

Lower Income Levels Correlate With Increased Prevalence of Gestational Diabetes Mellitus: A Systematic Review and Network Meta-Analysis

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Research

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Abstract

Background

Income level is an important factor that influences the occurrence of gestational diabetes. Thus, this systematic review and network meta-analysis aimed at evaluating the correlation between income levels and the prevalence of gestational diabetes.

Methods

Relevant published studies were searched in Pubmed, Web of Science, Cochrane library, and Ovid from the establishment time of database to January 3, 2020. Finally, 13 eligible clinical studies involving 1,817,801 women were selected from a total of 3776 studies and included in this study. The statistical softwares Revman5.3 and Stata14.0 were used to compare the prevalence of gestational diabetes in five different income levels; low, lower middle, medium, upper middle, and high.

Results

The incidences of gestational diabetes in people with different economic income levels were: high income <middle income <upper middle income <lower middle income <low income.

Conclusion

There is no linear correlation between income levels and incidences of gestational diabetes. However, the overall prevalence of gestational diabetes is inversely proportional to income level, that is, the higher the income level, the lower the prevalence of gestational diabetes.

Background

Gestational diabetes mellitus (GDM) refers to carbohydrate intolerance of varying severity with first appearance or onset recognition during pregnancy[1, 2]. Due to the increasing abundance of material life, GDM has become one of the most common complications during pregnancy[3]. The current global incidences of GDM vary between 0.3% -28% with annual increases[4]. This disease is a health concern for pregnant women and newborns. Pregnant women with GDM are more likely to have macrosomia, because the fetus is too large to be delivered naturally, through the vagina. Therefore, the rate of caesarean section during delivery and the possibility of postpartum infection after delivery is higher[5, 6]. In addition to pregnancy associated complications, epidemiological studies have found that pregnant women with GDM have a significantly higher risk of type 2 diabetes in the future[7, 8]. The adverse effects of GDM on the newborn are manifested through giant children and hypoglycemia. Moreover, the child's long-term intelligence level is low, and their risk for developing type 2 diabetes increases in adulthood[9-12]. The GDM risk is often assessed by the glucose challenge test in 24-28 weeks' gestation women, and the results of the test help to diagnose GDM[13].

Race, gestational age, and BMI are known risk factors for GDM[14-16]. Moreover, socio-economic factors are also important factors influencing the occurrence of diabetes, including gestational diabetes. As an economic indicator of personal social wealth and quality of life, income is an integral part of socio-economic factors. Income levels determine, to some extent, the quality of the living environment, the nutritional health of the pregnant woman's diet, and the convenience of access to medical resources. Collectively, these factors affect the risk of GDM in pregnant women. Establishing the correlation between income levels and GDM will help formulate preventive and treatment measures for specific income groups with a high prevalence of GDM, thereby, helping reduce GDM incidences while improving the health of pregnant women and newborns.

Studies from various countries and regions have analyzed the correlation between personal economic income and GDM incidences. However, their conclusions are inconsistent. On the basis of 1,817,801 female participants, this study used a network meta-analysis method and collected 13 clinical trials that have been implemented worldwide to determine the correlation between GDM and income level on a larger statistical scale.

Methods

Search strategy

Medical literature on income levels and gestational diabetes mellitus were searched in the Pubmed, Web of Science, Cochrane library, Ovid databases, with search keywords 'socioeconomic status', 'income', 'financial statement' and 'gestational diabetes mellitus' from January 3, 2020. As a result, 566, 230, 6, and 2974 related studies were obtained from the above four databases. A total of 280 articles were included in the preliminary selection after filtering. Subsequently, two researchers with related background knowledge (He Qiong and Zhang Mengyuan) independently conducted the second-round literature screening. If there was any objection, a third researcher (Liu Yunfeng) would be asked for their views regarding article inclusion. After reading the titles, abstracts, and full text, 13 articles were finally included, and a total of 1,817,801 patients entered the network meta-analysis study (Figure 1).

Inclusion and exclusion criteria

According to the study purpose of this study, the specific inclusion criteria for the correlation between income levels and incidences of gestational diabetes were: i. A study population of pregnant women, including both primiparous and multiparous women; ii. Economic income levels including at least four levels of low, lower middle, medium, upper middle, and high income, stratified by quartiles, quintiles or numeric. In this study, income is defined as household income or maternal income. To make the income levels comparable between studies, currencies of other countries were converted to U.S. dollars based on the current exchange rates; c. Studies with a clear meaning of income level and diagnostic criteria for gestational diabetes; d. Studies in which the number of enrollment and the number of patients with gestational diabetes has been given, or can be calculated based on the data available in the article.

Exclusion criteria were: i.. If the study population involved the general social population, including both men and women; ii. Women with type 1, type 2 and other types of diabetes before pregnancy; iii. Patients with impaired glucose tolerance or other diseases that do not meet the diagnostic criteria for gestational diabetes; iv. Non-clinical research articles such as reviews, guidelines, or case reports.

According to the above inclusion and exclusion criteria, the quality of the selected documents was strictly controlled, and a total of 13 studies that met the conditions entered the statistical analysis stage. The information and characteristics of the included literature were summarized. The characteristics of each study including the author, year of publication, region, type of study, inclusion and exclusion criteria, diagnostic criteria for gestational diabetes, income level grading, total number of groups, number of gestational diabetes patients, and prevalence were extracted [see Additional file 1].

Literature quality assessment

According to the Cochrane Handbook for Systematic Reviews of Interventions, Revman 15.3 software was used to evaluate the quality of the 13 included clinical studies. Quality is mainly evaluated from seven aspects; random sequence generation, allocation concealment, blindness of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting of research results and other source biases. Quality evaluation is divided into three levels of low, unclear and high. The higher the quality of the article, the more reliable its conclusions. After comprehensive analysis of the 13 included articles, it was concluded that their quality was high, and subsequent statistical analysis could, therefore, be trusted. The results of the evaluation are shown in Figure 2.

Bias Evaluation

For each of the 13 studies included in this article, five different income levels were compared in pairs to evaluate publication bias, as shown in Figure 3. From the basic symmetry of the funnel graph, it was concluded that the possibility of small sample impact and publication bias in this study was low, the quality of included articles was high, and the statistical results data have clinical significance.

Overall inconsistency estimation

The overall inconsistency of the included literature was tested. The statistical result was $p = 0.083$ ($\neq 0.05$). Therefore, the overall inconsistency of the 13 studies included in this article was not significant (Figure 4). There were reasons to believe that the consistency of the 13 articles was good, therefore, local inconsistencies were used to further evaluate the quality of the included 13 articles.

Local inconsistency test

Local inconsistency was tested through the node-splitting method. It was found that the p value in each comparison was greater than 0.05. Therefore, there was no significant local inconsistency in the network meta-analysis, and it can be tested by the consistency model (Figure 5).

Consistency evaluation

A total of 13 studies and 5 income levels formed a closed loop, and the closed-loop was tested for consistency (Figure 6). It was found that the closed-loop consistency was good.

Results

Network diagram

Figure 7 shows the network diagram. The five income levels included in this study are represented by 1, 2, 3, 4, and 5, respectively. The specific correspondence is 1 for low income, 2 for lower middle income, 3 for middle income, 4 for upper middle income, and 5 for high income. The presence of a line segment between the two numbers indicates the presence of a direct comparison between the two groups while the absence of a line segment indicates the absence of a direct comparison between the two groups. In this study, all the comparisons between different income level groups were direct comparison, which means that there was no need to indirectly analyze data to obtain relative results, so the results have high credibility. Thickness of the line segment between the two points indicates the number of study groups included in the comparison. From the network diagram, it can be concluded that the number of participants in the low-, lower middle-, upper middle-, and high-level income groups is big, while the number in the middle income group is small.

Network meta-analysis results

There were 10 direct comparisons among the 5 income levels. The effects of the 5 income levels on the prevalence of gestational diabetes were found to be significantly different ($p < 0.05$). The relative risks and 95% confidence intervals for comparisons between groups are shown in Figure 8.

The prevalence of gestational diabetes in different income levels

The group with a higher SUCRA value indicates a lower prevalence of gestational diabetes. The incidences of gestational diabetes in the five economic income groups from low to high was: high income < middle income < upper middle income < lower middle income < low income.

Discussion

We found that the prevalence of gestational diabetes among the five income classes is high income < middle income < upper middle income < lower middle income < low income. Among them, the high-income, upper middle income, and middle income groups exhibited higher SUCRA values, with small differences. Therefore, it can be considered that GDM risk is low in people with incomes above the middle level. In contrast, the SUCRA values of the low income and lower middle income groups were significantly smaller than the other three groups, implying that the prevalence of GDM was significantly higher in the low-income groups.

There was no strict linear correlation between the level of income and the incidence of gestational diabetes, but there was an overall negative correlation between the prevalence of gestational diabetes and income levels, that is, the higher the income level, the lower the prevalence of gestational diabetes. Our results were obtained from pregnant women without obvious complications, and cannot be extrapolated to those patients who had impaired glucose tolerance, type 1, type 2 or other types of diabetes before pregnancy.

Socio-economic status indicators are differently associated with health outcomes in general and during different phases of life[17]. The results of pooled estimates revealed that pregnant women with high income levels have healthier pregnancy outcomes, which may be associated with the advanced medical resources and healthy dietary and sports concepts brought about by a solid economic foundation. Meanwhile, education can also be used to explain the relationship between income level and GDM. Educational experience usually determines one's future income level. Women with higher income levels usually have a better educational and cultural background, therefore, they pay more attention to health checks during pregnancy. Once their blood glucose levels deviate from the normal, they seek medical treatment in time. At the same time, high-income groups have more opportunities to have nutritional diets, which helps in maintaining BMI within the normal ranges and reducing the risk of GDM. Conversely, Subrina *et al.* [18]found that the risk of GDM was significantly higher among women with higher household income. They attributed their finding to the fact that higher income groups are more likely to engage in sedentary work, which may increase the risk of obesity and GDM. Given these findings, income levels may influence the prevalence of GDM through various ways.

There are several highlights in this study. First, to our knowledge, this is the first network meta-analysis of the relationship between GDM prevalence and different income levels. We grouped the study population into 5 income levels. Our findings will help develop suitable preventive and therapeutic measures for potential GDM patients of different income levels. Second, a total of 1,817,801 globally distributed women were included in this study. Based on the huge statistical population, the results of this study are generally representative.

However, there are a few limitations associated with our study. First, because there is no internationally unified GDM diagnostic standard[19, 20], there may exist deviations in the number of confirmed GDM patients included in different studies. More clinical studies are needed to accurately and objectively reveal the correlation between income and GDM incidences after the international unified diagnostic standard is updated. Second, differences in income categories across studies may result in the heterogeneity of pooled estimates. Though we have converted currencies of other countries to U.S. dollars based on the current exchange rates, the income levels are not absolutely comparable due to different standards of income classification across studies. Another limitation is that many studies included did not describe and adjust confounding variables, such as gestational age, smoking status and educational levels, which may also play a role in GDM occurrence. Thus, the pooled estimates may be confounded.

Conclusions

There is no linear correlation between income levels and gestational diabetes incidences. However, the overall prevalence of gestational diabetes is inversely proportional to income level, that is, the higher the income level, the lower the prevalence of gestational diabetes. Further clinical studies should be conducted to reveal the correlation between income level and GDM incidences.

Abbreviations

GDM: Gestational diabetes mellitus; BMI: Body Mass Index; SUCRA: The surface under the cumulative ranking curve; RR: relative risk.

Declarations

Ethical approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The data that support the review findings of this study are included in the manuscript.

Competing interests

There are no competing interests.

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Authors' contributions

He Qiong: data extraction, writing the manuscript; Zhang Mengyuan: software analysis; Yongle Wang: revising the manuscript; Zhang Yi: topic selection; Liu Yunfeng: supervision.

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Figures

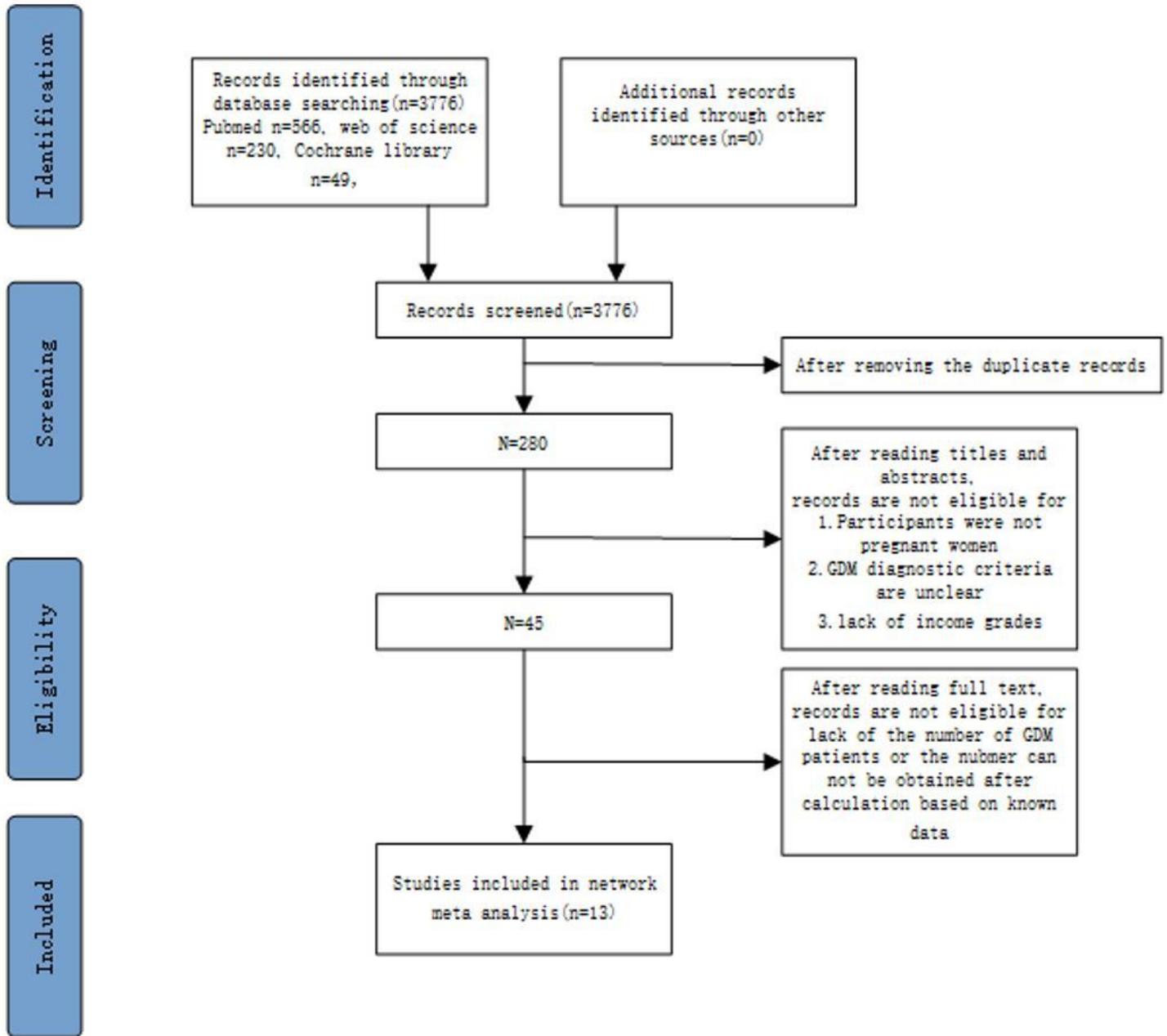


Figure 1

Flow diagram for selection of studies

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Abdulbari Bener 2011	?	?	+	+	+	+	+
Andrew Collier 2017	?	?	+	+	+	+	?
Bin Liu 2019	?	?	+	?	+	?	+
G. Chodick 2010	+	?	?	?	+	?	+
G. X. Shen 2015	+	?	?	?	+	?	+
Jinnan liu 2018	?	-	?	+	+	+	+
K. Rönö 2018	+	?	?	?	+	?	+
Kirke AB 2014	?	?	+	+	?	-	?
L. Song 2017	+	+	-	?	+	-	?
Liwei Chen 2019	+	-	+	+	+	+	?
Marion Abouzeid 2015	+	+	+	-	?	+	?
Subrina Jesmin 2013	-	+	+	+	+	+	+
Vibeke Anna 2008	+	?	?	?	+	?	+

Figure 2

Literature quality assessment. Green indicates low risk of bias, yellow indicates unclear risk of bias, while red indicates high risk of bias. The 13 articles included in this study were of a high overall quality.

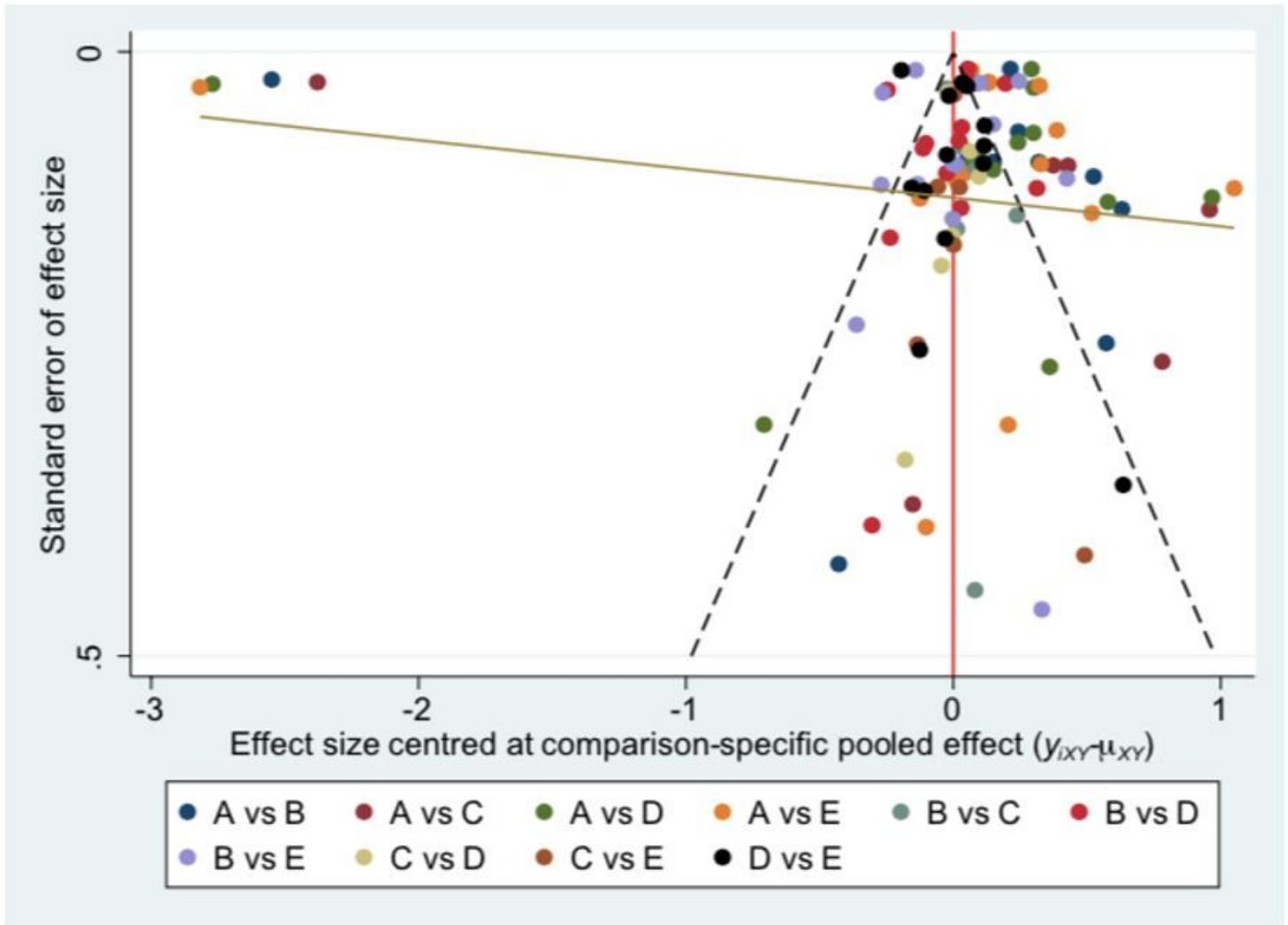


Figure 3

Funnel plot. The income levels as indicated by the letters in the figure are: A for low income, B for lower middle income, C for middle income, D for upper middle income, and E for high income. The red line represents the combined relative risk (RR) value, while the two dashed lines represent the 95% confidence interval. From the basic symmetry of the funnel chart, there was less possibility of small sample research and publication bias among the five income classifications.

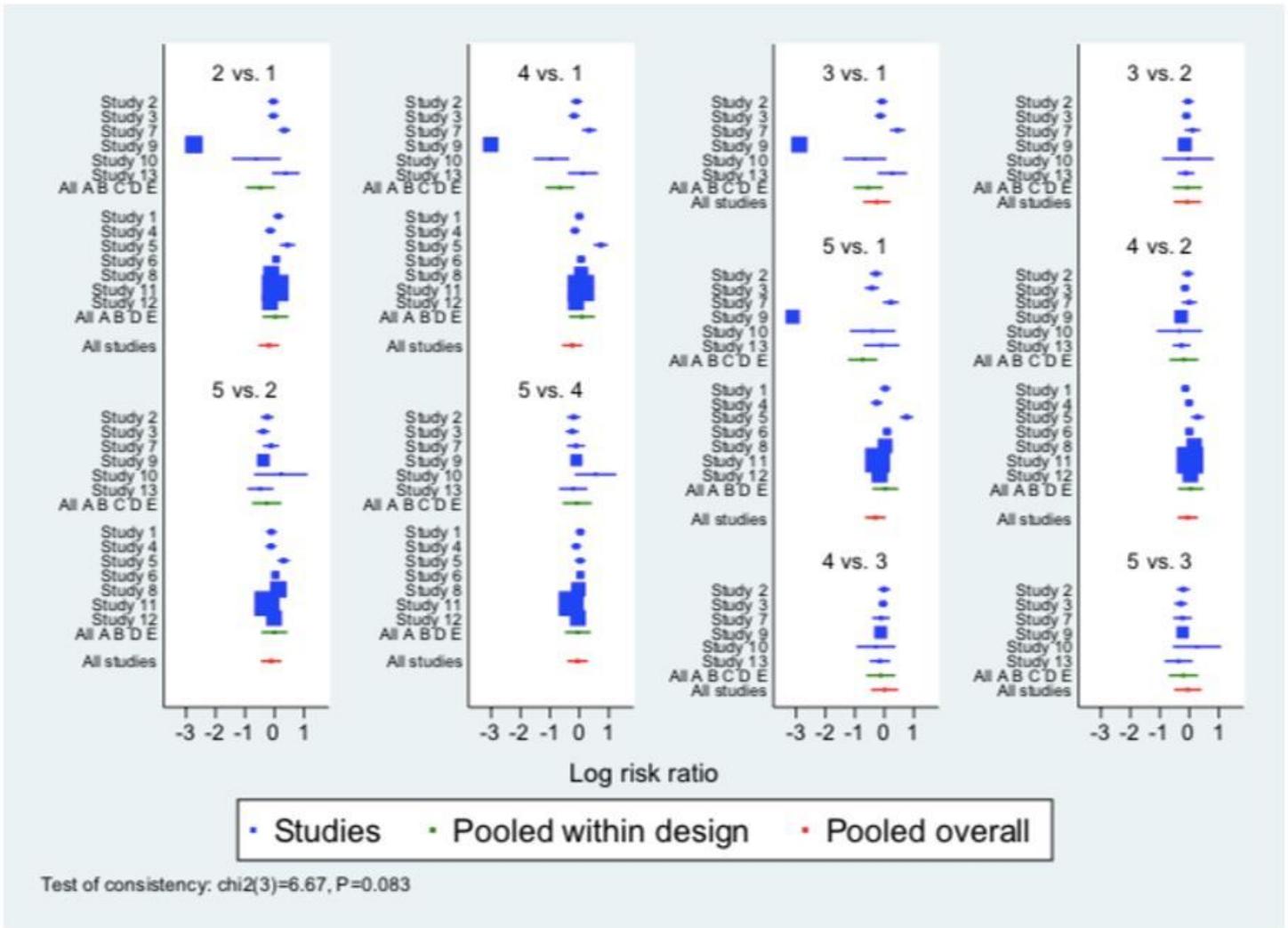


Figure 4

Overall inconsistency test evaluation. The results show that $p = 0.083$, therefore, there was no significant inconsistency in this network meta-analysis.

Side	Direct Coef.	Std. Err.	Indirect Coef.	Std. Err.	Difference Coef.	Std. Err.	P>|z|	tau
A B	.	.	.	.	.	.	.	.
A C +	-.5389165	.2488367	.8111058	.483383	-1.350022	.5444273	0.013	.5805353
A D	.	.	.	.	.	.	.	.
A E	.	.	.	.	.	.	.	.
B C +	-.0612763	.2665783	-.0719007	.5199528	.0106244	.584588	0.985	.6268243
B D	.	.	.	.	.	.	.	.
B E	.	.	.	.	.	.	.	.
C D +	-.1200077	.2610081	.5189594	.5113228	-.6389671	.572718	0.265	.6172379
C E +	-.1970067	.2639112	.4936838	.5105181	-.6906905	.5769887	0.231	.6144462
D E	.	.	.	.	.	.	.	.

Figure 5

Evaluation of local inconsistency. The results show that p value in each comparison was greater than 0.05, which means no significant inconsistency existed.

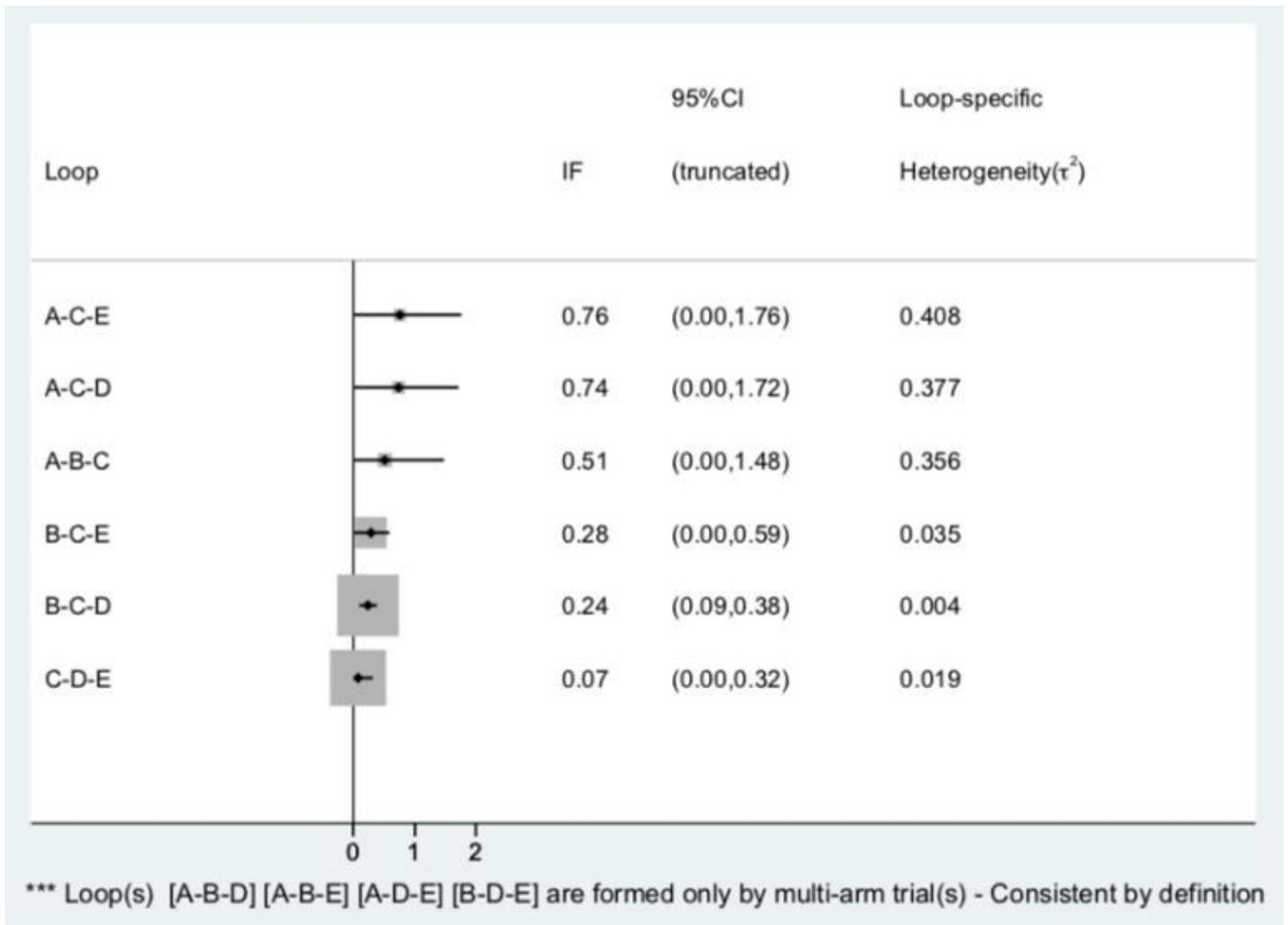


Figure 6

Consistency evaluation. The results in the figure show that the inconsistency factors (IF) were 0.76, 0.74, 0.51, 0.28, 0.24, 0.07. The lower limit of 95% CI was 0, indicating that the closed-loop consistency was good.

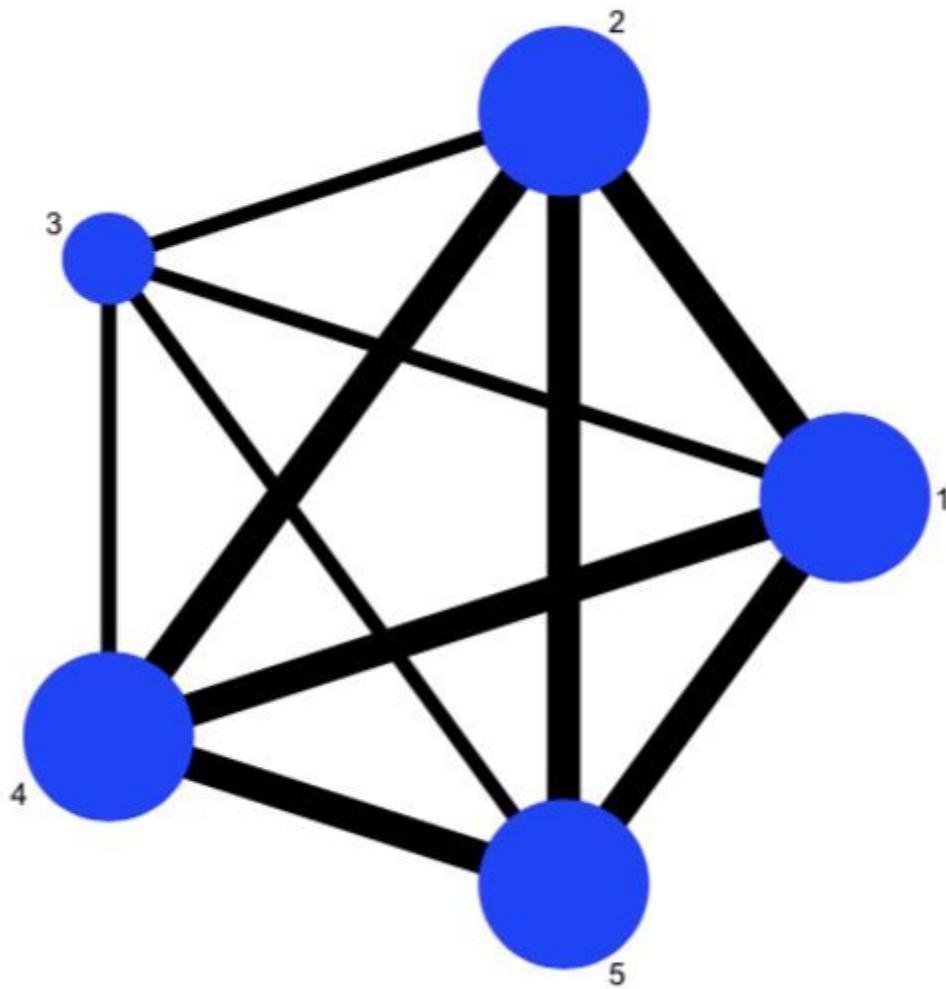


Figure 7

Network meta-analysis of the correlation between income level and incidences of gestational diabetes. The numbers in the network diagram represent groups of different income levels, of which 1 represents low income, 2 represents lower middle income, 3 represents middle income, and 4 represents upper middle income, 5 stands for high income. The size of the blue dots represent the number of people included in each group. The thickness of line segment between two points indicates the number of study groups directly compared between the two.

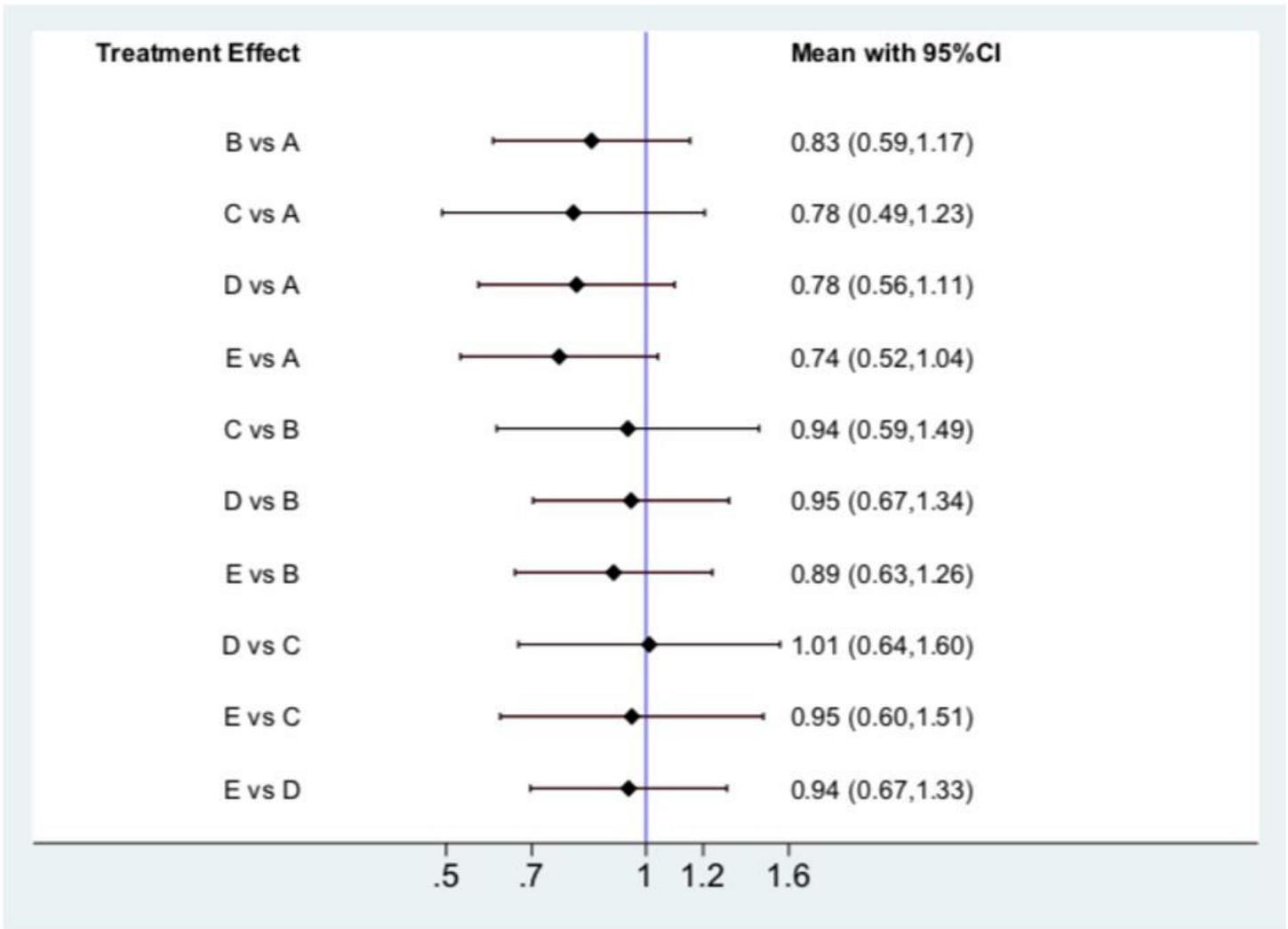


Figure 8

Forest plot. Letters in the figure represent different income levels, where A represents low income, B represents lower middle income, C represents middle income, D represents upper middle income, and E represents high income. The RR of each group of letters is the relative risk, and the 95% CI is the 95% confidence interval.

Treatment	SUCRA	PrBest	MeanRank
A	10.6	0.5	4.6
B	47.2	10.8	3.1
C	60.2	31.3	2.6
D	59.7	20.2	2.6
E	72.3	37.2	2.1

Figure 9

SUCRA value ranking. The letters in the figure respectively represent five income levels, where A represents low income, B represents lower middle income, C represents middle income, D represents upper middle income, and E represents high income. The SUCRA values of the five income levels are ranked from high to low as E > C > D > B > A. That is to say, the prevalence of gestational diabetes among the five income classes is high income < middle income < upper middle income < lower middle income < low income.

Supplementary Files

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