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SYSTEMATIC REVIEW

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Association between maternal dietary diversity during pregnancy and birth outcomes: evidence from a systematic review and meta-analysis

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Abstract

Background Maternal nutrition is a key factor influencing birth and offspring health outcomes in later life. Dietary diversity (DD) is a proxy for the macro/micronutrient adequacy of an individual's diet. There is inadequate comprehensive evidence regarding maternal nutrition during pregnancy, measured through DD and birth outcomes. This study aimed to provide extensive evidence on maternal DD during pregnancy and birth outcomes.

Methods A comprehensive search was performed using PubMed, HINARI, and Google Scholar databases up to January 17, 2024. Studies conducted among pregnant mothers and measuring maternal DD with an evaluation of birth outcomes (low birth weight, small for gestational age, preterm birth), in the global context without design restriction were included. The Newcastle Ottawa Scale and the Cochrane Risk of Bias tool were used to assess the risk of bias. The results are summarized in a table, and odds ratios were pooled where possible. Between-study heterogeneity was evaluated using I^2 statistics. Potential publication bias was assessed using a funnel plot and Egger's regression test. To explore the robustness, a leave-one-out sensitivity analysis was conducted.

Results Thirty-three studies were used to synthesize narrative evidence (low birth weight: 31, preterm birth: 9, and small for gestational age: 4). In contrast, 24 records for low birth weight, eight for preterm birth, and four for small for gestational age were used to pool the results quantitatively. Of the 31 studies, 17 reported a positive association between maternal DD and infant birth weight, 13 studies reported a neutral association (not statistically significant), and one study reported a negative association. Overall, inadequate DD increased the risk of low birth weight OR = 1.71, 95% CI; (1.24–2.18), with I^2 of 68.7%. No significant association was observed between maternal DD and preterm birth. Inadequate DD was significantly associated with small for gestational age (OR = 1.32, 95% CI; 1.15–1.49, and $I^2 = 0.0\%$).

Conclusion Inadequate maternal DD is associated with an increased risk of low birth weight and small for gestational age but not preterm birth, underscoring the importance of promoting adequate DD during pregnancy. To address these issues, it is essential to implement and expand nutritional programs targeted at pregnant women,

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especially in low-resource settings, to ensure they receive diverse and adequate diets. Further research is needed to address the current limitations and to explore the long-term implications of maternal nutrition on child health. The study was prospectively registered on PROSPERO (registration number CRD42024513197). No funding was received for this study.

Keywords Dietary diversity, Birth weight, Preterm, Small for gestational age, Meta-analysis

Introduction

Nutritional vulnerability occurs during preconception, pregnancy, and breastfeeding in women of reproductive ages. With this in mind, special emphasis is given to the first 1000 days of life, which covers the time between a woman's pregnancy and her child's second birthday [1]. Maternal nutrition has intergenerational effects. Preconception and pregnancy nutrition shape fetal metabolic programming and are widely addressed as a risk factor for early malnutrition and late obesity with metabolic syndrome [2]. In utero, excessive nutritional exposure leads to fetal adaptation, which influences the functional state of many fetal organ systems, including insulin-secreting pancreatic cells. Early life adaptation and later nutritional abundance are commonly proposed as strong risk factors for non-communicable diseases [2]. Much of the research in this area has focused on maternal gestational weight gain and the risk of chronic non-communicable diseases in offspring.

Dietary diversity, a measure of the variety of different food groups consumed by an individual, is increasingly recognized as a crucial determinant of maternal and child health [3]. Maternal dietary diversity refers to the range of foods consumed by a pregnant woman. A diverse diet can provide a more complete spectrum of essential nutrients [3], which are vital for fetal development and healthy birth outcomes [4, 5].

Adverse birth outcomes remain a crucial global issue. For example, despite a reduction in the incidence of preterm birth from 16.06 million in 1990 to 15.22 million in 2019, the age-specific mortality rate of neonatal preterm births increased by a mean of 2.09% in southern sub-Saharan African countries [6]. The global nutrition target 2025 is to achieve a 30% reduction in the number of infants born less than 2.5 kg by 2025. It also aims to reduce the burden of low birth weight from 20 million in 2012 to 14 million in 2025 globally [7]. This plan demands a 3% reduction per year, and evidence in this regard shows that the effort should be doubled to achieve the ambitious target [8]. Data from 2012 estimated that 23.3 million infants were born small for gestational age in lower- and middle-income countries, of which 21.9% of neonatal deaths were attributable to small for gestational age (SGA). This is equivalent to one in four neonatal deaths [9].

Studies have evaluated gestational weight gain as a proxy for maternal nutritional status and have provided guidelines. Gestational weight gain less than or greater than the guideline recommendations increases the risk of adverse maternal and infant outcomes [10]. Infant outcomes included SGA, large for gestational age, preterm birth, macrosomia, and caesarian delivery [11]. In addition to short-term birth outcomes, there are other long-term consequences, such as impaired growth, development, and learning readiness in childhood and chronic diseases in adulthood [12]. A risk factor study from 81 low- and middle-income countries [13] for SGA traced back maternal nutritional status as having the greatest population-attributable fraction.

Previous reviews [14, 15] were either systematic reviews that failed to pool the appropriate effect sizes or hampered our comprehensive understanding by focusing on specific outcomes, geographical areas, and time points. Besides, several primary studies have been conducted since their publication [16–18]. The current study has no geographical or publication limits; our outcomes were low birth weight, small for gestational age, and preterm birth, based on the availability of the study. This study comprehensively reviews maternal dietary diversity with birth outcomes and intends to provide input to consolidate the evidence on this issue.

Methods

Literature search

PubMed, HINARI, and Google Scholar were searched using the following terms: Population; pregnant mothers, Comparison: adequate vs. inadequate dietary diversity, Outcome: low birth weight, small for gestational age, preterm birth, and Context; globally. Details of the search strategy are provided in Additional File 1(Table 1). The search was updated on January 17, 2024. We wrote this review according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines [19].

Study eligibility

Eligibility criteria

The population, context, and study design used in this study are described in Table 1.

Inclusion

- Healthy Pregnant Mothers Globally (human studies),
- Evaluated at birth.

Table 1 Population, condition, context and design

Population	The population of the current study are women of reproductive age (age 15–49 years), whose dietary diversity was measured during pregnancy, and the specified birth outcome was evaluated.
Context	Globally
Outcomes/condition	The collective term outcome here indicates the following parameters; low birth weight, small for gestational age, and preterm birth.
Study designs	Observational studies (prospective or retrospective cohort, case-control studies, and comparative cross-sectional or cross-sectional studies without comparison group). Or randomized and non-randomized trials

- Any study designs.
- Setting – globally.
- English language.
- Reported either of low birth weight, Preterm birth, small for gestational age.
- Publication status: published or unpublished.

Exclusions

- Diseased mothers e.g. HIV, DM, etc.
- Expert opinions, conference proceedings, any form of reviews [narrative, scoping, systematic review, and meta-analysis].
- Incomplete articles (failed to report the outcome or exposure) and duplicates (including different studies conducted on the same population) were excluded to avoid double counting.

The search results were exported to the Endnote software. Duplicates were then removed. We performed a two-stage study screening: (1) search results were screened based on the title and abstract by two reviewers; (2) after the initial screening, the same two reviewers performed full-text screening. A third author resolved disagreements at each stage.

Data extraction

A standard data extraction tool was developed according to the Cochrane Collaboration and Center for Review and Dissemination. Data were extracted on publication details, including title, author, year, and country in which the study was conducted; design; type of study (observational studies, cross-sectional, cohort, case-control, clinical trial), and outcome measures; all reported estimates; or sufficient information to calculate the effect size of the outcome.

The exposure

Dietary diversity was the exposure variable in this study. Dietary diversity was measured by the minimum dietary diversity for women (MDD-W) of the Food and Agricultural Organization (FAO) [20]. MDD-W is a dichotomous indicator of whether or not women aged 15–49 years have consumed at least five out of ten defined food groups on the previous day or night. The proportion of women aged 15–49 years who reach this minimum in a population can be used as a proxy indicator for higher micronutrient adequacy, defined here as adequate dietary diversity [20].

Measuring outcome

Low birth weight (weight at birth of <2500 g), small for gestational age (weight less than the 10th percentile for gestational age), and preterm birth (born alive before 37 weeks of pregnancy are completed) were treated as dichotomous variables (either the presence or absence of outcome). For all these outcomes the odds ratio either was taken directly or was computed when unavailable.

Quality assessment

The methodological quality of the observational studies was assessed using the Newcastle Ottawa Scale (NOS) [21], and the risk of bias of individual studies was rated. The Cochrane Risk of Bias (ROB) tool was used to appraise randomized trials [22].

Data analysis

After data extraction, the outcomes were summarized using tables. We pooled the odds/risk ratios with 95% confidence intervals. The random effects inverse variance (DerSimonian and Laird) method was applied to accommodate possible sources of heterogeneity. Studies have reported both odds ratio and relative risk; considering that the prevalence of adverse birth outcomes in studies was low, we assumed relative risks as odds ratios [23].

We investigated the potential source of heterogeneity related to both methodological and clinical characteristics of the studies using Cochran's Q test ($P<0.05$, considered significant) and I^2 (>50% representing moderate heterogeneity) statistics [24]. In the presence of heterogeneity ($I^2>50\%$), subgroup analyses were performed [25]. Sensitivity analyses were conducted to identify study-level factors that best described the occurrence of outcomes. Publication bias due to study size was also addressed and adjusted using inverse-variance weighting techniques to provide valid information on study estimates. Potential publication bias was assessed using funnel plots. Egger's regression test was considered based on the number of studies. A cut-off point of P value ≤ 0.05 cut-point was used to declare statistical significance. All analyses were performed using the STATA software (Version 17. StataCorp, Texas, USA).

Results

Protocol registration

The study was prospectively registered on PROSPERO on February 15, 2024 (registration number CRD42024513197).

Search results

Of the 1129 records searched in the three databases, 142 duplicates were removed before screening. The titles and abstracts of the remaining 987 studies were screened, of which 47 studies underwent full-text screening. Thirty-three studies were used to synthesize narrative evidence (low birth weight=31, preterm birth=nine, and small for gestational age, 4). In contrast, 24 records for low birth weight, 8 records for preterm birth, and 4 records for small for gestational age were used to quantify the results. The details of study screening and selection are shown in Fig. 1.

Study characteristics

The included studies are summarized in Table 2.

Maternal dietary diversity and low birth weight

Thirty-one studies [26–56] reported birth weight in relation to maternal dietary diversity. Of the 31 studies, 17 reported a positive association between adequate maternal dietary diversity and infant birth weight [27, 29, 31–33, 35–38, 42, 44, 45, 47, 50, 54–56], 13 studies reported a neutral association (not statistically significant) [26, 28, 30, 34, 39–41, 43, 46, 49, 51–53], and one study [48] reported a negative association. The reported associations were stronger in some studies, and we found that 24 studies [27–32, 34–37, 39, 41, 42, 45, 47–56] had effect sizes for the meta-analysis. Table 3 summarizes the association between maternal dietary diversity and the risk of low birth weight.

LBW=low birth weight, DD=Dietary Diversity, OR=odds ratio, PTD=preterm delivery. The association column indicates whether maternal dietary diversity had beneficial or neutral effects on the risk of low birth weight. As such, positive association means maternal dietary diversity had beneficial effects in reducing the risk of low birth weight in infants.

Pooling the results of 24 studies, the overall effect size was 1.71, 95% CI; (1.24–2.18), with I^2 of 68.7%. We can observe that maternal dietary diversity is associated with low birth weight in infants, Fig. 2. Inadequate maternal dietary diversity was associated with increased odds of low birth weight.

As we can observe in the figure (Fig. 2), mothers with inadequate dietary diversity had higher odds of low birth weight compared with adequate dietary diversity.

Further subgroup analysis with design and continent disclosed that there were variations between designs and geographical areas in the role of maternal dietary diversity. For example, while there was no significant association between maternal dietary diversity and low birth weight in cross-sectional and cohort studies, case-control studies showed positive effect of maternal nutrition on low birth weight. In case-control studies, the odds of low birth weight among mothers with inadequate dietary diversity increased by 3.07, 95% CI; 1.58–4.56, and I^2=0.0%, Fig. 3.

Subgroup analysis based on geographic areas (continents) indicated that the effect is significant in African countries (total of 19 (79%) studies), while in Asia (5 studies) and America (1 study) is not significant. In African countries mothers with inadequate dietary diversity have 1.99, 95% CI; 1.38–2.59, I^2=69.3% higher odds of low birth weight [not shown].

Maternal dietary diversity and preterm delivery

Nine articles [28, 31, 34, 38–40, 43, 53, 54] reported about maternal dietary diversity and preterm delivery. The majority of the studies reported six (66.7%) reported a neutral association between the outcome and maternal dietary diversity, and the remaining three studies [31, 38, 54] reported a positive (beneficial) association. No study reported a negative association between maternal dietary diversity and preterm delivery, Table 4.

From the nine studies, we were able to pool the effect sizes from eight studies (except [40]). The result of the meta-analysis showed no significant association between maternal dietary diversity and preterm birth (effect size=1.10, 95% CI; 0.83–1.37, and I^2=56.5%, Fig. 4.

Maternal dietary diversity and small for gestational age

Four studies [28, 43, 57, 58] were included to examine the association between maternal dietary diversity and small gestational age, we found that 75% of the studies reported a positive association, Table 5.

Pooling the results of these four studies about small for gestational age indicated that inadequate dietary diversity significantly exposed to small for gestational age. The effect size was 1.32 with 95% CI; 1.15–1.49 and I^2=0.0%, Fig. 5.

Publication bias

We assessed publication bias and small study effects using a funnel plot and Egger's regression test. There was no publication bias and small study effects on preterm birth and small for gestational age (p-value>0.05). The funnel plots for SGA and preterm birth were symmetric

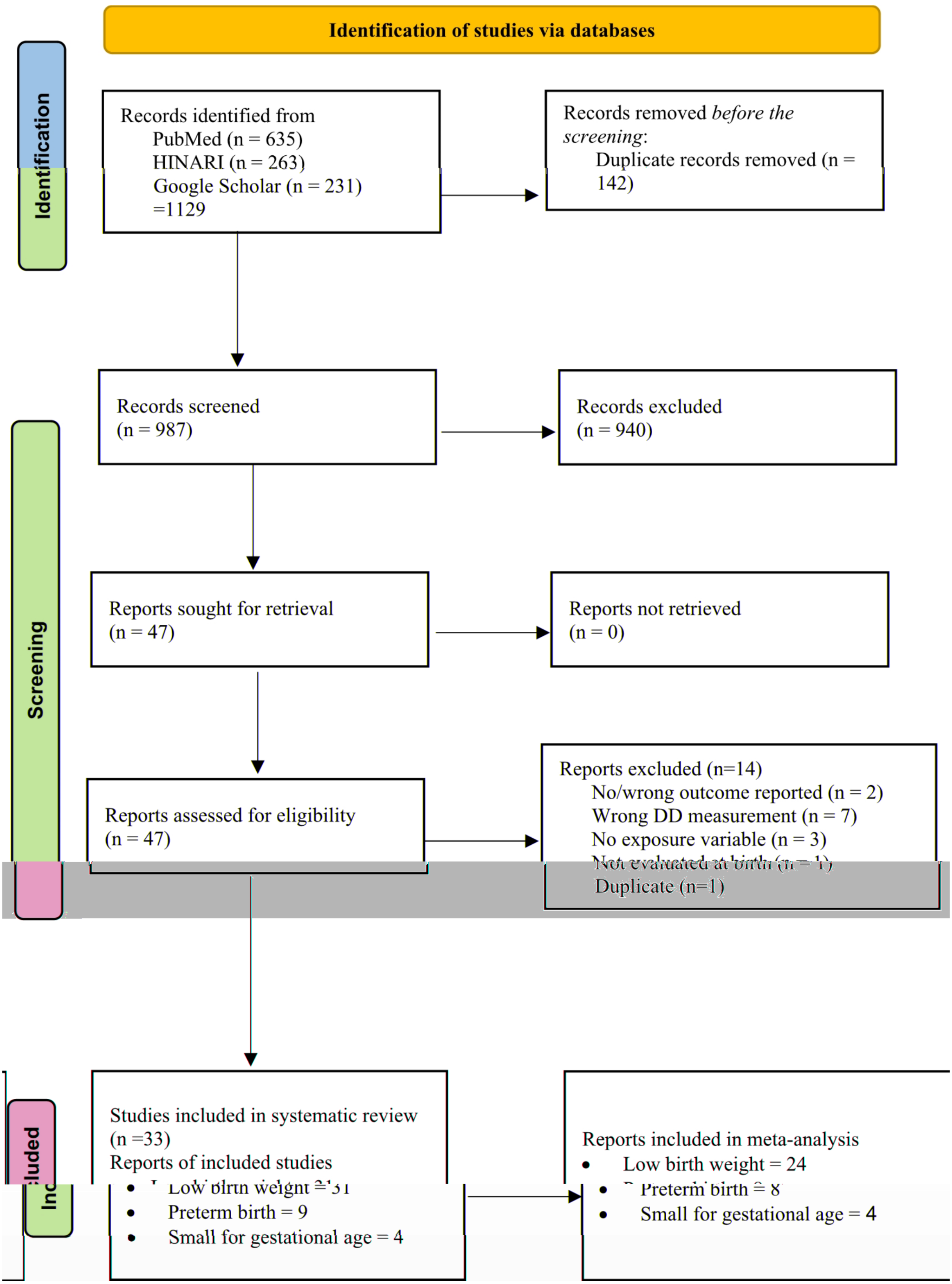

Fig. 1 PRISMA flow chart for study screening and selection

Table 2 Country, study design, and outcomes reported among included studies

	Author	Year	Country	Design	LBW	SGA	Preterm
1	Sun et al. [26]	2023	China	Cohort	No	Yes	No
2	Weldegebriel et al. [27]	2023	Ethiopia	CS	Yes	No	No
3	Manjula et al. [28]	2023	India	CS	Yes	No	No
4	Yang et al. [29]	2023	Tanzania	RCT	Yes	Yes	Yes
5	Seid et al. [30]	2022	Ethiopia	Case-control	Yes	No	No
6	Asefa et al. [31]	2022	Ethiopia	Cohort	Yes	No	No
7	Wondemegegn et al. [32]	2022	Ethiopia	Cohort	Yes	No	Yes
8	Walle et al. [33]	2022	Ethiopia	CS	Yes	No	No
9	Sharma et al. [34]	2021	India	Case-control	Yes	No	No
10	Annan et al. [35]	2021	Ghana	CS	Yes	No	Yes
11	Adem OS et al. [36]	2020	Ethiopia	Case-control	Yes	No	No
12	Bekela et al. [37]	2020	Ethiopia	Case control	Yes	No	No
13	Berhe et al. [38]	2020	Ethiopia	Cohort	Yes	No	No
14	Nsereko et al. [39]	2020	Rwanda	Cohort	Yes	No	Yes
15	Bater et al. [40]	2020	Uganda	Cohort	Yes	No	Yes
16	Therrien et al. [41]	2020	Vanuatu	Cohort	Yes	No	Yes
17	Alemu and Gashu [42]	2020	Ethiopia	CS	Yes	No	No
18	Quansah and Boateng [43]	2020	Ghana	CS	Yes	No	No
19	Madzorera et al. [44]	2020	Tanzania	RCT	Yes	Yes	Yes
20	Madzorera et al. [45]	2020	Uganda	RCT	Yes	No	No
21	Girma et al. [46]	2019	Ethiopia	Case control	Yes	No	No
22	Tela et al. [47]	2019	Ethiopia	Cohort	Yes	No	No
23	Vanie et al. [48]	2019	Ivory Coast	Cohort	Yes	No	No
24	Rammuhan et al. [49]	2019	India	CS	Yes	No	No
25	Imran M et al. [50]	2019	Pakistan	CS	Yes	No	No
26	Ahmed S et al. [51]	2018	Ethiopia	Case control	Yes	No	No
27	Rashid et al. [52]	2018	Haiti	Case control	Yes	No	No
28	Jamalzehi et al. [53]	2018	Iran	CS	No	Yes	No
29	ManerKar and Gokhale [54]	2017	India	Cohort	Yes	No	No
30	Madlala [55]	2017	South Africa	CS	Yes	No	Yes
31	Zerfu et al. [56]	2016	Ethiopia	Cohort	Yes	No	Yes
32	Abubakari and Jahn [57]	2016	Ghana	CS	Yes	No	No
33	Saaka [58]	2012	Ghana	CS	Yes	No	No

CS – Cross-sectional, RCT – Randomized Control Trial, LBW – Low Birth Weight, SGA – Small for Gestational Age

and Eggers regression test results were insignificant (Additional file 1, Figs. 2 and 3). Thus, there is no publication bias for the two outcomes. The funnel plot for LBW was not symmetric and Egger's test was significant (p-value < 0.05), Fig. 6.

We evaluated the small study effects using nonparametric trim-and-fill analysis and imputed 10 studies on the left side (Supplementary Fig. 1). Imputation of 10 studies gave an effect size of 1.27 with 95% CI (0.61–1.94).

Sensitivity analysis

To identify influential studies, a leave-one-out analysis was performed. Results for the three outcomes indicated that there is no single study influencing the outcomes. The results of the sensitivity analysis are provided in Additional File 1 (Figs. 4, 5 and 6).

Discussion

We conducted this systematic review and meta-analysis to evaluate the association between maternal dietary diversity and birth outcomes, including low birth weight, preterm birth, and small for gestational age. The results indicate that inadequate maternal dietary diversity is significantly associated with increased odds of LBW and SGA, while no significant association was found with PTB. Our findings align with previous research suggesting that maternal nutrition plays a crucial role in fetal growth and development [15, 59]. Although the parameters used to measure diet are not similar, Chia et al., found that a healthy dietary pattern defined as a high intake of vegetables, fruits, whole grains, low-fat dairy, and lean protein foods was associated with a lower risk of preterm birth [59]. Whereas, a high intake of refined grains, processed meat, high saturated fat, or sugar was associated with lower birth weight [59]. The impact of

Table 3 Maternal dietary diversity and risk of low birth weight in infants

	Author	Year	Association	Findings
1	Weldegebriel et al.	2023	Neutral	LBW was not significantly associated with maternal DD
2	Yang et al.	2023	Neutral	No significant association between all three outcomes and DD
3	Manjula et al.	2023	Positive	a significantly higher percentage of LBW in lower maternal DDS
4	Asefa et al.	2022	Neutral	A higher percentage of LBW among mothers with higher dietary diversity (not significant)
5	Seid et al.	2022	Positive	Inadequate DD increased the risk of LBW with OR = 4.13 (1.4, 12.16)
6	Walle et al.	2022	Positive	low dietary diversity score increased the risk of low birth weight with AOR 2.425 (1.342, 6.192)
7	Wondemegegn et al.	2022	Positive	women in the inadequate WDDS group were at increased risk of LBW (ARR = 6.4(3.4–12) and PTD (ARR = 6.3(3.3–11.95))
8	Annan et al.	2021	Neutral	A higher percentage of LBW for mothers with inadequate DD
9	Sharma et al.	2021	Positive	higher maternal DD was associated with lower odds of LBW OR = 0.79; 95% CI: 0.65, 0.96
10	Alemu and Gashu	2020	Neutral	Inadequate DD increased the risk of LBW (OR = 1.2[0.5–2.5]), not significant
11	Bater et al.	2020	Neutral	Dietary diversity was not associated with LBW OR = 1.20(0.86,1.68), adequate DD reduced the risk of preterm birth OR = 0.81(0.70,0.95)
12	Madzorera et al.	2020	Neutral	Higher DDS was associated with a lower risk of SGA (RR highest compared with lowest quintile: 0.74; 95% CI: 0.62, 0.89), not significantly associated with LBW and preterm
13	Therrien et al.	2020	Neutral	No relationship between DD, and birth weight and gestational age
14	Adem OS et al.	2020	Positive	The risk of LBW increased by 2.8 for inadequate DD
15	Bekela et al.	2020	Positive	Inadequate DD increased the risk of LBW with OR = 5.78(2.95–11.3)
16	Berhe et al.	2020	Positive	Inadequate DD increased LBW with RR = 1.9(1.05,2.61)
17	Madzorera et al.	2020	Positive	The highest quantile of DD in mothers has significantly higher birth weight than the lowest quantile
18	Nsereko et al.	2020	Positive	Low maternal DD increased LBW OR = 3. 19; 95%CI: 1.23; 8.25
19	Quansah and Boateng	2020	Positive	Lower DD score was associated with increased risk of LBW OR = 4.29 (1.24–6.48), but not medium
20	Rammuhan et al.	2019	Negative	higher odds of LBW OR = 2.245 (1.107 4.556) with higher DD
21	Noreen et al.	2019	Neutral	No significant association b/n LBW and DD
22	Tela et al.	2019	Neutral	No significant association between birth weight and maternal DD
23	Girma et al.	2019	Positive	Inadequate DD predispose to LBW with OR = 6.65(2.31–19.16)
24	Vanie et al.	2019	Positive	Women with medium and higher DD gave significantly heavier child
25	Rashid et al.	2018	Neutral	No significant association b/n LBW and DD, OR = 1.83(0.57–5.89) for inadequate
26	Ahmed S et al.	2018	Positive	Inadequate DD increased the risk of LBW (OR = 6.65 (2.31,19.16))
27	Madlala	2017	Neutral	A non-significant higher percentage of LBW and preterm for lower DD
28	ManerKar and Gokhale	2017	Neutral	there is no significant association between LBW and DD of mothers
29	Zerfu et al.	2016	Positive	Inadequate DD was associated with LBW OR = 2.06(1.03,4.11), and preterm OR = 4.61(2.31,9.19)
30	Abubakari and Jahn	2016	Positive	Adequate DD reduced the risk of LBW OR = 0.10 (0.04–0.13)
31	Saaka	2012	Positive	lower DD was associated with higher odds of LBW (OR = 2.33(1.18–4.57)

maternal dietary diversity during pregnancy, not only during birth, but may extend to childhood. This is supported by previous evidence [60, 61] where, childhood stunting was associated with low consumption of a diversified diet, and adequate maternal dietary diversity was associated with higher child weight-for-height z-score and weight-for-age z-score and lower risk of wasting.

Many factors can explain the important role of dietary diversity and birth outcomes. Maternal adequate dietary diversity could be translated into the consumption of more food groups including dairy products, vegetables, fruits, and other food groups. These food groups, for example, dairy products are a good source of essential nutrients including calcium and protein [62]. Calcium and proteins are essential elements in fetal growth [63]. On the other hand, maternal consumption of fruits, and dark green leafy vegetables was associated with a lower risk of adverse birth outcomes including low birth weight [64]. The effect of maternal dietary diversity on low birth weight was more pronounced in case-control studies compared to cross-sectional and cohort studies. The odds of low birth weight were 3.07 higher among mothers with inadequate dietary diversity in case-control studies. There are several possible explanations for this. First, case-control studies recruited mothers who delivered low birth weight babies (cases), this may introduce bias as cases and controls may have different degrees of recall. Second, in cross-sectional studies, it is difficult to infer mother's current diet caused low birth weight in the newborn. Third, in cohort studies, still dietary diversity is measured at some point in time which failed to account for the difference in different periods of pregnancy. Thus,

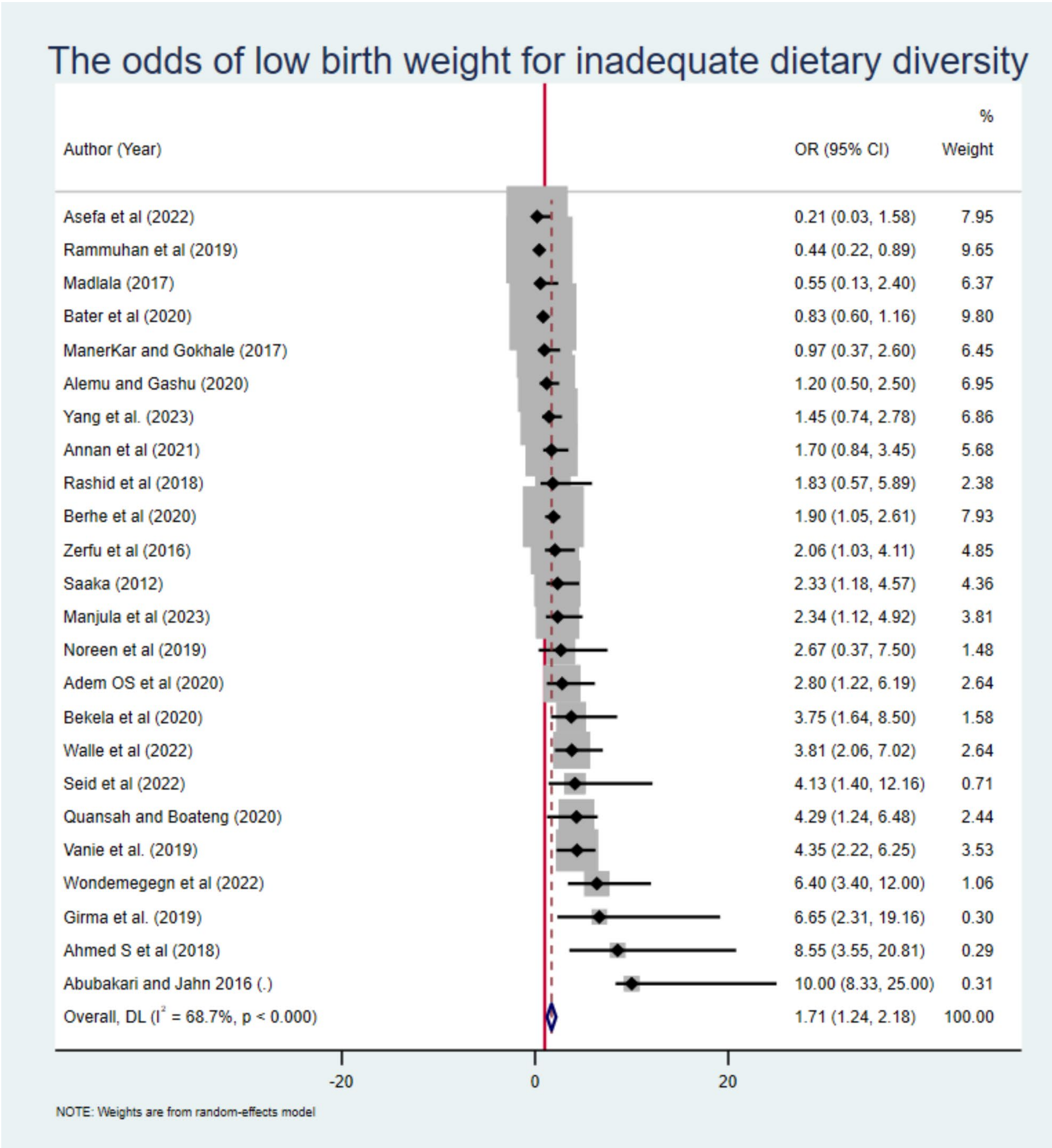

Fig. 2 Forest plot showing the association between maternal dietary diversity and low birth weight in infants. The reference group was mothers with adequate dietary diversity.

cohort studies might underestimate the effect because they failed to account for dietary changes throughout pregnancy.

Subgroup analysis by geographic region showed that the effect of maternal dietary diversity on low birth weight was significant in African countries, but not in Asian or American countries. Mothers in Africa with inadequate dietary diversity had a 1.99 higher odds of delivering a low-birth-weight infant. This could be due to differences in dietary patterns, socioeconomic factors, or healthcare systems across regions. For example, there is a significant relationship between maternal anemia and low birth weight [65], where maternal anemia is common in Africa. These, and other health conditions might

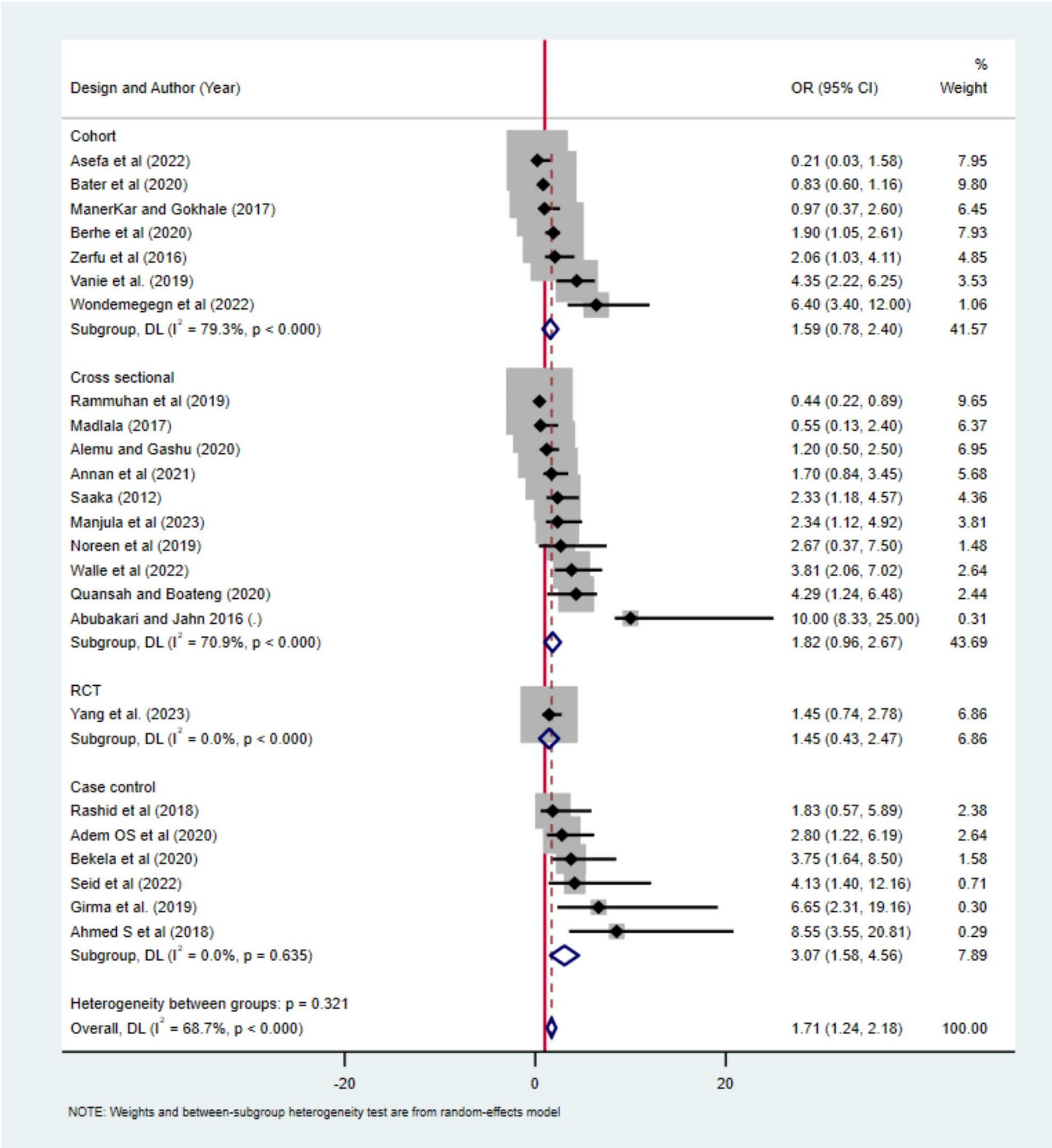

Fig. 3 Forest plot showing the association between maternal dietary diversity and the risk of low birth weight based on study design

confound the association between maternal dietary diversity and birth outcomes.

The findings of this review have significant implications for public health and clinical practice. Ensuring adequate maternal dietary diversity could be a key intervention to reduce the risk of LBW and SGA, which are critical indicators of neonatal health and long-term development. Healthcare providers should emphasize the importance of a varied diet during pregnancy as part of routine prenatal care. Policymakers should prioritize nutritional programs that support pregnant women, especially in regions with high rates of inadequate dietary diversity.

This review has several strengths, including a comprehensive search strategy and rigorous selection criteria, which ensured the inclusion of relevant studies. The current study has no geographical or publication limits; our

Table 4 The association between maternal dietary diversity and preterm birth

	Author	Year	Association	Findings
1	Yang et al.	2023	Neutral	No significant association between DD and preterm birth
2	Wondemegegn et al.	2022	Positive	women with inadequate DD were at increased risk of PTD (ARR = 6.3(3.3–11.95))
3	Annan et al.	2021	Neutral	For inadequate DD, a lower percentage of preterm (not significant
4	Bater et al.	2020	Neutral	Adequate DD reduced the risk of preterm birth OR = 0.81(0.70,0.95)
5	Madzorera et al.	2020	Neutral	DD is not significantly associated with preterm
6	Therrien et al.	2020	Neutral	No relationship between DD, and gestational age
7	Nsereko et al.	2020	Positive	low maternal DD increased preterm OR = 3.94 [1.57;9.91]
8	Madlala	2017	Neutral	a non-significant higher percentage of preterm for lower DD
9	Zerfu et al.	2016	Positive	Inadequate DD was associated with preterm OR = 4.61(2.31,9.19)

DD = dietary diversity, PTD = preterm delivery

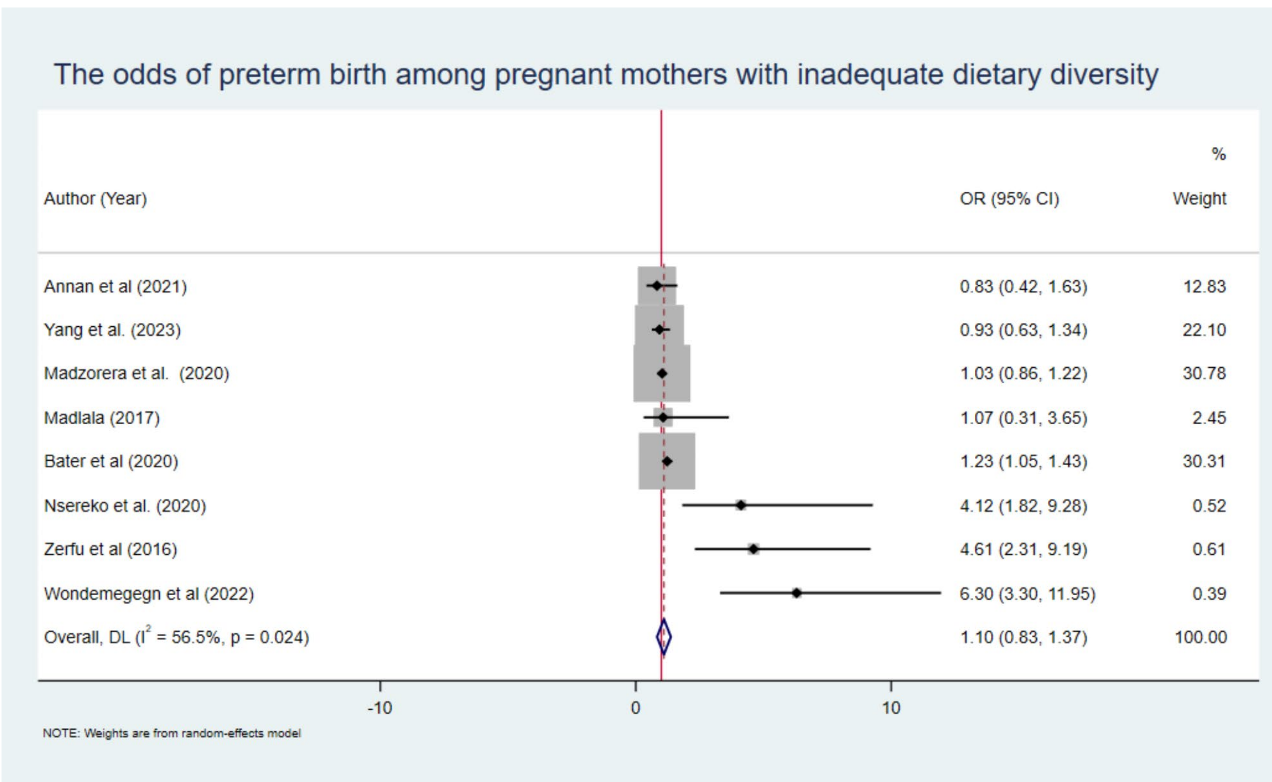

Fig. 4 Forest plot showing the association between maternal dietary diversity and preterm birth in infants

Table 5 Maternal dietary diversity and small for gestational age

	Author	Year	Association	Findings
1	Yang et al.	2023	Neutral	No significant association between DD and SGA
2	Sun et al.	2023	Positive	DDS exhibited a protective effect against SGA (0.76; 95% CI: 0.62–0.95)
3	Madzorera et al.	2020	Positive	Higher DD was associated with a lower risk of SGA (RR highest compared with lowest quintile: 0.74; 95% CI: 0.62, 0.89
4	Jamalzehi et al.	2018	Positive	a significantly higher percentage of SGA in lower maternal DD

DD = dietary diversity, SGA = small for gestational age

outcomes were low birth weight, small for gestational age, and preterm birth, based on the availability of the study. The use of meta-analysis provides a robust estimate of the effect size, enhancing the generalizability of the findings. However, these studies also have some limitations. First, the heterogeneity among included studies, particularly in terms of study design and population characteristics, could affect the generalizability of the results.

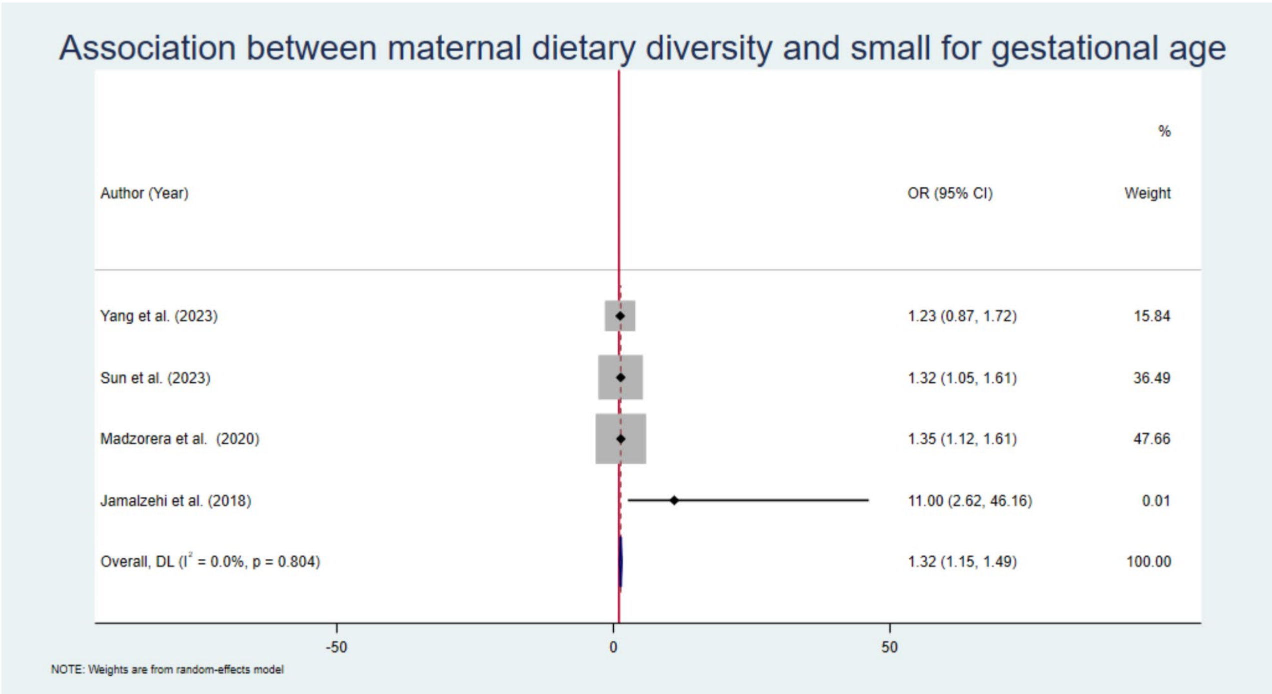

Fig. 5 Forest plot showing the association between maternal dietary diversity and small for gestational age in infants

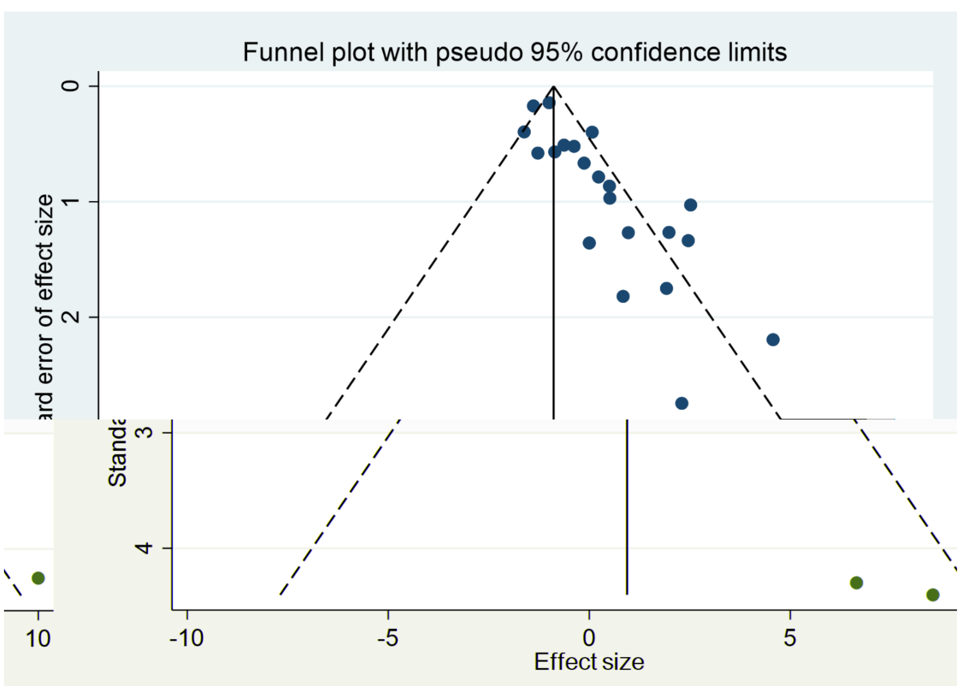

Fig. 6 Funnel plot for low birth weight

Second, the quality of the included studies varied (Additional file 1, Tables 2A – 2D), with some studies having methodological flaws that might influence the results. On the other hand, there is publication bias for LBW. Imputation of studies during trim and fill analysis indicated the effects might not be significant. Third, regarding the use of MDD-W despite providing insight on adequate diversity, the exact food items (that might be more related to positive birth outcomes) were unexplored.

In conclusion, this systematic review and meta-analysis provide evidence that inadequate maternal dietary diversity is associated with increased odds of LBW and SGA, but not PTB. These findings underscore the importance of promoting adequate dietary diversity during pregnancy to improve birth outcomes. It is essential to implement and expand nutritional programs targeted at pregnant women, especially in low-resource settings, to ensure that they receive diverse and adequate diets. Additionally, advocating for policies that increase access to nutritious foods and support maternal health, such as subsidies for healthy foods and education campaigns, is vital. Further research is needed to address the current limitations and to explore the long-term implications of maternal nutrition on child health.

Abbreviations

DD	Dietary diversity
LBW	Low Birth Weight
MDD	W–minimum dietary diversity for women
PTB	Preterm Birth
RCT	Randomized Control Trial
SGA	Small for gestational age

Supplementary Information

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Supplementary Material 1

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Author contributions
A.A.T. conceived the study. A.A.T., E.G.M., B.K.M., and J.H. contributed substantially to designing the methodology, screening, extraction, running the synthesis, and writing the manuscript. A.M. supervised the work from inception to completion, revised the protocol and the manuscript. All authors have read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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