Association between maternal dietary quality and gestational diabetes mellitus based on the Diet Balance Index for Pregnancy

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Abstract

Background: Maternal diet is critical to the development of gestational diabetes mellitus (GDM), but sparse studies have applied the Chinese Dietary Balance Index for Pregnancy (DBI-P) to assess the maternal dietary quality and its relationship with GDM. We aimed to examine the maternal dietary quality and its relationship with GDM risk using the newly developed DBI-P.

Methods: We included 1122 pregnant women from the Tongji Birth Cohort (TJBC) in Wuhan, China. The semi-quantitative food frequency questionnaire (FFQ) was used to obtain the dietary information during pregnancy. The newly developed DBI-P, including DBI-P components and DBI-P dietary patterns, was applied to comprehensively evaluate the maternal dietary quality. GDM was diagnosed by the 75-g, 2-h oral glucose tolerance test at 24-28 weeks gestation. We used a generalized linear regression model to examine the relationship between DBI-P components and blood glucose levels, and a logistic regression model to examine the relationship between dietary patterns and GDM.

Results: A total of 179 participants (16.0%) were diagnosed with GDM. There is a widespread phenomenon of dietary imbalance among pregnant women in Wuhan. With per score increase in nuts and eggs, fasting blood glucose increase by 0.03 mmol/l (95% CI: 0.01, 0.05) and 0.01 mmol/l (95% CI: 0.01, 0.03), respectively, while per score increase in fruits, 1-h post-load blood glucose decreased by 0.05 mmol/l (95% CI: -0.10, -0.01). Besides, compared with pattern E characterized by higher intake of total energy, total fat, fruits, and cooking oil, pattern B (OR: 0.51, 95% CI: 0.26, 0.99) and pattern C (OR: 0.27, 95% CI: 0.09, 0.81) were associated with a lower GDM risk. The associations between dietary patterns and GDM risk may be partly attributed to the intakes of dietary total fat, carbohydrate, cholesterol, eggs, and cooking oil.

Conclusions: Unfavorable dietary quality during pregnancy is associated with a higher risk of
GDM. The newly established DBI-P can provide an easy-to-implement tool to assess maternal dietary quality. These findings will provide new insights for the exploration of preferable dietary evaluation methods and prevention and control of GDM.

Keywords: Diet Balance Index, Gestational diabetes mellitus, Diet quality, Dietary patterns

Background

Gestational diabetes mellitus (GDM), defined as any degree of glucose intolerance that initiates or is first detected during pregnancy, is a frequent complication of pregnancy [1]. The detrimental effects of GDM on both mothers and children will run throughout pregnancy, puerperium and even the whole life process [2-4]. With the social-economic growth and the alteration in people’s lifestyles, rapid rises in GDM incidence are occurring worldwide [3, 4], affecting approximately 12.8 – 16.7% of pregnant women in China [5].

Diet during pregnancy plays a pivotal role in the development of GDM [6, 7]. While several studies have examined a single nutrient or specific food group in relation to GDM, such as carotenoids, heme iron, cholesterol, legumes [7-10], the relationship between overall dietary quality during pregnancy and GDM risk remains equivocal. In recent years, employing dietary patterns to assess maternal dietary quality has gradually attracted attention worldwide [11]. Dietary patterns take into account the combined effect of nutrition and food, widely used to explore the relationship between diet quality and definite health-related disease [11, 12]. In terms of current nutrition studies, Mediterranean Diet Score (MDS), Dietary Approaches to Stop Hypertension (DASH), and Healthy Eating Index (HEI) are predominantly adopted to assess the diet quality of diverse populations, especially in western countries [7, 12-14]. Diet Balance Index (DBI) is mainly employed in China, which is a dietary evaluation system advocated by the Chinese Nutrition Society and established in conformity to the Dietary
Guidelines for Chinese Residents and the Chinese Food Guide Pagoda [15]. The DBI was designed as a continuous scoring system that can reflect the degree of dietary insufficiency, dietary excess, and dietary imbalance, which was closely connected with the occurrence and development of non-communicable diseases [16].

DBI has been modified several times since its release to facilitate more reasonable assessments, and its applicability in dietary quality assessment has been widely verified in different populations [16-18]. Wang et al. developed a DBI for pregnancy (DBI-P) to assess the dietary quality among pregnant women, however, its finding was compromised by cross-sectional study design and consistent scoring criteria for various gestations [19, 20]. Since the latest revised Dietary Guidelines for Pregnant Women in China was released in 2016, there has been a lack of data on the development of a new DBI-P to examine the maternal dietary quality and its relationship with GDM.

Therefore, this study is aimed at developing a new DBI-P based on the typical DBI and the Dietary Guidelines for Chinese pregnant women (2016) to evaluate the dietary quality of pregnant women in Wuhan, and further elucidate the relationship between maternal dietary quality and GDM risk.

Methods

Study population and design

The Tongji Birth Cohort (TJBC) is an ongoing longitudinal cohort study, established in the central Chinese city of Wuhan in March 2018. We recruited TJBC participants if they reported a singleton pregnancy with gestational weeks of 13-28 weeks, accomplished an oral glucose tolerance test (OGTT), and a food frequency questionnaire (FFQ) before their OGTT. The women who had missing GDM diagnosis (n=188), serious lack of baseline data (n=239),
previous diagnosis of GDM or type 2 diabetes (n=5), and incredible total energy intake (<600 or >4500 kcal/day, n=3) were excluded. Finally, 1122 pregnant women were included in this analysis (Fig. 1).

Dietary data collection

Semi-quantitative FFQ was conducted to derive maternal long-term dietary intake, and its validity and repeatability in assessing the nutrient and food intake of pregnant women in China have been measured in previous studies [21]. The FFQ was an acceptable and effective tool designed by the dietary habits of the Chinese population and consisted of 74 detailed food items that were assembled into 10 non-overlapping food groups: cereals, meats, aquatic products, eggs, beans, vegetables, nuts, milk and milk products, beverages, and fruits [6]. With the assistance of food molds and colorful food photography atlas, the participants were required to recall how often and how much of each food they had consumed over the past 4 weeks. Daily intake of nutrients and energy was calculated according to the China Food Composition Database (2nd edition) revised in 2009 [22], and each nutrient intake was adjusted by the nutrient-density method [23].

Dietary balance index for pregnancy

We developed a DBI-P based on the typical DBI-07 and Dietary Guidelines for Chinese pregnant women (2016) to assess the overall dietary quality among pregnant women. The DBI-P components consist of the following 10 categories: cereals, vegetables and fruits, milk and milk products, soybean and its products and nuts, animal foods, iron-rich foods, seaweed, condiments, drinking water, and dietary diversity. Additionally, animal foods consist of meats, aquatic products, and eggs, and condiments include cooking oil and salt. A score of 0 for each
The DBI-P component indicated that the recommended intake is being met. People are given a positive score when they consume more than the “reduced” or “limited” amounts recommended by the dietary guidelines, such as excessive intake of cooking oil. Additionally, vegetables, aquatic products, milk and milk products, etc. are given negative scores (range -12-0), all of which are recommend consuming in “appropriate” amount by the dietary guidelines [17, 24].

One of the DBI-P components “C10- dietary diversity” is assessed by calculating the score of 12 kinds of food subgroups [17, 24]. Scoring details of DBI-P can be found in Supplementary Table S1.

After figuring up each DBI-P score, there three indicators of DBI-P were further calculated. The higher bound score (HBS) was calculated by adding all the positive scores, indicating the extent of excessive dietary intake; the lower bound score (LBS) was obtained by adding the absolute values of negative scores, indicating inadequate dietary intake; the diet quality distance (DQD) was defined as the sum of the LBS and HBS to evaluate the degree of overall dietary balance [17, 18]. In our study, the lower and upper bound of HBS, LBS and DQD were: 0-34, 0-82, 0-90, respectively. With the increment of HBS, LBS and DQD, the degree of excessive dietary intake, insufficient dietary intake and dietary imbalance raise likewise. A score of 0 shows an optimal diet (no problem); a score that is less than 20% of the total score shows a good diet (almost no problem); a score that is between 20% and 40% of the total score shows an acceptable diet (low level); a score that is between 40% and 60% of the total score shows a poor diet (moderate level); a score greater than 60% of the total score shows the terrible diet (high level) [17, 18, 25].

To further assess the individual dietary quality, LBS was divided into three different levels: the scores below 20, 20-40 scores and above 40 scores, meanwhile, HBS was divided into three levels: the scores below 10, 10-20 scores and above 20 scores. Nine dietary patterns from
pattern A to patterns I were defined according to various combinations of LBS and HBS levels [15, 26]. (see Supplementary Fig. S1)

**Diagnosis of gestational diabetes mellitus**

All pregnant women were routinely implemented 75-g, 2-h OGTT at 24-28 weeks of gestation, with fasting for at least 8 hours prior to OGTT. Fasting plasma glucose (FPG) and 1- and 2-h post-load plasma glucose (1-h, 2-h PBG) levels were measured by enzymatic assays using an automated biochemical analyzer. According to the recommendations from the International Association of Diabetes and Pregnancy Study Groups (IADPSG), GDM was diagnosed between the 24th and 28th week of pregnancy when FPG ≥5.1 mmol/l or 1-h PBG ≥10.0 mmol/l or 2-h PBG ≥8.5 mmol/l [27]. The participants were the new diagnosed pregnant which did not use any insulin or medication therapy.

**Assessment of other variables**

At the baseline enrollment, the information on maternal sociodemographic characteristics, anthropometric data and lifestyle were obtained by face-to-face interview with a structured questionnaire. Maternal age was divided into four groups (≤25, 26-30, 30-34 and ≥35 years). Ethnicity was divided into two categories (Ethnic Han, others). Years of education were allocated into four categories as ≤9, 10-12, 13-15 and ≥16 years. Average personal income was divided into four categories (≤3000, 3000-4999, 5000-9999, and ≥10000 Chinese Yuan per month). The pre-pregnancy body mass index (BMI, kg/m^2) calculated from self-reported pre-pregnancy weight and height was divided into four categories (<18.5, 18.5-23.9, 24.0-27.9 and ≥28.0 kg/m^2) according to the BMI classification criteria for Chinese [28]. Smoking or drinking defined as the habit of smoking or drinking at least once a week before pregnancy was divided
into two levels (Yes/No). The other variables, including primiparity, physical activity, family
history of diabetes and hypertension, and the history of abnormal pregnancy (including ectopic
pregnancy, induced labor, spontaneous abortion et al.) were treated as dichotomized variables
(Yes/No).

Statistical analysis
The continuous variables (e.g., age, Pre-pregnancy BMI, and the average daily intake of
nutrients and foods) were presented as mean and standard deviation (SD), and categorical
variables (e.g., ethnic, education levels, and smoking) were expressed as frequencies
(percentages). One-way analysis of variance (ANOVA) and $\chi^2$ test were used to detect the
differences in percentages and means, respectively. We also performed a generalized linear
regression model to examine the relationship between DBI-P components and blood glucose
levels. The results were presented as coefficients ($\beta$) with 95% confidence intervals (95% CIs).
Logistic regression models were used to evaluate the relationship between DBI-P dietary
patterns and GDM risk, further explored the contribution of nutrient and food intake to the
association between dietary patterns and GDM by calculating the odds ratios (ORs) and 95%
CIs. All statistical analyses were conducted using SPSS version 25.0 (IBM Corporation). A two-
tailed value of $P<0.05$ was considered indicative of statistical significance.

Results
Participant characteristics
Table 1 displays the sociodemographic characteristics of the participants. There were 1122
participants in this study, and a total of 179 (16.0%) pregnant women were diagnosed with
GDM. The average age of the participants was 28.7 years old. Compared to pregnant women
without GDM, those with GDM were older (29.8 years vs. 28.5 years), were more in lower education level (≤9 years), had higher pre-pregnancy BMI, FPG, 1-h PBG, and 2-h PBG, and were more likely to have a greater prevalence of a reported family history of diabetes (19.0% vs. 9.2%). No significant differences were found in ethnicity, average personal monthly income, primiparity, family history of hypertension, smoking, alcohol drinking, physical activity, history of abnormal pregnancy, LBS, HBS, and DQD.

Maternal diet quality based on DBI-P

Table 2 reports the scores for DBI-P components and the percentages of each score in the GDM and non-GDM group. Insufficient intake of iron-rich foods, soybean and its products, aquatic products, milk and milk products, eggs, and meat were common in both two groups, with 96.1%, 94.4%, 79.9%, 78.2%, 68.2%, 61.4% of the GDM women getting negative scores, respectively. Moreover, 93.7%, 94.1%, 77.7%, 78.9%, 68.2%, 59.1% of the women without GDM also had negative scores, respectively. Conversely, excessive intake of fruits, cooking oil, and salt was also universal, with nearly 50.0-75.0% of the pregnant women in the two groups getting a positive score. The dietary diversity among pregnant women was extremely inferior, with almost all of them (99.2%) getting a negative score.

Table 3 shows the distribution of DBI-P indicators among the participants. Over 65.0% of participants had a low level of dietary deficiency, and approximately 20.0% had a moderate level of dietary deficiency. The distribution of HBS indicated about 60.0% of the participants had almost no problems with dietary excess, while about 30.0% of the participants had a low level of dietary excess. In terms of DQD, more than 95.0% of pregnant women in both groups had a low or moderate level of dietary imbalance. There were no significant differences between
Association between maternal dietary quality and GDM based on DBI-P

as shown in Table 4. After adjusting for maternal age, ethnicity, pre-pregnancy BMI, and all variables shown in the table, with per score increase in nuts and eggs, FPG increased by 0.03 mmol/l (95% CI: 0.01, 0.05) and 0.01 mmol/l (95% CI: 0.01, 0.03), respectively, while per score increase in fruits, 1-h PBG decreased by 0.05 mmol/l (95% CI: -0.10, -0.01). No significant relationships were found between DBI-P components and 2-h PBG levels.

Table 5 shows the average daily intake of nutrients and foods in various DBI-P dietary patterns. Only five dietary patterns found in this study, including pattern A to pattern E. The optimal pattern A accounted for 18.4%. A total of 669 participants had a pattern B, in which the average daily intakes of most dietary nutrients were below the recommended intakes, such as dietary protein, vitamin A, magnesium, calcium, and iron et al. The results suggested that from patterns A to pattern B to pattern C, the average daily intake of most nutrients and foods decreased significantly (except for dietary vitamin C, magnesium, and total iron intake), and pregnant women with pattern D consumed more nutrients and foods than those with pattern E (except for dietary vitamin C). Besides, pregnant women with pattern D and pattern E consumed excessive intake of total energy, total fat, cereals, fruits, and cooking oil. The average daily intake of nutrients and foods in various dietary patterns were significantly different (all $P<0.05$).

Table 6 shows the relationship between DBI-P dietary patterns and GDM. The adjusted models showed that pregnant women with pattern B and pattern C were related to a lower risk of GDM compared to those with pattern E, with an adjusted OR of 0.51 (95% CI: 0.26, 0.99) and 0.27 (95% CI: 0.09, 0.81), respectively. We further investigated the contributions of energy-
yielding nutrients and food intake on the association between dietary patterns and GDM risk and found that the association of pattern B with GDM risk was no longer significant after extra adjustment for dietary total fat (OR: 0.53; 95% CI: 0.27, 1.05), or carbohydrate (OR: 0.53; 95% CI: 0.27, 1.03), or cholesterol (OR: 0.52; 95% CI: 0.27, 1.03), or eggs (OR: 0.52; 95% CI: 0.26, 1.02), or cooking oil (OR: 0.52; 95% CI: 0.27, 1.03). The association between pattern C and GDM risk was attenuated slightly but maintained statistical significance after adjusting the above factors. These findings suggested that dietary total fat, carbohydrate, cholesterol, eggs, and cooking oil may partly contributed to the difference in GDM risk. Besides, no large or statistically significant changes in OR (95% CI) for GDM risk were observed after adjusting for other dietary nutrients and food.

**Discussion**

In this prospective cohort study, we newly developed a DBI-P to investigate the maternal dietary quality and its relationship with GDM. Firstly, there is a widespread phenomenon of dietary imbalance among pregnant women in Wuhan, China, which is mainly manifested as dietary insufficiency. Secondly, we found nut and egg scores were positively related to FPG, while fruit scores were inversely related to 1-h PBG. Thirdly, five dietary patterns were identified in this study. Compared with pattern E characterized by high total energy, fruit and cooking oil intake, pattern B and pattern C were related to a lower GDM risk. The associations between dietary patterns and GDM risk may be partly attributed to the intakes of dietary total fat, carbohydrate, cholesterol, eggs, and cooking oil.

Almost all pregnant women (96.1%) in the study had insufficient iron intake and 61.4% of pregnant women had insufficient meat intake. During the survey, we were somewhat astonished to note that multiple pregnant women never prefer to consume animal entrails before pregnancy, which may be one of the reasons why the participants had such a severe iron-rich food
deficiency during pregnancy. Since iron-rich food deficiency is related to premature, postpartum hemorrhage, and low birth weight, it is indispensable to augment the intake of iron-rich foods during pregnancy [29, 30]. Besides, soybean and its products, aquatic products, milk and milk products, eggs, and meats are generally considered favorable sources of high-quality protein and minerals, yet more than 60% of participants did not meet the recommended intake. Adequate dietary protein intake during pregnancy is crucial to ensure a healthy outcome. Bao et al.’s studies found that higher intake of vegetable protein was associated with a lower blood glucose [23], while protein deficiency is associated with small-for-gestational-age infants and premature birth [31]. As for cereals and vegetables, we found the intake of cereals (267.7 g/d) and vegetables (327.6 g/d) basically met or exceeded the recommended intake, however, about half of the participants still had insufficient intake, suggesting a possible polarization of dietary intakes of cereals and vegetables. Meanwhile, the average fruit intake in our study was 477.1 g/d and nearly 55.0-75.0% of participants consumed excessive fruits, cooking oil and salt. We speculate that the reason for excessive intake of fruit might be due to poor appetite during pregnancy and the preference for sweet and sour foods, while excessive intake of cooking oils and salt may be due to the inherent dietary characteristics of Wuhan people.

Diet during pregnancy has been described as a potentially modifiable factor for GDM [7]. In this study, we found higher nut scores were associated with an increase in FPG. This finding is contrary to what has been reported previously. For instance, Kendall et al. observed higher nut intake was associated with a lower postprandial glycemia, whereas no significant association was found in other studies [32-34]. Considering that the average nuts intake in our study was 15.3 g/d, exceeding the recommended intake of dietary guidelines for pregnant women, the energy and fat or carbohydrate content of nuts and the types of nuts may be the primary cause of the diverse effect. Additionally, we observed a positive correlation between egg scores and
FPG, which was consistent with two cohort studies in China and a prospective epidemiological study in Polish [35, 36]. One possible mechanism may be that increased egg consumption is correlated with higher cholesterol levels, which is related to systemic inflammation and has recently been linked to the development of GDM [35]. Furthermore, we also found that fruit score was negatively correlated with 1-h PBG. Evidence showed that fruits are rich in antioxidants as well as vitamins, minerals, polyphenols, and flavonoids, and the mechanism of lowering blood glucose level in pregnant women may be related to the dietary total antioxidant capacity [37]. Consistent with our study, the Tongji Maternal and Child Health Cohort observed higher fresh fruit consumptions in mid-pregnancy were associated with a lower plasma 1-h PBG and 2-h PBG [6], whereas the Nurses’ Health Study II conducted in US female nurses found no significant association between higher whole fruit intake and GDM risk, but moderate consumption of fruit juice appeared to lower GDM risk [38]. The accessibility of fruits in various regions, and the differences in nutritional value and glycemic index of fruits may partly explain these inconsistent findings. Besides, we were somewhat surprised to notice that the DBI-P components had an effect on FPG and 1-h PBG, but not on 2-h PBG. One possible reason may be due to the different individual pathophysiological mechanisms, i.e., some pregnant women showed decreased insulin secretion and impaired fasting glucose, while some only showed abnormal glucose tolerance [39]. A previous study showed that patients with abnormal FPG have higher levels of fasting insulin than those with elevated PBG [40]; Other reason may be related to the different in nutrient content in foods, which may cause different blood glucose and insulin responses. For example, Xu et al. [41] indicated that bilberry had insulin lowering effect in the early postprandial period (0–90 min), while rose hip resulted in decreased insulin response at 30, 45 and 90 min of postprandial period. Further research efforts are needed to discover the underlying mechanisms.
In addition to examining DBI-P components in relation to blood glucose, DBI-P dietary patterns were further utilized to explore their relationship with GDM. Compared to pregnant women with pattern E, those with pattern B and pattern C were associated with a lower risk of GDM. Although theoretically, the degree of dietary deficiency in pattern E was similar to that in pattern B and less than that in pattern C, the dietary intake of total energy, protein, total fat, carbohydrate, cooking oil, fruits, nuts, eggs, etc. in pattern E was higher than that in pattern B and pattern C. Despite fruit intake as described previously in this study was negatively correlated with 1-h PBG, this result suggests that the overall dietary over-consumption is more likely to increase GDM risk than overall dietary under-consumption. That might be because overall overeating is often accompanied by excessive intake of total energy, saturated fat and cholesterol, which was related to a higher risk of GDM [42]. A growing body of evidence indicates that adjusting energy intake to meet the guidelines for weight gain during pregnancy may be favorable in reducing maternal blood glucose and insulin levels [43]. Moreover, we specifically investigated the contributions of energy-yielding nutrients and food intake on the association between DBI-P dietary patterns and GDM risk. Interestingly, we observed that the difference in GDM risk between pattern B and pattern E may be partially attributed to dietary intake of total fat, carbohydrate, cholesterol, eggs, and cooking oil. A Chinese cohort study found higher dietary cholesterol from eggs intake during pregnancy was related to higher risk of GDM. Moreover, Park et al. indicated that high energy and saturated fat intakes significantly increased GDM risk. The results of the above two studies are similar to our study [6, 44]. Though single food or nutrient during pregnancy in relation to GDM has been demonstrated in several previous studies, further studies are warranted to verify the impact of these overall diet on GDM and to explore the potential mechanisms.

This study has several strengths. First, this is the first study to develop a DBI-P to
prospectively examine maternal dietary quality in relation to GDM risk. Similar to HEI and DQI, DBI-P adopts the priori reasoning method, being capable of recognizing the differences in diet quality. Second, based on prospective design, we comprehensively analyzed the maternal dietary quality and its relationship with GDM from three perspectives of food groups, nutrients and dietary patterns rather than individual dietary components. Most importantly, we found that the association between dietary patterns and GDM can be observed by using DBI-P, which may provide a new perspective for dietary evaluation and the prevention and control of GDM.

Some limitations of this study should be acknowledged. Firstly, we used FFQ to collect dietary data of pregnant women in the past 4 weeks, which may cause information bias, however, the FFQ we used in this study has been effectively verified in previous study [21]. Secondly, the subjects of this study were permanent residents in central China. Despite we have endeavored to eliminate the influence of confounders on the results, future studies with a large sample should be carried out to verify the applicability and effectiveness of the DBI-P. Thirdly, the nutrients intake in this study only referred to daily diet, excluding the addition of nutritional supplements, which may underestimate the total nutrient intake. Therefore, energy-adjusted nutrient intake was performed to eliminate the effect of differences in energy intake. Finally, although we revealed that pregnant women with pattern B and pattern C were significantly correlated with the lower risk of GDM, it is not yet clear which pattern is optimal. Future studies are needed to explore the consistency of the relationship between maternal dietary quality and GDM, using other methods like cluster analysis and reduced-rank regression [45, 46].

Conclusions

In summary, the newly established DBI-P can provide an easy-to-implement tool to assess maternal dietary quality, and the results showed that unfavorable dietary quality during
pregnancy is associated with a higher risk of GDM. These findings will provide new insights for the exploration of preferable dietary evaluation methods and prevention and control of GDM.

**List of abbreviations**

GDM: Gestational diabetes mellitus; DBI-P: Dietary Balance Index for Pregnancy; TJBC: Tongji Birth Cohort; OGTT: Oral glucose tolerance test; FFQ: Food frequency questionnaire; CI: Confidence interval; MDS: Mediterranean Diet Score; DASH: Dietary Approaches to Stop Hypertension; HEI: Healthy Eating Index; DBI: Diet Balance Index; HBS: Higher bound score; LBS: Lower bound score; DQD: Diet quality distance; FPG: Fasting plasma glucose; 1-PBG: 1-h post-load plasma glucose; 2-PBG: 2-h post-load plasma glucose; BMI: Body mass index; SD: Standard deviation; ANOVA: One-way analysis of variance; OR: Odds ratios; CNY: Chinese Yuan; En%: Percentage energy

**Declarations**

**Ethics approval and consent to participate**

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Review Committee of the Tongji Medical College, Huazhong University of Science and Technology, registered as ChiCTR1800016908 at clinicaltrials.gov (registered date: 2nd Jul, 2018). All the participants provided their written informed consent before administrating the survey.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The data that support the findings of this study are available from Tongji Medical College,
Huazhong University of Science and Technology but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Tongji Medical College, Huazhong University of Science and Technology.

Competing interests
We have no competing interests.

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Authors' contributions
SW, LH and GX designed the research. XY supervised the study conduct. SW, NW, CL, RZ, YD, HX, YL, YX, DW, and YL conducted the research. SW analyzed the data and wrote the manuscript. LH and GX coedited, revised, and finally reviewed the manuscript critically for important intellectual content. All the authors read and approved the final version of the manuscript.

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| Characteristic                        | Total (n=1122) | GDM (n=179) | Non-GDM (n=943) | P value* |
|--------------------------------------|----------------|-------------|-----------------|----------|
| Age (years)                          | 28.7±3.3       | 29.8±3.7    | 28.5±3.2        | <0.001   |
| Ethnic groups                        |                |             |                 | 0.836    |
| Ethnic Han                           | 1097 (97.8)    | 175 (97.8)  | 922 (97.8)      |          |
| Others                               | 21 (1.9)       | 3 (1.7)     | 18 (1.9)        |          |
| Missing                              | 4 (0.4)        | 1 (0.6)     | 3 (0.3)         |          |
| Pre-pregnancy BMI (kg/m²)            |                |             |                 |          |
| <18.5                                | 213 (18.8)     | 15 (8.4)    | 193 (20.2)      | <0.001   |
| 18.5-23.9                            | 779 (69.4)     | 122 (68.2)  | 657 (69.7)      | <0.001   |
| 24-27.9                              | 116 (10.3)     | 31 (17.3)   | 85 (9.0)        |          |
| ≥28                                  | 34 (3.0)       | 11 (6.1)    | 23 (2.4)        |          |
| Education levels (years)             |                |             |                 | 0.017    |
| <9                                   | 80 (7.1)       | 22 (12.3)   | 58 (6.2)        |          |
| 10-12                                | 175 (15.6)     | 29 (16.2)   | 146 (15.5)      |          |
| 13-15                                | 352 (31.4)     | 53 (29.6)   | 299 (31.7)      |          |
| ≥16                                  | 513 (45.7)     | 74 (41.3)   | 439 (46.6)      |          |
| Missing                              | 2 (0.2)        | 1 (0.6)     | 1 (0.1)         |          |
| Average personal monthly income (CNY)|                |             |                 | 0.455    |
| ≤3000                                | 13 (1.2)       | 4 (2.2)     | 9 (1.0)         |          |
| 3000-4999                            | 135 (12.0)     | 24 (13.4)   | 111 (11.8)      |          |
| 5000-9999                            | 641 (57.1)     | 94 (52.5)   | 547 (58.0)      |          |
| ≥10000                               | 308 (27.5)     | 49 (27.4)   | 259 (27.5)      |          |
| Missing                              | 25 (2.2)       | 8 (4.5)     | 17 (4.5)        |          |
| Primiparity (yes)                    | 934 (83.2)     | 149 (83.2)  | 785 (83.2)      | 0.999    |
| Family history of diabetes (yes)     | 121 (10.8)     | 34 (19.0)   | 87 (9.2)        | <0.001   |
| Family history of hypertension (yes) | 287 (25.6)     | 38 (21.2)   | 249 (26.4)      | 0.164    |
| Smoking (yes)                        | 32 (2.9)       | 2 (1.1)     | 30 (3.2)        | 0.129    |
| Alcohol drinking (yes)               | 67 (6.0)       | 11 (6.1)    | 56 (5.9)        | 0.915    |
| Physical activity (yes)              | 472 (42.1)     | 82 (45.8)   | 390 (41.4)      | 0.269    |
| History of abnormal pregnancy (yes)  | 357 (31.8)     | 58 (32.4)   | 299 (31.7)      | 0.855    |
|       | Mean ± SD | Mean ± SD | Mean ± SD | P-value |
|-------|-----------|-----------|-----------|---------|
| LBS   | 27.0±9.0  | 27.0±8.8  | 27.0±9.0  | 0.941   |
| HBS   | 6.4±4.0   | 6.3±4.2   | 6.4±4.0   | 0.826   |
| DQD   | 33.3±8.4  | 33.3±8.4  | 33.4±8.4  | 0.980   |
| FPG   | 4.57±0.38 | 4.94±0.58 | 4.50±0.28 | <0.001  |
| 1-h PBG | 7.74±1.60 | 9.73±1.63 | 7.38±1.29 | <0.001  |
| 2-h PBG | 6.69±1.31 | 8.41±1.52 | 6.36±0.97 | <0.001  |

*P* values were calculated by one-way analysis of variance (ANOVA) for continuous variables of parametrically distribution. Categorical variables were presented as frequencies (percentages) and *P* values were from chi-square test.

GDM gestational diabetes mellitus, BMI body mass index, CNY Chinese Yuan, LBS lower bound score, HBS higher bound score, DQD diet quality distance, FPG fasting plasma glucose, 1-h PBG 1-h post-load plasma glucose, 2-h PBG 2-h post-load plasma, OGTT oral glucose tolerance test.
Table 2 Scores for the DBI-P components and the percentages of participants with each score (%).

| Components                  | Score range | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score | Groups     | Score |
|-----------------------------|-------------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|
| Cereals*                    | (-12) - (-12) | GDM        | 1.1   | 2.2        | 8.4   | 22.9       | 22.3  | 24.6       | 10.6  | 4.4        | 1.1   | 1.2        | 0.0   | 1.2        |       |            |       |
|                             | (12)        | Non-GDM    | 0.1   | 0.2        | 2.9   | 7.7        | 18.0  | 21.6       | 30.0  | 11.5       | 4.8   | 2.1        | 0.7   | 0.4        |       |            |       |
| Vegetables                  | (-6) - (-6) | GDM        | 2.2   | 11.7       | 30.2  | 55.9       |       |            |       |            |       |            |       |            |       |            |       |
|                             | (0)         | Non-GDM    | 2.8   | 15.6       | 28.7  | 52.9       |       |            |       |            |       |            |       |            |       |            |       |
| Fruits                      | (-6) - (-6) | GDM        | 0.6   | 0.7        | 8.9   | 38.5       | 21.8  | 12.2       | 17.3  |           |       |            |       |            |       |            |       |
|                             | (6)         | Non-GDM    | 1.4   | 7.0        | 33.6  | 18.3       | 14.6  | 25.1       |       |            |       |            |       |            |       |            |       |
| Milk and milk products      | (-6) - (-6) | GDM        | 27.9  | 22.4       | 27.9  | 21.8       |       |            |       |            |       |            |       |            |       |            |       |
| Soybeans and its products   | (-3) - (-3) | GDM        | 57.5  | 36.9       | 5.6   |           |       |            |       |            |       |            |       |            |       |            |       |
|                             | (0)         | Non-GDM    | 56.6  | 37.5       | 5.9   |           |       |            |       |            |       |            |       |            |       |            |       |
| Nuts                        | (-3) - (-3) | GDM        | 22.9  | 21.2       | 55.9  |           |       |            |       |            |       |            |       |            |       |            |       |
|                             | (0)         | Non-GDM    | 21.2  | 23.7       | 55.1  |           |       |            |       |            |       |            |       |            |       |            |       |
| Meats†                      | (-4) - (-4) | GDM        | 38.0  | 23.4       | 22.9  | 5.6        | 10.1  |           |       |            |       |            |       |            |       |            |       |
|                             | (4)         | Non-GDM    | 31.5  | 27.6       | 23.5  | 10.3       | 7.1   |           |       |            |       |            |       |            |       |            |       |
### Aquatic products

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-4) - (0)           | 58.7  | 21.2    | 20.1    |

### Eggs

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-4) - (4)           | 33.0  | 35.2    | 20.1    | 3.9   | 7.8   |

### Iron-rich foods

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-6) - (0)           | 52.0  | 34.0    | 10.1    | 3.9   |

### Seaweed

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-4) - (0)           | 30.2  | 26.2    | 43.6    |

### Cooking oil

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (0)-(4)              | 33.5  | 46.4    | 20.1    |

### Salt

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (0) - (4)            | 25.8  | 59.5    | 14.7    |

### Drinking water

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-12) - (0)          | 0.6   | 1.6     | 14.6    | 10.0  | 26.3  | 4.4   | 42.5  |

### Dietary diversity

|                      | GDM   | Non-GDM |
|----------------------|-------|---------|
| (-12) - (0)          | 1.7   | 17.3    | 50.8    | 29.6  | 0.6   |

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*GDM* gestational diabetes mellitus  
*rice, wheat, dried legumes (exclude soybeans).*  
*red meats and products, poultry, and game.*  
*fish and shellfish.*
Iron-rich foods refer to animal blood and liver. Seaweed includes kelp, nori and sea cabbage.

Table 3 Distribution of DBI-P indicators among the participants.

| Indicators       | Range | Groups     | Mean±SD | Distribution of DBI-P indicators (n, %) | $P$ value$^*$ |
|------------------|-------|------------|---------|----------------------------------------|---------------|
| Inadequate intake | LBS$^\dagger$ 0-82 | GDM 27.0±8.8 | 0 (0.0) | 22 (12.3) | 117 (65.4) | 38 (21.2) | 2 (1.1) | 1.000 |
|                  |       | Non-GDM 27.0±9.0 | 0 (0.0) | 114 (12.1) | 622 (66.0) | 196 (20.8) | 11 (1.2) |               |
| Excessive intake | HBS$^\ddagger$ 0-34 | GDM 6.3±4.2 | 9 (5.0) | 111 (62.0) | 49 (27.4) | 10 (5.6) | 0 (0.0) | 0.453 |
|                  |       | Non-GDM 6.4±4.0 | 40 (4.2) | 563 (59.7) | 304 (32.2) | 36 (3.8) | 0 (0.0) |               |
| Overall imbalance | DQD$^\S$ 0-90 | GDM 33.3±8.4 | 0 (0.0) | 3 (1.7) | 117 (65.4) | 58 (32.4) | 1 (0.6) | 0.564 |
|                  |       | Non-GDM 33.4±8.4 | 0 (0.0) | 28 (3.0) | 578 (61.3) | 326 (34.6) | 11 (1.2) |               |

DBI-P Diet Balance Index for Pregnancy, $SD$ standard deviation, $LBS$ lower bound score, $HBS$ higher bound score, $DQD$ diet quality distance, $GDM$ gestational diabetes mellitus

$^*$ $P$ values were calculated by Chi-square test for comparing the distribution of three indicators between GDM and non-GDM groups.

$^\dagger$ The range of LBS is 0-82; No problem: 0; Almost no problem: 1-16; Low level: 17-33; Moderate level: 34-49; High level: >49.

$^\ddagger$ The range of HBS is 0-34; No problem: 0; Almost no problem: 1-7; Low level: 8-14; Moderate level: 15-20; High level: >20.

$^\S$ The range of DQD is 0-90; No problem: 0; Almost no problem: 1-18; Low level: 19-36; Moderate level: 37-54; High level: >54
Table 4 Associations between the score of DBI-P components and plasma glucose level.

| Components                        | Fasting plasma glucose | 1-h plasma glucose | 2-h plasma glucose |
|-----------------------------------|------------------------|--------------------|--------------------|
|                                   | $\beta$ (95% CI) | $P$ Value | $\beta$ (95% CI) | $P$ Value | $\beta$ (95% CI) | $P$ Value |
| Cereals                           | 0.00 (-0.02, 0.01)  | 0.796             | -0.03 (-0.09, 0.03) | 0.395      | 0.01 (-0.04, 0.06) | 0.711     |
| Vegetables                        | -0.02 (-0.04, 0.00) | 0.055             | 0.08 (-0.01, 0.16) | 0.071      | 0.05 (-0.01, 0.12) | 0.114     |
| Fruits                            | -0.01 (-0.02, 0.01) | 0.291             | **-0.05 (-0.10, -0.01)** | **0.041** | -0.02 (-0.06, 0.02) | 0.395     |
| Milk and milk products           | 0.01 (-0.01, 0.02)  | 0.436             | -0.01 (-0.06, 0.04) | 0.666      | 0.01 (-0.04, 0.05) | 0.772     |
| Soybeans and its products        | 0.01 (-0.02, 0.04)  | 0.479             | -0.01 (-0.13, 0.10) | 0.798      | 0.03 (-0.06, 0.12) | 0.501     |
| Nuts                              | **0.03 (0.01, 0.05)** | **0.011**         | 0.02 (-0.06, 0.11) | 0.584      | 0.00 (-0.07, 0.07) | 0.993     |
| Meats                             | 0.01 (-0.01, 0.02)  | 0.443             | -0.02 (-0.07, 0.04) | 0.561      | 0.02 (-0.03, 0.06) | 0.497     |
| Aquatic products                  | 0.00 (-0.01, 0.02)  | 0.609             | 0.06 (-0.01, 0.13) | 0.113      | 0.05 (-0.01, 0.10) | 0.112     |
| Eggs                              | **0.01 (0.01, 0.03)** | **0.040**         | 0.05 (-0.01, 0.10) | 0.073      | 0.02 (-0.02, 0.07) | 0.322     |
| Iron-rich foods                   | -0.01 (-0.02, 0.01) | 0.376             | 0.03 (-0.04, 0.10) | 0.399      | 0.00 (-0.05, 0.06) | 0.918     |
| Seaweed                           | 0.00 (-0.02, 0.01)  | 0.836             | 0.02 (-0.04, 0.07) | 0.621      | 0.02 (-0.03, 0.07) | 0.475     |
| Cooking oil                       | 0.00 (-0.02, 0.03)  | 0.808             | -0.06 (-0.16, 0.05) | 0.302      | 0.00 (-0.08, 0.09) | 0.922     |
| Salt                              | 0.02 (0.00, 0.03)   | 0.100             | 0.02 (-0.05, 0.10) | 0.556      | 0.04 (-0.03, 0.10) | 0.271     |
| Dietary diversity                 | -0.02 (-0.04, 0.00) | 0.111             | -0.08 (-0.17, 0.01) | 0.098      | -0.06 (-0.14, 0.01) | 0.100     |

CI confidence interval

*Adjusted for maternal age, ethnicity, pre-pregnancy BMI, education levels, average personal monthly income, primiparity, family history of diabetes, family history of hypertension, smoking, alcohol drinking, physical activity, history of abnormal pregnancy, energy intake. Values are linear regression coefficients and 95% CI. $P$ values in bold are statistically significant at the 0.05 level.
Table 5 Participants’ nutrients and foods average daily intake in various dietary patterns (n=1122).

| Characteristics                  | Overall         | Dietary patterns          |       |       |       |       | P value |
|----------------------------------|-----------------|---------------------------|-------|-------|-------|-------|---------|
|                                  |                 | A       | B       | C       | D       | E       |         |
| n (%)                            | 1122 (100.0)    | 206 (18.4) | 669 (59.6) | 82 (7.3) | 73 (6.5) | 92 (8.2) |         |
| Total energy intake (kcal)       | 2132.4±495.0    | 2336.7±293.4 | 2002.6±340.3 | 1376.4±364.8 | 3000.8±434.6 | 2603.6±379.4 | <0.001 |
| Protein (g/day)                  | 61.3±16.1       | 72.4±10.6 | 56.8±10.7 | 36.7±10.2 | 88.6±15.5 | 70.2±13.0 | <0.001 |
| Total fat (g/day)                | 76.0±25.5       | 88.9±16.8 | 68.9±19.2 | 42.2±17.3 | 116.5±22.0 | 96.6±22.7 | <0.001 |
| Carbohydrate (g/day)             | 308.6±73.4      | 320.6±52.7 | 296.1±59.0 | 217.4±59.1 | 410.8±74.4 | 372.9±75.3 | <0.001 |
| Calories from protein (%)        | 12.4±1.4        | 11.4±1.5 | 10.7±1.6 | 11.8±1.2 | 10.8±1.4 | 11.5±1.5 | 0.004  |
| Calories from total fat (%)      | 34.2±5.0        | 30.9±6.3 | 27.2±7.6 | 35.0±4.7 | 33.5±6.6 | 31.7±6.5 | <0.001 |
| Calories from carbohydrate (%)   | 54.8±5.2        | 59.2±6.7 | 63.5±7.7 | 54.7±5.0 | 57.2±7.1 | 58.2±6.9 | <0.001 |
| Dietary cholesterol (mg/day)*    | 318.3±152.2     | 379.5±104.5 | 305.5±147.4 | 268.7±225.3 | 338.9±134.5 | 302.1±171.0 | <0.001 |
| Dietary vitamin A (mg/day)*      | 525.0±266.0     | 628.9±344.1 | 496.2±239.0 | 430.9±196.3 | 605.2±227.6 | 521.6±258.3 | <0.001 |
| Dietary vitamin C (mg/day)*      | 190.4±71.3      | 182.8±60.1 | 188.5±70.3 | 197.8±97.1 | 197.4±68.6 | 209.2±73.5 | 0.028  |
| Dietary vitamin E (mg/day)*      | 41.8±13.2       | 43.2±12.0 | 41.2±13.1 | 39.8±15.2 | 44.3±14.6 | 43.3±12.3 | 0.048  |
| Dietary magnesium (mg/day)*      | 332.2±48.0      | 343.2±46.7 | 329.6±47.1 | 334.7±60.4 | 335.7±40.1 | 320.7±46.3 | 0.001  |
| Dietary calcium (mg/day)*        | 589.2±175.9     | 669.6±162.5 | 577.6±176.5 | 525.8±198.8 | 588.1±125.4 | 550.4±157.2 | <0.001 |
| Dietary total iron (mg/day)*     | 19.6±2.4        | 20.1±2.3 | 19.5±2.4 | 19.7±2.9 | 19.6±2.1 | 18.9±2.3 | 0.001  |
| Dietary zinc (mg/day)*           | 10.9±1.4        | 11.5±1.8 | 10.8±1.3 | 10.4±1.3 | 10.8±0.9 | 10.4±1.1 | <0.001 |
| Dietary selenium (ug/day)*       | 37.4±9.4        | 42.9±9.6 | 36.3±9.0 | 33.1±8.4 | 40.1±8.1 | 34.8±8.3 | <0.001 |
| Category                                   | Mean ± Standard Deviation | Mean ± Standard Deviation | Mean ± Standard Deviation | Mean ± Standard Deviation | Mean ± Standard Deviation | Mean ± Standard Deviation | p Value |
|-------------------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------|
| Cereals (g/day)†                          | 267.7 ± 79.6              | 274.9 ± 55.9              | 259.5 ± 67.9              | 190.2 ± 69.6              | 341.6 ± 100.0             | 321.1 ± 108.2              | <0.001  |
| Grains (g/day)                            | 31.6 ± 34.8               | 41.7 ± 34.0               | 26.3 ± 27.7               | 15.4 ± 17.6               | 51.7 ± 51.6               | 46.0 ± 55.6                | <0.001  |
| Vegetables (g/day)                        | 327.6 ± 141.5             | 379.6 ± 126.6             | 307.2 ± 129.4             | 199.9 ± 115.7             | 446.2 ± 141.1             | 378.9 ± 148.5              | <0.001  |
| Fruits (g/day)                            | 477.1 ± 250.5             | 462.7 ± 223.4             | 441.6 ± 226.8             | 338.5 ± 180.5             | 724.3 ± 292.1             | 694.6 ± 249.9              | <0.001  |
| Milk and milk products (g/day)            | 200.3 ± 142.8             | 278.0 ± 135.9             | 180.7 ± 132.4             | 85.1 ± 94.6               | 281.3 ± 149.3             | 206.7 ± 146.6              | <0.001  |
| Soybeans and its products (g/day)‡        | 7.8 ± 7.8                 | 9.6 ± 7.2                 | 7.1 ± 7.7                 | 4.5 ± 4.7                 | 12.4 ± 8.2                | 8.3 ± 8.9                  | <0.001  |
| Nuts (g/day)                              | 15.3 ± 16.4               | 20.2 ± 16.0               | 12.9 ± 12.6               | 9.2 ± 20.9                | 27.0 ± 20.4               | 17.9 ± 24.1                | <0.001  |
| Meats (g/day)§                            | 47.5 ± 32.0               | 60.7 ± 24.7               | 40.9 ± 26.2               | 18.9 ± 22.5               | 87.2 ± 34.3               | 60.4 ± 44.3                | <0.001  |
| Aquatic products (g/day)‖                 | 33.7 ± 30.2               | 49.8 ± 30.6               | 29.2 ± 26.5               | 12.8 ± 17.7               | 57.2 ± 41.7               | 30.1 ± 27.1                | <0.001  |
| Eggs (g/day)                              | 33.6 ± 21.8               | 42.9 ± 14.9               | 30.4 ± 19.7               | 19.1 ± 19.8               | 46.5 ± 27.1               | 39.6 ± 30.0                | <0.001  |
| Iron-rich foods (g/day)§                  | 2.2 ± 4.4                 | 3.8 ± 5.7                 | 1.6 ± 3.0                 | 0.6 ± 1.4                 | 5.8 ± 8.9                 | 2.0 ± 3.6                  | <0.001  |
| Cooking oil (g/day)                       | 37.1 ± 15.2               | 41.0 ± 12.2               | 34.0 ± 13.5               | 21.6 ± 11.8               | 54.9 ± 13.1               | 50.0 ± 13.9                | <0.001  |
| Drinking water (ml/day)                   | 1224.7 ± 545.3            | 1537.1 ± 539.0            | 1174.2 ± 499.3            | 786.8 ± 485.1             | 1486.3 ± 467.1            | 1075.2 ± 553.4             | <0.001  |

SD standard deviation
†Indicates values are energy-adjusted (2100 kcal/day).
‡Denotes rice, wheat, dried legumes (exclude soybean).
§Denotes soybeans, soybean milk, bean curd, and so on.
‖Denotes red meats and products, poultry and game.
¶Denotes fish and shellfish;
§Denotes animal blood and liver.

P values were calculated by One-way analysis of variance (ANOVA).
Table 6 The contribution of nutrients and food intake to the association between dietary patterns and GDM (n=1122)\textsuperscript{†}.

| GDM, n (%) | A          | B          | C          | D          | E          |
|-----------|------------|------------|------------|------------|------------|
|           | 36 (17.5)  | 100 (14.9) | 12 (14.6)  | 13 (17.8)  | 18 (19.6)  |
| Adjusted models\textsuperscript{†} | 0.69 (0.34, 1.36) | 0.51 (0.26, 0.99) | 0.27 (0.09, 0.81) | 1.13 (0.48, 2.67) | 1 (Reference) |

Nutrients

| Adjusted model + dietary protein (g/day) | 0.72 (0.35, 1.48) | 0.51 (0.26, 0.99) | 0.26 (0.09, 0.80) | 1.19 (0.49, 2.88) | 1 (Reference) |
| Adjusted model + dietary total fat (g/day) | 0.69 (0.35, 1.38) | 0.53 (0.27, 1.05) | 0.29 (0.10, 0.88) | 1.11 (0.47, 2.63) | 1 (Reference) |
| Adjusted model + dietary carbohydrate (g/day) | 0.67 (0.34, 1.34) | 0.53 (0.27, 1.03) | 0.29 (0.10, 0.87) | 1.09 (0.46, 2.59) | 1 (Reference) |
| Adjusted model + protein, En% | 0.69 (0.34, 1.41) | 0.51 (0.26, 0.99) | 0.27 (0.09, 0.81) | 1.14 (0.48, 2.75) | 1 (Reference) |
| Adjusted model + total fat, En% | 0.69 (0.35, 1.37) | 0.53 (0.27, 1.04) | 0.30 (0.10, 0.91) | 1.13 (0.48, 2.66) | 1 (Reference) |
| Adjusted model + carbohydrate, En% | 0.67 (0.34, 1.34) | 0.53 (0.27, 1.03) | 0.30 (0.10, 0.91) | 1.11 (0.47, 2.62) | 1 (Reference) |
| Adjusted model + dietary cholesterol (mg/day)\textsuperscript{‡} | 0.68 (0.34, 1.35) | 0.52 (0.27, 1.03) | 0.29 (0.09, 0.89) | 1.10 (0.47, 2.62) | 1 (Reference) |
| Adjusted model + dietary vitamin A (mg/day)\textsuperscript{‡} | 0.68 (0.34, 1.36) | 0.51 (0.26, 1.00) | 0.28 (0.09, 0.84) | 1.12 (0.47, 2.65) | 1 (Reference) |
| Adjusted model + dietary vitamin C (mg/day)\textsuperscript{‡} | 0.69 (0.35, 1.39) | 0.50 (0.26, 0.99) | 0.27 (0.09, 0.82) | 1.13 (0.48, 2.68) | 1 (Reference) |
| Adjusted model + dietary vitamin E (mg/day)\textsuperscript{‡} | 0.68 (0.34, 1.36) | 0.50 (0.25, 0.97) | 0.26 (0.09, 0.79) | 1.14 (0.48, 2.68) | 1 (Reference) |
| Adjusted model + dietary magnesium (mg/day)\textsuperscript{‡} | 0.68 (0.34, 1.36) | 0.51 (0.26, 0.99) | 0.27 (0.09, 0.81) | 1.13 (0.48, 2.67) | 1 (Reference) |
| Adjusted model + dietary calcium (mg/day)\textsuperscript{‡} | 0.65 (0.32, 1.30) | 0.51 (0.26, 0.99) | 0.29 (0.09, 0.86) | 1.09 (0.46, 2.59) | 1 (Reference) |
| Adjusted model + dietary total iron (mg/day)\textsuperscript{‡} | 0.65 (0.33, 1.30) | 0.51 (0.26, 0.99) | 0.28 (0.09, 0.85) | 1.03 (0.43, 2.45) | 1 (Reference) |
| Adjusted model + dietary zinc (mg/day)\textsuperscript{‡} | 0.67 (0.33, 1.36) | 0.50 (0.26, 0.98) | 0.27 (0.09, 0.81) | 1.12 (0.47, 2.65) | 1 (Reference) |
GDM gestational diabetes mellitus, En% percentage energy.

*Logistic regression models were conducted, presented in odds ratios and 95% CIs (confidence intervals).

†Adjusted models were adjusted for maternal age, ethnicity, pre-pregnancy BMI, educational level, average personal monthly income, primiparity, family history of diabetes, family history of hypertension, smoking, alcohol drinking, physical activity, history of abnormal pregnancy, total energy intake.

‡Indicates values are energy-adjusted (2100 kcal/day).

| Food groups                                      | Odds Ratio (95% CI)       | 1 (Reference) |
|-------------------------------------------------|---------------------------|---------------|
| Adjusted model + dietary selenium (ug/day)‡      | 0.68 (0.34, 1.37)         | 1.13 (0.47, 2.68) |
| Adjusted model + cereals (g/day)                | 0.69 (0.35, 1.37)         | 1.14 (0.48, 2.68) |
| Adjusted model + whole grains (g/day)            | 0.70 (0.35, 1.38)         | 1.17 (0.49, 2.76) |
| Adjusted model + vegetables (g/day)              | 0.69 (0.35, 1.37)         | 1.13 (0.48, 2.66) |
| Adjusted model + fruits (g/day)                  | 0.58 (0.28, 1.19)         | 1.08 (0.45, 2.55) |
| Adjusted model + milk and milk products (g/day)  | 0.69 (0.35, 1.39)         | 1.14 (0.48, 2.68) |
| Adjusted model + soybean and its products (g/day)| 0.70 (0.35, 1.40)         | 1.17 (0.49, 2.78) |
| Adjusted model + nuts (g/day)                    | 0.68 (0.34, 1.34)         | 1.11 (0.47, 2.62) |
| Adjusted model + meats (g/day)                   | 0.69 (0.35, 1.37)         | 1.12 (0.47, 2.66) |
| Adjusted model + aquatic products (g/day)        | 0.74 (0.37, 1.49)         | 1.22 (0.51, 2.91) |
| Adjusted model + eggs (g/day)                    | 0.69 (0.35, 1.38)         | 1.12 (0.47, 2.65) |
| Adjusted model + iron-rich foods (g/day)         | 0.73 (0.37, 1.45)         | 1.29 (0.54, 3.10) |
| Adjusted model + cooking oil (g/day)             | 0.72 (0.36, 1.43)         | 1.16 (0.49, 2.74) |
Fig. 1 Flow chart for selection of study participants from TJBC study

Pregnant women who reported a singleton pregnancy and completed FFQ between 13th and 28th week of gestation in the cohort (n=1557)

Excluded:
missing GDM diagnosis (n=188)
severe absence of baseline data (n=239)
previous diagnosis of GDM or type 2 diabetes (n=5)

Eligible for analysis (n=1125)

Further excluded:
implausible total energy intake: <600 or >4500 kcal/day (n=3)

Final inclusion in the study (n=1122)