REVIEW ARTICLE

A Systematic Review of Maternal Dietary Intake and its Association with Childhood Stunting

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ABSTRACT

The first 1,000 days of a child's life is a critical period of development in preventing childhood stunting. Despite various intervention programs, the global prevalence remains high. Maternal nutrition during pregnancy and exclusive breastfeeding plays an important role in infant development; thus, a systematic review of the relationship between maternal dietary intake and childhood stunting was conducted. The Web of Science, Scopus, PubMed, and Google Scholar electronic databases were used. Articles related to maternal nutrition and supplement intake with children's anthropometry data were included. Eleven studies met the inclusion criteria and seven were included after quality assessment. The studies were reviewed thematically as the statistical analysis was not possible due to data heterogeneity. The Appraisal Tool for Cross-Sectional Studies (AXIS) and Critical Appraisal Skills Program tools were used to assess the quality of the included studies. The findings demonstrated that pregnant women need to eat a diverse diet with the inclusion of at least five food groups to fulfill the nutritional requirement. Daily protein intake between 0.8 and 1.1g/kg body weight is recommended for positive birth weight and height outcomes. Supplementation of vitamin A, vitamin C, iron, zinc, vitamin D, and calcium, was also shown to improve pregnancy outcomes. However, future studies should consider confounding factors such as hygiene level and clean water availability to determine the transparent effect of nutrition on childhood stunting. More longitudinal studies are required to ascertain the relationship between maternal dietary intake and childhood stunting, especially in Malaysia.

Keywords
Maternal dietary intake; Childhood Stunting; Pregnancy; Exclusive Breastfeeding; Nutrients

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INTRODUCTION

Maternal dietary intake during pregnancy plays a vital role in her offspring's growth, health, and survival. Not only that, but the impairment of maternal nutritional status in pregnancy might also affect her child's health and development in the long term.[1] The first 1,000 days of life span (from conception until two years of age) is the most critical. During the first half of this period, the developing child relies on their mother as the sole source of nutrition in utero, after which exclusive breastfeeding is recommended during the first six months of life.[2]

Dietary recommendations for pregnancy are practically indistinguishable from other female adults except for a few additional nutrients. However, the physiological changes experienced by pregnant women imply the additional requirement of calories and specific nutrients. A healthy diet is essential to be practiced all the time and especially during the pregnancy phase. The growing foetus needs a healthy and diverse diet to thrive. Thus, the requirements might be increased during the pregnancy to support the changes in the body. According to the Malaysian Recommended Nutrition Intake (RNI) 2017[3], for mothers with normal pre-pregnancy weight, an additional 80 calories should be taken during the first trimester, followed with an additional 280 and 470 calories for the second and third trimesters respectively. In addition,

pregnant women should also be consuming enough iron, folate, calcium, vitamin A, and vitamin C to reduce any health risks to the foetus.

Maternal suboptimal nutritional status during pregnancy has been indicated as one of the major determinants of foetal intrauterine growth retardation, infant low birth weight, and child stunting during growing up.[1] Woman with reduced height (less than 145cm) or below normal body mass index, BMI (less than 18.5 kg/m^2) before or during early pregnancy are shown to have increased risk for having small-for-gestational-age (SGA) infants, an indicator of growth restriction in foetus. In addition, SGA is linked to greater morbidity and mortality risks in children[4] and reportedly contributes to about one-fifth of the global stunting prevalence.[5] Other than maternal nutritional status during pregnancy, the physical growth of children during the first two years of their lives could also be affected by psychosocial factors such as low maternal education level and maternal mental health disease.[6]

Stunting or also known as short-for-age is due to insufficient intake and/or absorption of nutrients compared to requirements. The World Health Organisation (WHO) defines stunting as the impairment of growth and development experienced by children, attributed to suboptimal nutrition, frequent infection, and insufficient psychosocial stimulation.[7] Stunted children would be recognised by a height-for-age that is more than two standard deviations lower than the WHO Child Growth Standards median. In Malaysia, the National Health and Morbidity Survey (NHMS) found that 20.7% of children in Malaysia suffered from stunted growth. The highest childhood stunting prevalence was recorded in the states on the east coast of peninsular Malaysia, namely Kelantan (34%), Terengganu (26.1%), and Pahang (25.7%).[8]

The conceptual framework of malnutrition established by the United Nations Children's Fund (UNICEF) demonstrates that a child's nutritional status in the first two years of its life and the presence of disease, which represent the intake, requirement, as well as utilization of nutrients, respectively, are the direct causes of childhood stunting.[9] The inadequacy of nutrient intake affects linear growth as well as brain and immune system development. Not only linear growth failure is associated with an increase in morbidity and mortality, but it is also linked to impairment in mental development, learning performance, and cognitive ability in children. In the longer term, childhood stunting has been shown to increase the risks for overweight and obesity as well as non-communicable diseases such as diabetes, and cardiovascular disease later in life.[10] The retardation of linear growth occurs more rapidly during the first two years of age, as commonly prevalent in many low to middle-income countries.[10] With a quarter of children affected globally, and considering its damaging short and long-term effects, the prevention of childhood stunting is recognised as a key global priority.[11]

The alarming incidence of stunting worldwide is related to maternal nutrition in the first thousand days of life. Several studies determine stunting as the consequence of nutritional intake before, during, and after the pregnancy. Thus, the main objective of this systematic review was to understand the association between maternal intake during a child's first thousand days of life and the prevalence of stunting in children. This knowledge may help to enrich the nutritional recommendations provided to pre- and postnatal women.

MATERIALS AND METHODS

Search strategies

This systematic review was conducted based on the PRISMA guidelines.[12] The literature search, study selection, and data extraction were conducted independently by two authors (NMN and NAMS). This review has been registered with Prospero (ID: CRD42021252323).

Literature Search

The search was conducted using the Web of Science, Scopus, PubMed, and Google Scholar databases. The keywords used to search the related studies were based on the PICOS searching tools, covering population, intervention, outcome, and study type. Based on these, the search terms used were 'maternal', 'pregnant women,

'nurturing', 'gestation', 'reproductive age', 'retard growth', 'low birth weight', 'low height for age 'stunting', 'pregnancy diet intake', 'maternal nutrition', 'nutrients deficit', 'macronutrients deficits', and 'micronutrients deficits'.

Study Selection

Article titles were first screened, and any articles related to 'maternal nutrition' and 'stunting' were included. Next, the abstracts were examined for the type of study, population, interventions, and outcomes related to stunting and maternal nutrition intake. Studies were excluded if the outcome did not relate to stunting among children. The study selection used the PRISMA guideline, conducted in a hierarchical order. The full text of the eligible papers was retrieved for further review.

A study would be included if the information on the pregnancy diet intake and children's weight outcomes were provided. The pregnant women population should consist of adults aged 18 to 49 years, and the children's age should be from birth to five years. Original studies and review papers on healthy mothers and infants were included. Mothers and infants with health problems or diseases may have different dietary requirements or effects on the health outcomes other than the nutritional problem itself and thus were not included. Studies that only provided birth weight data without further follow-up were also excluded. No specific time frame was specified for this review to avoid missing eligible materials since articles on this topic were quite limited. Only studies in the English language were included.

Assessment of Data Quality

The quality assessment was undertaken using the Critical Appraisal Skills Program (CASP) tool[13] for most of the included study designs. In addition, the Appraisal tool for Cross-Sectional Studies (AXIS)[14] was used for cross-sectional study design as it is designed explicitly for a cross-sectional study. The quality appraisal was conducted after the full-text review. Three researchers (NAMS, NMN, and NM) assessed the quality of the selected papers independently. Studies that met almost all the quality assessment criteria were included in this review upon all the assessors' consensus.

Data Syntheses and Analysis

A matrix table was adapted from Messina et al., (2017) (Supplementary Table) to key in all the relevant data extracted from the included studies.[15] The table helped to summarise all the gathered articles systematically.

This review included quantitative studies and a review paper. The thematic analysis was used for quantitative studies, and narrative analysis was used for the review paper. The investigation began after all the needed information was tabulated and organized accordingly. Data from the selected articles were extracted using the Atlas-Ti® software. These data were then thematically analysed, and the main themes and sub-themes were identified to appraise the studies further. Statistical analysis was not possible due to the heterogeneity across the studies included in this review. Thus, the authors agreed to evaluate and summarise any significant outcomes from the included studies.

RESULTS AND DISCUSSION

The PRISMA flow diagram (Figure 1) was used to present the publication selection process in detail.[12] A total of 828 publications were yielded from the initial search. Forty-one publications were excluded as some were books and with duplication. Further, 583 articles were removed after the title and abstract evaluations. From 204 articles, only 179 full-text articles were able to be retrieved. After the full-text assessment, 11 articles met the research questions and all the inclusion and exclusion criteria. Finally, these 11 articles underwent the quality assessment, which left seven articles eligible for this review. Two main themes were identified from the analysis.

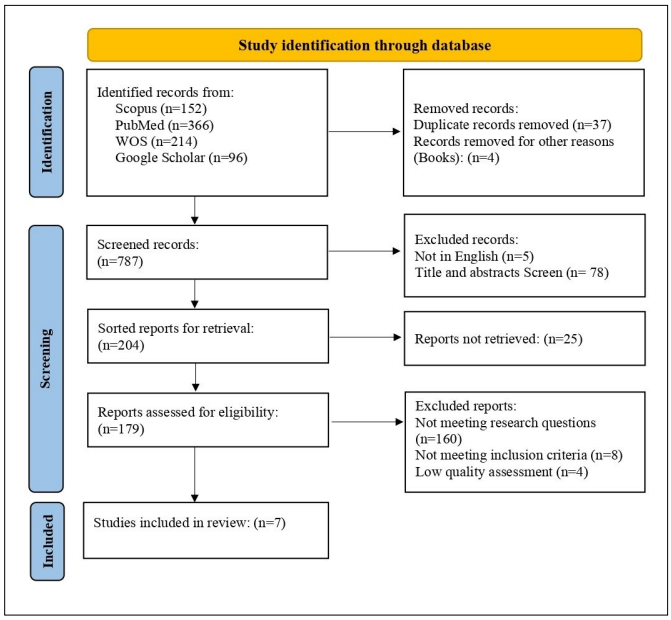

Figure 1 Flow diagram using the PRISMA for studies identification

Theme 1: Nutrient intakes of mothers in the first thousand days of their children

Apart from the macronutrient intake, a pregnant woman is provided with nutritional supplements for better pregnancy outcomes. The standard supplementation includes iron, folate, vitamin A, vitamin C, calcium, and zinc. Of the seven papers included, three[16–18] discussed nutrient supplementation for pregnant women. In addition to the regular iron and folic acid supplements, the WHO also recommends multiple micronutrient supplementation (MMS)[19] comprised of vitamin A, vitamin E, vitamin C, Vitamin D, niacin, folic acid, vitamin B_1, vitamin B_2, vitamin B_6, vitamin B_{12}, zinc, iron, selenium, copper, and iodine.

A study by Islam-Khan (2013)[17] provided their research participants (pregnant women) with iron-folic acid supplementation, MMS supplementation, and energy-protein supplementation for those with a BMI of less than 18.5kg/m². Likewise, a national study conducted in Ethiopia found that vitamin A supplementation during pregnancy, improved water sources, and a hygienic environment after delivery was important for pregnant mothers and child's health.[16] A more recent review[18] concluded that supplementation of vitamin A, iron, zinc, vitamin D, and calcium (versus placebo) showed improvement in two specific measures for pregnant women. These include reducing the risk of pre-eclampsia/eclampsia and blood retinol concentration (µmol/L) in pregnant women. Furthermore, the review found that iron -folic Acid (IFA) supplementation suggests a better outcome for both mother and child's health than folic acid (FA) alone.

Despite the supplements, dietary intake is an essential measure. The food intake can be assessed using diet recall, food diary, or food history, and then the intake can be analysed using diet diversity or macro/micronutrient assessments. Most of the pregnant women in a study done by Huang et al. (2018) consumed five to 10 food groups (diverse diet) during their pregnancy, yet about 40% did not meet the minimum food group intake.[20] Another study among Korean pregnant women found that the vitamin C and vegetable intakes did not meet the estimated average requirement (EAR) of the Korean Dietary Reference Intake by 36.1%. The study's findings concluded that vitamin C status was significantly related to the intake of fruits and vegetables, which are vital during pregnancy.[21]

Protein requirement is normally calculated as a percentage of total daily energy intake or as grams per kilogram of body weight. Geraghty and colleagues (2018) conducted a national cohort study regarding protein intake during pregnancy and its effects on the baby within five years.[22] The finding indicated that a high protein intake of the mother might produce a higher birth weight baby, but not at six months. Thus, the intake of 0.8–1.1g/kg body weight was considered adequate for pregnant women.

Theme 2: Relationship between maternal intake and childhood stunting incidence

A diverse dietary intake was associated with stunting prevalence. An individual is considered to have a diverse nutritional intake when they consume at least five food groups per day. A study conducted by Huang et al. (2018) found that diverse prenatal diets were highly associated with increased weight-for-height z-score and weight-for-age z-score ($p = 0.01$).[20] Furthermore, it also reduced the number of waste among the children with an odds ratio of 0.22.

Protein requirements given by bodyweight adjustment were associated with children's anthropometric measurements. Infants' birth weight and length are positively associated with prenatal maternal protein intake (0.8 - 1.1g/kg body weight). However, the children's weight and length were negatively correlated with prenatal protein intake at six months and two to five years.[22] At the same time, the insulin-like growth factor 1 (IGF-1) concentration analysis found no association between maternal protein intake and later child body composition at five years old.[22] Additionally, vegetarianism among pregnant mothers does contribute to stunting prevalence among children. A study conducted in India reported that children of vegan mothers were vulnerable to stunting and wasting compared to children of non-vegan mothers.[23] However, lactovegetarian children are less likely to become stunted or wasted than nonvegetarian children, as they consume a high amount of dairy products and vegetables.[23]

Fruits and vegetables are the sources of vitamins for mothers and their foetuses. Intake of fruits and vegetables may increase vitamin C stores, resulting in higher birth weight.[24] The fruit and vegetable intake increases foetal diameter if taken above 519 g/day.[21] Furthermore, the mixed model repeated measure of infant weight from birth to six months was higher if they were born to a mother who consumed fruits and vegetables more than 519g/day than those who consumed lower fruit and vegetables.[21]

Micronutrient supplementation for pregnant mothers is an essential intervention during the pregnancy period. In a study, the stunting proportion was reduced significantly in mothers taking the necessary supplementation.[17] Similarly, vitamin C intake above the estimated average requirement (EAR) (85mg/d) is positively associated with a foetal abdominal circumference in late pregnancy.[21] The same study found that prenatal vitamin C intake (EAR ≥85mg/d) positively increased the weight and length of an infant from birth to six months of age. However, a study found that intake of MMS resulted in more stunting cases among children, especially boys.[17] Nevertheless, a recent meta-analysis concluded that the MMS supplementation improved the serum retinol concentration and reduced diarrhoea incidence more than iron-folic acid supplementation[18], resulting in fewer stunting cases. Even though the findings were not statistically significant, the children's stunting cases were more prevalent among underweight mothers than normal BMI mothers.[17]

Nutrition intake is a crucial element during pregnancy. Proper prenatal nutrition was associated with a lower risk of preterm birth or SGA.[25] Moreover, unhealthy prenatal nutrition was related to lower birth weight and induced long-term diseases such as obesity, cardiovascular disease, and diabetes.[25–27] The current review found that intake of diverse diets and supplements during pregnancy was associated with reduced stunting incidence from six months to five years. Pregnant mothers should consume at least five food groups to have various food selections with additional supplements such as folic acid, iron, vitamin A, vitamin C, Calcium, and vitamin B. However, intake of MMS was associated with increased stunting incidents among children compared to standard IFA supplements.

Our review demonstrates that a diverse diet reduced the stunting incidence. Similarly, a study and a review found that mothers who eat a diverse diet with five or more food groups a day may reduce the stunting incidence among their children.[28,29] Furthermore, a balanced energy and protein intake is known to help reduce the low birth weight and SGA,[30] which is related to stunting in the children's later life.[31] Undernourished pregnant women, especially those with BMI <18 kg/m^2, should be provided with 25% protein for better pregnancy outcomes, yet there is no known benefit of taking more than 25%.[30]

On the other hand, protein intake in early childhood also plays an important role to reduce stunting.[32] This was supported by the finding of our review, which showed that the protein intake during pregnancy did not affect the children's growth from six months onwards. Thus, postnatal and children's nutritional intake are as crucial as prenatal intake to reduce stunting.[33] In addition, a study has shown that proper dietary intake during pregnancy, breastfeeding, and early childhood nutrition contributed to the increment of 8cm of mean height in one generation.[34] Additionally, diarrhoea, low socioeconomic

status, and low protein intake were associated with stunting and, if left untreated, will become worse as the children grow.[35]

Despite a significant body of evidence demonstrating the need for proper nutrition during pregnancy, approximately 20% to 30% of pregnant women globally are vitamins deficient.[36] Therefore, the inadequate intake of micronutrients is prominent among pregnant women. The review identified that the common micronutrient supplements provided to pregnant women are MMS or IFA/FA. A study done by Cheng and colleagues (2019) found that supplementation with MMS results in lower weight for age and weight for length z-score at birth compared to IFA supplementation, yet it is not directly related to stunting. Moreover, Cheng (2019) found that MMS significantly improves communication, fine motor and problem-solving skills, and social behaviour at 36 months. A recent review concluded that MMS might have better health benefits than IFA for the babies and the mothers,[38] which contradicts the finding in a study conducted in Bangladesh.[17] MMS uses during pregnancy requires further research before a firm recommendation can be established.

Apart from prenatal nutrient intake, postnatal nutrition intake, especially for exclusive breastfeeding mothers, is essential for babies' optimal growth. Maternal postnatal intake affects the infant growth rate; results from a study done in Vietnam concluded that complete macro and micronutrient intake in breastfeeding mothers significantly increases the babies' body weight and height[39]. Practicing proper hygiene may reduce the incidence of diarrhoea and food poisoning among children. Studies regarding WASH (improved water, sanitation, and handwashing) determine that hygiene is significantly associated with child growth.[40,41] However, this intervention should be parallel with the nutrient intake among the children.[42] The stunting cases were reported higher in rural areas than in urban regions; proper hygiene and good nutrients reduced the number of cases between 2011 and 2016 by 15%.[16]

The strength of this systematic review is that it applies strict inclusion and exclusion criteria and follows the PRISMA guideline thoroughly. It also included prominent databases to retrieve related papers. However, this review is not without limitations; the studies were mainly conducted in rural or developing countries as the prevalence of stunting is known to be higher in those places. The study design should be longitudinal or cohort; thus, not many available studies were published in this area. However, with the available studies included in this systematic analysis, we managed to conclude about maternal intake and child stunting incidence.

CONCLUSION

Macro and micronutrient intakes within the first thousand days of a child's life are essential interventions to reduce the prevalence of stunting. It is concluded that pregnant women should consume at least five food groups to meet their nutritional needs. The protein intake should be in the range of 0.8 – 1.1 g/kg body weight to ensure proper growth of the foetus and infant. Micronutrient supplementation is useful in minimising vitamin deficiencies among pregnant women; thus, MMS or IFA supplementation has benefited pregnant women and their children. Equally important, some other confounding factors such as hygiene and clean water that may lead to food poisoning and prolonged diarrhoea should be taken into consideration in the effort to reduce stunting prevalence.

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