x

[40] Zhu Y, Zheng Q, Huang L et al. The effects of plant-based dietary patterns on the risk of developing gestational diabetes mellitus: A systematic review and meta-analysis. PLoS One 2023; 18: e0291732. doi:10.1371/journal.pone.0291732

[41] Zhang Y, Xia M, Weng S et al. Effect of Mediterranean diet for pregnant women: a meta-analysis of randomized controlled trials. J Matern Fetal Neonatal Med 2022; 35: 4824–4829. doi:10.1080/14767058.2020.1868429

[42] da Silva SG, Ricardo LI, Evenson KR et al. Leisure-Time Physical Activity in Pregnancy and Maternal-Child Health: A Systematic Review and Meta-Analysis of Randomized Controlled Trials and Cohort Studies. Sports Med 2017; 47: 295–317. doi:10.1007/s40279-016-0565-2

[43] Han S, Middleton P, Crowther CA. Exercise for pregnant women for preventing gestational diabetes mellitus. Cochrane Database Syst Rev 2012 (7): CD009021. doi:10.1002/14651858.CD009021.pub2

[44] Sanabria-Martínez G, García-Hermoso A, Poyatos-León R et al. Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: a meta-analysis. BJOG 2015; 122: 1167–1174. doi:10.1111/1471-0528.13429

[45] Zheng J, Wang H, Ren M. Influence of exercise intervention on gestational diabetes mellitus: a systematic review and meta-analysis. J Endocrinol Invest 2017; 40: 1027–1033. doi:10.1007/s40618-017-0673-3

[46] Davenport MH, Ruchat S-M, Poitras VJ et al. Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis. Br J Sports Med 2018; 52: 1367–1375. doi:10.1136/bjsports-2018-099355

[47] Bennett G, King N, Redfern K et al. Supervised physical activity and the incidence of gestational diabetes mellitus: a systematic review and meta-analysis. J Matern Fetal Neonatal Med 2023; 36: 2155043. doi:10.1080/14767058.2022.2155043

[48] Nasiri-Amiri F, Sepidarkish M, Shirvani MA et al. The effect of exercise on the prevention of gestational diabetes in obese and overweight pregnant women: a systematic review and meta-analysis. Diabetol Metab Syndr 2019; 11: 72. doi:10.1186/s13098-019-0470-6

[49] Paulsen CP, Bandak E, Edemann-Callesen H et al. The Effects of Exercise during Pregnancy on Gestational Diabetes Mellitus, Preeclampsia, and Spontaneous Abortion among Healthy Women-A Systematic Review and Meta-Analysis. Int J Environ Res Public Health 2023; 20: 6069. doi:10.3390/ijerph20126069

[50] Muhammad HFL, Pramono A, Rahman MN. The safety and efficacy of supervised exercise on pregnant women with overweight/obesity: A systematic review and meta-analysis of randomized controlled trials. Clin Obes 2021; 11: e12428. doi:10.1111/cob.12428

[51] Pascual-Morena C, Cavero-Redondo I, Álvarez-Bueno C et al. Exercise versus Metformin to Improve Pregnancy Outcomes among Overweight Pregnant Women: A Systematic Review and Network Meta-Analysis. J Clin Med 2021; 10: 3490. doi:10.3390/jcm10163490

[52] Zhang J, Wang HP, Wang XX. Effects of aerobic exercise performed during pregnancy on hypertension and gestational diabetes: a systematic review and meta-analysis. J Sports Med Phys Fitness 2023; 63: 852–863. doi:10.23736/S0022-4707.23.14578-6

[53] Díaz-Burrueco JR, Cano-Ibáñez N, Martín-Peláez S et al. Effects on the maternal-fetal health outcomes of various physical activity types in healthy pregnant women. A systematic review and meta-analysis. Eur J Obstet Gynecol Reprod Biol 2021; 262: 203–215. doi:10.1016/j.ejogrb.2021.05.030

[54] Makaruk B, Galczak-Kondraciuk A, Forczek W et al. The Effectiveness of Regular Exercise Programs in the Prevention of Gestational Diabetes Mellitus-A Systematic Review. Obstet Gynecol Surv 2019; 74: 303–312. doi:10.1097/OGX.0000000000000673

[55] Du MC, Ouyang YQ, Nie XF et al. Effects of physical exercise during pregnancy on maternal and infant outcomes in overweight and obese pregnant women: A meta-analysis. Birth 2019; 46: 211–221. doi:10.1111/birt.12396

[56] Ming WK, Ding W, Zhang CJP et al. The effect of exercise during pregnancy on gestational diabetes mellitus in normal-weight women: a systematic review and meta-analysis. BMC Pregnancy Childbirth 2018; 18: 440. doi:10.1186/s12884-018-2068-7

[57] Kuang J, Sun S, Ke F. The effects of exercise intervention on complications and pregnancy outcomes in pregnant women with overweight or obesity: A systematic review and meta-analysis. Medicine (Baltimore) 2023; 102: e34804. doi:10.1097/MD.0000000000034804

[58] Bennett CJ, Walker RE, Blumfield ML et al. Interventions designed to reduce excessive gestational weight gain can reduce the incidence of gestational diabetes mellitus: A systematic review and meta-analysis of randomised controlled trials. Diabetes Res Clin Pract 2018; 141: 69–79. doi:10.1016/j.diabres.2018.04.010

[59] Oteng-Ntim E, Varma R, Croker H et al. Lifestyle interventions for overweight and obese pregnant women to improve pregnancy outcome: systematic review and meta-analysis. BMC Med 2012; 10: 47. doi:10.1186/1741-7015-10-47

[60] Shepherd E, Gomersall JC, Tieu J et al. Combined diet and exercise interventions for preventing gestational diabetes mellitus. Cochrane Database Syst Rev 2017(11): CD010443. doi:10.1002/14651858.CD010443.pub3

[61] Song C, Li J, Leng J et al. Lifestyle intervention can reduce the risk of gestational diabetes: a meta-analysis of randomized controlled trials. Obes Rev 2016; 17: 960–969. doi:10.1111/obr.12442

[62] Thangaratinam S, Rogozinska E, Jolly K et al. Effects of interventions in pregnancy on maternal weight and obstetric outcomes: meta-analysis of randomised evidence. BMJ 2012; 344: e2088. doi:10.1136/bmj.e2088

[63] International Weight Management in Pregnancy (i-WIP) Collaborative Group. Effect of diet and physical activity based interventions in pregnancy on gestational weight gain and pregnancy outcomes: meta-analysis of individual participant data from randomised trials. BMJ 2017; 358: j3119. doi:10.1136/bmj.j3119

[64] Tang Q, Zhong Y, Xu C et al. Effectiveness of five interventions used for prevention of gestational diabetes: A network meta-analysis. Medicine (Baltimore) 2022; 101: e29126. doi:10.1097/MD.0000000000029126

[65] Teede HJ, Bailey C, Moran LJ et al. Association of Antenatal Diet and Physical Activity-Based Interventions With Gestational Weight Gain and Pregnancy Outcomes: A Systematic Review and Meta-analysis. JAMA Intern Med 2022; 182: 106–114. doi:10.1001/jamainternmed.2021.6373

[66] Guo XY, Shu J, Fu XH et al. Improving the effectiveness of lifestyle interventions for gestational diabetes prevention: a meta-analysis and meta-regression. BJOG 2019; 126: 311–320. doi:10.1111/1471-0528.15467

[67] Behnam S, Timmesfeld N, Arabin B. Lifestyle Interventions to Improve Pregnancy Outcomes: a Systematic Review and Specified Meta-Analyses. Geburtshilfe Frauenheilkd 2022; 82: 1249–1264. doi:10.1055/a-1926-6636

[68] Lim S, Takele WW, Vesco KK et al. Participant characteristics in the prevention of gestational diabetes as evidence for precision medicine: a systematic review and meta-analysis. Commun Med (Lond) 2023; 3: 137. doi:10.1038/s43856-023-00366-x

[69] Wu S, Jin J, Hu KL et al. Prevention of Gestational Diabetes Mellitus and Gestational Weight Gain Restriction in Overweight/Obese Pregnant Women: A Systematic Review and Network Meta-Analysis. Nutrients 2022; 14: 2383. doi:10.3390/nu14122383

[70] Zhang C, Ning Y. Effect of dietary and lifestyle factors on the risk of gestational diabetes: review of epidemiologic evidence. Am J Clin Nutr 2011; 94 (Suppl 6): 1975S–1979S. doi:10.3945/ajcn.110.001032

[71] Bao W, Tobias DK, Hu FB et al. Pre-pregnancy potato consumption and risk of gestational diabetes mellitus: prospective cohort study. BMJ 2016; 352: h6898. doi:10.1136/bmj.h6898

[72] Bowers K, Tobias DK, Yeung E et al. A prospective study of prepregnancy dietary fat intake and risk of gestational diabetes. Am J Clin Nutr 2012; 95: 446–453. doi:10.3945/ajcn.111.026294

[73] Zhang C, Liu S, Solomon CG et al. Dietary fiber intake, dietary glycemic load, and the risk for gestational diabetes mellitus. Diabetes Care 2006; 29: 2223–2230. doi:10.2337/dc06-0266

[74] Bao W, Bowers K, Tobias DK et al. Prepregnancy dietary protein intake, major dietary protein sources, and the risk of gestational diabetes mellitus: a prospective cohort study. Diabetes Care 2013; 36: 2001–2008. doi:10.2337/dc12-2018

[75] Tobias DK, Zhang C, Chavarro J et al. Prepregnancy adherence to dietary patterns and lower risk of gestational diabetes mellitus. Am J Clin Nutr 2012; 96: 289–295. doi:10.3945/ajcn.111.028266

[76] Owe KM, Nystad W, Bø K. Association between regular exercise and excessive newborn birth weight. Obstet Gynecol 2009; 114: 770–776. doi:10.1097/AOG.0b013e3181b6c105

[77] Hegaard HK, Petersson K, Hedegaard M et al. Sports and leisure-time physical activity in pregnancy and birth weight: a population-based study. Scand J Med Sci Sports 2010; 20: e96–102. doi:10.1111/j.1600-0838.2009.00918.x

[78] Evenson KR, Wen F. Prevalence and correlates of objectively measured physical activity and sedentary behavior among US pregnant women. Prev Med 2011; 53: 39–43. doi:10.1016/j.ypmed.2011.04.014

[79] Domingues MR, Barros AJD. Leisure-time physical activity during pregnancy in the 2004 Pelotas Birth Cohort Study. Rev Saude Publica 2007; 41: 173–180. doi:10.1590/s0034-89102007000200002

[80] Elmaraezy A, Abushouk AI, Emara A et al. Effect of metformin on maternal and neonatal outcomes in pregnant obese non-diabetic women: A meta-analysis. Int J Reprod Biomed 2017; 15: 461–470

[81] Crawford TJ, Crowther CA, Alsweiler J et al. Antenatal dietary supplementation with myo-inositol in women during pregnancy for preventing gestational diabetes. Cochrane Database Syst Rev 2015(12): CD011507. doi:10.1002/14651858.CD011507.pub2

[82] Barrett HL, Dekker Nitert M, Conwell LS et al. Probiotics for preventing gestational diabetes. Cochrane Database Syst Rev 2014(2): CD009951. doi:10.1002/14651858.CD009951.pub2

[83] Kalafat E, Sukur YE, Abdi A et al. Metformin for prevention of hypertensive disorders of pregnancy in women with gestational diabetes or obesity: systematic review and meta-analysis of randomized trials. Ultrasound Obstet Gynecol 2018; 52: 706–714. doi:10.1002/uog.19084

[84] Arabin B. Irresponsible and responsible resource management in obstetrics. Best Pract Res Clin Obstet Gynaecol 2017; 43: 87–106. doi:10.1016/j.bpobgyn.2016.12.009

[85] Arabin B, Baschat AA. Pregnancy: An Underutilized Window of Opportunity to Improve Long-term Maternal and Infant Health-An Appeal for Continuous Family Care and Interdisciplinary Communication. Front Pediatr 2017; 5: 69. doi:10.3389/fped.2017.00069

[86] Berwick DM, Hackbarth AD. Eliminating waste in US health care. JAMA 2012; 307: 1513–1516. doi:10.1001/jama.2012.362

[87] Shennan AH, Suff N. Inconclusive evidence for optimal preterm birth prevention. BJOG 2019; 126: 568. doi:10.1111/1471-0528.15587

[88] Prior M, Hibberd R, Asemota N et al. Inadvertent P-hacking among trials and systematic reviews of the effect of progestogens in pregnancy? A systematic review and meta-analysis. BJOG 2017; 124: 1008–1015. doi:10.1111/1471-0528.14506

[89] Higgins J, Altman D, Sterne J. Chapter 8: Assessing Risk of Bias in included Studies. Higgins JPT, Churchill R, Chandler J, Cumpston MS (eds.). Cochrane Handbook for systematic Reviews of Interventions. Chichester: John Wiley & Sons Ltd; 2011

[90] Schwartz LM, Woloshin S, Welch HG. The drug facts box: providing consumers with simple tabular data on drug benefit and harm. Med Decis Making 2007; 27: 655–662. doi:10.1177/0272989X07306786

[91] McDowell M, Rebitschek FG, Gigerenzer G et al. A Simple Tool for Communicating the Benefits and Harms of Health Interventions: A Guide for Creating a Fact Box. MDM Policy Pract 2016; 1: 2381468316665365. doi:10.1177/2381468316665365

[92] Rogozinska E, D'Amico MI, Khan KS et al. Development of composite outcomes for individual patient data (IPD) meta-analysis on the effects of diet and lifestyle in pregnancy: a Delphi survey. BJOG 2016; 123: 190–198. doi:10.1111/1471-0528.13764

[93] Sun Y, Shen Z, Zhan Y et al. Effects of pre-pregnancy body mass index and gestational weight gain on maternal and infant complications. BMC Pregnancy Childbirth 2020; 20: 390. doi:10.1186/s12884-020-03071-y

[94] Kumaran K, Birken C, Baillargeon JP et al. An intergenerational life-course approach to address early childhood obesity and adiposity: the Healthy Life Trajectories Initiative (HeLTI). Lancet Glob Health 2023; 11 (Suppl 1): S15. doi:10.1016/S2214-109X(23)00098-0

[95] Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. Health Aff (Millwood) 2008; 27: 759–769. doi:10.1377/hlthaff.27.3.759

