Proceedings of the Nutrition Society (2022), **81**, 87–98 doi:10.1017/S0029665121003724

First published online 27 October 2021

The Nutrition Society Irish Section Conference 2021 was held virtually on 22–24 June 2021

Conference on Nutrition, health and ageing – translating science into practice Postgraduate Symposium

Addressing the gaps in nutritional care before and during pregnancy

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The present paper outlines current issues in the nutritional care of women during pregnancy and potential resources to address them. Globally, overnutrition, undernutrition and nutritional imbalances are widespread among women of reproductive age; increasing the risk of pregnancy complications and non-communicable diseases in both mothers and their children. Most women do not meet dietary guidelines for pregnancy. The World Health Organisation (WHO) recommends nutrition and weight counselling during pregnancy for all women. However, clinical practices focusing on nutrition vary and there is no consensus on which outcomes are most important for pregnancy nutrition interventions, with little consideration for the 'patient voice'. The International Federation of Gynaecology and Obstetrics (FIGO) nutrition checklist is a clinical practice tool that is available for healthcare professionals that will address this issue. The pregnancy nutrition core outcome set will also support advancement of antenatal nutrition by identifying the most critical nutrition-related outcomes from the perspective of healthcare professionals, researchers and women with experience of pregnancy. While poor nutrition can result in adverse outcomes across women of all weight categories, those with obesity may require specialist care to reduce their risk. Obesity is a chronic, progressive, relapsing disease that has high individual variability in its prognosis. The use of obesity staging systems, which consider mental, physical and functional health, can stratify individuals into risk categories and aid in treatment prioritisation in pregnancy. As the prevalence of obesity continues to rise, an obesity staging approach may support clinicians, especially those in limited resource settings.

Key words: Pregnancy: Nutrition: Obesity: Antenatal: Dietary intakes

Malnutrition, including overnutrition, undernutrition and nutrient imbalances, is a major global health issue causing significant morbidity and mortality across a range of health systems and is associated with economic burden[1]. Globally, overweight- and obesity-related chronic diseases cause 4 million deaths annually, up to 800 million people are undernourished, and at least 1 billion people experience micronutrient deficiencies[2]. Estimates suggest that malnutrition costs society up to 3·5 trillion US dollars annually to treat[3]. Due to higher

Abbreviations: BMI, Body mass index, CMDS, cardiometabolic disease staging system, EOSS, Edmonton obesity staging system, FIGO, International Federation of Gynaecology and Obstetrics, UN, United Nations, WHO, World Health Organisation.
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nutritional requirements during adolescence, pregnancy and lactation, women of reproductive age are especially vulnerable to nutritional inadequacies[4]. Pregnancy nutrition is integral to promoting population health and achieving the United Nations (UN) sustainable development goals, which aim to reduce hunger and promote good health and well-being[5,6]. Dietary interventions during pregnancy are also likely to be cost-effective, reducing future economic burden[7]. A life course approach to healthcare that is underpinned by interventions to improve the nutritional status of women holds great potential to reduce global non-communicable diseases across generations[8]. In this review, the current issues in the nutritional care of women of reproductive age are outlined and potential resources that could be incorporated into routine antenatal clinical practice are explored.

Why pregnancy nutrition?

Improving maternal nutrition during pregnancy is integral to optimising child health outcomes and protecting women's health postpartum and beyond[9,10]. Inadequate or excess maternal nutrient intakes affect the intrauterine environment, and can 'programme' the fetus to adapt to the level of nutrient provision[11]. This mismatch in epigenetic and other programming may predispose children to metabolic and other non-communicable disease[11,12]. Maternal hyperglycaemia can increase the risk of gestational diabetes, which itself increases the risk of later type 2 diabetes mellitus for the mother[10]. Equally, excessive maternal intake of macronutrients or micronutrients affects fetal development. Excess carbohydrate intake can lead to maternal hyperglycaemia resulting in excess glucose transfer across the placenta and increased fetal growth[13–15]. Higher birth weights may increase the risk of caesarean delivery, birth injuries for mothers and infants and neonatal hypoglycaemia[16]. In the longer term, infants who are born with macrosomia may be predisposed to a high trajectory of weight gain leading to obesity and associated health risks later in life[17]. Low energy and macronutrient intake affects fetal substrate provision and may lead to intrauterine growth restriction and small for gestational age or low birth weight infants[15]. Both intrauterine nutrient excess and inadequacy may increase the risk of chronic diseases such as type 2 diabetes mellitus[18].

Habitual inadequate intakes of macronutrients or micronutrients such as protein, calcium, iron, vitamin B12, vitamin D and folic acid may predispose women to deficiency during pregnancy, when requirements increase to meet the demands of the growing fetus[19–21]. In the case of inadequate micronutrient intakes, maternal stores of nutrients including iron and calcium may become depleted as fetal transfer takes place regardless of low maternal dietary intakes[22]. In the short term, this can increase the risk of maternal complications such as anaemia[19,22]. This affects the mother throughout gestation by increasing shortness of breath, risk of infection and lethargy[23]. It can also pose problems during delivery, especially in the case of postpartum haemorrhage, and in severe cases, lead to maternal death[24]. Low calcium status in pregnancy may increase the risk of pregnancy-induced hypertension or pre-eclampsia, and calcium supplements may be effective in preventing these complications[25]. In the longer term, inadequate calcium status may lead to reduced maternal bone mass, predisposing the mother to bone diseases such as osteopenia, osteoporosis or tooth loss[26]. The impact of maternal diet on bone health may also extend to the child later in life[27,28]. Inadequate folic acid intake can increase the risk of neural tube defects in the fetus and result in other adverse pregnancy outcomes, especially in women with obesity who may have greater risk and higher folic acid requirements[29,30].

Taken together, these data suggest that non-communicable diseases, which account for 70 % of annual global deaths, are in fact communicable from parents to offspring[5,31]. It is now recognised that increasing proportions of the population may be exposed to different forms of malnutrition throughout the life course and the negative effects can be passed across generations[12]. This is the basis of the developmental origins of health and disease, a concept that recognises the impact of the 'exposome' of parents and grandparents on the disease risk of future generations[32,33]. As pregnancy nutrition influences lifelong disease risk in mothers and children, improving it as part of a 'life course approach' in maternity services holds great potential to reduce the global disease burden of conditions such as cancer, cardiometabolic disease and obesity[5,34]. The World Health Organisation (WHO) previously stated that nutrition, including maternal nutrition, is the highest priority issue for global public health[35]. This is reflected in the significant emphasis placed on maternal health, nutrition and obesity in the UN sustainable development goals[36]. Of note, improving maternal health through optimum nutrition during pregnancy will support global targets to end all forms of malnutrition by 2030 (goal 2·2), reduce the global maternal mortality ratio to <70 per 100 000 live births (goal 3·1), end premature deaths of newborns and children under five years of age (3·2) and reduce premature deaths from non-communicable diseases by one-third (goal 3·3)[37].

Dietary intakes in the preconception period influence the nutritional status of mothers on entering pregnancy and outcomes later in life for both mothers and children[38]. Limited evidence from antenatal studies suggests that women who reported intended pregnancies demonstrated healthier diet and physical activity behaviours[39]. As many pregnancies are unplanned and there is limited access to preconception care, promotion of optimal nutrition in all women with reproductive potential is warranted[38,40–42]. It is, however, difficult to engage women of reproductive age outside of pregnancy[43]. Public health messaging intended to improve preconception health in women who are not planning a pregnancy may be negatively received, as seen in response to the WHO's messaging to reduce alcohol consumption in women of reproductive age[44]. In addition, dietary requirements change in pregnancy compared to

https://doi.org/10.1017/S0029665121003724 Published online by Cambridge University Press

preconception[19]. A study using longitudinal data from the Japan environment and children's cohort, which included over 30 000 pregnant women, found that the percentage of women not meeting the dietary reference intakes for a variety of nutrients increased from preconception to pregnancy, including iron (80 and 99 %, respectively), vitamin C (50 and 54 %, respectively), folate (40 and 86 %, respectively), saturated fat (80 and 85 %) and salt (54 and 59 %, respectively)[45]. Maternity healthcare providers can leverage the increased contact they have with women throughout pregnancy to improve dietary intakes, promote healthy gestational weight gain and encourage lifestyle behaviours in the postpartum period that support women in maintaining good health later in life[5]. Pregnancy has been described as a 'teachable moment' in the lifecycle, during which, women may be more open to receiving diet and lifestyle information[46,47].

The current clinical perspective

Obesity is the most common condition in women of reproductive age[48]. In the USA, evidence suggests that obesity prevalence in women aged 20–39 is at least 31 % and may be over 61 % in women with low incomes[49]. In some regions of India, over 40 % of women may have obesity as defined by body mass index (BMI) ≥30 kg/m2[50]. Globally, obesity prevalence is rising and is estimated to be >20 % in all women by 2025[51,52]. Another significant proportion of women live with a BMI in the overweight category[53]. Cumulatively, this means overweight and obesity are becoming prominent in antenatal services. Data from Ireland in 2017 suggest as many as 48·4 % of pregnant women have overweight or obesity[54]. In 2018, a systematic review found the prevalence of pre-pregnancy overweight, and obesity was 42 % in the USA, 30 % in Europe and 10 % in Asia[55]. Data from the Brazilian food and nutrition surveillance system shows that pre-pregnancy overweight and obesity increased from 32·4 % in 2008 to 48·6 %, while maternal underweight decreased from 6·8 % to 4·8 % in 2018[56]. In high-income countries such as Norway, underweight is less common at 3·8 %[57]. Collectively, pre-pregnancy underweight BMI is estimated to be present in 5 % of women in the USA, 3 % in Europe and 17 % in Asia. Reynolds *et al.*, using Irish data, report only 1·7 % of women had a BMI in the underweight category[54]. While the data in Brazil illustrate the shift in nutritional status experienced in some low-middle income countries, others still report high levels of maternal undernutrition. In Jordan, for example, Karasneh *et al.* reported high levels of low BMI in mothers, at 42 %[58]. These data highlight that maternal malnutrition, including underweight and overweight, is common and a growing area of concern in both high- and low-middle income countries.

In addition to body weight, nutritional imbalances caused by suboptimal maternal dietary practices are an area in need of urgent attention. A systematic review of international observational studies found that most women of reproductive age do not adhere to the dietary guidelines for pregnancy[59]. This has been further replicated in more recent studies[7,60,61]. In terms of food intake, Caut *et al.*'s systematic review found that pregnant women did not eat enough vegetables, cereal grains or folate. In addition, up to 91 % of women may not consume enough iron in their diet and 55 % may have an inadequate calcium intake[59]. Micronutrient deficiencies are common and up to 30 % of women of reproductive age have anaemia[62]. The prevalence of anaemia varies substantially from country to country and could be over 50 % in some areas[63]. In a cross-sectional study of pregnant women in Australia, Bookari *et al.* found that none of the 388 included women met the recommended intakes for all five food groups assessed which included bread and cereals, fruit, vegetables, meat and alternatives, and dairy[64]. In a study in Ireland with 402 women, 99 % did not meet the estimated average requirement for vitamin D, 56 % had inadequate iodine intake and over 90 % had excess saturated fat consumption[65]. The recent study by Bailey *et al.*, which used a sample of 1003 pregnant women, representative of the US population found that even with the use of dietary supplements, issues about achieving recommended levels of intake remained[7]. Evidence suggests that those with obesity may be more likely to experience micronutrient deficiencies such as vitamin B12, iron and vitamin D[66,67]. Ultimately there is much room for improvement in terms of dietary intakes and nutritional status of women during pregnancy which can be addressed through appropriate nutrition counselling.

Nutrition counselling

A recent systematic review suggested that dietitian-delivered medical nutrition therapy is effective in antenatal care in improving maternal and child outcomes[68]. Registered dietitians are trained experts in delivering nutritional care and are well placed to support women during pregnancy to achieve an optimal dietary intake[35]. Evidence from meta-analyses suggests that dietary interventions are more effective when delivered by dietitians[69–71]. Clinical guidelines for obesity management, for example, recommend access to a dietitian if available[72]. Staffing issues in dietetics are common across a range of areas and health services, including antenatal care[73–75]. Access to dietetic services in antenatal care is not universal and when available, may not meet the level of demand highlighted earlier[76]. Use of existing antenatal health services and a variety of healthcare providers to deliver nutritional care to women during pregnancy may be key to maximising coverage to all women during pregnancy while minimising delivery costs[77]. This approach would allow for basic nutritional counselling for all women, as recommended by the WHO[78]. Women with nutritional needs that require specialist care could be referred to dietetics if available, making best use of available dietetic staff and filling in service gaps[76,79,80].

Nutrition education given to pregnant women by trained healthcare professionals in antenatal clinics has

https://doi.org/10.1017/S0029665121003724 Published online by Cambridge University Press

been shown to improve pregnancy-specific nutrition knowledge in women[81]. It has also been shown to improve maternal dietary intakes and clinical outcomes such as maternal anaemia, gestational weight gain and birthweight[82]. Counselling interventions to reduce excessive gestational weight gain may also reduce the risk of associated complications such as gestational diabetes, emergency caesarean delivery, macrosomia and large for gestational age[83]. Healthcare providers are encouraged to discuss nutrition information with women of childbearing age but, despite this, professional practices vary[84,85]. The reasons for this are multifaceted and include a lack of healthcare professional nutrition training, a lack of supportive resources and short clinic times which see other clinical issues prioritised over nutrition[86,87]. This is an unmet need in healthcare. Women want more nutrition counselling, consider pregnancy nutrition important and see clinicians as the most reliable source of this information[64,84,88–91]. In both high- and low-middle income countries, nutrition knowledge may be limited in pregnant women[92,93]. Women may further struggle with complex nutrition recommendations, such as those for fish intake[94]. All of this is compounded by the limited nature of nutrition counselling in antenatal care and potential nutrition information deficits amongst healthcare providers[87,93,95,96]. In a recent systematic review, Callaghan *et al.* found obstetricians and midwives had insufficient knowledge of gestational weight gain guidelines[97]. The absence of nutritional care during pregnancy has the potential to leave women reliant on other and perhaps less evidenced-based sources of information such as internet or family and friends[88,98]. In addition, health literacy is an important consideration in pregnancy that may influence how women engage with this health information[99]. Globally, up to 40 % of adults may have lower levels of health literacy[100]. More specifically, data from studies with pregnant women suggest that levels of health literacy are mixed in this group and that lower levels are associated with unhealthy behaviours during pregnancy[101].

Nutrition counselling tools

Shekar *et al.* in the 2021 Lancet series on maternal and child undernutrition highlighted that progress on what is known to work in the area of nutrition was slow and called for more implementation research to support progress in this area[9]. Beulen *et al.* recently published a systematic review of tools to promote a healthy diet during pregnancy[102]. Interventions identified included mobile health, printed materials and cooking classes supported with telephone or face-to-face consultations[102]. Mobile health interventions hold great potential to improve dietary intakes in women given the ease of remote access on a mobile device. They also show promise in terms of cost-effectiveness[103]. The pregnancy exercise and nutrition research study smartphone app was designed to support a healthy diet and lifestyle and was found to be acceptable to pregnant women, especially in those with lower socioeconomic backgrounds[104]. This is important as a review of research on pregnancy app use suggests that smartphone app uptake may be lowest in pregnant women with low incomes, due to issues about technological features, health literacy and language barriers[105]. Features of smartphone apps for pregnancy include information provision, goal setting and tracking[106,107]. Nutrition assessment, including collection of BMI and dietary intake data, is a step that can guide nutrition counselling[108]. Assessment of baseline nutritional status and diet will identify potential nutrition issues. Recent qualitative evidence identified that generating awareness of dietary issues with pregnant women is a key opportunity to support mothers to make healthy dietary changes[109].

The American College of Obstetricians and Gynaecologists recommends clinical checklists in obstetrics and gynaecology to support standardised and optimum care[110]. A nutrition checklist that facilitates standardised nutrition assessment could support non-nutrition healthcare providers in maternity services to address nutrition as part of their routine clinical care. A similar approach has been taken in India where their government along with the UN children's fund (UNICEF) and other colleagues, has launched a treatment algorithm with checklist points to guide healthcare providers in addressing key aspects of antenatal care, including diet and weight[50]. Other regions may have locally developed tools to support nutrition assessment and feedback. While no formal dietary metric exists that addresses both maternal and child health and non-communicable disease[111], the International Federation of Gynaecology and Obstetrics (FIGO) nutrition checklist has been shown to be valid and suitable for use in both low-middle and high-income settings. It is therefore a potentially pragmatic approach to diet quality assessment in the clinical setting.

The FIGO nutrition checklist

The FIGO nutrition checklist is a globally relevant clinical practice tool that may support healthcare professionals in addressing nutrition and weight with women[112]. The questions in the FIGO nutrition checklist are informed by the FIGO recommendations on adolescent, preconception and maternal nutrition: 'think nutrition first'[20]. The FIGO nutrition checklist was created in 2015 after a 2 d round table discussion with members of the FIGO initiative on adolescent, preconception and maternal nutrition. It is a one-page questionnaire that captures information on special diets (e.g. vegetarian, vegan and other food avoidances or allergies), height and weight for calculation of BMI, diet quality (six simple 'yes' or 'no' questions on key food groups) and micronutrients (vitamin D, iron and folic acid). The checklist has 12 questions in total, with six of these focused on diet quality[87]. The back of the checklist includes evidence-based information for the healthcare provider including nutritional guidance from the 'think nutrition first' guidelines and the Institute of Medicine recommendations for gestational weight gain[113].

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The FIGO nutrition checklist is validated for use in pregnancy[114]. In a study with 156 healthy pregnant women, Tsoi *et al*. found that the dietary information in the checklist correlated with the same data collected by a validated food frequency questionnaire. In addition, the quality of diet suggested by the checklist correlated with more detailed and well-established dietary indices, including the dietary approaches to stop hypertension and the Mediterranean diet scores[114]. With knowledge of the need for more implementation research to support meaningful change in clinical practice globally, Killeen *et al*. conducted an acceptability and feasibility study of the checklist with 105 women in a busy, routine antenatal outpatient department in Dublin, Ireland. They found that most of the pregnant women, and two out of three obstetricians who took part recommended using the checklist to improve how nutrition is addressed in regular antenatal care[87]. Importantly, the checklist encouraged obstetricians to address nutrition in cases when they otherwise would not have, however time was a potential barrier to implementation[87]. The feasibility of a tool for nutrition counselling depends on factors such as practicality, time and provider characteristics such as motivation, skills and knowledge[102]. A follow-on qualitative study with pregnant women further supported its use in practice with some women reporting that completing the checklist increased their awareness of dietary issues, while others valued the checklist's ability to support healthcare provider conversations on nutrition[98].

The FIGO nutrition checklist is effective in identifying potential nutritional issues and therefore could be used as a nutritional risk screening tool. In the study by Tsoi *et al*., 95 % of women reported at least one suboptimal dietary practice that could put them at nutritional risk for their pregnancy[114]. Likewise, the study by Killeen *et al*. found that the checklist captured at least one suboptimal dietary practice in over 80 % of their convenience sample of women attending routine antenatal services, 16 % of which reported three or more out of six potential issues with diet quality[87]. There has been much research to date looking at a variety of dietary indices in predicting adverse outcomes in pregnant women[115,116]. There are over 80 dietary indices in the literature which vary widely in the content, scope and suitability for use across a range of resource settings[117,118]. Some are generalisable such as the dietary inflammatory index, while others are region specific, or based on unique dietary guidelines including the healthy eating index-2015 (based on the 2015–2020 dietary guidelines for Americans) and healthy eating index for Australian adults-2013[119–121]. Most indices rely on the collection of robust dietary information from participants with the use of tools such as a food frequency questionnaire[119]. While the association between diet quality indices and health outcomes informs the dietary recommendations given to pregnant women, they may not be practical to apply in the clinical setting given their length and the time needed to complete them.

Future work could involve the translation of identified nutritional risks in the FIGO nutrition checklist to nutritional scores that could predict the risk of adverse maternal and child outcomes and support the development of treatment algorithms. One such study already exists that used an adapted version of the FIGO nutrition checklist in Italy and found that designated scores were associated with outcomes such as pregnancy-associated plasma protein A and placental volume[122]. While the available data warrant investigation of the FIGO nutrition checklist in practice, urgent work is needed to validate it against outcomes relating to the double burden of malnutrition on maternal health, child outcomes and non-communicable diseases. The evolution of this evidence will elevate the checklist's standing compared with other available resources and support the change in clinical practice needed to achieve global nutrition and public health targets[111].

Further assessment in overweight and obesity

Another aspect of risk categorisation is to examine the health status of the individual, rather than the health behaviours. One marker typically used to classify individuals into risk categories is BMI. This measure is simple to calculate using height and weight so is well suited in the context of public health. Use of varying cut-offs to determine patient risk is informed by the myriad of available literature on the impact or low or high BMI on health outcomes[123]. There is much evidence to support that women with obesity are at greater risk of adverse maternal and child outcomes compared with those with a healthy BMI[29,38,124]. In addition, women with low BMI are at increased risk of complications such as small for gestational age[125]. Evidence suggests that both overweight and underweight in women are associated with higher risk of complications such as spontaneous abortion compared to those with a healthy BMI[126]. Moving from epidemiology to clinical practice, the utility of BMI is questioned due to the significant variance in health status of individuals within the same BMI category. Although women with obesity are at higher risk of adverse outcomes, most will experience their pregnancy and delivery without complications[127]. In addition, as obesity makes up a substantial proportion of those attending antenatal services, further steps to clearly delineate risk are needed to inform care planning and treatment prioritisation, especially in resource-limited settings. Metabolic markers are commonly used to predict pregnancy outcomes such as gestational diabetes and pre-eclampsia[128–130]. Wu *et al*. found that second trimester lipid profiles predicted pregnancy complications including pregnancy-induced hypertension in an age-dependent manner with specific cut-offs suggested[131]. However, while metabolically healthy and unhealthy obesity phenotypes have been studied widely in the literature, there remains a paucity of evidence in pregnancy[127]. The definitions of metabolically healthy and unhealthy obesity also vary significantly and this limits applicability in the clinical setting[132].

The cardiometabolic disease staging system (CMDS) and the Edmonton obesity staging system (EOSS) are two clinical scoring systems that consider metabolic health in determining obesity severity[133]. The EOSS

https://doi.org/10.1017/S0029665121003724 Published online by Cambridge University Press

was proposed by Sharma and Kushner in 2009, it considers the global impact of obesity on health including mental, metabolic and functional parameters[134]. The CMDS, however, considers only metabolic health in determining risk scores[135]. Application of obesity staging using tools such as CMDS or EOSS may help in decision making about care plans for those with obesity across a range of settings[136]. This approach captures the variety of obesity phenotypes seen in clinical practice and aligns with the perceptions of those with raised BMIs who through qualitative studies, have voiced a broader view of health in the context of their weight. In fact, focusing on weight in the absence of the other health measures may perpetuate weight-related stigma[137,138]. This is especially important in the context of pregnancy which has been identified as a particularly vulnerable time for weight stigma[139].

Data from our group suggest that raised CMDS and EOSS may be common in women of reproductive age with overweight and obesity. In a cross-sectional study of 64 women with a BMI ≥28 kg/m^2, 46·9 % had CMDS scores in the 'at risk' group while 81·3 % had raised EOSS scores[140]. Data from the pregnancy exercise and nutrition research study (PEARS) trial in Dublin, Ireland, suggests that metabolically unhealthy obesity, defined by raised EOSS scores is also common in pregnancy, affecting over 80 % of women[141]. A single published study has applied EOSS in pregnancy[142]. Demsky *et al.* found that the EOSS helped predict the chance of caesarean delivery in a high-risk group of nulliparous women undergoing induction of labour at term. Like our data, 80·8 % of women with obesity had raised EOSS scores[142]. A separate study looked at metabolic profiling into unhealthy and healthy groups[127], but did not find much additional predictive value for adverse obstetric outcomes beyond that of BMI. Future studies on the role of obesity staging systems in risk categorisation in a pregnant population are therefore needed. The CMDS uses a lower number of criteria in the scoring system and a lower cut-off for HDL (with female-specific values). This explains the lower proportion of women being classified as metabolically unhealthy using the CMDS compared to the EOSS, suggesting it may be of greater use in stratifying women based on risk in the clinical setting[135]. Ejima *et al.*, using data from National Health and Nutrition Examination Survey 2014, compared CMDS and EOSS on the prediction of mortality and found CMDS had greater discriminatory value in those aged 40–75 years[133]. More research on CMDS and EOSS is needed in maternal health before definite conclusions to guide treatment can be drawn.

Treatment prioritisation

Nutrition interventions can influence a variety of outcomes in pregnancy[78]. Due to the clear importance of maternal nutrition in the context of global health, there is a large volume of pregnancy nutrition research emerging in the literature. More systematic reviews and meta-analyses are therefore needed in maternal nutrition to consolidate findings from multiple studies[143]. The potential for these evidence syntheses in pregnancy nutrition research is limited however, as there is large variability in the outcomes that are reported in pregnancy nutrition research. Rogozińska *et al.* in the international weight management in pregnancy network found that in lifestyle interventions for weight management of obesity in pregnancy, a total of 142 unique outcomes were reported and seventy-two were reported only once[144]. Food intake and weight were reported in only thirteen of seventy-eight studies and energy was reported four times[144]. This lack of consistency in outcome reporting leads to significant research waste, potential bias towards specific or niche outcomes, and a deficit of high-quality evidence for nutrition interventions on other outcomes which may be important[145]. The need for consistency in study design to enable systematic reviews in pregnancy nutrition was highlighted by Stoody *et al.* in the US Department of Agriculture's pregnancy and birth to 24 months project. In their review of the literature, the evidence did not support conclusions in relation to pregnancy nutrition across a range of outcomes of public health importance[146]. In the systematic review by Beulen *et al.*, a lack of inclusion of outcomes related to healthy dietary intake in pregnancy was identified as an important gap in the literature[102].

To address this issue, over 50 journals collaborated to launch the core outcomes in women's health initiative in 2014. The aim was to encourage researchers in the area of obstetrics and gynaecology to develop core outcome sets[147]. A core outcome set is a list of outcomes that are critically important for a subject area[145]. There are now over 80 women's health journals that encourage the development and use of core outcome sets[148]. In addition to a lack of consistency, evidence suggests that outcomes which are important to patients tend to be underrepresented in the literature[148]. Unsurprisingly, many clinical practice guidelines on pregnancy nutrition also lack patient involvement and are largely based on the outcomes for which high-quality evidence exists[35]. This has been shown, for example, in work by Dadouch *et al.* as part of their development of a core outcome set development for studies on obesity in pregnant patients, they found a lack of focus on neonatal outcomes and measures related to life impact such as physical or social functioning, wellbeing or quality of life[149]. Additionally, a review of qualitative research for obesity in pregnancy highlighted the importance placed on measures relating to life impact and delivery of care by women[150]. In other areas such as rheumatoid arthritis, fatigue was highlighted as an important outcome to patients and was subsequently included as a core outcome to measure in future trials[151]. The WHO evidence base for the recommendation on dietary interventions for a positive antenatal experience does not include any measures of life impact[78,152]. The full list of outcomes reported in the evidence base for recommendation A.1·1 to A.1·4 on dietary interventions in pregnancy relates to clinical pregnancy outcomes and physiological functioning. These include pre-eclampsia, caesarean delivery, total/excessive gestational weight gain, preterm birth and macrosomia. This contrasts with what is the work of Dadouch *et al.* which found that clinical outcomes comprise only a minority of outcomes reported by pregnant women[150].

We are developing a pregnancy nutrition core outcome set (PRENCOS). This will be a list of the most critical outcomes relating to general pregnancy nutrition trials that studies will be expected to measure at a minimum[153]. This will be the only core outcome set that is focused on dietary studies conducted with pregnant women. It will be developed after extensive systematic review of the literature that builds on the work of Rogozińska *et al.* but differs as it will include any study that measures dietary intakes in pregnancy, not just those relating to weight management. The review will also include observational studies on dietary intakes so that the full suite of potentially relevant outcomes can be identified. As this is a core outcome set for pregnancy, the outcomes will relate to pregnancy or delivery only, but future work could explore expanding it into postpartum and other timepoints. The systematic review will be supplemented with qualitative interviews among women with personal experience of pregnancy who will suggest the outcomes most important to pregnancy nutrition from their perspective[153]. It is recommended to involve the health service users to which a core outcome set relates as soon as possible in the development process[145]. The impact of this is illustrated with the core outcome set for preterm birth which resulted in thirteen outcomes, but only four of these were frequently reported in the literature prior to the development process[148]. Once a full list of candidate outcomes is developed, the most critical of these in relation to pregnancy nutrition will be identified through a consensus process, using the Delphi technique, followed by a consensus meeting[153]. By developing and implementing PRENCOS, evidence will build for the most critical outcomes agreed by healthcare professionals, researchers and women with experience of pregnancy. This will support funding applications for pregnancy nutrition research by guiding outcome measurement and enable comparison among a large volume of studies.

Conclusions

Maternal nutrition needs to be urgently addressed in routine antenatal care to reduce the global burden of non-communicable and chronic disease. Nutrition counselling can improve pregnancy outcomes and the FIGO nutrition checklist holds great potential to support clinicians in delivering it as part of the standard practice. The growing obesity prevalence in women is increasing demands on maternity services and future studies should investigate strategies to stratify risks to guide treatment prioritisation Finally, the outcomes which are most important for pregnancy nutrition interventions are not clear but will be identified through pregnancy nutrition core outcome set, a core outcome set for pregnancy nutrition research that is being informed by the opinions of healthcare professionals, researchers and women with experience of pregnancy. Ultimately, these practical resources will support healthcare providers in delivering evidence-based nutrition interventions in antenatal care with the purpose of optimizing maternal and infant health.

Financial Support

This publication has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under grant No. 12/RC/2273 and 16/SP/3827 which included co funding from PrecisionBiotics Group Ltd.

Conflict of Interest

None.

Authorship

The authors had sole responsibility for all aspects of preparation of this paper.

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