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Maternal Nutrition and Psychological Health in Low-Resource and Conflict-Affected Settings: A Systematic Review

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Abstract

Background: Perinatal mental health disorders remain a leading cause of maternal morbidity globally, with disproportionate burden in low-resource and conflict-affected settings. Emerging evidence suggests that maternal nutritional status—encompassing micronutrient intake, food security, and systemic nutrition-related inflammation—represents a modifiable risk factor for depression, anxiety, and stress during pregnancy and the postpartum period. However, no comprehensive systematic review has examined the integrated relationship between maternal nutrition and psychological health outcomes in these vulnerable contexts.

Objectives: To systematically assess the relationship between maternal nutritional status (including micronutrient status, food security, and dietary patterns) and psychological health outcomes (depression, anxiety, stress, PTSD) during pregnancy and postpartum in low-resource and conflict-affected settings, identify mechanistic pathways, map implementation barriers, and highlight evidence gaps with particular relevance to maternal health in Libya.

Methods: This systematic narrative review synthesized peer-reviewed literature from Scopus, Web of Science, and PubMed databases published 2017–2025, with seminal works retained from earlier periods. Inclusion criteria: English-language, peer-reviewed studies examining maternal nutrition and psychological health outcomes in pregnancy/postpartum periods, prioritizing low-resource and conflict-affected populations. Study quality and bias were evaluated using standard appraisal tools. A biopsychosocial-systems approach guided thematic synthesis.

Key Findings: Multiple mechanistic pathways link maternal nutrition to psychological health: (1) **micronutrient pathways** involving iron (dopamine/monoamine synthesis), B vitamins (folate cycle, homocysteine metabolism), and vitamin D (neuroinflammation regulation); (2) **systemic inflammation pathway** through stress-induced immune dysregulation and placental dysfunction; (3) **food insecurity as social determinant** with bidirectional relationships to maternal depression. Meta-analytic evidence shows: vitamin D deficiency associated with 2–2.3-fold increased odds of perinatal depression; iron supplementation improves both hemoglobin and depressive symptoms (EPDS); household food insecurity associated with 2.5–4.4-fold increased odds of depression. Critical gaps exist in conflict-affected settings, integration of mental health into nutrition services, and Libya-specific evidence.

Conclusion: Maternal nutrition and psychological health are inextricably linked through multiple biological, behavioral, and social determinants. In low-resource and conflict-affected settings, addressing maternal nutrition represents a high-impact, feasible, and cost-effective entry point for perinatal mental health promotion. Integration of nutritional assessment, micronutrient supplementation, and food security interventions into routine maternal health services—with task-shifting to community health workers—offers promise for reducing mental health burden. Future research must prioritize conflict-affected contexts, implementation science approaches, and context-specific evidence generation in the Global South.

Keywords: maternal nutrition, perinatal depression, postpartum anxiety, food insecurity, micronutrients, low-resource settings, conflict-affected settings, mental health integration, systematic review, implementation science.

1. Introduction

1.1 Research Problem and Context

Perinatal mental health disorders—encompassing antenatal and postpartum depression, anxiety, and trauma-related conditions—affect an estimated 10–20% of pregnant women globally, with prevalence rising to 25–30% in low- and middle-income countries (LMICs).[1][10][112][113] These disorders are a leading cause of maternal morbidity and, untreated, contribute substantially to pregnancy-related deaths, impaired maternal-infant bonding, adverse child neurodevelopmental outcomes, and perpetuation of intergenerational mental health burdens.[103][116]

In conflict-affected and low-resource settings, this burden intensifies dramatically. Armed conflict is associated with substantial and persistent excess maternal and child deaths beyond direct violence-related harm; it destabilizes health systems, erodes food security, amplifies poverty and social fragmentation, and heightens exposure to trauma and chronic stress.[19][22][23][24][25][26][27] The estimated 26 million women of reproductive age living in emergency situations face compounding maternal and mental health vulnerabilities.[21] Women in these contexts experience disproportionately high rates of nutritional deficiencies—both micronutrient deficiencies and general malnutrition—which occur alongside elevated psychological distress, yet interventions addressing the nutrition-mental health nexus remain fragmented and under-resourced.

Simultaneously, an expanding body of evidence demonstrates that maternal nutritional status—encompassing micronutrient biomarkers (iron, B vitamins, vitamin D, zinc, selenium), dietary pattern quality, and household food security—represents a modifiable biological and social risk factor for perinatal psychological outcomes.[1][12][16][17][76][82][118][121][122] This evidence spans mechanistic pathway research (inflammation, HPA axis dysregulation, neurotransmitter synthesis) and observational/interventional epidemiology. Yet current clinical and public health responses to perinatal mental health in LMICs remain largely disconnected from nutritional assessment, supplementation, and food security interventions.

1.2 Novelty and Gap in Existing Knowledge

Existing systematic reviews have examined discrete elements of this relationship:

- Individual micronutrients and perinatal depression (e.g., vitamin D, B vitamins in isolation)[17][76][118][129][130][131][132]

- Food insecurity and maternal mental health (without integration of nutrient biomarkers or mechanistic pathways)[10][111][114]
- Perinatal mental health epidemiology in the Middle East and North Africa region (without specific nutrition integration)[110]
- Sub-Saharan Africa maternal mental health burden (without nutritional mechanisms)[112][113]
- Interventions targeting single modalities (iron supplementation, mindfulness-based interventions, food vouchers) without exploring synergistic nutrition-mental health effects[37][38][49][59][105]

To our knowledge, no comprehensive systematic review has synthesized:

1. The **integrated, multi-pathway relationship** between maternal nutritional status (micronutrient deficiency, food insecurity, dietary patterns) and psychological health outcomes across pregnancy and postpartum
2. Evidence **specifically from low-resource and conflict-affected settings** where this relationship carries greatest public health significance
3. The **mechanistic pathways** linking nutrition to mental health (inflammation, HPA axis, neurotransmitter synthesis) with attention to biological plausibility
4. **Implementation science evidence** on integration of nutrition and mental health services in primary care settings with limited resources
5. Evidence with explicit attention to **Libya and the broader MENA/North Africa region**, where maternal health data remain scarce

This review addresses these gaps by synthesizing evidence through a biopsychosocial-systems framework, explicitly foregrounding low-resource and conflict-affected populations, and articulating actionable implications for maternal health programs and policy in these settings.

1.3 Theoretical Framework

This review is grounded in a **biopsychosocial-social determinants framework** that recognizes maternal mental health and nutritional status as products of interacting biological, psychological, and social systems operating at multiple levels (individual, household, community, structural). Key theoretical assumptions:

1. **Bidirectional causality**: Maternal depression/anxiety may impair dietary intake and nutrient absorption; conversely, nutritional deficiency impairs neurotransmitter synthesis and increases systemic inflammation, exacerbating mood disorder risk.
2. **Mechanistic integration**: Biological pathways (e.g., iron-dopamine-mood; folate-homocysteine-inflammation; vitamin D-immune regulation) operate within social contexts of food insecurity, poverty, and trauma exposure.
3. **Implementation as evidence**: Barriers and facilitators to integrating nutrition into mental health services (or vice versa) are **data**, not merely context-specific constraints; understanding task-shifting, health system capacity, and community acceptability is essential for evidence-based scale-up.
4. **Equity lens**: Maternal mental health and nutrition inequities are socially patterned; this review prioritizes evidence from populations bearing greatest

burden—low-resource and conflict-affected settings—rather than assuming generalizability from high-income settings.

2. Review Methodology

2.1 Search Strategy and Information Sources

This systematic narrative review followed **PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews)** principles to balance comprehensiveness with conceptual synthesis. A comprehensive search was conducted across **PubMed, Scopus, and Web of Science** from database inception through **January 2026**, prioritizing publications from 2017–2025 while retaining key seminal works (2005–2016) establishing foundational mechanistic evidence.

Search terms employed (with database-specific syntax):

- **Core concept clusters**: ("maternal nutrition" OR "maternal nutrient status" OR "micronutrient deficiency" OR "food insecurity" OR "dietary pattern" OR "food security") AND ("pregnancy" OR "pregnant women" OR "perinatal" OR "postpartum" OR "postnatal") AND ("mental health" OR "depression" OR "anxiety" OR "psychological distress" OR "PTSD" OR "stress" OR "mood disorder")
- **Mechanism-focused searches**: ("maternal nutrition" OR "micronutrient") AND ("inflammation" OR "cytokine" OR "cortisol" OR "HPA axis" OR "neurotransmitter" OR "dopamine" OR "serotonin") AND ("pregnancy" OR "postpartum")
- **Population-focused searches**: ("low-resource" OR "low-income" OR "LMIC" OR "conflict-affected" OR "fragile state" OR "humanitarian" OR "Libya" OR "Sub-Saharan Africa" OR "Middle East" OR "North Africa") AND ("maternal" OR "pregnancy") AND ("nutrition" OR "food security" OR "mental health")
- **Implementation-focused searches**: ("maternal mental health" OR "perinatal mental health") AND ("integration" OR "task-shifting" OR "community health worker" OR "primary care" OR "implementation") AND ("low-resource" OR "LMIC")

Screening and selection: Reviewers independently screened titles/abstracts against pre-specified inclusion criteria. Full texts of potentially eligible studies were retrieved and assessed. Disagreements were resolved through consensus discussion.

2.2 Inclusion and Exclusion Criteria

Inclusion criteria:

- **Study design**: Systematic reviews, meta-analyses, randomized controlled trials, quasi-experimental designs, longitudinal/prospective cohort studies, cross-sectional observational studies, qualitative/mixed-methods studies examining mechanisms or implementation
- **Population**: Pregnant women (any trimester) or postpartum women (up to 12 months) in low-resource or conflict-affected settings; or studies conducted in high-income settings but explicitly examining low-resource populations or relevant to LMIC implementation

- **Exposure**: Maternal nutritional status measures including: micronutrient biomarkers (serum iron, hemoglobin, ferritin, folate, B12, vitamin D, zinc, selenium); dietary pattern or food frequency data; household food insecurity measures; supplementation interventions
- **Outcomes**: Validated psychological health measures including: depressive symptoms (Edinburgh Postnatal Depression Scale [EPDS], Patient Health Questionnaire [PHQ], Beck Depression Inventory); anxiety symptoms (Generalized Anxiety Disorder scale, State-Trait Anxiety Inventory); stress/trauma symptoms (Perceived Stress Scale, PTSD Checklist); psychological distress scales
- **Language**: English-language peer-reviewed publications
- **Time period**: 2005–2026, with priority weighting to 2017–2026

Exclusion criteria:

- Non-peer-reviewed sources, dissertations, grey literature (except key reports from WHO, World Bank)
- Studies focusing exclusively on non-perinatal populations
- Reviews examining nutrition and mental health without explicit pregnancy/postpartum context
- Studies in high-income countries without explicit low-resource population focus or LMIC relevance
- Narrative opinion pieces lacking empirical evidence

2.3 Quality Assessment and Appraisal

Study quality was evaluated using:

- **For RCTs**: Cochrane Risk of Bias tool (selection, performance, detection, attrition, reporting biases)
- **For observational studies**: Newcastle-Ottawa Scale (selection, comparability, outcome assessment)
- **For qualitative studies**: CASP Qualitative Appraisal Checklist
- **For systematic reviews**: AMSTAR 2 (methodological rigor)

Quality was not used as exclusion criterion but rather as context for interpreting findings and identifying heterogeneity sources. Low-quality studies were retained if they provided unique evidence from underrepresented populations (e.g., conflict-affected settings) and were clearly flagged.

2.4 Data Synthesis Approach

This review employed **systematic narrative synthesis** with the following structure:

1. **Thematic-conceptual organization**: Evidence was synthesized around key mechanistic and implementation themes rather than strictly by study design, allowing integration of quantitative and qualitative evidence
2. **Strength-of-evidence assessment**: For each theme, evidence density, consistency, study quality, and applicability to low-resource settings were characterized using an adaptation of GRADE (Grading of Recommendations, Assessment, Development and Evaluations) framework

3. **Meta-analytic data**: Where meta-analytic findings were available (e.g., vitamin D and depression; food insecurity and depression), results are presented with effect estimates, confidence intervals, and heterogeneity measures
4. **Implementation analysis**: Barriers, facilitators, and effectiveness evidence for integration approaches were synthesized using framework analysis informed by implementation science literature
5. **Geographic/population-specific analysis**: Particular attention to evidence from LMIC, conflict settings, and where available, Libya-specific data

3. Mechanistic Pathways Linking Maternal Nutrition to Psychological Health

3.1 Micronutrient-Neurotransmitter Pathways

Iron and monoamine metabolism: Iron is essential cofactor for tyrosine hydroxylase, the rate-limiting enzyme in dopamine synthesis, and for other monoamine neurotransmitter biosynthetic pathways.[41] Iron deficiency anemia (present in ~50% of pregnancies globally) is associated with dopamine-dependent behavioral impairments, fatigue, and mood disturbance. In pregnancy specifically, gestational anemia is associated with antenatal and postpartum psychological distress, with mechanisms proposed including impaired cerebral oxygen delivery and neurotransmitter dysfunction.[42] A 3-year follow-up trial of IV iron supplementation in anemic pregnant women demonstrated not only improved vitality and physical energy but also reduced clinical depression ($p=0.003$), improved overall mental health ($p<0.001$), and increased breastfeeding duration in the treatment group.[46] More recently, a prospective trial of single-dose IV ferric derisomaltose (1000 mg) in 78 pregnant women with iron-deficiency anemia showed improvements in hemoglobin (+1.3 g/dL, $p<0.001$), fatigue (Edinburgh Postnatal Depression Scale score improvement, $p=0.003$), and cord blood ferritin levels, with minimal adverse effects.[37][38]

B vitamins and one-carbon metabolism: Folate (B9) and vitamin B12 are critical cofactors in one-carbon metabolism, which supports both DNA methylation (essential for gene regulation including stress response genes) and monoamine neurotransmitter synthesis. B vitamin deficiency disrupts the folate cycle, leading to hyperhomocysteinemia, increased oxidative stress, and impaired synthesis of dopamine, serotonin, and γ-aminobutyric acid (GABA)—all implicated in depression pathogenesis.[66] Multiple observational studies document associations between low serum folate and perinatal depression,[77][78][80] and between vitamin B12 deficiency and postpartum depression in vulnerable populations.[79] A Bangladesh randomized controlled trial found that maternal B12 supplementation (250 µg/day from 11–14 weeks gestation through 3 months postpartum) reduced plasma oxidative stress markers (8-hydroxydeoxyguanosine, $p<0.05$) and proinflammatory cytokines, with corresponding improvements in infant immune markers.[82] A prospective Brazilian cohort found that women with anxiety symptoms during pregnancy had significantly lower serum and milk B12 concentrations at postpartum timepoints.[102] A 2025 meta-analysis identified that vitamin B6, B9, and B12 supplementation showed promise in reducing maternal depressive symptoms, particularly when addressing underlying deficiency.[66]

Vitamin D and neuroinflammation: Vitamin D functions as a neuroactive steroid hormone, regulating neurotransmitter synthesis, calcium homeostasis, and immune-mediated inflammation. Vitamin D deficiency (defined as serum 25-hydroxyvitamin D <20 ng/mL) occurs in 30–50% of pregnant women in low-resource settings and has been consistently associated with perinatal depression in meta-analytic syntheses. A 2024 meta-analysis of 13 studies found significantly lower vitamin D levels in women with perinatal depression compared to controls: prenatal depression (Standardized Mean Difference [SMD] −0.41, 95% CI −0.57 to −0.25; minimal heterogeneity); postpartum depression (SMD −1.62 to −2.28, 95% CI ranging 1.60–3.25; substantial heterogeneity I^2=92%).[121][127] A Brazil prospective cohort of 713 pregnant women demonstrated that vitamin D deficiency (≤19.9 µg/mL) assessed in early pregnancy was associated with 2-fold increased odds of postpartum depression diagnosis at 3 months postpartum (OR 2.0, 95% CI 1.0–4.2; adjusted for age, SES, depression history).[119] Mechanistically, vitamin D suppresses hepcidin expression (improving iron bioavailability), regulates inflammatory cytokine production (IL-6, TNF-α, IL-1β), and modulates serotonin and dopamine pathways.[33][82] A 2024 Cochrane review of vitamin D supplementation in pregnancy found protective effects against gestational diabetes (RR 0.65, 95% CI 0.49–0.86; n=12 trials, 1,992 participants) and modest improvements in birth weight (+53g), though mental health outcomes were not systematically evaluated in RCTs.[122]

Zinc and trace element metabolism: Zinc is a critical cofactor for protein synthesis, immune regulation, and synaptic plasticity. Across multiple Canadian birth cohorts, serum zinc was identified as a significant micronutrient for anxiety symptoms, while a case-control study in India found significantly lower serum zinc levels in women with postpartum depression (mean 21.63 µg/dL in depression cases vs. 54.16 in controls, p<0.001) with negative correlation between zinc levels and depression severity.[133][142] An early pregnancy metals mixture analysis in 1,226 women found that zinc, copper, and other trace element concentrations in the first trimester were associated with antepartum and postpartum depressive symptom severity, with interactions suggesting that trace element balance may be as important as individual micronutrient status.[143]

3.2 Inflammation and HPA Axis Dysregulation Pathway

A large body of evidence demonstrates that maternal psychological stress during pregnancy is associated with elevated systemic inflammation (elevated IL-6, IL-1β, TNF-α, CRP) and altered HPA axis function (cortisol dysregulation, α-amylase imbalance). This maternal inflammatory-endocrine milieu is transmitted to the fetus in utero via placental transfer of cytokines and glucocorticoids, potentially programming fetal and infant neurodevelopment and increasing risk of neurodevelopmental and psychiatric disorders in offspring.[84][92][93][96][97]

Nutrition modulates this pathway bidirectionally:

- **Inflammatory amplification through malnutrition**: Micronutrient deficiencies (iron, B vitamins, vitamin D, zinc, selenium) impair antioxidant defense, increase oxidative stress, and dysregulate immune tolerance mechanisms. Maternal macronutrient undernutrition and food insecurity—common in conflict settings—activate innate immune pathways, elevating proinflammatory cytokines and perpetuating a cycle of systemic inflammation.[82][83][86][88]
- **Inflammation-mental health pathway**: Elevated prenatal maternal inflammation is independently associated with reduced infant cognitive

development at 12 weeks, independent of maternal depressive or anxiety symptoms.[84] Placental transcriptomic studies show that prenatal stress, anxiety, and depression induce downregulation of immune tolerance genes and upregulation of inflammatory pathways at the maternal-fetal interface.[96] A 2023 systematic review of in vitro models found that glucocorticoid and cytokine challenges on placental and fetal neural progenitor cells activate the kynurenine pathway (a pro-depressive neuroimmune cascade) and inhibit hedgehog signaling (essential for neural progenitor proliferation), with epigenetic priming of stress-reactive gene regions.[87]

Mechanistic integration: Adequate micronutrient status supports antioxidant defense (via selenium-dependent glutathione peroxidase, zinc-dependent superoxide dismutase), helps suppress hepcidin-mediated iron dysregulation, and dampens TLR-mediated innate immune activation. Vitamin B12 supplementation reduces homocysteine-mediated endothelial dysfunction and NF-κB inflammatory signaling. Vitamin D directly suppresses Th1/Th17 proinflammatory differentiation while promoting regulatory T cell expansion. Conversely, food insecurity and malnutrition deplete these micronutrient-dependent antioxidant systems, perpetuating inflammation that both drives depression and impairs nutrient absorption—a vicious cycle particularly severe in conflict settings where trauma exposure further amplifies HPA-immune dysregulation.

3.3 Food Insecurity as Social Determinant

Household food insecurity—defined as inadequate economic access to sufficient, safe, nutritious food—is a powerful upstream social determinant structuring both nutritional status and mental health in low-resource and conflict-affected settings. A systematic review and meta-analysis of 18 studies comprising 27,882 pregnant individuals (meta-analysis n=18,987) found household food insecurity during pregnancy associated with increased odds of depressive symptoms (OR 2.52, 95% CI 2.11–3.02; I^2=73.23%), with prevalence of depressive symptoms ranging 18–49% among food-insecure pregnant women.[10] Importantly, the relationship is bidirectional: a prospective study found food insecurity at baseline predicted increased maternal depression odds 6 months later (OR 1.36, 95% CI 1.27–1.47), controlling for concurrent depression; and depression at baseline predicted increased food insecurity odds at follow-up (OR 1.53, 95% CI 1.43–1.66), controlling for concurrent food insecurity.[57]

Food insecurity clusters with other material hardships: a California cohort of 14,274 low-income pregnant women found 23.4% food insecure, with each additional severe hardship (partner job loss, intimate partner violence, lack of practical support, depressive symptoms) increasing odds of marginal/low food insecurity by 36–54%.[54][58] In Ethiopia, household food insecurity was among the strongest independent predictors of mental distress in pregnant women (adjusted odds ratio 2.01, 95% CI 1.06–3.80).[61] These associations persist despite food-secure household classification: a recent analysis found that within food-secure households, mothers often reduce their own intake first, and this maternal-specific food insecurity is independently associated with worse mental health outcomes.[62][64]

Mechanistic integration: Food insecurity operates through multiple pathways: (1) **nutritional deficiency**: inadequate income limits access to micronutrient-dense foods (animal products, fresh produce), directly precipitating iron, B vitamin, and vitamin D deficiency; (2) **psychological mechanism**: food insecurity activates threat vigilance and scarcity-focused cognitive patterns, independently increasing anxiety and depressive symptoms; (3) **chronic stress activation**: unpredictable food access chronically activates HPA axis, elevating cortisol, and dysregulating immune tolerance; (4) **social-structural mechanism**: food insecurity often reflects and reinforces women's limited economic autonomy and social marginalization, reducing access to prenatal care, mental health services, and community support.

In conflict-affected settings, food insecurity reaches severe proportions: approximately 2 billion people live in conflict-affected countries, with disproportionate exposure among women. Armed conflict disrupts agricultural systems, destroys supply chains, displaces populations, and diverts resources to military activities, creating acute and chronic food insecurity. Pregnant women in these settings experience compounding maternal undernutrition, elevated trauma exposure, and minimal access to maternal health services—conditions documented in case studies from Yemen, Syria, Somalia, and other conflict zones.[19][22][23][24][26][27]

4. Empirical Evidence: Systematic Thematic Synthesis

4.1 Iron Micronutrient Pathways and Maternal Mental Health

Evidence density: Very strong. Evidence derives from mechanistic studies (cellular iron homeostasis, dopamine synthesis), multiple large observational cohorts (n>1,000), and recent RCT interventions.

Observational findings: Gestational anemia is present in ~50% of pregnancies globally, with iron-deficiency anemia (IDA) predominant in low-resource settings.[31][39][40][43][44] Cross-sectional and prospective cohort studies from diverse settings have found associations between gestational anemia and antenatal/postpartum psychological distress, with effect sizes ranging OR 1.5–2.0 after adjustment for covariates.[30][42] A FinnBrain prospective cohort demonstrated that women with gestational anemia had higher baseline antenatal depression scores and elevated postpartum anxiety and pregnancy-related anxiety, with associations persisting after adjustment for baseline depression, suggesting iron deficiency may exacerbate rather than merely correlate with existing distress.[42]

Intervention evidence: A landmark 3-year follow-up of an RCT comparing IV iron to oral iron in anemic pregnant women found that the IV iron group reported significantly improved mental health outcomes measured at 6 and 12 weeks postpartum: reduced psychological downheartedness ($p=0.005$), lower clinical depression scores ($p=0.003$), and improved overall mental health ($p<0.001$), with benefits persisting at 3-year follow-up.[46] More recently, single-dose IV ferric derisomaltose (FDI) trials in pregnant women with IDA showed dramatic hematologic improvements (hemoglobin +1.3 g/dL from baseline to delivery; ferritin 6.6-fold increase) alongside significant improvements in EPDS depression scores ($p=0.003$) and patient-reported fatigue ($p<0.001$), with excellent safety profiles and no major infusion reactions in 75 pregnant participants.[37][38] These trials are particularly relevant to low-resource and conflict settings because FDI requires single-dose administration (~20 minutes), eliminating adherence barriers associated with multi-dose oral iron supplementation.

Gaps and limitations: Few studies have examined iron-mental health relationships specifically in conflict-affected or severely food-insecure populations, though observational evidence from India, Kenya, and other low-resource settings is available.[30][42][52] Most trials are from high-income settings, limiting LMIC generalizability. No trial has yet examined combined iron and psychosocial intervention impact on maternal mental health, nor have studies examined whether maternal iron repletion influences postpartum mental health outcomes through behavioral pathways (improved energy/function facilitating engagement with infant/support services).

4.2 B Vitamin Pathways and One-Carbon Metabolism

Evidence density: Very strong. Multiple meta-analyses, observational cohorts, and mechanistic studies support causal pathways.

B vitamin deficiency prevalence and associations: Meta-analytic evidence indicates that prepregnancy overweight and obesity increase risk of B12 and folate deficiency during pregnancy (OR 1.5–2.0 for deficiency in overweight/obese vs. normal-weight women).[71] A 2025 Kyushu Okinawa Maternal and Child Health Study examined B vitamin intake during pregnancy and risk of postpartum depressive symptoms, finding that higher intakes of B vitamins (particularly B6, B9, B12) were protective.[65] Cross-sectional and prospective studies have documented associations between low serum folate and higher depression scores in pregnancy,[77][80] and between low B12 status and postpartum depression in Indian populations.[79] A Brazilian prospective cohort found that women with anxiety symptoms in the third trimester of pregnancy had significantly higher postpartum homocysteine and lower serum/milk B12 concentrations at 2–8 days and 28–50 days postpartum, suggesting that pregnancy-associated psychological distress may deplete B vitamin status further—a bidirectional relationship.[102]

Mechanistic specificity: Folate and B12 deficiency disrupt the methionine-homocysteine cycle, leading to elevated homocysteine (hyperhomocysteinemia), which impairs monoamine neurotransmitter synthesis through decreased substrate availability and through homocysteine-mediated oxidative stress and endothelial dysfunction. Folate also directly supports DNA methylation, including methylation of genes regulating HPA axis function and stress resilience.[70] B6 (pyridoxine) is essential for homocysteine metabolism and for synthesis of dopamine, serotonin, and GABA. The interplay of these nutrients is critical: elevated folate with low B12 (as seen in some populations with high folic acid fortification but limited B12 sources) may paradoxically increase depression risk by exacerbating the "methylation trap," limiting B12 availability for critical methylation reactions.[69]

Intervention evidence: The NUTRIMUM trial randomized 88 medication-free pregnant women (12–24 weeks gestation) with EPDS ≥13 to broad-spectrum micronutrients (including B vitamins, minerals, omega-3) or active placebo (iodine + riboflavin) for 12 weeks, finding clinically significant improvement in antenatal depression symptoms in the micronutrient group (though methodological limitations preclude firm conclusions).[14][75] A systematic review and meta-analysis of folate and B12 for depression in non-pregnant populations found modest but significant effect sizes supporting their role in mood regulation.[67] Cochrane reviews of B12 supplementation in pregnancy (5 RCTs, 984 women) found insufficient evidence to recommend routine supplementation for mental health specifically, though B12 supplementation was associated with improvements in birth outcomes and infant neurodevelopment in deficient populations.[68]

Gaps and applicability to low-resource settings: Few RCTs have examined B vitamin supplementation specifically for perinatal mental health prevention/treatment in LMIC. However, observational evidence from Africa, Asia, and Latin America documents high prevalence of B12 deficiency (particularly among vegetarian/vegan populations and those with limited access to animal products) and folate deficiency (especially in settings with inadequate food fortification), suggesting that B vitamin supplementation may have substantial mental health co-benefits in these populations if integrated into routine antenatal care.

4.3 Vitamin D and Neuroinflammation

Evidence density: Very strong, with consistent meta-analytic findings and dose-response evidence.

Vitamin D deficiency prevalence in low-resource settings: A 2025 Sub-Saharan Africa meta-analysis of 30 observational studies (6,853 pregnant women) found pooled vitamin D deficiency prevalence of 34.8% (95% CI 20.75–48.76), with substantial geographic variation: East Africa 45.65%, Southern Africa 13.83%.[125] Deficiency is driven by limited sun exposure (particularly in winter, urban areas, veiled populations), dietary insufficiency (limited fortified foods, minimal fish/egg consumption), and malabsorption (common in settings with high infectious disease burden). Climate data suggest that Libya, at 32°N latitude, receives adequate sun for vitamin D synthesis, yet limited epidemiologic data on vitamin D status exists for Libya specifically.

Perinatal depression and vitamin D: Meta-analytic findings: The 2024 meta-analysis synthesized 13 studies (study dates 2008–2023) comparing vitamin D levels in women with and without perinatal depression.[121][127] Three studies ($n<1,000$) examined prenatal depression: women with depression had lower vitamin D levels (SMD −0.41, 95% CI −0.57 to −0.25; $I^2<25\%$, low heterogeneity). Three studies examined postpartum depression (outcome timing 2–8 weeks): heterogeneity was substantial ($I^2=96\%$), but direction was consistent (SMD −1.62, 95% CI −2.62 to −0.62). Seven studies examined vitamin D deficiency as categorical predictor of postpartum depression: six of seven showed deficiency associated with depression (OR 2.28, 95% CI 1.60–3.25; $I^2=92\%$, substantial heterogeneity; no publication bias detected). Heterogeneity likely reflects variation in study design (observational vs. case-control), depression measurement tool, vitamin D cutoff definitions, and population characteristics (age, BMI, education, ethnicity).

Dose-response and supplementation: A Brazil prospective cohort demonstrated dose-response: vitamin D sufficiency (≥20 µg/mL assessed up to 24 weeks gestation) was protective against postpartum depression, with 2-fold increased odds at deficient levels (OR 2.0, 95% CI 1.0–4.2).[119] A 2024 Cochrane review of vitamin D supplementation (66 RCTs, 17,276 participants, primarily from high-income countries) found vitamin D supplementation protective against gestational diabetes (RR 0.65, 95% CI 0.49–0.86) and increased infant birth weight (+53g, 95% CI 16–90), but mental health outcomes were not routinely assessed as primary or secondary outcomes.[122] However, two small RCTs of vitamin D supplementation for depression prevention showed improvements in

depressive symptoms in the supplementation group, though sample sizes precluded firm conclusions.[129][132]
Mechanistic specificity and relevance to inflammation pathway: Vitamin D functions as a secosteroid hormone, binding vitamin D receptor (VDR) on immune cells, endothelial cells, and microglia, suppressing Th1 and Th17 proinflammatory T cell differentiation while promoting regulatory T cell expansion and IL-10 production. VDR activation also suppresses TLR-mediated NF-κB signaling (key inflammatory amplifier) and increases expression of antimicrobial peptides and tight junction proteins (fortifying epithelial and blood-brain barriers against translocation of microbial lipopolysaccharides).[123] In the context of pregnancy, where a shift toward anti-inflammatory Th2 immunity is necessary to tolerate the fetal semi-allograft, vitamin D deficiency may impair this shift and perpetuate pro-inflammatory milieu, increasing neuroinflammation-associated depression risk.

4.4 Zinc, Selenium, and Trace Element Status

Evidence density: Moderate, with emerging mechanistic and observational evidence; fewer RCTs than for iron, B vitamins, or vitamin D.
Observational findings: A metabolomics study of 300+ pregnant women found zinc significant for anxiety symptoms in women with poor mental health.[133] A case-control study from India (80 postpartum women with depression, 80 controls) found significantly lower serum zinc in depression cases (mean 21.63 μg/dL vs. 54.16 in controls, $p<0.001$), with negative correlation between serum zinc and depression severity measured by EPDS.[142] A 2022 metal mixture analysis of 1,226 US women found that first-trimester erythrocyte copper, zinc, and selenium concentrations were associated with antepartum and postpartum depressive symptoms when examined as mixtures, with evidence of interaction effects (i.e., balance among trace elements may be important).[143]
Mechanistic pathways: Zinc is essential cofactor for protein synthesis, immune regulation, and synaptic plasticity. Zinc deficiency impairs T cell development and function, exacerbates pro-inflammatory responses, and impairs antioxidant defense (zinc-dependent superoxide dismutase). Selenium is incorporated into selenoproteins including glutathione peroxidase (antioxidant defense) and thioredoxin reductase (intracellular signaling). Copper is essential for cytochrome c oxidase and other oxidative enzymes. These trace elements work synergistically; imbalances (e.g., elevated copper without adequate zinc) can paradoxically increase oxidative stress.[139][146]
Intervention evidence and prevalence: The Alberta Pregnancy Outcomes and Nutrition (APrON) prospective cohort of 600 women found that selenium and omega-3 supplemental intakes were higher in women with lower postpartum depression scores ($p=0.0015$ and $p=0.01$, respectively).[141][147] However, a Mendelian randomization study of major depressive disorder using genetic instrumental variables suggested a possible U-shaped relationship with selenium supplementation—benefit at physiologic levels but potential harm at high supplemental doses—highlighting the importance of avoiding excessive supplementation.[146]
Gaps and LMIC applicability: Limited RCT evidence specifically examining zinc or selenium supplementation for perinatal mental health. Trace element status data in low-resource and conflict settings remain scarce. Given prevalence of zinc and selenium deficiency in Sub-Saharan Africa and South Asia (particularly in populations dependent

on cereal-based diets lacking diversification), research is warranted examining whether comprehensive micronutrient supplementation including trace elements improves mental health outcomes in these populations.

4.5 Household Food Insecurity and Bidirectional Mental Health Effects

Evidence density: Very strong, with consistent meta-analytic, observational, and intervention evidence; growing implementation science literature.

Meta-analytic synthesis of food insecurity and depression: The 2024 Maternal & Child Nutrition meta-analysis synthesized 18 studies (27,882 pregnant individuals; 18,987 in meta-analysis) examining food insecurity and symptoms of depression/anxiety during pregnancy.[10] Household food insecurity was associated with significantly increased odds of depressive symptoms (pooled OR 2.52, 95% CI 2.11–3.02; I^2=73.23%, indicating substantial heterogeneity). Reported prevalence of food insecurity ranged 12.6–62.1% across studies; prevalence of depressive symptoms in food-insecure vs. food-secure groups ranged 18–49% vs. 5–15%. Anxiety symptom data were sparse (n=2 studies), but similarly showed increased odds with food insecurity (OR 2.25, 95% CI 1.05–4.84).

Bidirectional relationship and dynamic pathways: A prospective study carefully examined temporal direction using cross-lagged models in 1,023 low-income mothers followed longitudinally.[57] Food insecurity at Time 1 predicted depression at Time 2 (controlled for Time 1 depression: adjusted depression increased 36%, OR 1.36, 95% CI 1.27–1.47). Depression at Time 1 predicted food insecurity at Time 2 (controlled for Time 1 food insecurity: adjusted food insecurity increased 53%, OR 1.53, 95% CI 1.43–1.66). This bidirectional relationship is consistent with social-ecological theories: depression impairs motivation, cognitive function, and economic productivity, reducing household resources; food insecurity activates threat vigilance and scarcity-focused cognition, amplifying depressive symptoms.

Co-occurring material hardships: A California cohort of 14,274 low-income pregnant women (below 400% federal poverty line) examined clustering of severe maternal hardships (intimate partner violence, loss of housing, job loss, etc.) with food insecurity.[54][58] Approximately 23.4% experienced food insecurity, 11.5% marginal food security. In adjusted analysis, nine of ten examined hardships were independently associated with food insecurity: partner job loss (aRRR 1.5–3.5 across food insecurity categories), depressive symptoms (aRRR 3.0–6.5), not having practical support (aRRR 2.0–8.0), and intimate partner violence (aRRR 2.5–9.0) were consistently significant across low, marginally secure, and food-insecure categories. Each additional hardship increased relative risk of food insecurity by 36%.

Income support interventions: A South Africa pilot of a food voucher program (bimonthly digital vouchers; N=205 pregnant women, 32% reporting baseline mental health difficulties) found significant reductions in mental health symptoms at midline and endline associated with voucher exposure (generalized estimating equation, $p<0.05$).[49] A US-based "Food-Is-Medicine" intervention (FreshRx) provided weekly fresh food meal kits plus nutrition counseling to 125 pregnant women with very low food security (67% at baseline); participants showed significant improvements in food security status, reduced depressive symptom prevalence (34.7% at baseline to ~13% at 60 days postpartum), and improved birth outcomes (gestational age 38.2 weeks, birthweight 6.7 pounds, compared to local population norms of preterm/low birthweight).[59][173]

Mechanisms integrating food insecurity and nutritional status: Food insecurity limits dietary diversity and micronutrient density. In a Kenya cross-sectional study of 262 pregnant women in urban low-income settings, 33.6% (95% CI 27.9–40.7) had depressive symptoms (EPDS >13).[52] Significant associations were found between poor nutritional status (measured by MUAC <23 cm) and depression (p<0.001), and between inadequate "brain food" essential nutrients (iron, B vitamins, omega-3) and depression (p=0.002). Food insecurity also activates chronic stress (HPA axis dysregulation), impairs sleep, and reduces access to prenatal care and social support—all independent mental health risk factors. Women who are food-insecure often reduce their own dietary intake before reducing household members' intake, paradoxically worsening their nutrient status despite a food-secure household classification.[62][64]

Critical gaps and applicability to conflict settings: Few studies have examined food insecurity and mental health specifically in armed conflict or acute emergency settings, though case studies from Yemen, Syria, and Somalia document severe food insecurity as a consequence of conflict.[26][27] Research is needed examining how rapid-onset vs. chronic food insecurity differentially affect mental health, and whether food security interventions in conflict settings reduce mental health burden. Integration of food security screening and emergency food assistance into perinatal care in conflict settings remains under-implemented.

5. Implementation and Integration Evidence

5.1 Barriers to Integration of Nutrition and Mental Health Services

Systemic barriers: An implementation science study of mental health integration into primary care in Lagos, Nigeria found that underfunding (<2% of health budget), high health worker turnover (30% annually), and community stigma—deterring 40% of eligible patients—drove programme drift and reduced treatment effectiveness.[152] Shortage of mental health specialists (need 1 per 5,000; actual <1 per 100,000), inadequate training, and weak supervision structures persist across sub-Saharan Africa.[160]

Capacity and knowledge gaps: Midwives acknowledge nutrition's importance but report insufficient time, training, and resources limiting counseling during antenatal visits.[167] Community health workers face high workload (77.6% report high burden), limited supervision (25.6%), and unclear role definitions for new nutrition-mental health tasks.[164][165] For mothers, stigma regarding mental illness, limited health literacy on nutrition-mental health links, cultural beliefs, and low service awareness limit help-seeking.

Structural barriers in conflict settings:

- **Supply chain disruptions**: Micronutrient supplements unavailable or unaffordable; food supply disrupted
- **Data gaps**: Limited maternal nutrition-mental health prevalence data impedes resource allocation
- **Health system fragmentation**: Separate nutrition, mental health, reproductive health programs lack integration

- **Limited LMIC-specific evidence**: Most evidence from high-income countries; generalizability uncertain

5.2 Task-Shifting and Community Health Worker Interventions

Task-shifting evidence: Systematic reviews support shifting clinical tasks from specialists to non-specialist health workers when coupled with training, supervision, and referral pathways.[162] An India study found Community Health Officers and ASHAs using standardized assessment checklists and regular follow-up significantly improved mental health service coverage and outcomes in rural areas.[148] Meta-analyses of 27 CHW-delivered mental health interventions found majority achieved significant symptom improvements for depression and stress.[149][155]

CHW acceptability and enablers: Qualitative studies found CHWs viewed mental health support within their caretaker role and expressed willingness to deliver evidence-based interventions with training.[150][155] Community members appreciated CHWs' shared background and community presence.[155] Success enablers included clear role definitions, adequate training, structured supervision, integration into existing programs, and community engagement.[151][158]

Challenges and emerging adaptations: (1) **health worker burden**: adding nutrition-mental health tasks compounds workload; (2) **fidelity-flexibility tension**: rigid protocols may reduce acceptability in resource-constrained, culturally diverse settings; (3) **sustainability**: donor-dependence leads to program collapse when external support ends; (4) **quality assurance**: limited supervision capacity challenges intervention quality.[152][164][165] A mixed-methods review found frontline providers made contextually appropriate protocol modifications (condensing visits, simplifying tools, prioritizing high-risk) that sometimes improved acceptability but risked reducing fidelity.[152]

5.3 Evidence-Based Integration Frameworks

C4 framework for LMICs: A task-shifting framework for LMICs proposes tiered maternal mental health service delivery:[151]

(1) **Tier 1 - Basic psychoeducation workers**: trained lay workers, ASHAs deliver basic perinatal mental health information, screen using EPDS, provide supportive listening

(2) **Tier 2 - Community counseling workers**: nurses, mental health-trained CHWs deliver brief evidence-based psychotherapies, coordinate care

(3) **Tier 3 - Specialist care**: physicians, mental health specialists provide pharmacotherapy, complex case management

This framework accommodates nutrition-mental health integration by ensuring all tiers receive basic education, nutrition screening (food security, dietary diversity) embedded at Tier 1, dietary counseling and supplementation coordination at Tier 2, and complex cases (depression plus severe malnutrition requiring hospitalization) escalated to Tier 3.

Perinatal provider training: A scoping review of 36 studies found midwives acknowledged nutrition's importance but few provided in-depth counseling due to time constraints, inadequate training, unclear referral pathways.[167] In low-resource settings, brief training in nutrition counseling and micronutrient supplementation integrated into routine antenatal visits may improve uptake and outcomes.

Food security integration models: FreshRx "Food-Is-Medicine" delivers fresh food, nutrition education, and psychosocial support coordination in integrated packages.[59][173] A South African maternal support grant using digital food vouchers demonstrated significant mental health improvements.[49] These models suggest integrating food insecurity screening into perinatal mental health care—rather than as separate welfare domain—may improve outcomes and maternal accessibility perceptions.

6. Critical Research Gaps and Future Research Agenda

6.1 Population and Geographic Gaps

Conflict-affected settings: Despite emerging evidence of severe maternal mental health and nutritional challenges in conflict settings, few rigorous studies examine the nutrition-mental health nexus specifically in armed conflict contexts. Case studies document challenges in Yemen, Syria, Somalia,[26][27] but interventional research is absent. Future research should employ rapid assessment methodologies, examine how acute vs. chronic conflict exposure differentially affect nutrition-mental health relationships, and test feasible integrated interventions (psychoeducation by lay counselors plus emergency food assistance) in conflict-affected populations.

Libya and broader MENA region: Limited epidemiologic data exist on maternal nutrition, maternal mental health, or their intersection in Libya. A 2007 Libya study documented child under-5 nutritional transition[177] but no perinatal mental health or maternal nutrition data are available. Given Libya's protracted conflict (2011–present), political instability, and health system disruption, urgently needed are: (1) population-based prevalence studies of maternal depression, anxiety, PTSD; (2) micronutrient status assessments in pregnant and postpartum women; (3) food security surveys in maternal populations; (4) qualitative research on barriers and facilitators to maternal mental health care and nutrition services. The broader MENA region (26 countries, 400+ million population) has limited perinatal mental health epidemiology compared to sub-Saharan Africa and South Asia.

Sub-Saharan Africa and South Asia: While more research exists than in MENA, significant gaps remain: (1) **mechanistic research**: few studies examined inflammation, HPA axis markers, or placental function in relation to nutrition-mental health in SSA; (2) **integrated interventions**: most interventions target single modalities (iron, mindfulness) rather than integrated nutrition-mental health approaches; (3) **context-specific evidence**: evidence from one SSA country may not generalize to another due to variations in food systems, health systems, cultural norms, and conflict exposure.

6.2 Methodological and Mechanistic Gaps

Bidirectional and dynamic relationships: Most studies examine nutrition as predictor of mental health or vice versa, but bidirectional and feedback-loop relationships remain understudied. Longitudinal studies with repeated measurement of nutritional biomarkers, psychological outcomes, and inflammatory markers across pregnancy and postpartum would elucidate whether mental health improvements lead to improved nutrient absorption, whether nutritional interventions independently improve mental health, or whether effects are mediated through inflammation reduction.

Mechanistic pathway specificity: Few studies simultaneously measured multiple putative mechanisms (micronutrient biomarkers, inflammatory cytokines, HPA axis markers) in relation to perinatal mental health in the same cohort. Multi-omic studies (genomics, proteomics, metabolomics) integrated with mental health phenotyping would clarify which mechanistic pathways drive depression vs. anxiety vs. PTSD in different maternal populations.

Intervention efficacy and effectiveness gaps: While several micronutrient supplementation RCTs exist, few designed mental health as primary outcome, and most are from high-income settings. Effectiveness studies (pragmatic RCTs, implementation science designs) in LMIC settings, examining real-world integration into existing maternal health programs, are needed. Combination interventions (e.g., iron + brief psychotherapy vs. iron alone vs. psychotherapy alone) have not been tested, nor have moderation/interaction analyses examining whether micronutrient supplementation benefits depend on concurrent psychosocial support.

6.3 Implementation Science and Health Systems Gaps

Integration models in low-resource settings: Few rigorous studies tested scalable models for integrating nutrition and mental health screening, counseling, and intervention into existing maternal health services in low-resource settings. Stepped-wedge or cluster RCT designs testing task-shifted, brevity-optimized integration models would generate evidence on scalability and cost-effectiveness.

Quality of CHW training and supervision: Standardized curricula for CHW training on nutrition-mental health integration remain limited, as do validated supervision tools. Comparative effectiveness research examining different training models (in-person vs. digital, brief vs. comprehensive, specialized vs. integrated into routine maternal health training) would inform efficient capacity-building.

Sustainability and real-world fidelity: Most nutrition-mental health integration pilots are time-limited and donor-funded. Research on how programs can be sustained within existing health budgets, maintained with local health worker capacity, and adapted to local contexts while maintaining fidelity to core components is critical.

6.4 Food Security and Social Determinants Gaps

Food security interventions for mental health in LMIC: While FreshRx and South African voucher programs show promise, few RCTs examined whether food security improvements reduce maternal mental health burden in LMIC. Research is needed comparing food-based vs. cash vs. nutritional supplementation approaches, optimal intervention duration and intensity, and mechanisms through which food security reduces mental health burden (nutritional repletion vs. reduced stress vs. improved engagement with health services).

Intersectional approaches: Most food insecurity-mental health research focuses on economic factors; limited research examines how gender-based violence, women's economic autonomy, and other intersecting social determinants interact with food insecurity to shape mental health. Qualitative and mixed-methods research in LMIC is needed to understand how nutrition-mental health relationships are shaped by multiple overlapping social inequities.

7. Discussion: Integrating Evidence and Implications for Practice

7.1 Synthesis of Evidence and Strength of Causal Inference

Very strong evidence: Iron-monoamine pathways, B vitamin-homocysteine-neurotransmitter pathways, vitamin D-neuroinflammation-mood regulation, and food insecurity-mental health associations are supported by consistent mechanistic, observational, and intervention evidence. For these pathways, sufficient evidence exists to recommend: (1) integration of micronutrient and food security assessment into routine perinatal care; (2) supplementation of documented deficiencies; (3) further research on mental health co-benefits in LMIC-specific populations.

Strong observational evidence, moderate intervention evidence: Zinc, selenium, and other trace elements implicated in perinatal mental health by emerging metabolomics, cohort, and case-control evidence, but RCT evidence for mental health-specific supplementation is limited. Recommendation: inclusion in comprehensive micronutrient supplementation, further mechanistic research, and trials in populations with documented deficiency.

Strong evidence for inflammation-HPA axis as mediator: Multiple studies document maternal stress/depression-associated inflammation and HPA axis dysregulation as independent contributors to adverse pregnancy and child development outcomes. Nutrition modulates these pathways through multiple mechanisms (antioxidant defense, immune tolerance, intestinal barrier function). Implication: micronutrient and food security interventions may exert mental health benefits partly through anti-inflammatory and immune-modulatory mechanisms, not solely through direct neurotransmitter substrate availability.

7.2 Theoretical and Practical Integration Model

A **biopsychosocial-systems approach** integrates these findings into actionable implications:

Individual/biological level: Pregnant women with documented micronutrient deficiencies (iron, B12, folate, vitamin D, zinc) or severe food insecurity are at elevated mental health risk. Screening for these nutritional risks (via biomarkers, dietary assessment, or validated food security scales) and delivering targeted supplementation and dietary counseling are evidence-supported interventions. Mental health screening and psychosocial support should be concurrent, recognizing that depression/anxiety may impair nutrient absorption and health-seeking behavior.

Household/community level: Women's access to adequate nutrition depends critically on household food security, which is shaped by household economic resources, social support, partner violence, and other material hardships. Maternal mental health is embedded in family relationships, community support systems, and cultural norms regarding mental health disclosure and help-seeking. Integration of food assistance, livelihood support, community-based maternal support groups, and mental health de-stigmatization into maternal health programs addresses multiple leverage points.

Structural/health system level: Health systems in low-resource settings are constrained by limited specialist capacity (physicians, mental health workers, dietitians), inadequate budgets, weak supply chains for micronutrient supplements, and fragmented programming (separate nutrition, mental health, reproductive health silos). Integration of nutrition-mental health screening and counseling into routine maternal health visits, supported by CHW task-shifting and brief evidence-based protocols, offers scalable solutions. For conflict-affected settings, integration must be linked to humanitarian response systems providing emergency food assistance, emergency obstetric care, and trauma-informed mental health support.

7.3 Specific Implications for Low-Resource and Conflict-Affected Settings

Reframing maternal nutrition as mental health intervention: Current maternal health programming in LMICs often presents nutrition as prerequisite for birth outcome prevention (low birthweight, preterm birth). This review suggests reframing maternal nutrition—particularly micronutrient sufficiency and food security—as essential for maternal mental health and family wellbeing. This reframing may: (1) increase prioritization and resource allocation to nutrition programs; (2) improve uptake of micronutrient supplementation (framing as mental health benefit, not solely for fetal development); (3) justify integration of maternal mental health screening into nutrition programs; (4) enable nutrition-mental health co-benefits messaging to women and families.

Pragmatic integration protocols for maternal health programs: Task-shifted, brief screening and intervention protocols could include:

(1) **Food security screening** (1–2 questions at first antenatal visit) + referral to food assistance programs

(2) **Maternal mental health screening** (EPDS or brief 2-item screener) integrated into nutrition assessment visits

(3) **Micronutrient supplementation protocols** based on regional deficiency burden and programmatic capacity (e.g., iron fortification, IFA supplementation, vitamin D prophylaxis in regions with documented deficiency)

(4) **Psychoeducation** on nutrition-mental health links delivered by trained CHWs

(5) **Referral pathways** to mental health care (psychotherapy, medication) for women screening positive for depression/anxiety, with explicit integration of nutrition counseling into mental health treatment.

Conflict-specific considerations: In active conflict and acute emergency settings, where health system capacity is minimal, integration models must be simplified and linked to humanitarian response:

(1) **Emergency food assistance** should be explicitly recognized as maternal mental health support

(2) **Rapid psychosocial assessment** during antenatal visits or emergency food distribution can identify women needing mental health support

(3) **Lay counselor models** (peer supporters, traditional birth attendants trained in psychological first aid and basic coping strategies) offer culturally acceptable, sustainable alternatives to specialist mental health workers

(4) **Micronutrient supplementation** (iron, folic acid, vitamin D where feasible) should be prioritized as accessible, low-cost maternal health intervention.

7.4 Cost-Effectiveness and Scalability Considerations

Micronutrient supplementation is among the most cost-effective maternal health interventions, with cost per DALY averted well below GDP per capita in most LMICs (e.g., iron/IFA supplementation estimated $5–10 per woman for full pregnancy course in bulk procurement).[175] Food security interventions (cash transfers, food vouchers, emergency food assistance) vary in cost but evidence from South Africa and US suggests benefits that extend beyond nutrition to mental health and maternal engagement with care. CHW-delivered mental health support is more cost-effective than specialist-delivered care; training costs are modest (typically $500–2,000 per worker for foundational mental health training), with recurrent costs mainly for supervision and materials.

Barriers to scale-up: Despite favorable cost-effectiveness profiles, implementation remains limited due to:
(1) **Fragmented funding**: nutrition, mental health, and food security programs often have separate funding streams, precluding integrated budgeting
(2) **Vertical programming**: donor-funded vertical programs operate separately from government health systems, reducing sustainability
(3) **Data gaps**: without reliable prevalence data on maternal mental health and nutrition in LMIC, health systems lack justification for resource allocation
(4) **Workforce gaps**: health worker shortages and competing priorities limit capacity for new integrated services
(5) **Supply chain constraints**: particularly in conflict settings, micronutrient supplements and food are unavailable or prohibitively expensive.
Scalability pathways: Integration into existing WHO-endorsed maternal health packages (antenatal care, postnatal care, breastfeeding support) offers most promise for scale-up. Most countries already deliver iron/IFA supplementation; adding mental health screening requires minimal additional burden (1–2 minutes of provider time with brief tool). Linking maternal mental health to food security programming—already present in many LMICs as separate initiatives—creates natural integration points.

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8. Conclusion

This systematic review synthesizes evidence demonstrating that maternal nutritional status—encompassing micronutrient sufficiency, food security, and dietary quality—represents a modifiable, cost-effective, and actionable lever for preventing perinatal mental health disorders in low-resource and conflict-affected settings. The evidence base spans biological mechanisms (iron-dopamine; B vitamins-homocysteine; vitamin D-inflammation), epidemiologic associations (meta-analytic evidence of 2–4-fold increased odds of depression with deficiency/food insecurity), and preliminary intervention efficacy (supplementation and food security interventions associated with mental health improvements).
Yet critical evidence gaps persist: the nutrition-mental health nexus remains understudied in conflict-affected settings and underrepresented in LMIC research. Integration of nutrition and mental health services into primary care remains limited despite promising implementation models. Libya and the broader MENA region lack epidemiologic and intervention evidence necessary for evidence-based policymaking.
For researchers: We urge prioritization of (1) LMIC and conflict-affected settings for nutrition-mental health research; (2) mechanistic pathway studies integrating inflammatory biomarkers, micronutrient status, and mental health outcomes; (3) effectiveness trials of integrated nutrition-mental health interventions delivered through CHWs in primary care; (4) qualitative and implementation science research on scalability, sustainability, and adaptation in resource-constrained contexts.
For policymakers and health system leaders: We recommend (1) integration of maternal mental health screening into existing nutrition and food security programs; (2) integration of food security and micronutrient assessment into perinatal mental health programs; (3) investment in CHW training for nutrition-mental health screening and brief counseling; (4) linkage of maternal mental health response to humanitarian food

assistance in conflict settings; (5) collection of maternal mental health and nutrition epidemiologic data to inform resource allocation.

For implementation and donors: Maternal nutrition and mental health integration offers a high-impact, cost-effective entry point for addressing leading causes of maternal morbidity in the Global South. Strategic integration into existing reproductive health platforms, rather than creating new vertical programs, maximizes sustainability and equity. Task-shifting to community health workers, with adequate training and supervision, makes integration feasible even in severely resource-constrained settings.

The evidence is clear: **maternal nutrition and psychological health are inextricably linked**. Addressing maternal nutrition is simultaneously addressing maternal mental health. In low-resource and conflict-affected settings where specialist mental health services are unavailable and maternal burden is highest, integrating nutrition-mental health assessment, supplementation, and food security interventions into routine care offers promise for reducing mental health burden, supporting family wellbeing, and advancing maternal health equity globally.

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