Chapter

Preconception and Prenatal Nutrition: Advancing Maternal and Fetal Health

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Abstract

This chapter explores the importance of addressing macronutrient and micronutrient needs in the pre-pregnancy and prenatal periods to support optimal maternal health, fetal development, and pregnancy outcomes. Framed within a social determinants of health perspective, the chapter examines how socioeconomic status, food security, education, and cultural practices influence access to and utilization of nutritious diets. It highlights strategies to manage common nutritional challenges, such as gestational diabetes, anemia, and food accessibility issues, while offering practical, culturally relevant, and affordable solutions to improve maternal and fetal health. By integrating evidence-based dietary guidelines with actionable strategies, this chapter provides insights for those dedicated to enhancing health outcomes through effective nutritional interventions.

Keywords: pregnancy, nutritional status, health behavior, telemedicine, delivery of health care

1. Introduction

Human development is influenced by nutritional programming from preconception through pregnancy [1]. During pregnancy, conditions like preeclampsia and gestational diabetes manifest with nutrition as an underlying factor for its development. Health impacts from diet continue to be seen throughout the lifespan, influencing the growth of obesity, heart disease, and stroke [2]. Understanding the role of macronutrients and micronutrients in human health is essential for supporting well-being and promoting positive health outcomes throughout all stages of life. The life course theory elucidates the relationship between maternal diet and biological and social impacts and disease manifestation and progression in the women and their offspring. Additionally, the social determinants of health access to care and technology will be explored to describe how these factors influence nutritional choices. The United States and the United Kingdom's food regulations and recommendations will be compared to highlight disparities and manifestations of these impacts on well-being and health.

During pregnancy, caloric needs increase modestly, with no additional intake required in the first trimester and an estimated increase of 340-450 kcal/day during the second and third trimesters based on maternal BMI and activity level [3].

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A nutrient-dense diet that includes adequate protein, fiber, essential fatty acids, and key micronutrients—such as folate, iron, calcium, vitamin D, iodine, and choline—is needed to support fetal development; caffeine intake should be limited to less than 200–300 mg/day, and alcohol should be avoided entirely. Nutrients are chemical substances in foods that provide energy for sustaining human life. They can be grouped into two main categories: macronutrients and micronutrients. Macronutrients, including proteins, fats, and carbohydrates, support metabolic pathways, hormone production, and the synthesis of vital molecules, particularly during pregnancy [4].

2. Macronutrients and micronutrients

During pregnancy, macronutrient and micronutrient needs increase in different amounts to support distinct physiological functions; for example, protein requirements rise to sustain fetal and placental growth, while micronutrients such as folate, iron, and iodine are needed in greater quantities to support neural tube development, hemoglobin production, and fetal thyroid function (**Table 1**). Details on nutrition recommendations during pregnancy are given in **Table 1**.

Carbohydrates are the body's primary energy source, providing 4 kcal/g of energy [6]. The recommended daily intake of carbohydrates is 175 g/day in pregnancy, up from 130 g/day in nonpregnant females. These macronutrients are in

Category	Recommendation	Additional details
Total calorie intake	• 1st trimester: No increase • 2nd trimester: approximately 340 kcal/day • 3rd trimester: 450 kcal/day	• Adjust based on BMI and activity level
Protein	• 71 g/day (1.1 g/kg/day)	• Lean meats, eggs, beans, nuts, dairy
Carbohydrates	• ≥175 g/day	• Focus on whole grains, fruits, vegetables
Fiber	• 25–34 g/day	• Helps with constipation; supports glucose control
Fat	• 20–35% of total kcal • <10% saturated fat	• Favor plant oils, fish, nuts; avoid trans fats
Calcium	• 1000–1300 mg/day	• Dairy, leafy greens, fortified foods
Vitamin D	• 600 IU/day	• Sunlight, fortified milk, supplements
Folate/folic acid	• 0.6 mg/day (diet + supplement) • 0.4–0.8 mg supplement preconception—1st trimester	• Prevents neural tube defects
Iron	• 27 mg/day	• Meats, legumes, fortified grains; supplements if deficient

Category	Recommendation	Additional details
Iodine	• 220–250 mcg/day	• Use iodized salt, dairy, seafood; prenatal vitamins should contain 150 mcg
Choline	• 450 mg/day	• Eggs, meat, dairy; many prenatal vitamins lack enough
Vitamin B12	• 2.6 mcg/day	• Animal products; supplement for vegans
Zinc	• 11–12 mg/day	• Meats, whole grains, legumes
Caffeine	• <200–300 mg/day	• About one 12-oz coffee; excess linked to miscarriage risk
Alcohol	• Avoid entirely	• No safe level during pregnancy
Vitamin A	• 750–770 mcg/day • Limit preformed vitamin A to <5000 IU/day	• Avoid liver and high-dose supplements

Source: Ref. [5]; nutrients-11-00443-v2 PDF (mdpi-res.com)

Table 1.
Essential macronutrients and miconutrients needed during pregnancy.

milk, vegetables, grains, and fruits and, when metabolized, become glucose. Blood glucose is influenced by carbohydrate intake, which is stored as glycogeconsumption of kcals from carbohydra when in excess. Intake of carbohydrates influences glucose uptake into the tissues and insulin secretion. Fiber, a non-digestible carbohydrate, promotes gastrointestinal health, improves satiety, and lowers cholesterol levels (for recommended levels see **Table 1**). During pregnancy and non-pregnancy, the recommended consumption of kcals from carbohydrates is 45–65% of the total caloric intake [4].

1 g of protein contains 4 kcal; however, their primary function is to aid in cellular and body regulation and structural (keratin, collagen), functional (enzymes, hormones, protein tranport), and biological mechanisms. Amino acids, a type of protein, can be found in foods like grains, legumes, vegetables, dairy, and meats. To support rapid growth during the third trimester of the pregnancy, approximately 71 g of protein are required. Approximately 10-35% of a pregnant woman's caloric intake should comprise protein.

Lipids are the primary source of energy storage, with 9 kcal of energy. Other functions of lipids include thermoregulation, structural and mechanical functions, and bodily protection. Food lipids are found in dairy, grains, meats, fish, oils, and fats, which, for most Americans, consume lipids primarily in triglycerides. The nutritional recommendation for pregnancy is that only 20–35% of total energy comes from lipids.

Fats, or lipids, provide 9 kcal/g and contribute to thermoregulation, cell structure, and the absorption of fat-soluble vitamins such as K, E, D, and A. They also serve as energy storage, offer protection for the body organs and support sex hormone production. Lipids are classified into triglycerides, sterols like cholesterol, and fatty acids, which are further divided into saturated and unsaturated fats, each with different effects on health. A well-balanced intake of these macronutrients is vital for maintaining maternal health and supporting fetal development throughout pregnancy. Consuming more or less of these macronutrients can contribute to adverse health outcomes [7].

Although needed in small amounts, micronutrients significantly impact growth, development, and physiological function during pregnancy. They are mainly categorized as vitamins-organic compounds like Vitamin A, D, E, K, B12, and Folate- and minerals like inorganic elements such as Iron, Calcium, Zinc, and Iodine.

The recommended iron intake during pregnancy is 27 mg/day [7], often met through Prenatal Vitamins. Iron supports fetal brain development and increases material red blood cell mass. Additionally, it helps prevent pregnancy complications, especially in the third trimester. Calcium recommendations vary based on age and range from 1000 to 1300 mg/day [8]. Calcium is important for fetal skeletal, muscle, and nerve function and tooth development. Absorption of calcium increases in pregnancy and is mobilized from maternal stores if dietary intake is low. Vitamin D is recommended at 600 IU/Day, it works with calcium for bone development, and may influence immune and metabolic health. Vitamin D deficiency is common; sunlight exposure and supplementation help meet the requirement of Vitamin D. Folate is ideally recommended as 600 mcg a day before conception and continuing during pregnancy. This prevents neural tube defects and is imperative for neural tube development and DNA synthesis. Choline is recommended at 450 mg/day, but many prenatal vitamins lack this amount. Choline is also essential for with the development of the fetal brain and spinal chord. Iodine is recommended at 220–250 mcg/day, and supplements are recommended at 150 mcg. Iodine supports fetal neurocognitive development, and its need increases during pregnancy and lactation. It is needed for brain and nervous system development. The recommended daily zinc intake is 12 mg. Zinc supports fetal growth, neurodevelopment, cell growth, DNA synthesis, and Immune function. Vitamin B12 recommendations include an intake of 2.6 mcg/day. This is especially important for vegetarians or vegans who need to supplement due to dietary limitations. Vitamin B12 works with Folate for DNA synthesis and nervous system development. Vitamin A is recommended at 750–770 ncg/day, with careful consideration to not exceed 10,000 IU/day due to its effect on the liver. Vitamin if consumed in the incorrect amounts may be is teratogenic, and if deficient, night blindness can occur. Vitamin A supports cellular growth, immune function, and eye development [2, 5, 7, 9].

3. Evidence-based dietary guidelines

The U.S. Department of Health and Human Services and USDA released a scientific report, the Dietary Guidelines Advisory Committee [10], with modified dietary guidelines for Americans. A major revision was the inclusion of specific nutritional guidance for pregnant individuals. These recommendations included the most recent research, the 1999 IOM (Institute of Medicine) reports on nutrition in pregnancy, the 2009 IOM on weight gain in pregnancy, and the 2006 IOM Dietary Reference Intakes (DRIs): The Essential Guide. The Recommended Dietary Allowances (RDAs) are nutrient levels established by a panel of experts from the IOM, backed by recent research, and designed to meet the needs of 97% of the population. Weight gain recommendations during pregnancy vary based on a person's prepregnancy body mass index (BMI). For those who are underweight (BMI <18.5 kg/m^2), the recommended total weight gain is 12.5 to 18 kg (28–40 lb), with a second and third-trimester weekly weight gain of approximately 0.51 kg (1.0 lb). Individuals with a normal BMI (18.5–24.9 kg/m^2) are advised to gain 11.5 to 16 kg (25–35 lb) in total, at a rate of 0.42 kg/week (0.8–1 lb/week) during the later trimesters. For those who are overweight (BMI 25.0–29.9 kg/m^2), the recommendation is 7 to 11.5 kg (15–25 lb) total, with a weekly gain of about 0.28 kg (0.6 lb). People classified as obese (BMI ≥30.0 kg/m^2) should aim for 5 to 9 kg (11–20 lb) in total, gaining around 0.22 kg/week (0.5 lb/week). These weekly gain estimates assume a weight gain of 0.5 to 2 kg (1.1–4.4 lb) in the first trimester. Weight gain recommendations are higher for those with multiple gestations [10].

4. Life course theory and maternal nutrition

Life course epidemiology studies how biological, social, and environmental exposures across the lifespan influence chronic disease risk. This theory originated with Baker's hypothesis that poor fetal nutrition leads to permanent changes in metabolism and increases the risk of adult diseases like diabetes, hypertension, and obesity. Contributing to this work, Elder's Theory positions early life socioeconomic hardship has lasting effects like a chronic disease- this was suggested by his studying children who lived through the great depression. The life course model, sensitive period, accumulation, pathway, and social mobility show how the timing and duration of exposure, like malnutrition, matter, especially during sensitive windows like pregnancy. Diet influences fetal brain development, immune programming, and metabolic health in preconception. Key nutrients like iodine, choline, and folic acid can be under-consumption, especially in high-risk or underserved populations. After delivery, nutrition remains essential for maternal recovery, lactation, and preparation for future pregnancy. Recovery time between pregnancies can also increase adverse pregnancy and birthing outcomes. Public health strategies rooted in the life course perspective help inform interventions across multiple levels, such as individuals, families, communities, and police. They help prioritize primordial prevention and decrease exposure. For example, improving maternal diet through food policies, education, and access to care can disrupt the cycle of poor health across populations [11, 12].

5. Behavioral factors influencing maternal nutrition

Health behavior theories provide valuable frameworks for understanding how various individual beliefs, psychosocial factors, social influences, and environmental factors shape health behaviors. For example, the Health Belief Model suggests that dietary decisions are driven by an individual's perception of risks and benefits, such as a pregnant woman choosing nutrient-dense foods to lower the risk of pregnancy or birth complications [13]. Similarly, the Theory of Planned Behavior focuses on how attitudes, social norms, and perceived control shape intentions that drive behavior [14]. For instance, if a pregnant woman believes that eating healthy benefits her baby (attitude) and her family encourages specific food choices (social norm), these factors influence her intention to adopt a nutritious diet, ultimately shaping her eating habits. Understanding the behavioral and psychosocial influences outlined in health behavior theories is essential for capturing the complexities of dietary decision-making and informing strategies to promote healthier eating among pregnant women.

6. Psychosocial determinants of dietary choices

Psychosocial determinants include a range of psychological, social, and cultural factors that influence food intake during pregnancy. These determinants are central in health behavior theories and can shape dietary behaviors, food preferences, and adherence to nutritional guidelines, impacting pregnancy and birth outcomes.

7. Psychological factors (stress, anxiety, depression, emotional eating)

Stress, anxiety, and depression (collectively referred to as psychological distress) are common during pregnancy and often co-occur. While prevalence estimates vary, studies suggest that approximately 20% of pregnant women experience depressive symptoms, up to 54% experience anxiety [15], and as many as 84% experience stress [16], with even higher rates reported in racial and ethnic minorities [17]. However, accurately measuring psychological distress is challenging due to variations in assessment methods, underdiagnosis, and the presence of subclinical symptoms that do not meet diagnostic thresholds but still impact well-being. Many cases go untreated, leading to an underestimation of the true burden of maternal mental health [18]. Research has demonstrated that stress, anxiety, and depression during pregnancy have been linked to a range of adverse maternal and birth outcomes, including increased risk for preterm birth, low birth weight, and neurodevelopmental issues in the infant [19–21]. Physiologically, psychological distress during pregnancy activates the hypothalamic-pituitary-adrenal (HPA) axis, leading to elevated cortisol levels, which may stimulate hunger and appetite, potentially increasing food intake [22, 23]. Additionally, hormonal changes such as rising progesterone levels further enhance appetite to support necessary fat accumulation for pregnancy [24]. Limited research in pregnant populations suggests that high stress levels are associated with increased consumption of energy-dense, nutrient-poor foods, often as a coping mechanism to regulate emotions [25–27], ultimately contributing to poorer diet quality [28–30]. For example, a cross-sectional study found that stress was associated with higher intakes of energy, fats, proteins, iron, and zinc, while anxiety was negatively associated with vitamin C intake. Stress was also linked to higher consumption of breads and foods from the fats, oils, sweets, and snack groups, while anxiety followed a similar pattern except for bread intake [31].

Depression has also been linked to poor diet quality in pregnancy. A study suggests that those with prenatal depression are at an elevated risk of poor diet quality compared to those who do not have prenatal depression the association between prenatal depression and diet found that higher levels of maternal depression were associated with lower Healthy Eating Index (HEI) scores [32]. The HEI is a measure of diet quality with scores ranging from 0 to 100 (higher scores indicate better diet quality) [33]. One study reported that women with prenatal depression had nearly twice the odds of poor diet quality compared to those without depression, with the association being even stronger among Hispanic women [34]. Additionally, pregnant women with depression consumed more fats, alcohol, and added sugars, as indicated by lower HEI 2010 empty calorie component scores.

Studies in non-pregnant populations suggest that emotional eating may be a key mechanism linking depression and poor diet quality [32, 35, 36]. Emotional eating theory states that negative emotions increase motivation to eat, and food consumption serves as a coping strategy to reduce the intensity of negative emotions [37, 38].

Supporting this, one study in pregnant women found that higher depressive symptoms in the second trimester were associated with an increased likelihood of emotional eating and poorer nutritional intake in the third trimester [39].

While preliminary evidence suggests a relationship between psychosocial factors and dietary behaviors in pregnant women, research in this area remains limited, and findings are often inconsistent. The complexity of pregnancy-related physiological and psychological changes likely modifies these relationships, underscoring the need for further research to clarify the impact of psychosocial factors on maternal dietary behaviors.

8. Pregnancy-related food preferences, cravings, and aversions

Pregnancy is often accompanied by significant changes in food preferences, including food cravings and aversions, which can influence dietary choices. Food cravings are defined as an intense desire for specific foods [40]. Food cravings are common during pregnancy. An estimated 50–90% of pregnant women report food cravings with frequency and intensity peaking in the second trimesters and subsequently declining as the pregnancy progresses and significantly dropping after birth [41]. While the types of foods craved during pregnancy varies, studies have commonly reported foods that are energy-dense, sweet, and carbohydrate-rich options such as chocolate, ice cream, fruits, and pastries are most desired [42]. Cravings for salty or savory foods are less common.

The underlying mechanisms of pregnancy cravings remain unclear, but hormonal changes, particularly fluctuations in estrogen and progesterone, are thought to play a role in altering taste and smell perception, which can intensify cravings for certain flavors and textures [43]. Additionally, some researchers propose that cravings may have a psychological component, acting as a means of coping with the physical and emotional changes associated with pregnancy [44]. Because cravings may often contribute to increased energy intake, particularly excessive consumption of sugars and unhealthy fats, this behavior may potentially contribute to excessive gestational weight gain and likely adverse metabolic outcomes [45, 46].

Conversely, food aversions, defined as strong dislikes or avoidance of specific foods, are also prevalent during pregnancy and may impact dietary quality [47]. Studies suggest that globally, approximately 50–60% of pregnant women experience food aversions [48] with common triggers including meat, fish, poultry, eggs, and non-alcoholic caffeinated beverages [46]. Like cravings, food aversions typically intensify during the second trimester and subsequently become diminished [49]. Food aversions may be driven by heightened sensitivity to smell and taste, which are influenced by hormonal changes such as increases in estrogen and progesterone [50]. Evolutionary theories suggest that food aversions are part of a protective function by discouraging the consumption of foods that could pose a risk of foodborne illness (e.g., eating undercooked meat or seafood) but it is essential to consider they can also lead to inadequate intake of essential nutrients like protein, iron, and folate [50, 51]. For example, aversions to meat or fish may increase the risk of iron deficiency anemia if alternative sources of iron are not consumed.

The combined effects of food cravings and aversions can significantly shape dietary patterns during pregnancy. Given the potential nutritional implications of cravings and aversions, pregnant women need support from healthcare providers to assess food preferences and provide guidance on how to maintain a balanced diet, ensuring adequate nutrient intake while accommodating changes in appetite and taste preferences. Further research is needed to better understand the mechanisms underlying pregnancy-related changes in food preferences, cravings, and aversions as well as their impact on dietary choices and therefore, long-term implications for maternal and fetal health.

9. Behavior change strategies to improve maternal nutrition

Improving dietary behaviors during pregnancy requires using targeted behavior change techniques (BCTs) that address both individual and environmental determinants of dietary intake. Behavior change techniques (BCTs) are systematic, theory-driven strategies designed to facilitate and sustain health-related behavior changes [52]. They include intervention components such as goal setting, self-monitoring, feedback, reinforcement, and motivational interviewing, among others [53]. Given the complexity of dietary behaviors and the challenges pregnant women face (e.g., psychosocial impacts, emotional eating, food cravings, aversions), effective interventions must go beyond nutrition education. A recent systematic review suggests that prenatal dietary interventions should utilize evidence-based strategies such as multimodal delivery methods, structured behavioral support from nutrition professionals, and include rewards and goal setting BCTs [54]. The following sections explore key behavior change strategies that have shown promise in promoting healthier dietary behaviors among pregnant women.

9.1 Motivational interviewing

Motivational interviewing (MI) is a client-centered counseling approach designed to enhance motivation and commitment to behavior change by resolving ambivalence and strengthening intrinsic motivation [55]. MI is particularly relevant in pregnancy, as women may experience conflicting emotions regarding dietary changes due to personal preferences, their psychosocial health, cultural food norms, or pregnancy-related food aversions. MI interventions focus on empathetic listening, open-ended questions, affirmations, and reflective statements to help individuals explore their reasons for change and set achievable goals. Studies have shown that MI-based interventions can improve dietary behaviors by increasing fruit and vegetable intake, reducing sodium intake, reducing the consumption of processed and high-fat foods, and promoting overall adherence to nutritional guidelines [56–59]. By fostering autonomy and self-efficacy, MI can be an effective strategy for promoting sustained improvements in maternal nutrition.

9.2 Goal setting and rewards

Goal setting is a well-established BCT that involves identifying specific, measurable, achievable, relevant, and time-bound (SMART) goals. When pregnant women set clear and attainable goals, they are more likely to make consistent dietary improvements. Self-monitoring, through food diaries or mobile health apps, can further enhance the effectiveness of goal setting by providing real-time feedback on progress. Goal setting using SMART goals can help establish a clear roadmap for more positive dietary behaviors [60–62].

Rewards can also serve as powerful motivators for dietary behavior change.

According to the Self-Determination Theory (SDT) rewards influence motivation based on how they support autonomy, competence, and relatedness. Applied to maternal dietary behaviors, SDT would suggest that positive reinforcement, such as verbal encouragement, small incentives, or social recognition, can strengthen adherence to healthy eating habits [63, 64]. Different types of rewards can either help or hinder one's motivation. Informational rewards, such as positive feedback and social recognition, enhance intrinsic motivation by reinforcing a sense of progress, whereas controlling rewards, like coercive financial incentives, may undermine long-term adherence by making behavior feel externally driven. During pregnancy, social influences and the health of the baby highly influence maternal health behaviors [63]. Rewards should be designed to support autonomy and enhance intrinsic motivation ensuring that dietary changes are personally meaningful and sustainable rather than solely driven by external incentives. When integrated with goal-setting interventions, rewards can enhance motivation and create a more sustainable approach to improving maternal dietary behaviors.

9.3 Habit formation and the role of behavioral nudges in dietary choices

Habits are automatic, learned behaviors that develop through repeated actions in a stable context. Developing habits are important in sustaining dietary changes during pregnancy such that repeated behaviors become automatic and require less cognitive effort over time [64] For example, consistently choosing a nutrient-dense breakfast or replacing sugary beverages with water can become habitual if reinforced through repeated practice in the same context. Behavioral nudges are subtle environmental cues or modifications that influence decision-making without restricting choices and can facilitate habit formation [65]. Strategies such as placing healthy snacks within easy reach, using reminders, or pre-planning meals can help pregnant women develop automatic, sustainable dietary behaviors that persist throughout pregnancy. However, research on behavioral nudges' effectiveness in improving diet in pregnant populations remains limited. Despite this, research in non-pregnant populations suggests nudges that relate to proximity/convenience and presentation alterations (altering sensory qualities) help move people toward adopting healthier dietary behaviors [66]. Understanding how nudges influence dietary habits in pregnant women may contribute to developing more sustainable, low-effort strategies to improve maternal dietary behavior.

9.4 Digital behavioral coaching and mobile interventions for sustained dietary changes

Digital behavioral coaching and mobile health (mHealth) interventions have emerged as promising strategies for promoting dietary changes during pregnancy [67–69]. These interventions leverage mobile apps, text messaging, and/or online coaching to provide personalized support, real-time feedback, and tailored dietary guidance. By incorporating evidence-based behavior change techniques (BCTs) such as goal setting, self-monitoring, feedback, rewards, and social support, mobile interventions can effectively help pregnant women improve their diet behaviors and sustain these changes over time. For example, mobile apps can prompt users to set specific and attainable dietary goals, track progress, and receive immediate reinforcement through digital rewards or encouragement messages, which align with principles from various health behavior theories (e.g., Self-Determination Theory) by fostering motivation and autonomy in behavior change [60, 61]. Additionally, mobile interventions can incorporate behavioral nudging strategies to guide food choices without restricting autonomy. For instance, push notifications reminding users to choose nutrient-dense foods, meal suggestions based on prior selections, or visual cues such as displaying healthier foods more prominently in a grocery list feature can subtly encourage better dietary decisions. These nudges work by making healthier choices easier and more intuitive, a key principle in habit formation [64]. Importantly, few digital health or mobile interventions consider ecological models of health behavior in their design, missing a key point that dietary choices are influenced by multiple levels of influence beyond individual decision-making [70–74]. At the individual level, factors such as knowledge, beliefs, and self-efficacy play a role, while the interpersonal level includes support from family, friends, and healthcare providers.

The organizational and environmental levels involve healthcare settings, community programs, and food accessibility, while the policy level includes broader public health initiatives and regulations. Effective mobile interventions may easily integrate strategies across these levels, combining personalized coaching, social support, and environmental modifications to enhance dietary behavior change during pregnancy. For example, a multilevel mHealth intervention may combine individual coaching (e.g., app-based goal setting and self-monitoring), interpersonal support (e.g., virtual peer support groups or dietitian coaching), and environmental modifications (e.g., integration with grocery store discounts for healthy food purchases). Research suggests that interventions grounded in ecological frameworks, which address both individual factors and broader social and environmental determinants, may be more effective in promoting sustained dietary changes than interventions that target only personal factors (e.g., motivation or knowledge) [75].

Despite these advantages, long-term effectiveness data on mHealth based dietary interventions in pregnancy remain limited. Future research should focus on refining engagement strategies, integrating culturally tailored approaches, and evaluating the impact of multilevel interventions on maternal dietary behaviors and long-term maternal and infant health outcomes. As technology continues to evolve, mHealth interventions hold great potential as a scalable, cost-effective way for improving maternal dietary behaviors and health outcomes.

9.5 The role of digital health in maternal nutrition

There are over 165,000 digital health apps available today, with a significant number focused specifically on diet and nutrition [76]. Many of these apps help users track dietary intake, monitor macronutrients, and support healthy behaviors. A key advantage of using this technology is the ability to receive ongoing feedback and benefit from remote monitoring, which can enhance the accuracy of dietary recall.

Recent advancements are introducing artificial intelligence into this space, with emerging features such as personalized diet optimization, food image recognition, risk prediction, and analysis of dietary patterns. These tools hold promise for improving health outcomes, particularly when integrated with electronic health records (EHRs) to enhance the screening and documentation of malnutrition and overnutrition. Looking ahead, future innovations may incorporate wearable technology that can collect biomarker data, offering deeper insights into how dietary patterns impact health. Telehealth and digital health interventions are feasible, accessible, and increasingly effective tools for managing excess gestational weight gain by providing personalized, remote support for behavior change during pregnancy [77].

10. Comparative perspective: Maternal nutrition in the USA vs. UK

Maternal nutrition is essential in shaping pregnancy outcomes and long-term health for both mother and child. While both prosperous, developed nations, the United States and the United Kingdom approach maternal nutrition through distinct healthcare systems, public health strategies, and cultural contexts. This comparison highlights key differences and similarities in healthcare systems, nutritional support, public health campaigns, food insecurity, education and access, and maternal health outcomes.

11. Healthcare systems and nutritional support

The healthcare system operates largely on a private insurance model in the United States, supplemented by government assistance programs for low-income populations. Programs like the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP) are pivotal in addressing maternal nutritional needs. WIC provides vouchers for specific nutritious foods, prenatal nutrition education, and healthcare referrals to eligible pregnant women and young children, targeting low-income families to reduce risks like gestational diabetes and low birth weight [78]. SNAP, meanwhile, offers broader food assistance but lacks the nutritional specificity of WIC, leaving gaps in ensuring access to nutrient-dense foods [79]. Access to these programs varies by state.

Another equally important distinction to note about the US maternal care system is that it is primarily led by obstetricians and gynecologists (OB-GYNs). Care tends to be medicalized compared to midwife-led models in other countries, with higher rates of interventions like C-sections (around 32% of U.S. births) [80] versus the 25–30% that the UK reports [81]. According to a 2010 survey of U.S. medical schools, the average time devoted to nutrition education was about 19.6 hours over 4 years, with much of this being integrated into other subjects rather than offered as a dedicated course [82]. For OB-GYNs, additional nutrition-related training may occur during their 4-year residency, particularly in prenatal care, gestational diabetes, and maternal health conditions influenced by diet. However, this training is often overshadowed by a focus on surgical skills, high-risk pregnancy management, and medical interventions. A 2024 study published in the *Journal of Women's Health* surveyed 218 OB-GYN residents across 247 U.S. residency programs in 2022. It found that 48% reported zero hours of dedicated nutrition-related education per year, 49% received 1–2 hours, and only 3% received more than 2 hours. Despite this, 92% of residents agreed that nutrition education would be useful for clinical practice, yet only 31% felt comfortable counseling patients on nutrition in pregnancy. The study also assessed objective knowledge, with residents averaging 74% correct responses on pregnancy-related nutrition questions, indicating some baseline understanding but highlighting gaps in formal training. This suggests that while nutrition is acknowledged as important, its integration into residency programs remains inconsistent and often inadequate [83].

The United Kingdom's National Health Service (NHS) is a government-funded system that provides universal health care to residents, largely funded through taxation [84]. This healthcare system is free at the point of use for patients, covering a wide range of services, including General Practitioner (GP) visits, hospital care, and specialist treatments. However, some fees, such as prescription charges, apply in England [85]. Although the NHS is a government-run system, private healthcare options also exist, often using the same staff and resources as the NHS, though these options are paid out of pocket or through private insurance [86]. The private sector generally offers shorter waiting times than the NHS for non-urgent procedures [87].

Despite the wait times for non-urgent treatments, the NHS emphasizes equal access to care for all, prioritizing equality over speed or choice [88]. One significant way the NHS integrates nutritional support into care is through the Healthy Start scheme. This initiative provides low-income pregnant women and families vouchers for essential food items like milk, fruits, vegetables, and vitamins, ensuring better nutrition during pregnancy [89].

Unlike the OBGYN-led U.S. system, the National Health Service (NHS) triages pregnancies into two broad categories: low and high risk. Midwives are the primary caregivers for most low-risk pregnancies, attending over two-thirds of births [90].

Nutritional education is essential to midwifery training, with programs emphasizing holistic care, including diet, exercise, and lifestyle. A review of midwifery practices found that UK midwives routinely provide nutritional advice [91], supported by national guidelines from the National Institute for Health and Care Excellence (NICE), an executive non-departmental public body of the UK Government's Department of Health and Social Care [92]. The broader 2016 Cochrane review includes UK data and finds that women under midwife-led continuity models report higher satisfaction with care overall, including information provision [93].

12. Public health nutrition campaigns and guidance

Public health nutrition campaigns in the United States are largely shaped by influential organizations such as the American College of Obstetricians and Gynecologists (ACOG) and the United States Department of Agriculture (USDA). ACOG provides evidence-based recommendations for maternal nutrition, emphasizing the importance of folate supplementation to prevent neural tube defects and promoting balanced diets to manage gestational weight gain [94]. The USDA's MyPlate guidelines offer a visual tool to encourage healthy eating, focusing on fruits, vegetables, whole grains, and lean proteins [95]. However, due to the decentralized nature of the U.S. healthcare system, implementation of these guidelines can vary significantly between states, with differences in funding and the scope of state-level maternal nutrition programs [96]. This inconsistency may result in pregnant women, particularly in underserved areas, lacking clear and actionable nutritional guidance [97]. As highlighted earlier, the lack of nutrition education that OB-GYNs receive and time constraints on appointments also hinder this educational transfer.

In contrast, the United Kingdom's National Health Service (NHS) follows a more centralized approach to public health nutrition. The NHS's Eatwell Guide is a unified national framework that provides consistent dietary advice for the general population and is adapted specifically for pregnant women. The guide promotes a balanced diet, with recommendations to limit sugar intake and increase fiber consumption and is informed by the work of the Scientific Advisory Committee on Nutrition (SACN), which ensures that the guidelines reflect the latest scientific evidence [98]. For example, SACN recommends vitamin D supplementation for pregnant women to address deficiencies and support maternal and fetal health [99]. The centralized nature of the UK's public health system allows for consistent messaging and more standardized delivery of nutrition programs, a contrast to the more fragmented approach in the U.S. [88].

13. Food insecurity, nutrition information deficits and access to nutrient-dense foods

Food insecurity and limited access to nutrient-dense foods have historically been significant barriers to maternal nutrition in the United States. Research has frequently highlighted the role of "food deserts" (areas that lack access to affordable, healthy foods) and "food swamps" (areas dominated by stores selling calorie-dense and unhealthy junk foods) as contributing factors to poor maternal nutrition choices [100]. These environmental factors have long been associated with poor dietary habits, including an increased reliance on inexpensive, highly processed foods high in sugar, fat, and sodium, which are often linked to poor maternal and child health outcomes [101].

However, the rise of food delivery services has started to mitigate some of these issues. According to a 2021 Brooking Institute report, 90% of individuals in low-income, low-access tracts now have at least one digital food access option, with service rates exceeding 95% in food deserts within metropolitan areas [102, 103]. This development suggests that digital access to fresh, nutritious foods is expanding, even in areas previously considered food deserts. Moreover, Supplemental Nutrition Assistance Program (SNAP) benefits are now accepted on these food delivery apps, further facilitating access to healthier options for low-income individuals [104].

Despite the improved access to fresh foods, whole grains, and other minimally processed options, there remains a gap in understanding why individuals in these areas continue to make poor food choices. More research is needed to examine the underlying factors contributing to this phenomenon, such as cultural, psychological, and behavioral influences on dietary decisions [105].

Food insecurity is a growing concern in the UK despite NHS initiatives [106]. The rise in food bank use—with over 2.5 million people relying on them annually by 2023 [107, 108]—reflects affordability challenges, even with programs like Healthy Start [109]. While food deserts are less prevalent than in the U.S., regional disparities and economic pressures limit access to nutrient-rich foods for some [110]. The Trussell Trust reports that 1 in 5 UK households faced food insecurity in 2022, underscoring that universal healthcare alone cannot fully address socioeconomic barriers to nutrition [107].

14. Maternal health outcomes and nutritional disparities

In the USA, postpartum care is primarily physician-led, with OBGYNs spearheading maternal care and pediatricians for infant care. The standard protocol includes a single postpartum visit for the mother at 4–6 weeks post-delivery, as the American College of Obstetricians and Gynecologists (ACOG) recommends. However, ACOG has advocated for a shift toward ongoing care, with an initial visit within 3 weeks and continued monitoring up to 12 weeks, especially for high-risk cases like those with gestational diabetes or hypertension [111]. Despite this, implementation of just the single postpartum visit remains standard. It is of concern to note that only about 60% of women attend this 6-week visit, with lower rates among underserved populations due to barriers like transportation or lack of paid leave [111]. This lack of attention to maternal health needs is of particular concern, given that more than one-half of pregnancy-related deaths occur after the birth of the infant [111]. Pediatric care begins within 48 hours of discharge, with 3–5 days, 1 month, and beyond visits focusing on infant health but rarely integrating maternal support [112]. According to the CDC's 2021 data, the maternal mortality rate was 32.9 deaths per 100,000 live births, totaling 1205 deaths [113].

In the United States prepregnancy obesity is a significant issue, with a prevalence of 29.0% among women of reproductive age [114], contributing to adverse outcomes like severe maternal morbidity (SMM) and mortality. A population-based retrospective cohort study conducted in Washington State, analyzing singleton hospital births from 2004 to 2013, found obesity increased SMM risk by up to 40% [115]. Nutritional deficiencies (e.g., iron, folate) are less studied but linked to higher rates of anemia in pregnancy (15–20% prevalence, per ACOG guidelines) [116].

Patient satisfaction with nutritional advice is underreported. However, a 2019 American College of Obstetricians and Gynecologists (ACOG) survey indicated that only 50% of women felt adequately counseled on diet during pregnancy, citing time constraints in physician visits [117].

In the United Kingdom, postpartum midwifery care extends into the community, with a structured schedule of home visits for both mother and baby. The first visit typically occurs within 24 hours of returning home, ensuring continuity of care [118]. Subsequent visits are individualized for the next 10 days postpartum, provided at home, depending on maternal and neonatal needs. For the period 2020–2022, MBRRACE-UK (Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries) reported a maternal mortality rate for the United Kingdom of 13.41 deaths per 100,000 live births [119].

The UK has a lower prepregnancy obesity rate (20.4%, per NHS Digital, 2022) than the USA, partly attributed to early nutritional interventions [120]. However, rising prepregnancy obesity poses a growing challenge. Concurrently, vitamin D deficiency is prevalent, affecting up to 40% of pregnant women, particularly in winter months, due to limited sunlight exposure and inadequate supplementation, and is linked to increased risks of preeclampsia and neonatal hypocalcemia [121]. Although challenges exist in the UK, a Lancet study found that midwifery-led care reduced preterm births by 24% and low birth weight by 19%, outcomes tied to maternal nutrition [122]. A 2016 NHS survey reported that 85% of women were satisfied with midwifery-led nutritional advice, valuing personalized discussions during frequent antenatal visits [123].

The UK's midwifery-led model correlates with better nutritional outcomes (lower obesity and adverse birth outcomes) than the USA's physician-led system. This may, in part, reflect the UK's proactive, centralized, and community-based approach versus the USA's reliance on OB-GYN-led care, less tailored nutritional advice, and a lack of streamlined postpartum clinical visits.

15. Conclusion

Nutrition during pregnancy is a powerful determinant of lifelong health. Macronutrients and micronutrients shape maternal cardiovascular, endocrine, and metabolic health while laying the foundation for fetal growth and neurodevelopment. These effects echo across generations, reinforcing the imperative role of prenatal nutrition in public health. Yet, optimal nutrition is not achieved through knowledge alone. Behavioral, psychological, cultural, and structural factors influence dietary choices during pregnancy. Cravings, aversions, stress, food insecurity, and inconsistent healthcare guidance create real barriers—especially in underserved communities. To drive change, we must go beyond education. Evidence-based strategies—like motivational interviewing, behavioral nudges, habit formation, and digital health coaching—offer scalable, personalized tools to transform maternal nutrition. These strategies are most effective when grounded in equity, supported by policy, and integrated across clinical, community, systems, and digital platforms. Investing in maternal nutrition is investing in generational health. By aligning science, behavior, and healthcare systems, we can ensure every pregnancy is nourished with intention, every mother is supported, and every child has the healthiest start possible.

Conflict of interest

The authors declare no conflict of interest.

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