The Role of Energy, Nutrients, Foods, and Dietary Patterns in the Development of Gestational Diabetes Mellitus: A Systematic Review of Observational Studies

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MANAGEMENT OF GESTATIONAL DIABETES MELLITUS

OBJECTIVE

Diet may influence the risk of gestational diabetes mellitus (GDM), but inconsistent findings have been reported. The purpose of this study was to synthesize evidence from observational studies on the associations between dietary factors and GDM.

RESEARCH DESIGN AND METHODS

Medline and Embase were searched for articles published until January 2015. We included observational studies of reproductive-aged women that reported on associations of maternal dietary intake before or during pregnancy, including energy, nutrients, foods, and dietary patterns, with GDM. All relevant results were extracted from each article. The number of comparable studies that adjusted for confounders was insufficient to perform a meta-analysis.

RESULTS

The systematic review included 34 articles comprising 21 individual studies (10 prospective cohort, 6 cross-sectional, and 5 case-control). A limited number of prospective cohort studies adjusting for confounders indicated associations with a higher risk of GDM for replacing 1–5% of energy from carbohydrates with fat and for high consumption of cholesterol (≥300 mg/day), heme iron (≥1.1 mg/day), red and processed meat (increment of 1 serving/day), and eggs (≥7 per week). A dietary pattern rich in fruit, vegetables, whole grains, and fish and low in red and processed meat, refined grains, and high-fat dairy was found to be beneficial. The current evidence is based on a limited number of studies that are heterogeneous in design, exposure, and outcome measures.

CONCLUSIONS

The findings support current dietary guidelines to limit consumption of foods containing saturated fat and cholesterol, such as processed meat and eggs, as part of an overall balanced diet. Further large prospective studies are warranted.

Gestational diabetes mellitus (GDM), defined as glucose intolerance with onset or first recognition during pregnancy (1), is a common pregnancy complication affecting ~7% of pregnancies (1,2). During the past 20 years, its prevalence has increased substantially across a range of multiethnic populations and is expected to continue

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to rise along with the increase in prevalence of obesity (3,4). GDM has a considerable impact on health outcomes of the mother and offspring during pregnancy, delivery, and beyond. Type 2 diabetes develops in >50% of women with GDM within 5–10 years after pregnancy (5). Children born to mothers with GDM are at an increased risk of childhood obesity and early onset of type 2 diabetes (6). Moreover, female offspring of mothers with GDM may be at an increased risk of GDM themselves, leading to an intergenerational cycle of the diabetes epidemic (4,7). The identification of modifiable risk factors could inform strategies and programs to prevent GDM.

The importance of diet therapy in GDM is well established (8). Evidence on the associations between diet before and during early pregnancy and GDM prevention, however, remains inconclusive. Systematic reviews and meta-analyses of intervention studies examining dietary factors during pregnancy have shown mixed findings. A lower risk of GDM was found for dietary interventions, including a balanced diet (9), but not for fortified food products or dietary counseling (10). Findings may be mixed because the meta-analyses combined heterogeneous studies examining various types of interventions using different approaches to maintain compliance, different diagnostic criteria for GDM, and diverse populations in terms of ethnicity and BMI. Observational studies are essential in nutrition research because they capture long-term habitual dietary intake, inform intervention studies, and contribute to the development of practical dietary guidelines. On the basis of a nonsystematic review published in 2011, Zhang and Ning (11) concluded that epidemiologic data provide evidence that diet may play a role in the development of GDM, but the evidence remains limited and inconsistent. Additional studies have been published since, but to our knowledge, current findings on the associations between dietary factors and GDM from observational studies have not been reviewed systematically. Thus, we aimed to systematically review current evidence from observational studies among reproductive-aged women on the association of energy, nutrients, foods, and overall dietary patterns with the development of GDM.

RESEARCH DESIGN AND METHODS

Data Sources and Searches

This systematic review was performed in accordance with Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines (12). The research question of interest was whether among women of reproductive age, the level of intake of energy, individual nutrients or foods, or overall dietary patterns are associated with GDM. A systematic literature search was conducted using Medline and Embase for eligible articles published from 1948 (Medline) or 1966 (Embase) until January 2015 using Medical Subject Headings terms and keywords "gestational diabetes mellitus," "diet," "nutrition," "food," and "vitamin." The search was restricted to articles published in English and studies in human populations. Reference lists from relevant articles and reviews were manually searched for potentially relevant citations not detected by the electronic search.

Study Selection

Studies that met the following criteria were considered for inclusion in the systematic review: *1*) original study (no review of previous studies); *2*) observational study design, including cross-sectional, case-control, and retrospective and prospective cohort, in women of reproductive age; and *3*) results on the associations of dietary intake before or during pregnancy (exposure) with development of GDM (outcome). To capture evidence on all components of an overall diet, studies were included if they reported on any of a wide range of dietary factors, including energy, nutrients, foods, or overall dietary patterns, alone or in combination with dietary supplements.

Studies were excluded if they reported on dietary supplements not in combination with dietary intake or examined only a biomarker of dietary intake. Because women with GDM generally receive dietary and lifestyle advice after diagnosis, prospective and cross-sectional studies were excluded if dietary intake was assessed to reflect the period after GDM diagnosis. Studies in <50 women, study populations comprising women with GDM with no control or comparison group with normal glucose control, and studies reporting on abnormal glucose tolerance but not GDM were not included. Only full-text articles were included; conference abstracts were excluded but used to search for related full-text articles. Intervention studies were not included because results from these studies have been systematically reviewed (9,10,13).

Articles identified from the literature search were screened for duplicates. Titles and abstracts were screened, and identified full-text articles were independently reviewed by two investigators (D.A.J.M.S. and S.S.S.-M.) for eligibility based on inclusion and exclusion criteria. Inconsistencies were referred to a third reviewer (G.D.M.) and resolved by discussion.

Data Extraction

The following information was extracted from each included article: study characteristics (author, year of publication, and study design, name, and country), population characteristics (number of women, number of GDM cases, recruitment location and period, baseline age, and exclusion criteria), exposure assessment (dietary factors and assessment method, validation, and period), outcome assessment (screening method and diagnostic criteria), and results (dietary intake [mean with SD, SE, or 95% CI] with 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).

Quality Assessment

Quality assessment of included studies was independently performed by two investigators (D.A.J.M.S. and S.S.S.-M.) using the Newcastle-Ottawa Scale (14). Discrepancies were resolved by discussion with a third reviewer (G.D.M.). The Newcastle-Ottawa Scale was adapted slightly to specifically evaluate the quality of assessment of exposure and outcome variables of interest (Supplementary Data).

Data Synthesis and Analysis

Due to heterogeneity across studies in dietary factors, GDM diagnostic criteria, confounding factors used in analysis, effect estimates, and study design, an insufficient number of studies were available to combine study findings in a meta-analysis. Instead, results indicating significance and direction of the observed associations were qualitatively summarized in tables for each dietary factor by study design. Information on study characteristics was extracted to describe studies and populations.

RESULTS

The numbers of identified and included articles are shown in Fig. 1. The database search and screening of bibliographies yielded 3,054 unique articles. After screening of titles and abstracts, 89 full-text articles were reviewed. Of these, 34 met the inclusion criteria. One article presented results from two studies (15), and multiple articles were published based on data from the Nurses' Health Study II (*n* = 10), the Omega Cohort Study (*n* = 3), the Alpha Study (*n* = 2), a study conducted at Mount Sinai Hospital in Toronto (*n* = 2), and a study conducted at the University of Torino (*n* = 2). The review, therefore, includes 21 individual studies. Dietary factors examined were mostly energy, macro- or micronutrients (26 articles/18 studies); fewer articles reported on foods (14 articles/10 studies), and only a few reported on dietary patterns (5 articles/3 studies).

Study Characteristics

Study characteristics, including assessment of dietary intake and GDM, significant results, and main confounders used, are described in detail in Supplementary Table 1 for the 21 included studies across 34 articles. Studies were mostly prospective cohort studies (10 studies in 83,189 women, 2,446 with GDM), six were cross-sectional (2,452 women, 478 with GDM), and five were case-control studies (1,657 women, 438 with GDM). The mean baseline age was between 24 and 35 years. All articles were published after the year 2000. Dietary intake was measured using a validated tool (dietary recall, diet history, food frequency questionnaire) in 14 of the 21 studies. Diet was assessed before pregnancy in three studies. GDM was assessed using an oral glucose tolerance test in hospital-based studies (17 studies); in two studies, GDM was ascertained using validated self-reported diagnosis (≥92% agreement with medical records), and two studies used linkage with administrative data sets. Screening methods used for GDM diagnosis were generally consistent; however, cutoff values for the oral glucose tolerance test for GDM diagnosis differed across studies. Prevalence of GDM ranged from 1.6 to 28.8% (Supplementary Table 1).

Quality Assessment

Quality assessment ratings and scores of included studies are shown in Supplementary Table 2 (case-control studies) and Supplementary Table 3 (cohort studies). Total scores ranged from 0 (highest degree of bias) to 9 (lowest degree of bias) points. Scores ranged from 4 to 6 for case-control studies, 4 to 7 for cross-sectional studies, and 4 to 9 for prospective cohort studies. Main concerns were *1*) representativeness of the study sample (no random sample of women in the community), *2*) diet assessment in case-control studies (either studies used nonvalidated methods or assessment was not blinded to case or control status), and *3*) comparability of exposed and unexposed participants based on design or analysis (a limited number of studies adjusted for potential key confounding factors, including lifestyle, socioeconomic status, previous macrosomia, and polycystic ovary syndrome).

Association Between Nutrients and GDM

Significant associations between nutrient intake and GDM adjusted for confounding factors are shown in Supplementary Table 1. With the exception of total fat, heme iron, and cholesterol, findings were not statistically significant or were reported by only one study.

Total Fat

Three prospective cohort studies examined dietary fat intake of which two showed a significant association between total fat intake and GDM risk (Supplementary Table 1) (16,17). In the Pregnancy, Infection, and Nutrition Study, total fat intake was significantly higher among women with than among those without GDM. Moreover, replacing carbohydrates with fat was associated with a higher GDM risk (each 1% of total energy: relative risk [RR] 1.10 [95% CI 1.02, 1.10]) (16).

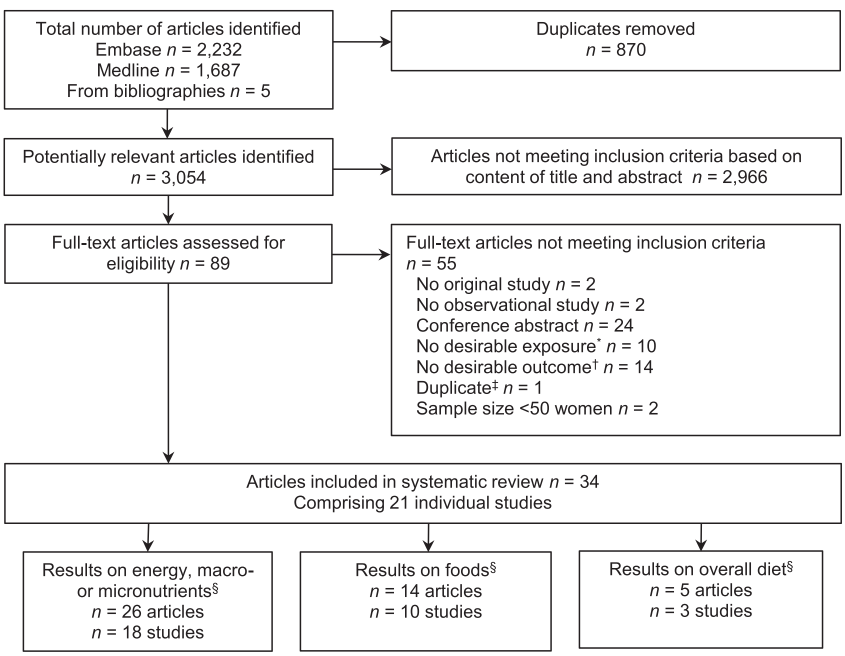

Figure 1—Flow diagram for the selection of articles included in the systematic review on the associations between dietary factors and GDM. *No desirable exposure (e.g., not reporting on maternal dietary intake but on dietary supplements not in combination with maternal dietary intake, on a biomarker of dietary intake, or on dietary intake reflecting the period after GDM diagnosis). †No desirable outcome (e.g., not reporting GDM but abnormal glucose tolerance or studies with no comparison group comprising women with normal glucose tolerance). ‡Duplicate (i.e., similar study findings reported in multiple articles). §Number of articles and studies reporting on nutrients, foods, and dietary patterns do not add up to the total number of articles and studies included in the systematic review because some reported on a combination of nutrients, foods, and dietary patterns.

Similarly, replacement of 5% of energy from carbohydrates with total fat slightly increased the risk of GDM (RR 1.04 [95% CI 1.00, 1.08]) in the Nurses' Health Study II (17). In both studies, carbohydrate intake was within daily requirements (45–65% of total energy intake); however, total fat intake was increased beyond that recommended (20–35% of total energy intake) (18,19). Fat subtypes were examined in two of the three prospective cohort studies, but results did not show significant associations between saturated, monounsaturated, and polyunsaturated fat and GDM risk (17,20).

Cholesterol

Study findings consistently indicated an increased GDM risk with a higher intake of cholesterol (Supplementary Table 1) (15,17,21,22). Prospective cohort studies indicated a significantly increased risk for women with a cholesterol intake of ~300 mg/day or more (15,17). RRs reported were 2.35 (95% CI 1.35, 4.09) for >294 mg/day versus <151 mg/day in the Omega Cohort Study (15) and 1.45 (95% CI 1.11, 1.89) for the highest quintile (median intake 310 mg/day) versus the lowest quintile (167 mg/day) in the Nurses' Health Study II (17).

Heme Iron

Two prospective cohort studies examining intake of heme iron before (23) and during pregnancy (24) showed an increased risk of GDM with higher intake (Supplementary Table 1). An intake of ≥1.1 mg/day was associated with a higher GDM risk in the Nurses' Health Study II (RR [95% CI] for quintiles 3 [median intake 1.1 mg/day], 4 [1.3 mg/day], and 5 [1.6 mg/day] vs. quintile 1 [0.66 mg/day]: 1.31 [1.03, 1.68], 1.51 [1.17, 1.93], and 1.28 [1.21, 2.08], respectively; *P* trend = 0.0001) (23) and in the Omega Cohort Study (RR [95% CI] for quartile 4 [≥1.12 mg/day] vs. quartile 1 (<0.48 mg/day): 2.15 [1.09, 4.27], *P* trend = 0.04) (24).

Associations Between Foods and Food Groups and GDM

Findings for most foods or food groups were not statistically significant or were reported by only one study. For higher consumption of red and processed meat and for eggs, two to four individual studies adjusting for main confounding factors consistently found an association with elevated GDM risk (15,25,26) (Supplementary Table 1).

Red and Processed Meat

Higher consumption before pregnancy of total red meat and processed red meat (beef, lamb, pork, hamburger, bacon, beef hot dogs and sausages, salami and bologna) were significantly associated with increased risk of GDM in the Nurses' Health Study II (25,26). For each increase of 1 serving/day of total red meat or processed red meat, GDM risk increased by 66% (95% CI 1.36%, 2.02%) and 47% (95% CI 0.98%, 2.20%), respectively (25). The Alpha Study reported a higher consumption of red and processed meat (types of meat not further specified) during pregnancy among participants with GDM than control participants (1.07 vs. 0.81 servings/day, *P* < 0.001) (15).

Eggs

GDM was more likely to develop in women with a high egg consumption of seven or more per week during early pregnancy versus those who consumed fewer than seven per week (13.5 and 16.1%, respectively) (Alpha Study: odds ratio 2.65 [95% CI 1.48, 4.72]; Omega Cohort Study: RR 1.77 [95% CI 1.19, 2.63]) (15). An egg consumption of fewer than seven per week was not significantly associated with GDM risk, but findings from both studies indicated a dose-response association for increasing egg consumption and higher GDM risk (15). More detailed results on all nutrients and foods examined in each study and factors controlled for are shown in Supplementary Tables 4–9.

Associations Between Dietary Patterns and GDM

Two studies examined associations between dietary patterns and GDM (26–29). Findings from the Nurses' Health Study II provided evidence on prepregnancy dietary patterns and development of GDM (26–28). Zhang et al. (26) examined a prudent and a Western dietary pattern identified using factor analysis relative to GDM risk. In multivariable models, low consumption of the prudent dietary pattern (characterized by a low intake of fruit, green leafy vegetables, poultry, and fish) (lowest vs. highest quintile RR 1.37 [95% CI 1.09, 1.72], *P* trend = 0.02) and high consumption of the Western dietary pattern (characterized by a high intake of red meat, processed meat, refined grain products, sweets, french fries, and pizza) (highest vs. lowest quintile RR 1.63 [95% CI 1.20, 2.21], *P* trend = 0.001) were associated with an elevated risk of GDM. In the same study, adherence to a low-carbohydrate dietary pattern (characterized by a high consumption of red meat, poultry, and high-fat dairy and a low consumption of fruit, vegetables, whole grains, and sugar-sweetened beverages) was associated with an increased risk of GDM after adjustment for confounding factors (highest vs. lowest quartile RR 1.27 [95% CI 1.06, 1.51], *P* trend = 0.03) (27).

Associations between a priori dietary pattern scores and GDM risk were examined in the Nurses' Health Study II (28). Prepregnancy adherence to the alternate Mediterranean diet (highest vs. lowest quartile RR 0.76 [95% CI 0.60, 0.95], *P* trend = 0.004), the Dietary Approaches to Stop Hypertension (RR 0.66 [95% CI 0.53, 0.82], *P* trend = 0.0005), and the alternate Healthy Eating Index (RR 0.54 [95% CI 0.43, 0.68], *P* trend < 0.0001) all significantly decreased the risk of GDM in adjusted models. Common components between the prudent dietary pattern and dietary pattern scores were high consumption of fruit, vegetables, legumes, whole grains, nuts, and fish and low consumption of red and processed meat, high-fat dairy, refined grain products, sugar-sweetened beverages, sweets, and pizza.

In line with these findings from the Nurses' Health Study II on prepregnancy dietary patterns, a study conducted in 10 Mediterranean countries showed that adherence to the Mediterranean diet was higher among women without GDM (mean diet index score 6.3 of 12) than among those with GDM (mean diet index score 5.8) independent of other risk factors (*P* = 0.03) (29). High adherence to the Mediterranean Diet Index was characterized by high consumption of fruit, vegetables, legumes, bread, and cereal and low consumption of meat, eggs, cheese, and dairy.

CONCLUSIONS

This systematic review of observational studies on the associations of energy, nutrients, foods, and dietary patterns with GDM shows that the current evidence is sparse and predominantly focused on intake of single nutrients and foods rather than on overall dietary patterns. Moreover, current evidence is dominated by findings from the Nurses' Health Study II and should be interpreted with caution because incomplete adjustment or clustering of health behaviors may have confounded the reported associations. In terms of nutrients, higher intake of total fat, cholesterol, and heme iron were associated with higher GDM risk (15–17,23,24). In terms of foods, higher consumption of red meat, processed meat, and eggs was associated with a higher risk of GDM (15,25,26). In terms of dietary patterns, an overall diet rich in fruit, vegetables, legumes, nuts, whole grains, and fish and low in red and processed meat, refined grain products, eggs, and high-fat dairy may be beneficial in reducing GDM risk (26–29).

To our knowledge, this systematic review is the first to synthesize evidence from observational studies on the association between dietary factors and GDM. In a nonsystematic review published in 2011, Zhang and Ning (11) concluded that intake of several nutrients, including a higher intake of fat and lower intake of carbohydrates, may be associated with an increased risk of GDM. In the current systematic review, we also found evidence for associations of higher consumption of total fat, cholesterol, heme iron, red and processed meat, and eggs before or during pregnancy. These associations were adjusted for main confounding factors, including maternal age, ethnicity, parity, history of GDM, family history of diabetes, lifestyle, BMI, and energy intake. Since Zhang and Ning's review, more studies on overall dietary patterns have been published, indicating that prepregnancy dietary patterns may be related to GDM risk. These findings remain predominantly based on U.S. data from the Nurses' Health Study II and need confirmation in other study populations.

Several trials have been aimed at reducing the risk of GDM through dietary interventions during early pregnancy. Study findings summarized in systematic reviews and meta-analyses are diverse but suggest a beneficial effect (9,10,13,30). Additional research is needed because of the differences in interventions examined (e.g., diet quality, energy restriction, provision of fortified food products, dietary counseling) as well as the heterogeneous study populations and GDM diagnostic criteria. Findings from the current review of observational studies examining habitual dietary intake may contribute to informing the development of future dietary interventions.

Current epidemiologic evidence on dietary factors and GDM suggests an increased risk with a higher intake of total fat [replacing 1–5% of energy from carbohydrates with fat beyond the daily fat recommendation of 35% of total energy intake (18,19)], cholesterol [beyond the daily recommended intake of 300 mg/day (18,19)], heme iron (≥1.1 mg/day), and foods containing these nutrients, including red and processed meat (increment of 1 serving/day) and eggs (seven or more per week). These results are in line with findings on risk of type 2 diabetes (31–34), which shares a common etiology with GDM. Associations of total fat, cholesterol, heme iron, red and processed meat, and eggs with GDM are biologically plausible, with worsening inflammatory markers and oxidative stress as potential biological pathways involved in the development of GDM (35–38). Exact pathways remain unclear, and further studies are needed to elucidate potential mechanisms for the relationship of dietary factors with risk of GDM.

Findings from the current review must be interpreted with caution because the evidence is based on a limited number of studies examining dietary factors in relation to GDM, and these studies have several caveats. First, even though diet was assessed using a validated tool in the majority of studies, self-reported dietary intake is known to be subject to measurement error. Misclassification of dietary intake may weaken or limit the detection of an association with GDM. In case-control studies, assessment of diet after GDM diagnosis may have resulted in recall bias. Second, most studies were restricted by the small sample size and, therefore, the power to detect an association. Moreover, selection bias should be considered because most study populations were not from a random sample from the community but from specific regions, cities, occupations, or ethnic groups, which may limit the generalizability of the findings. Third, studies used different diagnostic criteria for GDM, with no clear pattern emerging regarding whether a significant association could be detected using less or more strict criteria. Some studies showed a gradient in dietary intake (e.g., increasing dietary fat intake) from normal glucose tolerance to abnormal glucose tolerance and GDM (39–41), whereas other studies found an association or no association consistent with both outcomes (16,20,42). Finally, the observed associations may be explained by residual confounding from unmeasured factors in the individual studies. Most studies adjusted for maternal age, ethnicity, parity, history of GDM, family history of diabetes, BMI, and total energy intake; however, less than one-half of the studies adjusted for other lifestyle factors, such as physical activity and smoking, and very few adjusted for gestational weight gain, previous macrosomia, polycystic ovary syndrome, or socioeconomic status, which may be important risk factors of GDM (43–45). Furthermore, because diets comprise a combination of food items, singling out the effect of an individual food item is difficult. For example, high egg consumption was against dietary advice at the time of the studies and may be an indicator of a diet that does not comply with guidelines and is high in deleterious food, such as processed meat. Specific types of foods not taken into account in the analyses (e.g., bacon) may contribute to explaining the observed association. Additionally, because of the interaction among nutrients, drawing conclusions on independent associations of specific individual nutrients is difficult; for example, heme iron has a strong positive correlation with animal protein, which was not taken into account in the analyses on heme iron and GDM risk.

Studies examining overall dietary patterns take into account the cumulative and interactive effects of nutrients and foods. Evidence on the association between overall diet and risk of GDM is in general agreement with findings on type 2 diabetes risk. A diet comparable to a Western dietary pattern (high intake of red and processed meat, sweets, savory snacks, and refined grains) has been found to increase risk (46,47) and a Mediterranean-style dietary pattern (high intake of fruit, vegetables, legumes, fish, and whole grains) to reduce risk (48). Moreover, these findings are in line with current international dietary guidelines for reproductive-aged women to 1) limit intake of foods that are high in sodium, added sugar, saturated fat, transfat, and cholesterol and 2) consume a diet rich in fruit, vegetables, legumes, whole grains, low-fat dairy, seafood, lean meat and poultry, and nuts (18,19,49). For pregnant women, guidelines recommend to only eat fresh seafood that has been cooked to kill *Listeria* and to avoid fish that may contain high levels of mercury. It should be noted that the Scientific Report of the 2015 Dietary Guidelines Advisory Committee (50), which informs the American federal government on current scientific evidence to develop a national nutrition policy, no longer includes the recommendation to limit cholesterol intake and defines eggs as a nutrient-dense food that should be part of an overall dietary pattern. Health-conscious women might change their dietary habits based on changes in dietary guidelines, and this needs to be assessed in future studies.

A strength of the current review is that it covers a wide range of dietary factors, including energy, nutrients, foods, and dietary patterns. Overall diet is a combination of foods that in turn contain a combination of nutrients. We found that a higher intake of total fat, cholesterol, and heme iron as well as a higher intake of foods containing these nutrients, including red and processed meat and eggs, were associated with higher GDM risk. Also as part of an overall Western dietary pattern, a diet rich in red and processed meats was associated with a higher risk of GDM. Causality cannot be inferred because of the observational design of the studies, and well-designed prospective intervention studies are needed to confirm these findings. Even though well-conducted trials are considered the highest level of evidence to infer causal relationships, observational studies are important in nutrition research. Diet is a complex combination and interaction among components that cumulatively affect health. Considering all components of an overall diet as well as good compliance in long-term intervention studies often is difficult to achieve, whereas well-designed observational studies capture habitual diet patterns. Evidence from prospective observational studies together with intervention trials could inform policy and contribute to the development of practical dietary guidelines for reproductive-aged women.

This systematic review is limited by the scarce number of published studies. A large diversity in nutrients, foods, and dietary patterns; criteria used for GDM diagnosis; and the way associations were analyzed and reported across various study designs was examined, limiting the consistency and comparability of findings and our ability to pool results in meta-analyses. Results from prospective cohort studies were dominated by analyses using data from the large Nurses' Health Study II (10 of 21 studies); however, these findings were confirmed by at least one other study. The current review only includes studies published in English. Moreover, no studies examined dietary intake both before and during pregnancy to draw conclusions on whether timing of dietary habits affects the association with GDM.

In conclusion, current evidence from observational studies indicates a role of diet in the development of GDM. The findings support current dietary guidelines for reproductive-aged women to limit their consumption of foods containing saturated fat and cholesterol, including red and processed meat and eggs, as part of an overall balanced diet that is rich in fruit, vegetables, legumes, whole grains, low-fat dairy, nuts, and fish. Examining dietary patterns is crucial in taking into account interactions and cumulative effects of multiple nutrients and foods consumed in an overall diet. Further well-powered prospective observational and intervention studies are needed to examine dietary patterns both before and during pregnancy in relation to risk of GDM in a range of populations. Results from these studies will build an evidence base to inform intervention studies and for translation to more comprehensive and practical public health messages.

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