REVIEW

Micronutrient supplementation in pregnancy after bariatric surgery: a narrative review

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Abstract

Objectives: bariatric surgery has significantly modified the obstetric profile of women of reproductive age, reducing complications associated with severe obesity while introducing a distinct set of risks related to micronutrient absorption and metabolism. Pregnancy in this context occurs in an anatomically and physiologically altered organism, in which the increased nutritional demands of gestation overlap with persistent absorptive limitations.

Methods: narrative review aims to synthesize current evidence on micronutrient deficiencies in pregnancy after bariatric surgery and to discuss practical strategies for supplementation and monitoring during prenatal care. Searches were conducted in the MEDLINE, LILACS, and SciELO databases from August to December 2025, using descriptors and free-text terms combined with Boolean operators. This review followed the recommendations of the Scale for the Quality Assessment of Narrative Review Articles (SANRA).

Results: Scientific studies show a consistent pattern of increased risk for deficiencies of iron, folate, vitamin B12, thiamine, vitamin D, calcium, and trace elements, with potentially severe maternal and perinatal consequences. International guidelines and consensus statements converge in recommending more robust supplementation than that used in conventional prenatal care, systematic laboratorial monitoring, and timely use of sublingual or parenteral routes according to the clinical context. Although the evidence base is predominantly observational, its consistency points to the relevance of a preventive, structured, and multiprofessional approach.

Conclusion: the organization of nutritional care, including supplementation strategies, monitoring, and therapeutic escalation emerges as a relevant component of maternal and fetal safety in pregnancy after bariatric surgery.

Key words *Bariatric surgery, Pregnancy, Micronutrient deficiencies, Dietary supplements, Prenatal care*

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Introduction

In just a few decades, bariatric and metabolic surgery has transformed the clinical profile of women of reproductive age with severe obesity. By promoting sustained reductions in body weight, insulin resistance, and blood pressure, these procedures have significantly altered the obstetric risks traditionally associated with obesity. There is a lower incidence of gestational diabetes, preeclampsia, and fetal macrosomia. However, this metabolic reorganization does not come without costs. The surgically modified gastrointestinal tract exhibits less predictable behavior in the absorption of micronutrients, precisely during a period of reproductive life marked by a significant increase in the demand for iron, folate, B-complex vitamins, vitamin D, calcium, and trace elements.[1,2]

Pregnancy following bariatric surgery, therefore, should not be understood merely as a pregnancy following a surgical procedure, but as a pregnancy that develops in an anatomically transformed body, with structurally altered digestive and absorptive physiology. The combination of reduced gastric volume, elevated intragastric pH, bypass of the duodenum and proximal jejunum, shortened intestinal transit time, reduced contact of chyme with bile and pancreatic juices, and, in certain procedures, exclusion of relevant segments of the small intestine creates a context of chronic nutritional vulnerability.[1-3]

Given the scarcity of randomized clinical trials and the methodological heterogeneity of the available studies, a narrative review was chosen as the appropriate format to integrate and critically discuss a body of evidence composed predominantly of observational studies, guidelines, and expert consensus statements.

This article is based on the perspective that, according to the available literature, pregnant women with a history of bariatric surgery present an increased risk of multiple micronutrient deficiencies, which reinforces the importance of prenatal care focused on the prevention, early detection, and correction of these deficiencies. In this sense, the approach stands to benefit from clinical reasoning that goes beyond the generic classification of high-risk pregnancy, integrating pathophysiology, observational evidence, recommendations from scientific societies, and practical feasibility in the outpatient setting.

Methods

A narrative literature review was conducted to synthesize and critically analyze the available evidence on micronutrient supplementation and monitoring during pregnancy following bariatric surgery, incorporating pathophysiological data, maternal and perinatal outcomes, as well as recommendations from international guidelines and consensus statements.

Searches were conducted in the MEDLINE/PubMed and *Biblioteca Virtual em Saúde* (BVS) (Virtual Health Library) databases, including LILACS and SciELO, from August to December 2025. The following descriptors and free-text terms were used, combined with Boolean operators: (Pregnancy OR gestation OR Gravidez OR Embarazo OR Gestación) AND (Bariatric Surgery OR Gastric Bypass OR sleeve gastrectomy OR Cirurgia Bariátrica OR Cirugía Bariátrica OR Bypass Gástrico OR Gastrectomía en manga) AND (Micronutrients OR Dietary Supplements OR Deficiency Diseases OR micronutrient deficiencies OR supplementation OR nutritional deficiencies OR Micronutrientes OR Suplementos Nutricionais OR Deficiências Nutricionais OR Suplementos Nutricionais OR Deficiencias Nutricionales).

Supplementary searches were conducted in the reference lists of the selected articles and in guideline documents from scientific societies.

We included observational studies, clinically relevant case series, systematic reviews, recent narrative reviews, and guideline and consensus documents from scientific societies, published in Portuguese, English, or Spanish, that addressed: (1) alterations in micronutrient absorption following different bariatric surgery techniques; (2) the prevalence and clinical impact of nutritional deficiencies during pregnancy; (3) associations between maternal micronutrient deficiency and maternal and fetal outcomes; and (4) strategies for screening, monitoring, and supplementation during the preconception and gestational periods. Editorials, letters to the editor without original data, isolated case reports without relevant conceptual contributions, and studies addressing exclusively pediatric or non-pregnant populations were excluded.

The selection was guided by structured guiding questions based on a conceptual adaptation of the PICO model, considering the narrative nature of the review: (1) in pregnant women with a history of bariatric surgery, which micronutrients present the highest risk of deficiency throughout pregnancy; (2) what are the maternal and perinatal consequences associated with deficiencies in iron, folate, vitamin B12, thiamine, vitamin D, calcium, and trace elements; and (3) what supplementation and monitoring strategies are recommended by guidelines, consensus statements, and recent reviews for the prevention and management of these deficiencies.

The structure and presentation of this review followed the recommendations of the Scale for the Quality Assessment of Narrative Review Articles (SANRA).[4]

This review does not aim to exhaust the available literature but to gather a sufficient body of evidence to support a critical synthesis of the main evidence and recommendations on the topic. A selection flowchart was not used, given the narrative nature of the study, which

prioritized the identification of sources with greater conceptual and clinical relevance.

Results

Bariatric surgery impact on pregnancy outcomes

A useful way to frame the analysis is to recognize that bariatric surgery shifts the obstetric risk profile without, however, eliminating it. Population based cohort studies and meta-analyses show, with relative consistency, the presence of a dual effect on pregnancy outcomes.

On the one hand, there is an improvement in outcomes traditionally associated with excess metabolic substrate. In a Swedish population based study, Johansson *et al*.[5] compared approximately 600 pregnant women who underwent bariatric surgery with pregnancies in controls matched pre-surgery body mass index. The operated women showed a reduced incidence of gestational diabetes, gestational hypertension, and large for gestational age newborns, indicating that sustained weight loss and metabolic improvement translate into measurable obstetric benefits.[5] In contrast, the same cohort showed an increased proportion of small for gestational age newborns and a reduction in gestational age at delivery. The meta-analysis by Akhter *et al*.,[6] aggregating more than 14,000 pregnant women followed by bariatric surgery, reinforced this pattern by demonstrating a reduction in macrosomia and post-term pregnancies, associated with an increase in small for gestational age infants, prematurity, certain congenital malformations, and perinatal mortality, particularly following procedures with a greater malabsorptive component.[6,7] This body of evidence suggests a relevant interpretation. Bariatric surgery mitigates part of the risk posed by obesity but introduces a new dimension of vulnerability related to maternal-fetal nutritional insufficiency. Systematic reviews describe high frequencies of deficiencies in iron, folate, vitamin B12, fat-soluble vitamins, and trace elements in pregnant women who have undergone bariatric surgery, despite the use of nutritional supplementation.[8–10] Observational studies also indicate an increased risk of low birth weight and neonatal micronutrient deficiencies in the children of women who have undergone gastric bypass surgery.[11] The repercussions extend beyond laboratory abnormalities, including reports of maternal Wernicke's encephalopathy, severe neuropsychomotor delay in children exposed to vitamin B12 deficiency, and neonatal hemorrhage associated with vitamin K deficiency.[7,9,12]

Furthermore, reviews highlight that, although there is a consistent reduction in the risk of gestational diabetes and macrosomia, these pregnant women present a higher frequency of small for gestational age newborns and a higher incidence of maternal hypoglycemic events, reflecting alterations in glycemic homeostasis following procedures such as gastric bypass and vertical gastrectomy, characterized by greater glycemic variability and episodes of postprandial hypoglycemia. This metabolic pattern has been identified as a possible intermediate mechanism between bariatric surgery and fetal growth restriction.[13]

Complementarily, clinical management studies highlight that these pregnant women often involve with reduced food intake, food intolerances, and lower adherence to supplementation, factors that, combined with altered intestinal absorption, contribute to the persistence of deficiencies even with prenatal care, reinforcing the chronic and multifactorial nature of nutritional vulnerability in this group.[14]

The interpretation of this body of evidence must take into account that most of the available data is observational and heterogeneous. Nevertheless, the consistency of the observed pattern has been deemed sufficient by scientific societies and international consensus groups to develop specific recommendations.

Physiology of pregnancy in post surgery

In a normal pregnancy, the mother's body reorganizes its priorities in favor of the fetus. This involves an expansion of plasma volume, increased erythropoiesis, intensified placental transport of iron, calcium, iodine, and other micronutrients, as well as significant changes in the hormonal axes that regulate bone and energy metabolism. Even in the absence of prior surgery, this increased demand must be sustained by maternal reserves, which are often already limited.

Post bariatric surgery, the starting point is different. In predominantly restrictive procedures, such as vertical gastrectomy, reduced gastric volume and early satiety result in lower overall food intake. Increased gastric pH and the possible reduction in intrinsic factor production compromise vitamin B12 absorption.[2] In mixed procedures, such as *Roux-en-Y* gastric bypass, food restriction is compounded by the anatomical bypass of the duodenum and proximal jejunum, the primary sites of absorption for iron, calcium, folate, and other micronutrients. In techniques with a distinctly malabsorptive component, such as biliopancreatic diversion and the duodenal switch, the length of the intestine in contact with bile and pancreatic juices is substantially reduced, also affecting the absorption of fat-soluble vitamins and fats.[1,3]

When this context is associated by nausea, first trimester hyperemesis, food aversions, the use of medications such as proton pump inhibitors, and the recurrent fear of weight regain observed in some of the operated pregnant women, the risk of nutritional impairment becomes evident. The fetus begins to compete

for nutrients in an environment where maternal storage may be reduced and absorptive capacity structurally compromised.

Guidelines and consensus applicable to pregnancy post bariatric surgery

The first structured initiative to organize care for pregnant women post bariatric surgery was the international consensus by Shawe *et al*.,[15] published in Obesity Reviews. The group used the *adaptação de diretrizes* (ADAPTE) (Guidelines adaptation) methodology, systematically reviewed the available literature, and, given the scarcity of randomized clinical trials, integrated observational evidence with the consensus of experts from different fields.[15] The document is not intended as a definitive guideline, but as a consistent initial reference for organizing clinical care. Concurrently, previously established guidelines for the nutritional follow-up of adults in the post bariatric period provide the framework for micronutrient supplementation that tends to be incorporated into the care of pregnant women. The recommendations of the Endocrine Society's Clinical Practice Guidelines[3] and the American Society for Metabolic and Bariatric Surgery (ASMBS) Integrated Health Nutritional Guidelines[16] establish supplementation targets and minimum laboratory panels for postoperative patients, regardless of pregnancy status. In the United Kingdom, the guidelines of the British Obesity and Metabolic Surgery Society (BOMSS) were subsequently updated, with an emphasis on peri and post operative monitoring of micronutrients.[17]

Although, these guidelines provide a consistent framework for nutritional care, their application during pregnancy requires specific adaptations, since most recommendations are derived from non pregnant populations. In this context, the need for individualized follow-up is highlighted, with adjustments to supplementation strategies and monitoring frequency based on the type of surgical procedure, the time elapsed since surgery, and the presence of symptoms or signs of nutritional deficiency.[14]

Based on this set of literature, more recent reviews focusing specifically on pregnancy propose an obstetric approach to bariatric surgery. Chapmon *et al*.[18] analyzed 46 studies and presented a practical guide to nutrition during pregnancy following bariatric surgery, detailing differences between surgical techniques, macro and micronutrient requirements, and the frequency of laboratory monitoring.[18] Huang *et al*.,[12] in turn, focused on strategies for screening and micronutrient supplementation, with an emphasis on thiamine, iron, vitamin B12, and vitamin D, explicitly discussing the limitations of the available evidence.[12]

Converging narrative reviews highlight that the heterogeneity of surgical techniques and individual metabolic responses limits the standardization of universal recommendations, reinforcing the importance of a patient centered approach, with integration among the obstetric, nutritional, and clinical teams for dynamic interpretation of laboratory and clinical findings throughout pregnancy.[19]

In the broader field of obstetrics, the Green-top Guideline No. 72 of the Royal College of Obstetricians and Gynaecologists (RCOG), dedicated to the management of obesity in pregnancy, includes specific sections for women with a history of bariatric surgery, emphasizing the increased risk, the need for follow-up in specialized services, and the importance of adequate supplementation, especially with folate and vitamin D.[20]

From a practical point of view, despite regional and institutional variations, the documents analyzed converge around three principles: (1) pregnant women who have undergone bariatric surgery require more rigorous monitoring than those without prior surgery; (2) the recommended supplementation regimens are more comprehensive than those used in conventional prenatal care; and (3) in the face of documented nutritional deficiencies, the guidelines recommend early transition to sublingual or parenteral routes, depending on the clinical context.[21]

In addition, there are significant gaps in the evidence, particularly regarding the definition of optimal micronutrient doses and the lack of robust clinical trials in post bariatric pregnant women, which contributes to variability among international recommendations and underscores the still evolving nature of the available guidelines.[22]

Preconception evaluation and first consultation

Ideally, care should begin before a positive pregnancy test. The preconception period is considered a strategic opportunity to identify anatomical and biochemical alterations related to bariatric surgery and, when possible, to intervene on them. The international consensus by Shawe *et al*.[15] recommends formal reproductive counseling for all women of childbearing age undergo bariatric surgery, with an emphasis on postponing pregnancy for 12 to 18 months after the procedure or until weight stabilization.[15] This interval aims to avoid the period of greatest catabolism, characterized by accelerated weight loss and an increased risk of nutritional deficiencies.[2]

The period immediately following surgery is marked not only by rapid weight loss but also by significant metabolic and hormonal alterations, including changes in glycemic homeostasis and nutrient absorption, which can negatively impact embryonic implantation and

early pregnancy development when conception occurs prematurely.[13]

Guidelines and consensus statements recommend that preconception evaluation, or, in the absence of this, the first prenatal visit, go beyond ordering laboratorial tests and include a detailed medical history, investigating the type of procedure performed, the time elapsed since surgery, the occurrence of complications, episodes of persistent vomiting, hospitalizations due to malnutrition, dietary patterns, food aversions, and use of and adherence to prescribed supplementation. Nonspecific symptoms, such as chronic fatigue, cramps, hair loss, and night vision changes, may represent early manifestations of multiple micronutrient deficiencies.

Additionally, clinical management studies indicate that symptoms such as persistent vomiting should be assessed early in this group, not only as a gastrointestinal manifestation but as a possible risk marker for thiamine deficiency, a condition that can rapidly progress to severe neurological complications if not recognized and treated promptly.[23]

From a laboratorial perspective, guidelines and reviews recommend a minimum panel that includes a complete blood count, ferritin, serum iron, transferrin saturation, vitamin B12, folate, 25-hydroxyvitamin D, calcium, phosphorus, magnesium, parathyroid hormone, vitamin A, and, when available, vitamin K, as well as trace elements such as zinc, copper, and selenium, albumin, and total protein. Depending on the clinical and care context, homocysteine, urinary iodine, and thyroid function testing may be added.[12,16,17] This is when the initial supplementation regimen is typically established. Recent guidelines recommend the use of a multivitamin formulated for bariatric patients, iron and vitamin B12 supplementation when indicated, correction of deficiencies identified prior to conception, and initiation of folic acid at doses higher than those of conventional prenatal, typically 1 mg per day, which may reach 4 to 5 mg per day in cases of residual obesity, diabetes mellitus, or a history of neural tube defects.[15,20]

Contemporary reviews also emphasize that, even in the presence of prior supplementation, the initial laboratorial evaluation should be comprehensive, since irregular adherence, variability in intestinal absorption, and differences between surgical techniques can result in subclinical deficiencies undetected by clinical history alone, reinforcing the need for systematic biochemical confirmation.[19]

Supplementation strategies during pregnancy post bariatric surgery

Guidelines for adults who have undergone bariatric surgery consistently recommend that nutritional supplementation should be routine and lifelong, rather than administered on an occasional or as needed basis.[3,16,17] In the context of pregnancy, the central question is not whether supplementation should be initiated, but at what dose, by which route, and with what degree of redundancy, considering the physiological alterations of pregnancy and impaired absorption.

The need for continuous supplementation stems not only from reduced food intake but also from persistent anatomical and functional alterations in the gastrointestinal tract, including decreased contact between food and key absorptive areas, alterations in gastric pH, and changes in intestinal transit, factors that limit the bioavailability of various micronutrients even in the presence of adequate intake.[24]

One way to organize the available recommendations is to systematize supplementation into three complementary tiers. This scheme, according to the consulted guidelines, provides for a total dose of at least 45–60 mg of elemental iron, 0.8–1 mg of folic acid, an adequate dose of vitamin B12 administered orally, sublingually, or parenterally, a generous dose of thiamine, equal to or greater than 12 mg, ideally around 50 mg, vitamin D in sufficient quantity to maintain serum 25-hydroxyvitamin D levels above 30 ng/mL, vitamin A exclusively in the form of beta-carotene, as well as zinc, copper, selenium, iodine, and other essential micronutrients.[12,17]

Observational studies and narrative reviews indicate that, even with standardized supplementation regimens, the prevalence of iron, vitamin B12, and vitamin D deficiency remains high throughout pregnancy, reflecting variability in individual absorption and the need for serial monitoring to adjust doses throughout the prenatal period.[25]

The second tier corresponds to targeted supplementation, including calcium in the form of citrate, at a daily dose of 1000–1500 mg of elemental calcium, divided into two or three doses and always taken separately from iron; vitamin D3 at a dose of 1000–2000 IU per day, with adjustments based on serum levels; and sufficient protein intake to achieve, in practice, 60–80 g per day, either through diet or the use of protein supplements.[2,3]

Ensuring adequate protein intake can be challenging in this group due to reduced gastric capacity and intolerance to certain foods, often requiring the use of protein supplements to guarantee sufficient intake, especially during phases of increased gestational demand.[22]

The third tier corresponds to intensified therapy, guided by laboratorial findings and clinical symptoms, with increased oral iron, vitamin B12, thiamine, or vitamin D, and, based on clinical assessment, escalation to sublingual or parenteral routes. It is important to note that much of this guidance stems from the integration of

pathophysiological plausibility and clinical experience, rather than from randomized clinical trials. Chapmon *et al*.[18] explicitly acknowledge that the suggested doses largely reflect expert consensus, adopting a deliberately conservative strategy aimed at erring on the side of caution in a potentially high-risk scenario.[18]

Clinical trials and systematic reviews suggest that in cases of moderate to severe iron-deficiency anemia or poor response to oral iron, the use of intravenous iron may be associated with greater efficacy in correcting anemia and faster recovery of iron storages, with an acceptable safety profile during pregnancy, making it a relevant alternative during the therapeutic intensification phase. Systematic reviews of high methodological quality corroborate these findings, demonstrating greater increases in hemoglobin and ferritin in a shorter time, as well as better gastrointestinal tolerability when compared to oral iron.[26,27]

For a better understanding and summary, Appendix A presents the monitoring and micronutrient supplementation regimens during pregnancy following bariatric surgery. The practical organization of supplementation should take into account the recommendations of available guidelines, adapting them to the clinical and care context of each facility.

Key micronutrients: Iron, Folate, Vitamin B12, Thiamine, Vitamin D, Calcium, and Trace Minerals

Iron represents one of the main critical issues in the care of pregnant women post bariatric surgery. The combination of reduced gastric acidity, duodenal bypass in malabsorption procedures, and limited food intake significantly compromises oral absorption. Cohort studies and systematic reviews report high prevalences of iron-deficiency anemia in this group, which often persists despite the use of conventional multivitamins.[8–10] From a practical point of view, recent guidelines and reviews recommend that post bariatric pregnant women receive at least 45 to 60 mg of elemental iron per day, with higher targets for women with low ferritin or a progressive decline in hemoglobin.[14,15,17] A central aspect of management is determining the timing for escalating to intravenous iron. Huang *et al*.[12] suggest that moderate or severe anemia in the second or third trimester, ferritin levels below 20–30 ng/ml in late pregnancy, significant intolerance to oral iron, or proximity to delivery with clearly depleted iron storages constitute strong indications for parenteral administration.[12]

Recent clinical trials in pregnant women, although not restricted to the post bariatric setting, demonstrate that intravenous iron is associated with a greater increase in hemoglobin and ferritin in a shorter time, compared to oral iron, as well as better gastrointestinal tolerability, which reinforces its applicability in contexts of impaired absorption and the need for faster correction of iron storages.[26]

The quality of evidence specific to the use of intravenous iron in post bariatric pregnant women derives largely from extrapolation of the literature on anemia in pregnancy in general and from case series. Nevertheless, the convergence of physiology and clinical experience supports a practical conclusion: attempting to correct established anemia via oral administration, just weeks before delivery, in patients with impaired absorption, has been considered a potentially avoidable approach in the literature.

Vitamin B12 occupies a central position at the interface between hematology and neurology. Reduced acid secretion and intrinsic factor, associated with the possible exclusion of the terminal ileum, makes vitamin B12 deficiency expected in the long-term follow-up after *Roux-en-Y* gastric bypass and biliopancreatic diversion, and not uncommon after vertical gastrectomy.[1,2] Jans *et al*.[9] describe cases of severe neuropsychomotor delay in children exposed to maternal vitamin B12 deficiency during pregnancy and lactation, which reinforces the importance of this micronutrient as a priority in prenatal care.[8]

Serum vitamin B12 levels may decline progressively throughout pregnancy, even in women taking supplements, suggesting that the increased demand associated with pregnancy may exceed standard supplementation, especially in contexts of reduced intestinal absorption.[25]

Guidelines and consensus statements recommend combined strategies, involving high-dose oral or sublingual vitamin B12, combined with monthly intramuscular administration in women with low levels, suggestive clinical signs, or undergoing procedures with a greater impact on absorption.[12,15,16,18] In practice, many high-risk care centers opt for standardized monthly parenteral vitamin B12 in pregnant women who have undergone gastric bypass surgery, regardless of baseline levels, considering the safety, relatively low cost, and clinical relevance of the nutrient.

Folate plays a classic role in obstetrics due to its association with neural tube defects. In women with obesity, the baseline risk is already higher; in the presence of a surgically modified gastrointestinal tract, this risk may be increased. Folate absorption occurs predominantly in the proximal jejunum, a segment that may be partially or totally bypassed in some bariatric techniques.[3,17]

General and specific guidelines recommend that post bariatric pregnant women receive at least 0.8 to 1 mg per day of folic acid, preferably starting in the preconception period. Higher doses, between 4 and 5 mg per day, should be considered in women with residual obesity, type 2 diabetes mellitus, or a personal or family history of neural

tube defects.[15,20] Although this recommendation is based primarily on biological plausibility and extrapolation, it is supported by case reports of neural tube defects in the children of women with folate deficiency following malabsorptive surgeries.[9]

While iron and vitamin B12 pose chronic challenges, thiamine is associated with acute and potentially catastrophic outcomes. The combination of reduced intake, persistent vomiting, and increased glucose metabolism creates a scenario conducive to the development of Wernicke's encephalopathy, with cases described in post bariatric pregnant women presenting with hyperemesis gravidarum.[2,3,12]

Wernicke's encephalopathy associated with thiamine deficiency remains underdiagnosed in pregnant women with persistent vomiting and is often recognized only in advanced stages, highlighting the importance of a preventive, low-threshold approach to empirical replacement therapy in high-risk situations.[23]

International consensus guidelines are unequivocal in recommending that any pregnant woman with a history of bariatric surgery who presents with persistent vomiting, rapid weight loss, or requires hospitalization due to dehydration receive intravenous or intramuscular thiamine prior to any glucose infusion.[3,12] In terms of prevention, oral doses of 50 to 100 mg per day are widely accepted in high-risk pregnant women, even in the absence of specific clinical trials, given the severity of the outcomes associated with deficiency.

The skeletal consequences of bariatric surgeries involving prolonged intestinal bypass are well documented in adults, including increased bone turnover, secondary hyperparathyroidism, osteopenia, and fragility fractures in long-term follow-up.[1,2] During pregnancy, fetal demand for calcium and vitamin D compounds a situation in which the woman may already have a pre-existing deficiency of these nutrients.

Guidelines recommend the use of calcium in the form of citrate, at doses of 1200 to 1500 mg per day, combined with vitamin D supplementation in sufficient quantities to maintain serum 25-hydroxyvitamin D levels above 30 ng/ml, often requiring doses of 1000 to 2000 IU per day or more.[3,17] Specific reviews on pregnancy following bariatric surgery reiterate these goals and add the recommendation for monitoring parathyroid hormone, with dynamic dose adjustments as needed.[12,18] Although direct evidence in pregnant women is limited, the pathophysiological rationale is consistent.

Recent reviews also indicate that vitamin D deficiency remains highly prevalent in this group, even with supplementation, reflecting not only absorption abnormalities but also behavioral and environmental factors, which reinforces the need for serial monitoring and individualized dose adjustments.[19]

Fat-soluble vitamins and trace elements often receive less attention but have significant clinical relevance. Vitamin A deficiency is associated with night blindness and ocular alterations, while excess retinol is known to be teratogenic. Observational studies report reduced vitamin A levels in some post bariatric pregnant women and recommend careful supplementation exclusively in the form of beta-carotene, avoiding overdose.[8,9]

Vitamin K absorption may be compromised in cases of steatorrhea, with reports of neonatal hemorrhage in infants of mothers with severe deficiency. In such cases, management involves maintaining a multivitamin containing vitamin K and conducting targeted investigations in the presence of suggestive clinical or laboratorial findings.

Zinc, copper, and selenium also present a risk of deficiency in the post bariatric period, requiring special attention to the balance between zinc and copper, since isolated and excessive zinc supplementation can induce secondary copper deficiency, with refractory anemia and neuropathy.[1,16] The predominant approach in the literature is to aim for coverage of the daily recommendations for pregnant women and adjust based on laboratorial results.

Trace element deficiency can occur simultaneously and subclinically, which limits identification based solely on symptoms and reinforces the importance of periodic laboratory monitoring as a strategy for preventing adverse maternal and neonatal outcomes.[22]

Iodine, finally, lies at the interface between maternal nutrition and fetal endocrinology. Its deficiency is associated with cognitive impairment and, in extreme cases, endemic cretinism. General pregnancy guidelines recommend a daily intake of 150 to 250 µg. In women who have undergone bariatric surgery, the reviewed literature does not suggest a reason for lower targets, in the absence of specific contraindications.[12,20]

A summary of monitoring and supplementation strategies for key micronutrients is presented in Table 1.

Monitoring throughout pregnancy

While supplementation is one of the cornerstones of care, systematic monitoring is what allows us to assess its effectiveness over time. Even well-structured supplementation regimens remain clinical hypotheses that must be continuously verified through serial assessments, with doses, routes of administration, and strategies adjusted according to the individual response.

Interindividual variability in micronutrient absorption following bariatric surgery can be wide, even among patients who have undergone the same procedure, which limits the predictability of the response to supplementation and supports the need for individualized longitudinal monitoring.[19]

Table 1

Monitoring and supplementation of micronutrients during pregnancy post bariatric surgery.

Micronutrient	Main risk factors	Recommended monitoring	Supplementation strategies
Iron	• Hypochlorhydria; • Duodenal exclusion; • Reduced food intake.	• Complete blood Count; • Ferritin; • Serum iron; • Transferrin saturation.	Oral iron 45–60 mg/day; consider intravenous iron in cases of moderate or severe anemia, ferritin <20–30 ng/ml in the second or third trimester, intolerance to oral iron, or proximity to delivery.
Vitamin B12	• Intrinsic factor reduction • Hypochlorhydria • Possible exclusion of terminal ileum	• Serum vitamin B12 according to clinical risk	High-dose oral or sublingual supplementation; monthly intramuscular administration in cases of deficiency, neurological symptoms, or procedures with significant impact on absorption
Folate	• Partial exclusion of the proximal jejunum; • Reduced dietary intake	• Serum folate, according to clinical context	Folic acid ≥0.8–1 mg/day; consider 4–5 mg/day in cases of residual obesity, diabetes mellitus, or a history of neural tube defects
Thiamine (B1)	• Reduced intake; • Persistent vomiting; • Increased carbohydrate metabolism	• Clinical evaluation; laboratory testing when available	Oral supplementation 50–100 mg/day in high-risk pregnant women; immediate parenteral administration in cases of persistent vomiting or prior to glucose infusion
Vitamin D	• Malabsorption of fats; • Residual obesity; • Reduced sun exposure	• 25-Hydroxyvitamin D and parathyroid hormone	Supplementation to maintain 25(OH)D >30 ng/mL, often 1000–2000 IU/day or more, depending on serum levels
Calcium	• Duodenal exclusion • Reduced vitamin D-dependent absorption	• Serum calcium, phosphorus, parathyroid hormone	Calcium citrate 1200–1500 mg/day, divided into doses, with adjustment based on parathyroid hormone
Vitamin A	• Malabsorption of fat-soluble vitamins	• Clinical evaluation; laboratory testing when available	Supplementation exclusively in the form of beta-carotene; avoid retinol due to teratogenic potential
Vitamin K	• Steatorrhea; • Malabsorption of fats	• Clinical evaluation; targeted investigation	Maintain a multivitamin containing vitamin K; investigate in cases of bleeding or abnormal laboratorial findings
Zinc	• Reduced intake and intestinal absorption	• Serum zinc when available	Supplementation according to daily recommendations for pregnant women; avoid excessive isolated supplementation
Copper	• Secondary deficiency to excessive zinc supplementation	• Serum copper when available	Ensure a balance between zinc and copper; supplement if a deficiency is confirmed
Selenium	• Reduced intestinal absorption	• Serum selenium when available	Supplementation according to daily recommendations for pregnant women
Iodine	• Inadequate dietary intake	• Urinary iodine in selected contexts	Daily intake of 150–250 µg, unless specifically contraindicated

Source: Heber *et al.*,[3] Parrott *et al.*,[16] Shawe *et al.*,[15] Denison *et al.*,[20] O'Kane *et al.*,[17] Chapmon *et al.*,[18] Huang *et al.*[12]

Consensus statements and reviews agree on the recommendation to repeat laboratorial tests at least every three months: complete blood count, ferritin, serum iron, transferrin saturation, vitamin B12, folate, 25-hydroxyvitamin D, calcium, magnesium, and parathyroid hormone, as well as trace elements and vitamins A and K in high-risk contexts.[12,15,18] In pregnant women undergoing procedures with a higher malabsorption component, such as biliopancreatic diversion with duodenal switch, in the presence of steatorrhea, persistent vomiting, or a history of severe nutritional deficiencies, shorter intervals, between 8 and 12 weeks, may be more appropriate.

In parallel with laboratorial evaluation, monitoring of gestational weight gain and fetal growth is a central component of prenatal care. Reviews indicate that many pregnant women after bariatric surgery have weight gain below the levels recommended by the traditional ranges of the Institute of Medicine,[28] an association that correlates with a higher frequency of small for gestational age newborns.[7,10]

Alterations in maternal glycemic homeostasis, including increased glycemic variability and episodes of hypoglycemia, may contribute to this pattern of reduced fetal growth, reinforcing the importance of a metabolic evaluation integrated into nutritional monitoring.[13]

Performing serial ultrasounds, with assessment of fetal biometry and, when indicated, Doppler velocimetry, allows for the early identification of growth restriction patterns and the adoption of more intensive monitoring strategies.

Diagnosis of gestational diabetes in women after bariatric surgery

In this context, the central challenge is not related to micronutrient deficiency but to the glycemic assessment strategy. The 75-g oral glucose tolerance test, the standard method for screening for gestational diabetes mellitus, may be inappropriate in women who have undergone *Roux-en-Y* gastric bypass or biliopancreatic diversion. In these patients, the glucose load may trigger early dumping syndrome, delayed hypoglycemia, and significant clinical symptoms, compromising both the tolerability and the interpretation of the results.[7,12]

Pathophysiological studies demonstrate that these patients exhibit greater glycemic variability, with hyperglycemic peaks followed by hyperinsulinemic responses and subsequent episodes of hypoglycemia, which compromises the reproducibility and accuracy of the oral glucose tolerance test in this context.[13]

It should be noted that there is no international consensus on the best diagnostic method in this scenario, reflecting the lack of validation of specific criteria for this population and the need for a pragmatic approach based on the individual glycemic profile.[14]

Given these limitations, some groups propose replacing the classic oral test with alternative strategies, based on serial fasting and postprandial blood glucose measurements, home blood glucose self monitoring for specific periods, or, when available, continuous glucose monitoring.[12]

The underlying rationale is that, although the risk of gestational diabetes is lower after bariatric surgery,[5,6] the absence of an ideal diagnostic method should not lead to the omission of screening, but rather to the adaptation of the diagnostic strategy to the physiological context of these women.

Escalation approach to supplementation: indications for parenteral therapies

The oral route remains the initial strategy in many clinical settings due to its convenience, lower cost, and effectiveness in some pregnant women. However, in women who have undergone bariatric surgery, indiscriminate reliance on the oral route may be inappropriate, especially in the face of persistent anatomical and absorptive alterations.

The response to oral supplementation in this group is often unpredictable, since factors such as the type of surgical technique, the extent of the bypassed intestinal segment, and the presence of gastrointestinal symptoms significantly influence the bioavailability of micronutrients.[19]

In the reviewed literature, the use of intravenous iron, intramuscular vitamin B12, and intravenous thiamine has been understood not as a therapeutic failure, but as an adaptation of care to a modified physiological context. From a practical point of view, guidelines and reviews suggest considering intravenous iron when moderate or severe anemia manifests in the second or third trimesters, particularly in the presence of ferritin levels below 20–30 ng/ml, significant intolerance to oral iron, or a short interval until childbirth.[12,18]

Intravenous iron replacement allows for faster correction of iron storages and hemoglobin levels, with better tolerability, especially in patients with poor intestinal absorption or gastrointestinal intolerance to oral iron.[26]

Early intramuscular administration of vitamin B12 has been recommended for pregnant women who have undergone *Roux-en-Y* gastric bypass surgery, considering the physiology of this absorption of micronutrient and the potential maternal and fetal consequences of deficiency.[9,16]

Intravenous thiamine constitutes an exception to the logic of gradual escalation. Consensus guidelines recommend that, in any pregnant woman with a history of bariatric surgery who presents with severe vomiting, hyperemesis, or risk of acute malnutrition, parenteral administration of thiamine should precede the infusion of glucose solutions, due to the risk of precipitating Wernicke's encephalopathy and other potentially severe neurological complications.[3,12]

Progression to Wernicke's encephalopathy can occur rapidly in settings of thiamine depletion, which justifies a low-threshold approach to parenteral replacement, even before laboratorial confirmation of deficiency.[23]

Discussion

The care of pregnant women following bariatric surgery requires organization, continuous monitoring, and multidisciplinary collaboration. Although the surgery reduces several adverse outcomes traditionally associated with severe obesity, it introduces a distinct set of risks related to the absorption and metabolism of micronutrients, which are not adequately addressed by conventional prenatal care models. In this context, strategies that structure clinical reasoning and reduce variability in practice can make a significant contribution to maternal-fetal safety.

International guidelines and consensus statements agree on the need for more robust nutritional supplementation, systematic laboratorial monitoring, and timely use of parenteral routes. However, implementing these recommendations in daily practice faces significant challenges. Standardized prenatal protocols generally assume intact digestive physiology, which contributes to the underdiagnosis of nutritional deficiencies in women with anatomically altered gastrointestinal tracts. The isolated prescription of conventional multivitamins or

infrequent ordering of laboratorial tests has been cited in the literature as insufficient to address the complexity of this clinical context.

Supplementation in this group should be understood as a dynamic process, the effectiveness of which must be continuously evaluated. Maintaining oral administration in the face of persistent deficiencies, progressive anemia, or approaching delivery has been identified as an avoidable risk. The escalation to intravenous iron, intramuscular vitamin B12, or parenteral thiamine has been understood in the literature as a physiological adaptation of care, rather than a therapeutic failure, aligning with the principle of a response proportional to the risk.

Serial monitoring plays a central role in this process. Periodic repetition of laboratorial tests allows for early adjustments and reduces prolonged exposure to subclinical deficiencies, while monitoring of maternal weight gain and fetal growth serves as an indirect marker of overall nutritional adequacy. These elements reinforce the need for structured and continuous follow-up throughout pregnancy.

It is important to recognize that most of the currently available recommendations are based on observational evidence. The literature consists predominantly of cohorts, case series, and meta-analyses of non-randomized studies, with heterogeneity in surgical techniques, supplementation regimens, small sample sizes, and loss to follow-up. Nevertheless, the convergence of pathophysiological plausibility, consistent reports of preventable serious maternal and fetal outcomes, and consensus among scientific societies has been considered a sufficient basis to guide a preventive and structured approach.

Another aspect illustrating the need to adapt traditional protocols concerns the screening for gestational diabetes mellitus. Although the absolute risk is lower after bariatric surgery, the indiscriminate use of the oral glucose tolerance test may be inappropriate in women who have undergone malabsorption procedures. The adoption of alternative screening strategies reinforces the importance of adapting diagnostic algorithms to specific physiological contexts without compromising safety.

Significant knowledge gaps remain, particularly regarding comparisons between different supplementation regimens, optimal replacement targets for specific micronutrients, and the impact of early parenteral escalation strategies. Ongoing prospective studies, including cohorts focused on maternal-fetal nutrition following bariatric surgery, have the potential to provide more robust evidence in the coming years.

Until these data are available, the organization of care tends to rely on the integration of physiology, rigorous clinical monitoring, and the best currently available consensus.

Final considerations

Pregnancy following bariatric surgery occurs in a distinct physiological context, marked by persistent anatomical and absorptive laterations. It is not necessarily a riskier condition than pregnancy associated with severe, untreated obesity; in many respects, the outcomes are more favorable. It is, however, a specific clinical situation, whose particularities have been recognized in the literature as warranting a differentiated approach.

The guidelines of the Endocrine Society, the American Society for Metabolic and Bariatric Surgery, and the British Obesity and Metabolic Surgery Society, as well as the international consensus by Shawe *et al*.[15] and recent reviews, show a high degree of conceptual convergence. Consistently, they highlight adequate nutritional supplementation, systematic laboratorial monitoring, judicious use of parenteral routes according to the clinical context, and multidisciplinary care as key elements in the management of these pregnant women.

In clinical practice, the literature suggests that supplementation regimens used in conventional prenatal care are often insufficient in this context, and that the incorporation of intravenous iron, intramuscular vitamin B12, and parenteral thiamine as available therapeutic options, the structuring of outpatient follow-up with regular laboratorial monitoring, and the adaptation of diagnostic and therapeutic strategies to the specificities of an anatomically altered gastrointestinal tract constitute directions reinforced by the available evidence. Above all, it implies understanding that bariatric surgery is not a distant antecedent, but the physiological context in which the entire pregnancy develops.

The central challenge, from this point forward, seems to lie not in formulating new recommendations, but in the systematic, longitudinal, and equitable incorporation of already available strategies throughout the continuum of care, so that nutritional follow-up becomes an integral part of these women's prenatal care.

Use of artificial intelligence

The authors declare the use of a generative AI tool (ChatGPT) for editorial/stylistic support—detailed in the cover letter.

Authors' contributions

Amorim MMR: conceptualization; project management; supervision; writing—review and editing.

Carvalho Filho AFP, Coutinho IC, Frank TC: research; data curation; writing—review and editing.

Freitas JLBF: research; data curation, formal analysis, writing—review and editing.

All authors approved the final version of the article and declare no conflict of interest.

Data availability

The entire dataset supporting the results of this study was published in the article itself.

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