

# Maternal dietary components in the development of gestational diabetes mellitus: a review of observational studies to timely promotion of health

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## Research Article

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# Abstract

There is ample evidence that considers diet an important factor in the prevention of gestational diabetes mellitus (GDM). The aim of this review is to synthesise the evidence between GDM and maternal dietary components. We performed a systematic bibliographic search in Medline, Latin American and Caribbean Health Sciences Literature (Lilacs) and the Latin American Nutrition Archive (ALAN) for regional and local literature, limiting the searches to observational studies published between 2016 and 2021. Search terms related to nutrients, foods, dietary patterns and the relationship to GDM risk were included. The review included 35 articles, 9 of which were located in América. The articles about maternal dietary components were as follows: 16 for nutrient intake, 4 for food intake, 2 combined nutrient and food analysis and 13 for dietary patterns. Iron, processed meat and a low carbohydrate diet were positively associated with GDM. Antioxidant nutrients, folic acid, fruits, vegetables, legumes and eggs were negatively associated with GDM. Generally, western dietary patterns increase GDM risk and prudent dietary patterns decrease the risk. The importance of a healthy diet early in life and during pregnancy needs to be addressed in clinical practice to anticipate the development of complications, enabling skilled nutrition professionals to act in a timely manner to promote healthy lifestyles.

## Introduction

Gestational Diabetes Mellitus (GDM) is one of the most common complications that occur during pregnancy, (1) it affects approximately 5-17% of pregnancies worldwide and is becoming a public health problem due to the great burden of the disease and its increasing prevalence (2). GDM can be defined as the alteration of glucose tolerance of variable severity that begins or is recognized for the first time during the current pregnancy (3,4). Generally, this resolves when the pregnancy ends, but it makes the woman prone to the development of premature labour, caesarean sections, hypertensive disorders, a new development of GDM in subsequent pregnancies, obesity and metabolic syndrome, and an increased risk of developing type 2 diabetes and cardiovascular diseases in the years following her pregnancy (3-6). On the other hand, babies born to mothers with GDM are at increased risk of developing fetal hyperinsulinemia, neonatal hypoglycemia, jaundice, being large for their gestational age, and developing obesity and type 2 diabetes later in life thus generating a cycle that favours metabolic dysfunction through the generations (6-8).

In the aetiology of GDM, various factors are identified that interact in a complex causal network. It is known that maternal age, pre-pregnancy overweight and obesity, excessive weight gain during pregnancy, sedentary lifestyle, and a diet rich in red and processed meat and poor in fruits, vegetables and whole grains, are risk factors for its development (9, 10). It is particularly noteworthy that diet before and during pregnancy is a potentially modifiable factor that can modulate the risk of GDM (11-14). Likewise, it has been evidenced this pathology has a significant economic impact in all countries, health systems and individuals, especially those with low incomes (3,4). The available evidence on the diet-GDM relationship still being scarce in the major world regions (15, 16), the objective of this review is to synthesize the evidence between nutrients, food, dietary patterns and other features of diet and the risk to develop GDM.

# Methods

## SEARCH STRATEGY

This systematic review followed The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement, an updated guideline for reporting systematic reviews. We asked about the relationship between components of the mother's diet and GDM. To carry out the search, we performed a systematic bibliographic search in Medline and The Cochrane library for international publications and Latin American and Caribbean Health Sciences Literature (Lilacs), the Latin American Nutrition Archive (ALAN) for regional and local literature, limiting the searches to observational studies published in the last 5 years.

## SEARCH TERMINOLOGY

The search terms included Medical Subject Headings (MESH) terms and keywords as “diabetes, gestational” AND “diet, western”, “feeding behavior”, “diet”, “food”, “food industry”, “food and beverages”, “eating”, “energy intake”, “nutrients”, “diet records”, “dietary pattern”, “maternal diet”, “food frequency questionnaire”, “zinc”, “mineral”, “vitamin”, “nutrition”, “fruits”, “vegetables”, “vitamin pattern”, “dietary intake”, “flavonoids”, “antioxidant”, “iron” OR “meat”, “fiber” OR “fibre”, “fat” OR “fatty acids”, “micronutrients” OR “macronutrients”, “carotenoid” OR “vitamin A” OR “carotene”, “vitamin C” OR “vitamin D” OR “folate” OR “vitamin b2” OR “vitamin b6”, “calcium” OR “potassium”. The search was limited to human observational studies published up to June 2021. Reference lists from relevant articles and reviews were manually searched for potentially relevant citations not detected by the electronic search.

## SELECTION CRITERIA AND DATA EXTRACTION

The selected studies met the following inclusion criteria: full text and original study; observational study design like cohort, case-control, cross-sectional in human women of reproductive age; and studies whose objectives, methodological designs and results included the association between maternal dietary components before or during pregnancy and development of GDM.

Studies were excluded if they reported on dietary supplements, not in combination with maternal dietary components. Studies reporting on abnormal glucose tolerance but not on GDM, conference abstracts and intervention studies were not included. Studies examining eating disorders, perceptions, sensations, clinical trials and qualitative methodological studies were not considered. Titles, abstracts and full-text articles identified from the literature search were screened for eligibility against inclusion and exclusion criteria.

Data were extracted for the evaluation of the study from the authors, year of publication, study design, number of women, number of GDM cases, recruitment location and period, baseline age, exclusion criteria, dietary factors and assessment method, screening method and diagnostic criteria. Finally, information on the results of the study was extracted: mean, SD, SE, OR, or 95% CI of maternal dietary

components with a number of women in each group, effect estimates, and 95% CIs for associations between dietary factors and GDM and confounding factors used in the analyses

## RISK OF BIAS AND QUALITY ASSESSMENT

Quality assessment of the studies included was independently performed by two researchers and discrepancies were resolved by discussion with a third reviewer. The Newcastle-Ottawa Scale was used to evaluate the quality of assessment of exposure and outcome variables of interest (Supplementary Information).

## DATA SYNTHESIS AND ANALYSIS

Search results indicating the significance and direction of the associations observed were qualitatively summarized in tables for each maternal dietary component by study design. Information on study characteristics was extracted to describe studies and populations.

# Results

## STUDY SELECTION

The selection process of the articles included in the review is summarised in **Figure 1**. At first, according to the search terms entered, the search returned a total of 675 articles, of which we found 368 in Pubmed, 38 in The Cochrane Library and 269 in Lilacs. A total of 649 duplicate articles and articles that did not meet the inclusion criteria based on title and abstract were removed. In this sense, the total number of articles included in the review was reduced to 35, 5 of which were published in Latin America, 5 in North America, 6 in Europe, 17 in Asia, 1 in Africa and 1 in Oceania. The maternal dietary components were macro or micronutrients intake (13 articles), food intake (4 articles), articles combining nutrient and food analysis (4 articles), and dietary patterns (14 articles). On the other hand, in Latin America, 2 articles on macro-and micronutrient intakes, 1 article on food intake and 2 articles on dietary patterns were found. Most of the studies that address food from a dietary pattern approach come from East Asia.

## STUDY CHARACTERISTICS

Study characteristics, including a number of subjects, study type, population characteristics, maternal dietary component analysis and its effect on GDM are described in **Table 1, table 2, table 3, table 4 and table 5** according to regional location. Results were mostly prospective cohort studies (18 studies), 12 were case-control studies and 5 were cross-sectional. The majority of the cross-sectional studies were Latin American. All the reports included women aged between 19 and 45 years old who visited hospitals or healthcare centres. The maternal dietary components were analysed before and during pregnancy in 2 articles, 8 articles before pregnancy and 25 articles during pregnancy.

## QUALITY ASSESSMENT

The quality assessment ratings and scores of the studies included were carried out according to the Newcastle – Ottawa quality assessment Scale (NOS). Two researchers evaluated quality studies and a third reviewer resolved discrepancies. The Newcastle-Ottawa Scale was adapted to specifically evaluate the quality of exposure and outcome variables of our interest. View **Supplementary information**.

## **ASSOCIATION BETWEEN MATERNAL DIETARY COMPONENTS AND GD**

Some reports have suggested that pre-pregnancy nutritional status and weight gain during pregnancy can modulate the development of GDM (6, 16). In recent years, diet and healthy nutrition were priorities to prevent adverse events in maternal and child health by the Global Health Alliance in Preconception, Pregnancy and Postpartum (HiPPP) (17). Increasing evidence suggests that an unbalanced pre-pregnancy and pregnancy diet can have a substantial impact on the health outcomes of women and children and the effects of fetal nutrition may persist into adulthood, with possible intergenerational effects (18-20). Likewise, various international studies have confirmed the existence of an association between some components of the diet and the incidence of GDM (11, 21). Below we will describe the results obtained on the various ways of studying the components of the diet associated with the risk of developing GDM.

## **ASSOCIATION BETWEEN NUTRIENTS AND GD**

### **ENERGY INTAKE**

Some authors support the idea that the development of GDM is not caused by dietary nutrients but by the excess of calories in general (6, 19), because energy intake is the main determinant of gestational weight gain (16). Thus, Daneshzad E et al. (2020) found that total energy intake was higher in women with GDM than in women without the condition ( $P < 0.05$ ) (22). Tryggvadottir EA et al. (2015), who studied the GDM-energy relationship from the dietary pattern perspective in 168 pregnant women, reported that those women with obesity ingested more energy ( $2206 \pm 535$  kcal) than those overweight ( $2108 \pm 459$  kcal) and with normal weight ( $2160 \pm 400$  kcal), although, energy intake was not associated with GDM (23).

### **MACRONUTRIENTS**

Five reports address the relationship between GDM and carbohydrate, protein and fatty acid intake. We didn't find evidence about fibre consumption and its association with GDM.

Daneshzad E et al. 2020 show lower intakes of carbohydrates in women with GDM with respect to women without GDM ( $P < 0.05$ ) (22). On the other hand, Zhou X et al. 2018, showed that high fish-meat-eggs scores, which were positively related to protein intake and inversely related to carbohydrate intake, were in turn associated with a higher risk of GDM [OR for quartile (Q) 4 v. quartile (Q) 1: 1.83; 95 % CI 1.21, 2.79;  $P$  trend=0.007]. In contrast, high rice-wheat-fruits scores, which were positively related to carbohydrate intake and inversely related to protein intake, were associated with a lower risk of GDM (adjusted OR for Q3 vs Q1: 0.54; 95 % CI 0.36, 0.83;  $P$  trend=0.010) (24).

With regard to fatty acids, Barbieri P. et al. 2016 found an inverse association between the highest intakes of total n-3 fatty acid, acid alpha-linolenic acid, and GDM (25). Similarly, in a case-control study in Tunes (26), monounsaturated fatty acids and saturated fatty acids consumptions were significantly higher in the control group ( $2.3 \pm 0.8$  vs  $1.7 \pm 0.7$ ,  $P < 10^{-3}$ ).

## MICRONUTRIENTS

Many studies examine the association between dietary micronutrients and adverse maternal outcomes but only some of them evaluate their relationship with GDM. Chen Q. et al. 2019 showed that the "vitamin" pattern (characterized as the consumption of a diet rich in vitamin A, carotene, vitamin B2, vitamin B6, vitamin C, dietary fibre, folate, calcium, and potassium) was positively associated with GDM. For every 25% of increase in the vitamin factor score during one year prior to conception and the first trimester, the GDM risk decreased by 9% (OR: 0.91, 95%CI: 0.86-0.96) and by 10% (OR: 0.90, 95%CI: 0.85-0.95) during the second trimester (27). In this sense, in another study, women in the highest quartile of the prepregnancy micronutrient adequacy ratio (constructed by vitamin A, folate, niacin, riboflavin, thiamin, vitamin C, vitamin E, calcium, iron, potassium, zinc, phosphorus and magnesium) had a 39% lower risk of developing GDM compared to women in the lowest quartile (RR 0.61, 95% CI 0.43-0.86, p for trend 0.01) (28). On the other side, micronutrients in isolation were analysed. Folic acid, antioxidant nutrients, calcium and Vit D showed a protective effect. Besides that, iron showed a promoter effect and evidence of selenium was inconsistent.

### **Protective micronutrients: folic acid, antioxidants, calcium and vitamin D**

Evidence on folic acid intake and GDM varies in the literature. One work showed that pre-pregnancy food folate intake was not associated with GDM risk ( $P_{trend} = 0.66$ ) while an inverse association was found between GDM and pre-pregnancy total supplement and food folate intake (29). The association between dietary components with antioxidant action and the development of GDM has been studied to a greater extent than other nutrients. Vitamin C consumption could have a protective effect against GDM. A cohort study showed pregnant women with dietary vitamin C intake above the recommended level (more than 200 mg/day) experienced lower odds of GDM (OR 0.68, 95% CI: 0.49-0.95) than those with just an adequate intake (115-200 mg/day) (30). A cross-sectional study observed the mean vitamin C intake was significantly higher in the control group than women with GDM (31). Furthermore, a case-control study observed that intakes of vitamin C, vitamins B6 and A, selenium, and manganese were significantly lower in women with GDM ( $P < 0.05$ ) (22). In the same way, other studies analysed vitamin E, selenium, zinc, magnesium, potassium, lycopene and flavonoids intake. A case-control study showed consumption of vitamin E ( $p < 0.001$ ), selenium ( $p < 0.05$ ) and zinc ( $p < 0.001$ ) were significantly lower in women with GDM as compared to healthy pregnant women (32). Moreover, a cohort study found women with lycopene intake in the highest quartile reduced 5% the risk of GDM (OR 0.50; 95 % CI 0.29, 0.86;  $P$  for trend = 0.007) compared with the lowest quartile (33). Also, a cohort study observed a high prevalence of inadequate dietary micronutrient consumption for magnesium (52.5%), potassium (63.8%) and vitamin E in pregnant women (78.6%), however it was not associated with the risk of GDM (28). Nor did a cross-

sectional study find any association between flavonoids intake and GDM but it showed a very low intake of flavonoids in pregnant women (34).

One cross-sectional, two cohort and two case-control studies evaluated a protective effect of calcium and Vitamin D intake against GDM too. Another cross-sectional study found the mean calcium intake was significantly higher in the control group than among the cases (31). One of cohort studies showed that, although not significantly, calcium intake was inversely associated with the risk of GDM (RR=0.58; 95 % CI 0.38, 0.90; P=0.015). Besides, in those women who consumed less than 1200 mg/day, increasing dietary intake by 200 mg/day reduced the risk of GDM by 22% (RR=0.78; 95% CI: 0.61-0.99; p value=0.042) (35). The other cohort found dietary vitamin D intake and total supplement and dietary vitamin D intake were inversely associated with risk of developing GDM, although it was not significant (36). The last two case-control studies, when compared in terms of intake, presented lower intake of vitamin D in relation to the controls ( $2.3 \pm 2.1 \mu\text{g} / \text{j}$  vs.  $6.3 \pm 3.3 \mu\text{g} / \text{j}$ ,  $P < 10^{-3}$ ) (26, 37).

### **Promoter micronutrients: Iron and selenium**

In general, the research works mostly evaluate the intake of iron supplements and only a few assess dietary iron. In this context, two cohort studies positively associated pre-pregnancy heme iron intake with GDM (OR = 2.21 95% CI 1.37-3.58, p-trend 0.003) (38) (OR 1.55; 95% CI 0.98, 2.46) (39). On the other hand, preconception dietary non-heme iron was associated with a decreased risk of GDM (OR: 0.48; 95% CI 0.28, 0.81) (39). As regards to selenium, a cohort study showed pregnant women with intakes in the highest quintile (OR: 1.15, 95% CI: 1.01–1.30) and also those in the lowest one presented increased risks of GDM (OR: 1.19, 95% CI: 1.01–1.41), using quintile 3 as the reference (40).

### **FOOD AND OTHER DIETARY FEATURES**

Three case-control studies, two cohorts and one cross-sectional study found an association between food or meals and the risk of developing GDM. The case-control studies evaluated adherence to dietary acid load (calculated using several nutrient intakes such as phosphorus, protein, calcium, magnesium and potassium) and mediterranean diet (adherence to vegetables, fruits, legumes, cereals and bread, pasta, rice; fish and seafood; meat, poultry; dairy products; alcohol and ratio MUFAs/SFAs), food consumption and the association with GDM risk (41,25, 42). Women with higher scores of dietary acid load and a low mediterranean diet score were more likely to have GDM during pregnancy (OR= 9,27; 95% CI: 4.00 – 21.46) (26, 41). Also, women with GDM exhibited significantly more frequent poultry, pork and smoked meat, dairy products and sweet beverages consumption. Women with GDM consumed less fresh vegetables compared to controls (42). Both cohort studies found association between risk of GDM, egg and fast food consumption. (43, 44). A negative association was shown between the frequency of egg consumption and GDM (43). On the other hand, total fast-food (OR 2.12; 95% CI 1.12-5.43) and french fries consumption (OR 2.18; 95% CI 1.05–4.70) was associated with higher risk of GDM (44). Finally, the cross-sectional study assessed the association between risk of GDM and the intake of minimally processed and ultra-processed foods in Brazilian women, but no association was found (45). Women with GDM were consuming more eggs ( $p = 0.040$ ). It was also found that full-fat milk was negatively

associated with GDM and low-fat milk, fortified yogurt, and fortified orange juice were positively associated with GDM ( $p < 0.05$ ) (37).

## PREPREGNANCY AND PREGNANCY DIETARY PATTERNS

Analysing a diet the dietary pattern approach allows combining different dietary components (nutrients, foods, food groups) into a single measure of dietary exposure and provides information about the nature, quality, quantity, proportions and frequency of consumption of different foods and beverages that are dominant in an individual's diet (46,47). Dietary patterns can be influenced by food availability and socio-cultural factors (48); therefore, it is worth analysing their regional variations because, principally in Asia, two different dietary patterns, prudent and western, during pre-pregnancy and pregnancy and GDM risk were described in the literature.

First, two case-control studies and one cohort study evaluated the association between pre pregnancy dietary patterns and GDM. Asadi et al. 2019 identified the prudent dietary pattern (higher intakes of fruits, low-fat dairy, potato, egg, fish, poultry, nuts, organs meat and red meat) was inversely associated with GDM risk (OR = 0.88, 95% CI: 0.44–0.99), and the western dietary pattern (higher intakes of sugar-sweetened beverages, refined grain products, fast foods, salty snacks, sweets and biscuit, mayonnaise and saturated oils) was significant associated with GDM risk (49). Unlike these findings, Sedaghat F, et al. 2017 found an association between western dietary pattern (high in sweets, jams, mayonnaise, soft drinks, salty snacks, solid fat, high-fat dairy products, potatoes, organ meat, eggs, red meat, processed foods, tea, and coffee) and GDM before and after adjustment for confounders (OR = 1.97, 95% CI: 1.27–3.04, OR = 1.68, 95% CI: 1.04–2.27), but they did not find a significant association of GDM with the prudent pattern (higher intake of liquid oils, legumes, nuts and seeds, fruits and dried fruits, fish and poultry whole, and refined grains) and risk of GDM (50). In the same way, in a cohort study Donazar-Ezcurra M, et al. 2017 identified two prepregnancy dietary patterns, a western dietary pattern (high consumption of meat-based products and processed foods) and the Mediterranean dietary pattern (high consumption of vegetables, fruits, fish and non-processed foods), similar to Iranian prudent patterns. They found a positive association in the multivariable model between the highest quartile of adherence to western dietary pattern and GDM compared with the lowest quartile (OR 1.56; 95 % CI 1.00, 2.43), however they didn't find an association between Mediterranean dietary pattern and GDM incidence (OR 1.08; 95 % CI 0.68, 1.70) for the highest quartile compared with the lowest (51), also Sedaghat F, et al.

Second, two case-control studies evaluated prepregnancy and pregnancy dietary pattern and GDM risk association in Asia. Chinese women with adherence to a vegetable dietary pattern (consumption of green leafy vegetables, cabbages, carrots, tomatoes, eggplants, potatoes, mushrooms, peppers, bamboo shoots, agarics, and garlic and bean products) prior to conception (OR 0.94; 95% CI, 0.89 to 0.99), during the first trimester (OR, 0.94; 95% CI, 0.88 to 0.99) and during the second trimester of pregnancy (OR, 0.91; 95% CI, 0.86 to 0.96) lowered the GDM risk (52). In the same sample, it was determined that the adherence to a vitamin-nutrient pattern (high intake of dietary vitamin A, carotene, vitamin B2, vitamin B6, vitamin C, dietary fibre, folate, calcium, and potassium) one year prior to conception (OR: 0.91, 95%CI:

0.86-0.96), in the first trimester (OR: 0.91, 95%CI: 0.86-0.96) and the second trimester of pregnancy (OR: 0.90, 95%CI: 0.85-0.95) decreased GDM risk (27).

Lastly, the adherence to a pregnancy dietary pattern and association with GDM risk was a bit more studied than prepregnancy dietary pattern. Two case control studies and six cohort studies were found. In the Iranian case-control studies, a plant based diet index, and a healthy and unhealthy dietary pattern were identified. Zamani B. et al. 2019 showed that the adherence to a high plant-based diet index score was inversely associated with risk of GDM (OR = 0.47; 95% CI: 0.28-0.78, P = 0.004) (53). An unhealthy dietary pattern (high intake of mayonnaise, soda, pizza and sugar) was associated with GDM (OR = 2.838, 95% CI: 1.039–7.751), and the adherence to a healthy dietary pattern (high intake of leafy green vegetables, fruits, poultry and fish) in the Q4 had 149% higher chance not to develop GDM (OR = 0.284, 95% CI: 0.096–0.838) compared with the Q1 (54). In this sense, a European cohort study identified the prudent dietary pattern (positive factor loadings for seafood; eggs, vegetables, fruits and berries, vegetable oils, nuts and seeds, pasta, breakfast cereals, and coffee, tea and cocoa powder, and negative factor loadings for soft drinks and french fries) was associated with a lower risk of GDM (OR: 0.54; 95% CI: 0.30, 0.98), even if they included only overweight and obese women (OR: 0.31; 95% CI: 0.13, 0.75) (23).

In a USA cohort study, three dietary patterns associated with increased risk for GDM were identified, the “high refined grains, fats, oils and fruit juice” pattern (AOR 4.9; 95% CI 1.4–17.0), “high nuts, seeds, fat and soybean; low milk and cheese” pattern (AOR 7.5; 95% CI 1.8–32.3) and the “high added sugar and organ meats; low fruits, vegetables and seafood” pattern (AOR 22.3; 95% CI 3.9–127.4) (55).

In China, Zhou X et al. 2018 showed that adherence to high fish–meat–eggs scores, which were positively related to protein intake and inversely related to carbohydrate intake, were associated with a higher risk of GDM (OR for Q4 v. Q1: 1.83; 95 % CI 1.21, 2.79; P trend=0.007). On the other hand, high rice–wheat–fruits scores, which were positively related to carbohydrate intake and inversely related to protein intake, were associated with lower risk of GDM (OR for Q3 v. Q1: 0.54; 95 % CI 0.36, 0.83; P trend= 0.010) (24). In this sense, another cohort study found the adherence to a low carbohydrate diet with high consumption of animal protein was associated with GDM risk (56). Also in China, Du HY et al. 2017 identified four dietary patterns. Compared with the prudent pattern, the Western pattern and the traditional pattern were associated with an increased risk of GDM (OR = 4.40, 95% CI: 1.58-12.22; OR = 4.88, 95% CI: 1.79-13.32). Compared to the lowest quartile, Q3 of the western pattern scores and Q3-Q4 of the traditional pattern scores were associated with a higher risk of GDM (57). In the last two studies realized in Brazil, Nascimento GR et al. 2016 did not find an association between dietary patterns during early pregnancy and GDM (58), but Sartorelli DS et al 2019 showed dietary pattern 1 (high rice, beans, and vegetables, with low full-fat dairy products, biscuits, and sweets) was inversely associated with GDM (OR 0.58; 95% CI 0.36-0.95; p = 0.03) (59).

Prepregnancy and pregnancy dietary patterns characterized by fruits, vegetables, whole grains, fish and dairy products had a protective effect against GDM risk. A dietary pattern characterized by refined grains,

sugar, fats, meat, processed food and snacks was associated with a higher risk of GDM.

## Discussion

As we have described, there is ample evidence considering diet an important factor in the prevention of GDM (60). In this regard, national and international groups have identified preconception and pregnancy as key opportunities in the life course for health promotion and disease prevention(17,61). However, the current evidence about which nutrients, foods and diet characteristics are associated with the risk of developing GDM is based on a limited number of studies that are heterogeneous in design, sample size, exposure and outcome measures, and in the populations involved. Also, dietary components have been analyzed in isolation, in food-groups or in dietary patterns.

Diet study from a dietary pattern approach is necessary because it makes it possible to study the associations between diet and the health-disease process, and to prevent incorrect interpretations of the results due to the complex interactions between the numerous components of the diet (15, 48). Also, this approach is the most comprehensive and their results are the clearest for the development of health promotion actions due to their ability to capture the variability of intake food in a population influenced in turn, by food availability and sociocultural factors. This could have better results and lower costs on health policies and clinical practice in developing countries (4-6, 9).

Most of the studies have been carried out in Asia, particularly in China and Iran, whose populations have lifestyles different those of from western countries, in addition to having genetic and cultural peculiarities. On the other hand, many studies have evaluated the efficacy of diet treatment over GDM or the diet in women with GDM, but the diet and risk of GDM has been poorly described in prospective studies. In Africa, Oceania and Latin America the relationship between GDM and diet were poorly described. In addition, the GDM prevalence has been little described around the world too. Only in 2019, did the International Diabetes Federation (IDF) unify prevalence of hyperglycaemia but not GDM prevalence (4). However, the prevalence of GDM is estimated to increase (1,3,4).

As a limitation of the review, we found differences between the studies in the diagnostic criteria of GDM. Besides, the instrument for food data collection was validated but different in each study because some of them used a food frequency questionnaire and others used a 24-hour dietary recall. Likewise, those kinds of instruments have measurement errors by memory bias in collection and the sample could have selection biases because most of the study populations were not drawn from a random sample, but from regions, cities or ethnic groups, which may limit the generalisability of the results.

The results of this review are consistent with dietary recommendations for women of reproductive age or during pregnancy commonly indicated by healthcare professionals. Likewise, habitually there are recommendations for weight gain and symptoms treatments during pregnancy (62) and there is consensus on dietary recommendations for its treatment. However, there is no consensus on dietary recommendations for the prevention of GDM. We know the importance of proper nutrition as a pillar in the treatment of GDM but it is necessary to highlight its importance in early pregnancy and even before

pregnancy, in healthy women or women with associated risk factors and thus improve the quality of life of women and their offspring (63,64). Prospective observational studies can directly provide tools for policy design and contribute to the development of practical dietary guidelines for women of reproductive age (65). Nevertheless, more prospective observational studies are needed to examine diet before and during pregnancy and the risk of GDM in Western societies.

As a conclusion, we consider it important to integrate nutritional assessment during preconception and prenatal medical care, making sure we act in time before GDM occurs (66). The study of diet through the dietary patterns approach would be important as the possibility that the data can be used in clinical practice.

The results of this review will provide a basis for further research that can be translated into more comprehensive practical and effective public health messages. The importance of a healthy diet early in life and during pregnancy needs to be addressed in clinical practice to anticipate the development of complications, enabling skilled nutrition professionals to act in a timely manner to promote healthy lifestyles.

## **Declarations**

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### **AUTHOR CONTRIBUTIONS**

Victoria Lambert designed the search strategy and the overall structure of review. She also analyzed and interpreted the data, evaluated quality studies and drafted the first version of this manuscript. VL provided final approval for the submitted version.

Carla Gil contributed to the search and analysis of the articles. She also evaluated quality studies and approved the final version.

Sonia Edith Muñoz and María Dolores Román revised the manuscript for important intellectual content and provided final approval for the submitted version. MDR resolved discrepancies in the quality assessment.

### **COMPETING INTERESTS**

The authors have no relevant interests to declare.

### **Ethical Approval and Consent to participate:**

Not applicable

## Consent for publication

The authors provided final approval for the publication.

## Availability of data and materials

Not applicable

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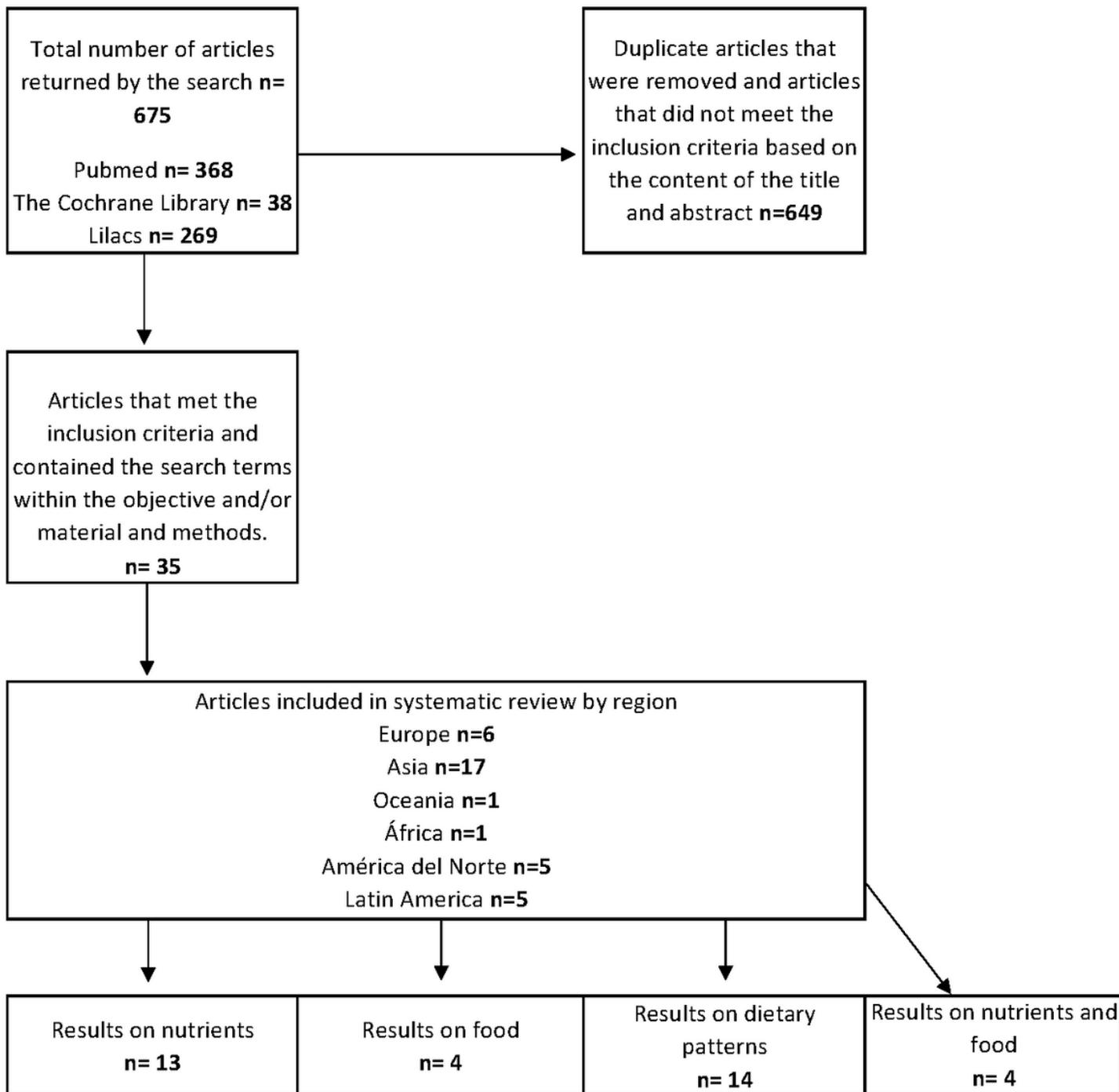
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## Tables

Tables 1 to 5 are available in the Supplementary Files section

## Figures



**Figure 1**

Flow chart with selection criteria of articles included in the systematic review on the association between dietary factors and GDM at the international and regional levels.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1LAMBERTVMUOZSEGILCROMANMD.xlsx](#)
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- [Table5LAMBERTVMUOZSEGILCROMANMD.xlsx](#)
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