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Nutrition Education and Counselling Provided during Pregnancy: Effects on Maternal, Neonatal and Child Health Outcomes

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Abstract

Nutrition education and counselling (NEC) is a commonly applied strategy to improve maternal nutrition during pregnancy. However, with the exception special populations and specific diets, the effect of NEC on maternal, neonatal and child health outcomes has not been systematically reviewed. Using a modified Child Health Epidemiology Reference Group method we systematically reviewed the literature and identified and abstracted 37 articles. We conducted meta-analyses for the effect of NEC on maternal, neonatal and infant health outcomes including gestational weight gain, maternal anaemia, birthweight, low birthweight and preterm delivery. NEC significantly improved gestational weight gain by 0.45 kg, reduced the risk of anaemia in late pregnancy by 30%, increased birthweight by 105 g and lowered the risk of preterm delivery by 19%. The effect of NEC on risk of low birthweight was not significant. The effect of NEC was greater when provided with nutrition support, for example, food or micronutrient supplements or nutrition safety nets. The overall quality of the body of evidence was deemed low for all outcomes due to high heterogeneity, poor study designs and other biases. Additional well-designed research that is grounded in appropriate theories of behaviour change is needed to improve confidence in the effect of NEC. Further, cost-effectiveness research is needed to clarify the added benefit and sustainability of providing NEC with nutritional support and/or safety nets, especially in areas where food insecurity and gender bias may limit women's capacity to adhere to NEC messages.

Keywords: *Pregnancy*, *nutrition education*, *anemia*, *birth weight*, *preterm delivery*, *weight gain*.

Background

Unfavourable maternal, neonatal and child health outcomes remain prevalent in developing countries.[1] The main causes of maternal morbidity and mortality are pregnancy-induced hypertension (PIH), haemorrhage, severe anaemia, obstructed labour, infections, unsafe abortions and their subsequent complications. Numerous studies report a role for modifiable maternal nutrition practices in these poor health outcomes.[2–6] For example, women with calcium deficiency have greater risk of PIH[7–9] while supplementation is associated with a 50% reduction in the risk of pre-eclampsia.[10] Anaemia, and especially severe anaemia, are associated with an increased risk of maternal mortality.[3,9,11] It is estimated that a population increase in maternal haemoglobin of 1 g/dL could reduce the risk of mortality by approximately 25%.[11] Micronutrient deficiencies during pregnancy as well as inadequate weight gain have significant implications for neonatal and infant outcomes including preterm delivery, low birthweight (LBW) and birth defects.[12] As illustrated by other articles in this supplement, interventions that improve maternal nutrition before and/or during pregnancy can reduce the risk of poor health outcomes in mothers and their children.

A widely used strategy to improve nutritional status of women during pregnancy is nutrition education and counselling (NEC). NEC strategies typically focus on enhancing maternal diet quality by increasing the diversity and amount of foods consumed, adequate weight gain through consumption of sufficient and balanced protein and energy, and the consistent and continued use of micronutrient supplements, food supplements or fortified foods. A review by Nielsen *et al*. observed that prenatal NEC interventions in pregnant adolescents positively impacted nutrition knowledge and diet quality.[13] Interventions

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also modestly improved gestational weight gain and birthweight. Another review of studies, largely in high-income countries (HIC) reported that nutrition education during pregnancy reduced excessive gestational weight gain.[14] Finally, a 2010 Cochrane systematic review that found that specific advice to increase protein and energy intakes during pregnancy improved intakes of these nutrients. Of the five studies included in this Cochrane review, findings for maternal weight gain, birthweight and preterm delivery were available from only two studies[15,16] and meta-analyses were not significant.

Other than the aforementioned reviews, there have been limited attempts to systematically review and quantify the effect of NEC during pregnancy on maternal and neonatal health outcomes. This is especially the case for studies in low/middle-income countries (LMIC) where food insecurity and inadequate health services, a high burden of infectious disease and poor health care infrastructure contribute to and exacerbate nutritional deficiencies.

Methods

We systematically searched the following databases for relevant experimental studies: PubMed, Popline, Web of Science, CINAHL and EMBASE. The search terms used singly and in combination were ‘diet’, ‘food’, ‘nutrition’, ‘pregnancy’, ‘antenatal’, ‘pregnant’, ‘counseling’, ‘education’ and ‘advice’. Including the specific outcomes of interest, specified below, in the search strategy did not provide additional articles. We also reviewed selected journals (*Journal of Nutrition*, *Social Science and Medicine*, *American Journal of Clinical Nutrition*, *African Journal of Food Agriculture and Nutrition*, *Public Health Nutrition*, *Nutrition Journal*, *Food and Nutrition Bulletin*) and hand-searched references from published articles and reviews. Because previous reviews for NEC included only special populations or specific diet advice, using their publication dates to set date limits would have excluded studies not previously reviewed, thus we did not put a limit on publication date. The last search date was conducted on July 2011.

Inclusion/exclusion criteria

Population, Intervention, Comparison, and Outcome tables were constructed to clarify inclusion criteria. For the purposes of this review the following inclusion/exclusion criteria were established:

1 Only experimental studies utilising a control group were included. Allowable study designs included randomised controlled trials (RCTs), cluster RCTs (cRCTs), and quasi-experimental (nonrandomised; QE) intervention studies.
2 Interventions were delivered to pregnant adults or adolescents and providing
3 The NEC intervention focused on improving maternal diet and nutritional status during pregnancy
4 The comparison group was a concurrent control or comparison group that did not receive NEC. In the event that both groups received NEC, the system of delivery, number of sessions and/or intensity differed.

The following types of studies were excluded:

1 Studies targeting pregnant women with rare or congenital diseases (i.e. inborn errors of metabolism) or those with pre-existing chronic conditions (i.e. obesity, diabetes, rheumatoid arthritis).
2 Studies utilising historical controls.
3 Studies prescribing special diets (i.e. reduced sodium, low glycaemic index) or that focused on improving infant-feeding practices.
4 Studies in a language other than English.

Outcomes of interest

This review is part of a series of systematic reviews examining the effect of maternal nutrition interventions to improve maternal, neonatal and infant health outcomes. The primary maternal outcomes of interest for this series included gestational weight gain, PIH, haemorrhage, gestational diabetes, anaemia and mortality. Neonatal and infant outcomes included birthweight, LBW as defined by study authors, prematurity as defined by study authors, gestational age, intrauterine growth retardation/small-for-gestational age, mortality (stillbirths, perinatal, neonatal and infant mortality), neonatal and infant morbidity and infant growth. For the purposes of this topic we additionally reviewed studies that reported on behaviours antecedent to the primary outcomes of interest including changes in diet practices, compliance to micronutrient supplementation, including iron-folic acid (IFA) supplements, and uptake of antenatal care. However, meta-analysis of these behavioural outcomes was beyond the scope of this review.

Data abstraction, analysis and summary measures

The systematic literature search was conducted by trained research assistants with the assistance of the authors and reference librarians at Emory University.* All titles and abstracts returned by the search were screened for relevance by the first author and two research assistants, one of whom is the second author. Those deemed not relevant were excluded. Abstracts and full text were then reviewed independently by the two research assistants for inclusion. Discrepancies relating to whether an article met the inclusion criteria were sorted through discussion with the first author. The research assistants abstracted data from those studies meeting inclusion criteria into a standardised abstraction table (available on request). A random subsample of 30% of the included articles was double abstracted by the first author to ensure the accuracy and completeness of the abstraction procedure. Key variables abstracted were related to the study identifiers and context, study design and limitations, intervention specifics, and effects on outcomes. The quality of the evidence was assessed and graded according to the Child Health Epidemiology Reference Group adaptation of the Grading of Recommendations, Assessment, Development and Evaluation technique.[17,18]

We conducted meta-analyses for the primary maternal, neonatal and infant health outcomes that had at least three studies with complete data (i.e. standard deviations, samples sizes). Meta-analyses were not conducted for the antecedent behaviours described previously as these were not included as outcomes across the series of reviews on maternal nutrition interventions and health outcomes. We calculated pooled relative risks (RR) or mean differences and their corresponding 95% confidence interval (CI) for dichotomous and continuous outcomes respectively. Statistical heterogeneity was assessed in the pooled data by visual inspection of forest plots, using a chi-square test and calculating the I^2 statistic. Heterogeneity was considered substantial if the P-value of the chi-square was <0.10 and I^2 exceeded 50%. Fixed models were used for primary analysis and random models were used, when heterogeneity exceeded 50%. Group (i.e. cluster) randomisation of study subjects was taken into account. Preference was given to cluster adjusted values provided by the study. If study results were not adjusted for cluster randomisation, models were adjusted by using an estimate of the intra-cluster correlation co-efficient reported in the literature.[19]

We conducted subgroup analysis according to country setting and category of NEC intervention. Study setting was defined based on World Bank classification of countries as low, lower middle-income, upper middle-income countries and high income (HIC). Low- and middle-income countries, including both lower middle and upper middle, were collapsed into an LMIC category. NEC categories are defined in *Results*. Meta-analyses were conducted using Review Manager Software (RevMan version 5.1).

Results

The search yielded 3877 publications. Of these, 94 abstracts were deemed relevant and their full texts reviewed for inclusion/exclusion criteria. Thirty-seven articles representing 34 studies met inclusion criteria, were abstracted and are included in this review (Figure 1). A summary of excluded studies is available upon request.

Of the 34 studies included, 11 were conducted in LMIC[20–31] and 16 were RCTs.[15,16,21,23,24,32–43] In reviewing the articles, three key NEC strategies emerged which we categorise here for convenience as categories 1, 2 and 3. Category 1 strategies provided NEC during pregnancy as the sole intervention; no additional messages or support were provided as part of the intervention (n = 15 studies). Category 2 strategies tested the effect of a package of health education messages that included an NEC component (n = 6 studies); these additional health related messages included, for example, stress/anxiety management, smoking cessation, danger signs during pregnancy, use of alcohol and drugs, and/or psychosocial support. Category 3 strategies combined NEC with nutrition support

*Research assistants were Masters of Public Health students in Nutrition or Reproductive Health. Research assistants and authors attended a 1 day training workshop to receive training on the methodology for conducting the systematic review, data abstraction, and assessing the overall quality of the evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) method. The training was led by experts in systematic reviews and the GRADE and Lives Saved Tools methods. During and after the training, but prior to commencing the systematic review the methods were piloted; inputs from the piloting activity led to modifications to the abstraction table and the GRADE technique for appropriateness. Information on the specific modifications made to the GRADE method and abstraction table is available on request.

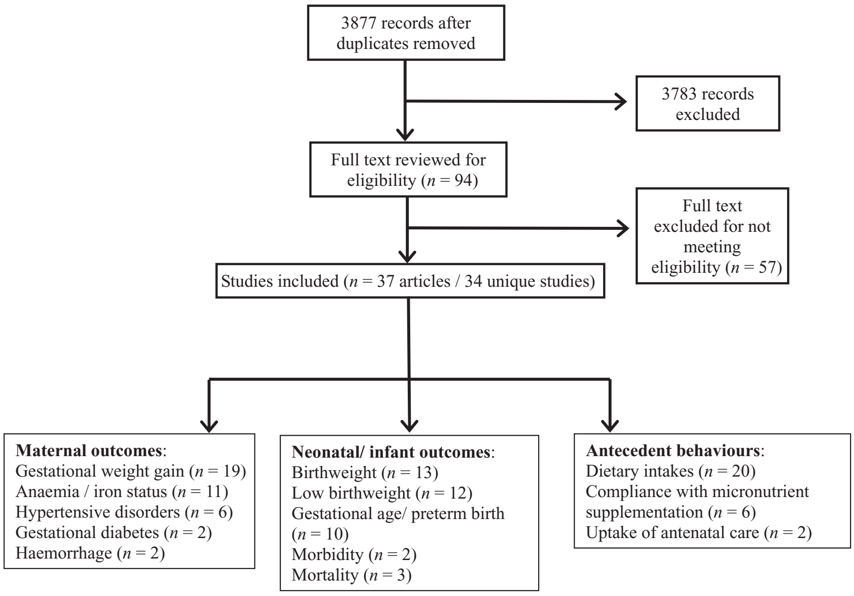

Figure 1. Flow diagram for identification and inclusion of studies evaluating nutrition education and counselling during pregnancy.

including for example, food baskets, food supplements or micronutrient supplements (n = 13 studies).

Maternal outcomes

Gestational weight gain

Thirteen studies reported data on weight gain during pregnancy and were included in the meta-analysis. The duration of the weight gain period was not specified in most studies. Five studies were RCTs,[15,16,21,32,40] four were conducted in developing countries[21,22,28,31] and three were conducted with pregnant adolescents.[40,44,45] Overall mean weight gain was significantly higher in intervention groups compared with control groups (0.45 kg [95% CI 0.12, 0.79] Table 1; Supporting Information Figures S1–S6). When stratified on category of NEC or study setting, significant differences between intervention and controls were only observed when NEC was provided with nutrition support (0.15 kg [95% CI 0.00, 0.29]) or when studies were conducted in high-income settings (0.76 kg [95% CI 0.20, 1.31]).

Two studies were not included in the meta-analysis because they did not report mean gestational weight gain,[46] or reported it as average weekly weight gain.[26] In both studies the effect of NEC was not significantly associated with weight gain outcomes. One RCT and two QE studies aimed to reduce excessive weight gain during pregnancy.[34,35,47] Because the intention of the intervention was to reduce weight gain in pregnancy, these studies were not included in the meta-analysis. In general, those receiving the NEC intervention gained less weight than those in the comparison groups.

Maternal anaemia and iron status

A total of 11 studies contributed data to the meta-analysis on anaemia. Eight were conducted in LMIC[20,21,23,25–27,30,31] and four were RCTs.[16,21,23,37] Overall, NEC reduced the risk of anaemia in late pregnancy by approximately 30% (0.70 [95% CI 0.58, 0.84]; Table 1; Supporting Information Figures S7–S12). Stratifying on country context revealed that NEC substantially and significantly reduced risk of anaemia in LMIC (0.69 [95% CI 0.56, 0.85]) but not in HIC (0.91 [95% CI 0.61, 1.36]). When stratified on category of NEC, effects were substantial and significant when NEC was provided with nutritional supplementation, usually micronutrients (0.58 [95% CI 0.44, 0.76]). Effects were less strong and only borderline significant when NEC was provided alone (0.84 [95% CI 0.70, 1.00]).

An insufficient number of studies precluded meta-analysis for mean haemoglobin and iron status indicators. However, findings for these outcomes are reviewed here qualitatively. An RCT in China,[31] a cRCT in Greece[16] and a QE study in India[26] provided traditional NEC with no additional messages or nutrition support (category 1). While the cRCT in Greece observed no effect of NEC on serum haemoglobin or serum iron, total iron binding capacity was

Table 1. Summary of meta-analyses for effect of nutrition education and counselling (NEC) during pregnancy on maternal, neonatal and infant outcomes by study site and category of NEC[a]

Outcome	I^2 (%)	Sample size	Effect estimation method	Effect size (mean difference or RR [95% CI])
Gestational weight gain				
Overall	42	2833	Fixed	0.45 kg [0.12, 0.79]
Low/middle-income countries	77	1307	Random	–0.06 kg [–1.12, 1.01]
High-income countries	0	1526	Fixed	0.76 kg [0.20, 1.31]
NEC category 1	69	872	Random	–0.07 kg [–1.29, 1.16]
NEC category 2[b]	NA	405	Fixed	0.22 [–0.15, 0.60]
NEC category 3	1	1556	Fixed	0.15 kg [0.00, 0.29]
Risk of anaemia				
Overall	71	2588	Random	0.70 [0.58, 0.84]
Low/middle-income countries	78	1942	Random	0.69 [0.56, 0.85]
High-income countries	10	730	Fixed	0.91 [0.61, 1.36]
NEC category 1	39	574	Fixed	0.84 [0.70, 1.00]
NEC category 2	0	675	Fixed	0.97 [0.68, 1.38]
NEC category 3	69	1359	Random	0.58 [0.44, 0.76]
Risk of low birthweight				
Overall	43	4311	Fixed	0.86 [0.70, 1.04]
Low/middle-income countries	85	2275	Random	0.41 [0.10, 1.73]
High-income countries	0	2036	Fixed	1.05 [0.54, 1.98]
NEC category 1	0	854	Fixed	1.04 [0.54, 1.98]
NEC category 2	0	3196	Fixed	0.99 [0.79, 1.24]
NEC category 3	73	261	Random	0.29 [0.08, 1.00]
Birthweight				
Overall	77	2196	Random	105.2 g [17.7, 192.7]
Low/middle-income countries	72	594	Random	151.7 g [–80.6, 384.0]
High-income countries	17	1130	Fixed	64.8 g [1.65, 128.0]
NEC category 1	0	553	Fixed	–8.1 g [–86.7, 69.6]
NEC category 2	0	595	Fixed	0.14 [–0.04, 0.32]
NEC category 3	44	987	Fixed	297.2 g [226.8, 367.6]
Risk of preterm delivery				
Overall	0	3384	Fixed	0.81 [0.66, 0.99]
Low/middle-income countries[b]	NA	1019	Fixed	0.90 [0.64, 1.25]
High-income countries	6	2365	Fixed	0.76 [0.59, 0.98]
NEC category 1	26	773	Fixed	0.62 [0.36, 1.05]
NEC category 2	8	1572	Fixed	0.82 [0.61, 1.10]
NEC category 3	0	1071	Fixed	0.88 [0.63, 1.23]

[a]NEC categories were defined as follows: Category 1 provided only nutrition education and counselling; no additional messages or support was provided. Category 2 provided NEC and additional health messages. Category 3 provided NEC and nutrition support in the form of food supplements, micronutrient supplements, or nutrition safety nets.
[b]Estimate is based on one study.
NA, not applicable; RR, relative risks.

significantly higher in the control compared with intervention groups at baseline and follow up.[16] Conversely, the studies in India[26] and China[31] each reported statistically significant increases in haemoglobin but only the study in India[26] reported statistical differences in iron status indicators; The study in China[31] additionally reported significant improvements in serum retinol in intervention compared with control groups. Two RCTs[21,37] and three QE studies[20,25,29] provided NEC with nutritional support (category 3). In all but one of these studies,[37] NEC with nutritional support significantly improved concentrations of haemoglobin and/or iron indicators in the intervention compared with the controls.

Maternal morbidity and mortality

There were insufficient numbers of studies providing complete data to conduct meta-analyses on any of the maternal morbidity outcomes. Seven studies examined maternal morbidity during pregnancy including pre-eclampsia,[45,48,49] eclampsia,[32,38] PIH,[40,45] bleeding during late pregnancy,[40] haemorrhage during labour[23,45] and gestational diabetes.[38,41] None of the seven studies reported a significant effect of the intervention on any maternal morbidity outcome although most studies were not adequately powered to assess morbidity outcomes. No studies reported maternal mortality as an outcome.

Fetal and infant outcomes

Birthweight

In total, 17 studies reported outcomes for birthweight. Twelve reported on risk of LBW of which three were in LMIC[28,31,50] and six were RCTs[16,36,39–41,50] The association between NEC and risk of LBW failed to achieve significance overall or in stratified meta-analysis (Table 1; Supporting Information Figures S13–S18).

Thirteen studies contributed data to the meta-analysis for mean birthweight: three from LMIC[22,28,31] and five RCTs.[15,16,32,39,41] NEC significantly increased mean birthweight by 105 g (105.2 g [95% CI 17.73, 192.67] Table 1; Supporting Information Figure S19). When stratified on study site NEC significantly increased birthweight in HIC (64.84 g [95% CI 1.65, 128.03]; Supporting Information Figure S20). In LMIC the effect appeared more substantial but failed to reach significance (151.72 g [–80.59, 384.02]; Supporting Information Figure S21) likely due to the small number of studies. Stratification by category of NEC revealed that significant gains in birthweight were achieved when NEC was provided with nutritional support (225.7 g [95% CI 148.82, 302.66]) but not when provided alone or with other health messages (Table 1; Supporting Information Figures S22–S24).

Gestational age and preterm birth

Ten studies, of which six were RCTs,[15,16,32,38,40,41,50] reported data on gestational age at delivery or preterm birth (<37 weeks). Only one was conducted in a developing country.[50] Although most individual studies reported nonsignificant reductions in preterm birth, in pooled analysis the overall reduction in preterm birth, however, was significant (0.81 [95% CI 0.66, 0.99]; Supporting Information Figure S25). No significant stratified effects were observed for type of NEC provided (Supporting Information Figures S26-30).

Fetal/neonatal/infant morbidity and mortality

Four studies, of which two were RCTs reported data on fetal, neonatal or infant morbidity or mortality outcomes. None of these studies were conducted in developing countries. In the Greek cRCT by Kafatos *et al*., there was a significantly greater incidence of early fetal deaths in the intervention group.[16] Conversely in the US, a QE study that provided NEC alone reported no effect on neonatal mortality.[48] In a four-country cRCT in Latin America, NEC provided as a comprehensive package of health messages had no effect on neonatal mortality or morbidity.[50] Another QE study in the US that delivered NEC as part of a package of health messages reported significantly reduced length of hospital stay and admittance to the neonatal intensive care unit in the intervention compared with the control group.[45] However, it is unclear to what extent these findings can be attributed the NEC component of the intervention due to the inclusion of other health messages.

Secondary outcomes

Changes in antecedent behaviours – diet, supplements and uptake of antenatal care (ANC) during pregnancy

Twenty studies reported data on the effect of NEC on dietary practices including changes in quantity and types of foods consumed or macro- and micronutrient intakes. Six studies reported on effect of NEC on compliance to micronutrient supplementation recommendations. Two studies examined the effect of NEC on uptake of antenatal care. These studies are qualitatively reviewed below.

Nutrition education and counselling generally improved maternal diets including dietary practices and consumption of specific macro and micronutrients. In three QE studies and one RCT in the US,[40,46–48] enhanced vs. standard NEC and any NEC vs. no NEC were each associated with a significantly higher proportions of women reporting positive dietary changes and/or adherence to an 'appropriate' or 'good' diet.

Similarly, a cRCT in Greece reported significantly increased snack consumption among women in the intervention clusters although other dietary measures were not different[16] Lastly, positive deviance approaches to NEC in Egypt[22] and Senegal[27] significantly increased consumption of animal source foods. As well, in the Egyptian study a significantly greater proportion of women in the intervention group consumed more food than usual during pregnancy, specifically vegetables.[22]

Four RCTs[16,24,31,42] and three QE studies[26,33,49] tested the effect of NEC provided alone vs. no NEC on macro- and micronutrient intakes. All but one study observed a positive impact of NEC on protein intakes.[33] Conversely, of the five studies reporting energy intakes[24,26,31,33,42,49] only one reported a significant positive impact in the intervention.[26] Of the four reporting micronutrient intakes,[24,26,31,33] the three studies conducted in developing countries[24,26,31] reported significantly higher dietary iron intakes in the groups receiving NEC; the study in Scotland, however, failed to observe a significant effect of NEC on iron intakes.[33]

Five studies examined the impact of providing NEC with nutrition support (i.e. category 3 intervention) on macro- and micronutrient intakes.[15,28,29,37,43,44] These studies reported significantly improved protein and energy intakes in late pregnancy in the intervention compared with the control groups. The exception was an RCT in Finland that provided NEC and special foods. The authors reported no significant impact on energy, protein or iron intakes during the three trimesters.[43] Exceptions to the findings just summarised have been reported.[33,51] However, in both of the QE studies reporting null findings, the NEC intervention relied on take home pamphlets or media; women did not receive advice from a counsellor or other health worker.

Two studies in the US[37,46] measured the effect of NEC on compliance to micronutrient supplementation and observed no significant effects. However, a QE study in India[26] and an RCT in Nepal[21] each found positive impacts of NEC on IFA compliance despite substantial differences in the intensity and format of the counselling. It should be noted that the study in Nepal provided micronutrient supplements to all participants[21] while the study in India did not provide supplements *per se* but supplements were available through standard of care protocols. Compliance was also closely monitored in the intervention but not in the control group.[26] In the two positive deviance studies, the Senegal study reported no impact on IFA compliance[27] while the study in Egypt reported significantly higher compliance in the intervention compared with the control group.[22] In Senegal, IFA was provided to women at a subsidised rate while in Egypt the intervention ensured the availability of supplements through the health care system, which were then provided free to women.

Only two studies examined the impact of NEC on uptake of ANC services. A QE study in India observed an increase in ANC utilisation in the NEC group compared with the control.[26] However, NEC had no effect on ANC uptake in the positive deviance study in Senegal.[27]

Grading the quality of the evidence

The overall quality of the body of evidence for an effect of NEC provided during pregnancy was considered to be low for outcomes of anaemia, weight gain and birthweight and low to very low for other primary outcomes (Table 2). Studies reporting on primary outcomes differed substantially with respect to target population, design, the delivery of the NEC intervention and in measurement of the outcome. This was evidenced by high I^2 values for most meta-analyses (Table 1). Only one of the RCTs clearly specified allocation method and concealment, adjusted for group differences when present at baseline, had an appropriate control group for attribution of effect to NEC, and specified intent to treat analysis (Table S1).[21] Additionally, for nonrandomised studies, quality was further downgraded for failure to assess and/or adjust for confounding, effect modification, and the sampling design. Several studies had insufficient sample sizes and were not powered to detect differences in the specified outcomes[15,28,29,34,35,45–47,51–53] while others suffered from high and/or differential losses to follow up.[15,16,32,35,36,38,48,52–54] Results could not be clearly attributed to NEC in 13 studies due to inappropriate comparison groups. In these studies the intervention but not the control group also received other interventions including additional health messages,[23,36,40,46,50] nutritional support in the form of food or micronutrient supplements,[22,25,27,32,38,43] advice on physical activity,[41,53] or dental care.[49]

Antecedent behaviours were not included in meta-analysis and are therefore not presented in Table 2.

However, the methodological strengths and limitations of each of these studies are presented in Table S1. Taken together, despite consistent findings for effects on dietary intakes, similar methodological risks for bias existed as were seen for studies examining primary outcomes. For compliance to micronutrient supplementation recommendations findings and uptake of antenatal care, inconsistent findings and methodological limitations hinder the evidence base for confidently assessing whether there is an effect of NEC on these outcomes.

Comments

This systematic review of the literature observed that NEC during pregnancy can reduce the risk of anaemia, increase gestational weight gain and improve birthweight. It is plausible these improvements in health outcomes are due in part to the improvements in antecedent behaviours noted in this review, namely improved dietary intakes in pregnancy and uptake of micronutrient supplementation. NEC was most effective in improving gestational weight gain and birthweight in HIC or when provided with nutritional support. Conversely, NEC significantly reduced anaemia in LMIC but not in HIC. This may be an artefact of the relatively lower prevalence of anaemia among pregnant women in HIC. NEC provided either alone or with nutritional support reduced maternal anaemia although the magnitude of the effect was stronger and significant when NEC was provided with nutritional support, usually in the form of micronutrient supplements such as iron and folic acid. Studies in which NEC was part of a package of other health messages consistently reported null effects for the outcomes of interest. It is plausible that the NEC component was diluted or de-emphasised as other messages were added. Health communication theory emphasises that effective messages are (1) on strategy, (2) relevant to the audience they are intended for, (3) attention-getting, (4) memorable, (5) motivational, and (6) simple and concrete.[55]

Anaemia is a highly prevalent morbidity among women with serious implications for pregnancy outcomes. Approximately half of all anaemia globally can be attributed to iron deficiency.[11] Currently the World Health Organization recommends that women consume 60 mg/day of iron for >90 days during pregnancy. Many countries have implemented programmes that provide free or subsidised iron, often with folic acid, through ANC services. However, compliance to this recommendation remains low.[56] While it is often perceived that demand side barriers, such as side effects and forgetfulness, are the primary impediments to compliance, Galloway *et al*. found, in an eight-country qualitative study, that inconsistent supply, inappropriate targeting, and inadequate counselling are the biggest barriers to compliance.[57] Studies reviewed here suggest that NEC can improve both anaemia outcomes and compliance to IFA supplementation recommendations in LMIC. However, the effect was stronger when access to supplements was assured suggesting that improved supply and accessibility are critical for compliance.

In this review, nutritional support enhanced the effects of NEC for multiple outcomes. NEC likewise may enhance the effectiveness of interventions that provide nutrition or food support. For example, pregnant women in the cRCT in Nepal were randomised to four groups: IFA supplementation only; IFA + pill counting to measure compliance; IFA + NEC; or IFA + pill counting + NEC.[21] The NEC messages were delivered through a single counselling session provided at enrolment that lasted approximately 7 min. The session included an explanation of anaemia, its impact on health, the importance of iron supplementation and how to handle side effects. Women who received NEC or whose compliance was assessed through pill counting had significantly and similarly greater increases in haemoglobin than women who received IFA alone or IFA + pill counting without NEC.

Two additional studies in adolescents[44,52] and one in low-income African American women[15] examined whether an enhanced NEC component provided as part of a national supplemental food programme [the Women, Infants, and Children (WIC) Program] could improve pregnancy outcomes compared with the standard NEC. Birthweight and/or gestational weight gain was significantly greater in two of the three studies.[15,44] Similarly a recent review of the effectiveness of agriculture interventions in improving nutrition outcomes, ranked home gardening projects that also provided nutrition education as moderate to high for achieving positive nutrition outcomes compared with those that did not provided education.[58] These findings suggest that effectiveness of nutrition and food programmes can be enhanced with targeted NEC.

Inadequate gestational weight gain contributes to poor pregnancy outcomes including LBW. Low gestational weight gain disproportionately affects women in LMIC. Balanced protein energy supplementation can improve both weight gain and birth outcomes (Bhutta, this supplement). Indeed, in this analysis, the effect of NEC on both LBW and weight gain appeared most effective when provided with nutritional support (either as micronutrient or food supplements). However, food supplementation strategies during pregnancy are rarely implemented at scale and even less so in LMIC. Our finding that NEC alone failed to improve weight gain may be especially relevant for LMIC where food insecurity potentially limits women's capacity to achieve recommended dietary intakes through food or where inconsistent supply of IFA prohibits regular consumption. In a systematic review of NEC strategies to improve complementary feeding practices, Dewey and Adu-Afarwuah similarly observed that while NEC was effective to improve infant and young child nutrition and health, in areas of food insecurity NEC may be more effective if coupled with nutritional support.[59]

When LMIC studies included in this review were examined individually for effective delivery strategies, no consistent pattern emerged with regard to inclusion of nutrition support. For example, a positive deviance approach in Egypt that provided NEC and a meal at weekly meetings significantly increased food consumption, IFA compliance and birthweight but failed to significantly increase weight gain in the intervention group compared with controls. Birthweight, however, was significantly higher in the intervention communities among mulitparous women. Adhikari *et al*. on the other hand provided NEC with micronutrient supplements and reported significantly greater gestational weight gain.[21] With the exception of the RCT by Adhikari *et al*. the studies conducted in LMIC suffered from multiple study design issues that undermine the confidence in the findings (Table 2).

Consumption of food and daily micronutrient supplements are complex behaviours informed by multiple and often competing personal priorities.[60,61] While health is often the focus of NEC to change diet practices, health may not be the most important determinant of food choices for an individual. Factors such as palatability, culture and social norms, attitudes and beliefs, availability, and accessibility influence food choices and consumption of supplements. Indeed, simply possessing knowledge of the benefits of healthy eating may be insufficient to motivate dietary change.[55,62–65] Rather, additional mediating variables such as attitudes towards the behaviour, self-efficacy, goal setting, and social norms and support should also be targeted to achieve behaviour change. Moreover, in settings where gender bias, poverty, poor public health infrastructure, and/or food insecurity is pervasive, women may have limited control over the types of foods and supplements available and accessible to them. NEC strategies that do not consider the multiple dimensions of decision making around food and supplements may have limited effectiveness.[66,67]

Only four studies explicitly indicated that their NEC interventions were grounded in specific behaviour change theories. Two studies used positive deviance theory,[22,27] one utilised goal setting,[15] and one indicated it utilised the Theory of Reasoned Action. While other studies may have been informed by theories of behaviour change this was not explicitly stated. Therefore, it is difficult to evaluate which theories may be most effective in producing behaviour change for nutrition in pregnancy. Furthermore, only the study by Anderson *et al*. indicated that their intervention considered the educational needs of adult learners.[33] Given the unique needs of adult learners[68] and that the target populations for NEC in pregnancy are primarily adult women it is troublesome that the interventions reviewed here did not specify whether adult learning needs were considered. Lastly recommended principles and guidelines for delivering NEC to adult populations have been published.[66,67,69,70] However, none of these studies included in this review referenced these specific guiding principles in their design and/or implementation.

Implications for research and practices

In summary, NEC that is targeted at maternal diet and supplement intakes during pregnancy, even when provided for a brief period of time, can improve multiple maternal and neonatal health indicators. However, these findings are grounded in a relatively weak evidence base that is largely characterised by QE studies or RCTs with design or analysis limitations. Additional well-designed research is needed to quantify the capacity for and cost-effectiveness of NEC provided during pregnancy that target improved nutrition of the pregnant mother to improve maternal, neonatal and child health outcomes and inform the development of best practices. Well-designed research is needed in both HIC and LMIC contexts to determine the additional benefit and cost-effectiveness of

Table 2. Quality assessment of studies included in meta-analyses testing the effect of nutrition education and counselling during pregnancy on maternal and neonatal health outcomes[a]

Quality assessment					Summary of findings		
No. studies and study design	Consistent size of effect	Generalisable to population of interest?	Generalisable to intervention of interest?	Sources of bias (e.g. major limitations in study design)	Number of participants	Statistical method	Effect estimate
Gestational weight gain: overall quality of evidence = low							
Four RCTs[15,32,40,52] Two cRCTs[16,21] Five QE[28,31,44,53,54] Two cQE[22,45]	With the exception of one study, mean differences, although nonsignificant largely favoured the intervention groups.	One studies conducted in India and China; one in Egypt; 14 in HIC; three studies conducted in adolescents in HMIC.	Not possible to attribute effect to NEC in three studies; one study compared enhanced NEC with standard NEC; six studies provided some form of nutritional support in addition to NEC.	Seven studies not randomised. In one study, subjects self-selected into group. five studies had inadequate sample sizes. For RCTs, method of randomisation, sequence generation, allocation concealment, and intent to treat analysis clearly specified in one study. No assessment of baseline differences or adjustment for confounding in eight studies. Only one cluster design study adjusted for sampling strategy. Contamination suspected in three studies.	1752	Risk ratio (M-H, Fixed [95% CI])	0.45 [0.12, 0.79]
Maternal anaemia in the third trimester/at delivery: overall quality of evidence grade = low							
Two cRCTs[16,23] Two RCTs[21,37] Three QE[25,26,31] Four cQE[20,27,30,45]	All are in direction favouring intervention; five are significant.	Eight studies conducted in LMIC; three in HIC. One conducted in adolescents in HIC.	Four studies provided NEC alone, two with other health messages and four with nutritional support indicating different NEC exposures. Cannot distinguish effect of NEC from other health messages or other interventions in six studies.	Seven studies not randomised. One study had inadequate comparison group because participants were in different stages of pregnancy. Methods of randomisation, allocation concealment and intent to treat analysis clearly specified in one RCT. No adjustment for confounding or baseline differences in eight studies; six cluster-design studies did not adjust for sampling strategy or it was unclear. One study had small sample size, two possible contamination; one study had large losses to follow up (30%). One study did not conduct between group comparisons or provide information on change in control group.	2588	Risk ratio (M-H, Random [95% CI])	0.70 [0.58, 0.84]
Low birthweight: overall quality of evidence grade = low							
Four RCTs[36,39–41] Two cRCTs[16,50] Five QE[28,31,44,46,53] One cQE[45]	Inconsistent with overall effect in favour of intervention but only six studies favoured intervention.	Three studies in LMIC; nine in HIC, of these three in adolescents.	Three studies provided only NEC with one comparing enhanced NEC to standard NEC; six provided NEC as part of package of health messages; three provided NEC with nutritional support; cannot distinguish independent effect of NEC in seven studies.	Seven not randomised. Method of sequence generation not indicated in RCTs. No adjustment for confounding or baseline differences in 11 studies. One study had small sample size. High and/or differential loss to follow up in three studies.	4311	Risk ratio (M-H, Fixed [95% CI])	0.86 [0.70, 1.04]
Birthweight: overall quality of evidence grade = low							
Three RCTs[15,32,39,41] One cRCTs[16] Six QE[28,31,44,46,52,54] Two cQE[22,45]	All but two studies' results in favour of intervention; two studies significant.	Ten studies in HIC of which three were with adolescents; three studies in LMIC (Egypt, India, China). No studies in Africa or Latin America.	Three studies provided NEC alone; two as part of a package of messages; and five provided NEC with other nutritional support; unable to attribute effect to NEC in three studies.	Seven not randomised. No RCTs provided sufficient information on method of sequence generation, allocation concealment and intent to treat analysis. No adjustment for confounding or baseline differences in 10 studies. No adjustment for clustering in studies.	1724	Mean difference (Random [95% CI])	105.2 [17.7, 192.7]
Preterm birth: overall quality of evidence grade = low							
Four RCTs[15,32,40,41] Two cRCTs[16,50] Three QE[46,48,52] One cQE[45]	Studies generally in direction favouring intervention; only one significant.	Nine HIC of which two in adolescents; one in cRCT in four countries in Latin America.	Two provided NEC alone; four provided NEC with other health messages; four provided NEC with nutritional support; cannot distinguish effect of NEC in five studies.	Four not randomised. Method of sequence generation, allocation concealment, masking, intent to treat analysis not indicated in RCTs. No adjustment for confounding or baseline differences in six studies. Four studies with small sample size; three studies with high and differential loss to follow up. One study conducted in 1952.	3384	Risk ratio (M-H, Fixed [95%CI])	0.81 [0.66, 0.99]

[a]According to the Grading of Recommendations, Assessment, Development and Evaluation system, the quality of overall evidence is graded as 'high' if we are confident in the estimate of effect and further research is unlikely to change the results if the intervention; 'moderate' if further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate; 'low' if further research is likely to have an important impact on the confidence in the estimate and is likely to change the estimate or 'very low' if we are very uncertain about the estimate.

Abbreviations used in the table: NEC, nutrition education and counselling; HIC, high-income country; LMIC, low/middle-income country; M-H, Mantel Hanzel; QE, quasi-experimental study; cQE, cluster designed quasi-experimental study; RCTs, randomised controlled trials; cRCTs, cluster randomised controlled trials.

adding nutritional support, for example, food or micronutrient supplements. Research in LMIC on the benefits and cost-effectiveness of NEC alone and combined with nutritional support is especially critical given the relatively large disease burden of poor pregnancy outcomes and the dearth of evidence available to inform best practices in these settings. Further, research is needed in all settings that tests whether interventions grounded in theories of complex behaviour change, that address other underlying determinants of dietary practices, or utilise adult educational theories are more effective than current NEC strategies.

Lastly data on whether women receive NEC during routine ANC or how it is delivered is not routinely collected, especially in developing country settings where health systems are weak. Both the Multiple Indicator Cluster Surveys and the Demographic and Health Surveys collect data on care provided during ANC visits. However, the only NEC-related data that is collected is whether a woman received information on breast feeding during ANC visits. Routine surveys should include whether pregnant women are receiving NEC related to improving their own diet and compliance to micronutrient supplements as part of ANC care.

Conflicts of interest

The authors declare they have no conflicts of interest.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Effect of nutrition education and counselling on weight gain during pregnancy.
Figure S2. Effect of nutrition education and counselling on weight gain during pregnancy in low/middle-income countries.
Figure S3. Effect of nutrition education and counselling on weight gain during pregnancy in high-income countries.
Figure S4. Effect of nutrition education and counselling alone (NEC category 1) on gestational weight gain during pregnancy.
Figure S5. Effect of nutrition education and counselling with comprehensive health messages (NEC category 2) on gestational weight gain during pregnancy.
Figure S6. Effect of nutrition education and counselling with nutrition support (NEC category 3) on gestational weight gain during pregnancy.
Figure S7. Effect of nutrition education and counselling during pregnancy on risk of anaemia during pregnancy.
Figure S8. Effect of nutrition education and counselling on risk of anaemia during pregnancy in low/middle-income countries.
Figure S9. Effect of nutrition education and counselling on risk of anaemia during pregnancy in high-income countries.
Figure S10. Effect of nutrition education and counselling only (NEC category 1) on risk of anaemia during pregnancy.
Figure S11. Effect of nutrition education and counselling with comprehensive health messages (NEC category 2) on risk of anaemia during pregnancy.

Figure S12. Effect of nutrition education and counselling with nutrition support (NEC category 3) on risk of anaemia during pregnancy.
Figure S13. Effect of nutrition education and counselling on risk of low birthweight.
Figure S14. Effect of nutrition education and counselling on risk of low birthweight in low/middle-income countries.
Figure S15. Effect of nutrition education and counselling on risk of low birthweight in high-income countries.
Figure S16. Effect of nutrition education and counselling only (NEC category 1) on risk of low birthweight.
Figure S17. Effect of nutrition education and counselling as a component of a comprehensive package (NEC category 2) on risk of low birthweight.
Figure S18. Effect of nutrition education and counselling with nutrition support (NEC Category 3) on risk of low birthweight.
Figure S19. Effect of nutrition education and counselling on birthweight.
Figure S20. Effect of nutrition education and counselling on birthweight in low/middle-income countries.
Figure S21. Effect of nutrition education and counselling on birthweight in high-income countries.
Figure S22. Effect of nutrition education and counselling alone (NEC category 1) on birthweight.
Figure S23. Effect of nutrition education and counselling as a component of a comprehensive package (NEC category 2) on birthweight.
Figure S24. Effect of nutrition education and counselling with nutrition support (NEC category 3) on birthweight.
Figure S25. Effect of nutrition education and counselling on preterm birth.
Figure S26. Effect of nutrition education and counselling on preterm birth in low/middle-income countries.
Figure S27. Effect of nutrition education and counselling on preterm birth in high-income countries.
Figure S28. Effect of nutrition education and counselling (NEC category 1) only on preterm birth.
Figure S29. Effect of nutrition education and counselling as a component of a comprehensive package (NEC category 2) on preterm birth.
Figure S30. Effect of nutrition education and counselling provided with nutrition support (NEC category 3) on preterm birth.
Table S1. Individual assessment of study quality for all studies included in review.[a]

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