

MICRONUTRIENTS AND MENTAL HEALTH: INFLUENCE OF VITAMINS AND MINERALS ON HORMONE SECRETION AND NERVOUS SYSTEM FUNCTION

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Article Received on 12 June 2026,
Article Revised on 02 July 2026,
Article Published on 03 July 2026,

<https://doi.org/10.5281/zenodo.21155173>

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How to cite this Article: Reetapa Chandra^{1*}, Arpita Singh², Pratyasha Tiwari³, Alsad Khan⁴ and Vinod Kumar Gupta⁵. (2026). Micronutrients And Mental Health: Influence Of Vitamins And Minerals On Hormone Secretion And Nervous System Function. World Journal of Pharmaceutical Research, 15(13), 1690-1701. This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

Mental health disorders, including depression, anxiety, stress-related conditions, and neurodegenerative diseases, represent a growing global public health challenge. Emerging evidence highlights the crucial role of nutrition, particularly micronutrients, in maintaining optimal brain function and psychological well-being. Micronutrients such as B-complex vitamins, vitamin D, magnesium, zinc, iron, iodine, copper, and omega-3 fatty acids are essential for neurotransmitter synthesis, neuronal signaling, myelination, energy metabolism, and neuroprotection. Deficiencies in these nutrients can impair cognitive performance, emotional regulation, and stress resilience, contributing to the development and progression of various psychiatric and neurological disorders. This review examines the biological functions of key micronutrients and their mechanisms of action within the nervous system.

Particular emphasis is placed on their involvement in neurotransmitter production, oxidative stress reduction, immune modulation, mitochondrial function, and gut–brain axis regulation. Clinical and epidemiological evidence demonstrates significant associations between micronutrient deficiencies and mental health conditions, including depression, anxiety disorders, attention-deficit/hyperactivity disorder (ADHD), Alzheimer’s disease, and Parkinson’s disease. The review further discusses the clinical implications of micronutrient assessment, dietary interventions, and supplementation as adjunctive strategies in mental healthcare. Routine screening for nutritional deficiencies, personalized nutrition approaches, and public health initiatives aimed at improving micronutrient intake may enhance mental health outcomes and reduce disease burden. Overall, maintaining adequate micronutrient status is essential for supporting cognitive function, emotional stability, and long-term neurological health, highlighting the importance of nutrition in contemporary mental health management.

KEYWORDS: Micronutrient deficiency, Mental health disorders, Neurotransmitter synthesis, Nutritional psychiatry, Neuroprotection.

1. INTRODUCTION

A significant public health concern is the fast global rise in mental health disorders like depression, anxiety, stress-related illnesses, and neurodegenerative diseases.^[1,2] Nutrition has become a critical determinant of mental health and neurological function, in addition to genetic, environmental, and psychosocial factors.^[3,4] Specifically, micronutrients—vitamins and trace minerals needed in trace amounts—are essential for preserving neurochemical balance, brain structure, and cognitive function.^[5,6]

The human brain uses about 20% of the body's energy due to its high metabolic activity.^[7] It is particularly vulnerable to nutritional deficiencies because of this high demand.^[8] Micronutrients support neurotransmitter synthesis, preserve neuronal integrity and signalling pathways, and function as cofactors for enzymatic reactions.^[9,10] These processes can be disrupted by even minor deficiencies, sometimes referred to as "hidden hunger," which can result in diminished stress tolerance, mood swings, and cognitive impairment.^[11,12] Widespread micronutrient deficiencies are a result of contemporary dietary patterns marked by processed foods, low nutrient density, and irregular eating habits.^[13,14] Nutrient absorption and utilisation are further hampered by variables like stress, infections, drugs, and lifestyle

choices like drinking alcohol and smoking.^[15] Adolescents, the elderly, and people with chronic illnesses are among the vulnerable groups that are even more at risk.^[16]

The reciprocal relationship between nutrition and mental health is also highlighted by new research.^[3,17] While mental illnesses may exacerbate nutritional status through decreased appetite, poor dietary choices, or metabolic changes, poor diet can also lead to mental disorders.^[18] Additionally, the role of diet and micronutrients as supplements to traditional pharmaceutical treatments is highlighted by the developing field of nutritional psychiatry.^[4,19]

Therefore, it is crucial to comprehend the role of micronutrients in mental health in order to improve treatment outcomes, prevent psychiatric disorders early, and improve cognitive and emotional well-being.^[3,19]

The biological functions of important micronutrients, their nervous system mechanisms of action, and their clinical significance in the treatment of mental illness are all examined in this review.

2. Role of Micronutrients in Brain and Nervous System

2.1 Neurotransmitter Synthesis

The production of neurotransmitters like serotonin, dopamine, and norepinephrine depends on micronutrients like vitamin B6, B12, and folate.^[20-22] One-carbon metabolism is disrupted by deficiencies, which raise homocysteine levels and hinder the synthesis of neurotransmitters.^[23,24]

2.2 Neuroprotection and Anti-inflammatory Effects

In neural tissues, micronutrients lessen inflammation and oxidative stress.^[25,26] Zinc, magnesium, and vitamin D have neuroprotective qualities and control immune responses in the brain.^[27-29]

2.3 Energy Metabolism and Mitochondrial Function

Neuronal activity depends on ATP synthesis and mitochondrial function, both of which are facilitated by micronutrients.^[30,31]

2.4 Myelination and Nerve Conduction

Neuropathy and cognitive impairment result from vitamin B12 deficiency, which is essential for myelin sheath formation.^[32-35]

3. Key Micronutrients Affecting Mental Health

3.1 B-Complex Vitamins

B vitamins play a role in methylation reactions and neurotransmitter synthesis.^[15,16] Depression, cognitive decline, and neuropsychiatric disorders are associated with their deficiency.^[36-38]

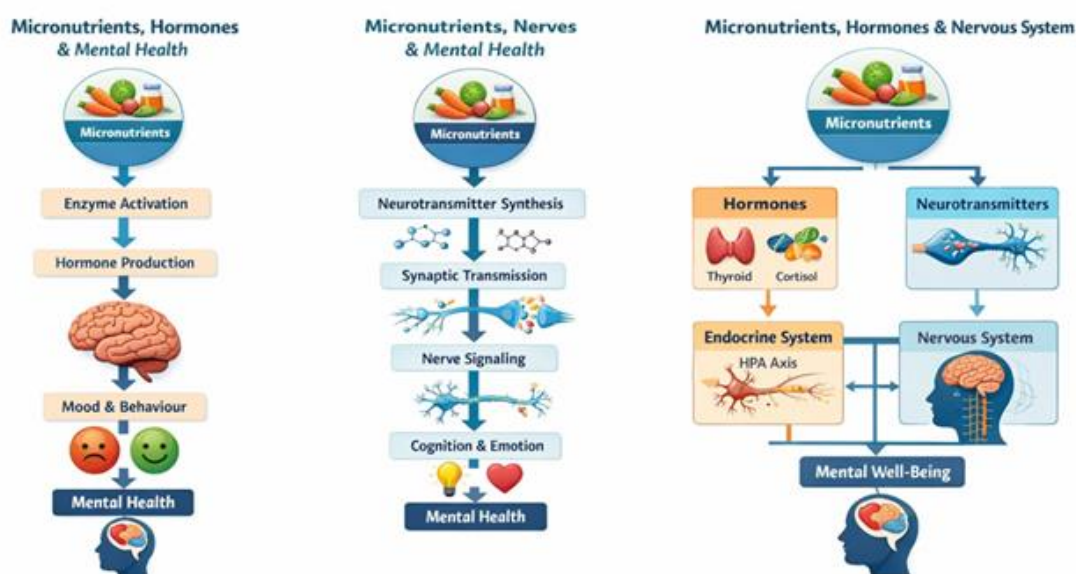


Fig. 1: Micronutrients affecting hormone secretion and mental well-being.

3.2 Vitamin D

As a neuro-steroid, vitamin D controls mood and brain growth.^[39-40] Depression and neurodegenerative diseases have been associated with deficiencies.^[41,42]

3.3 Magnesium

Neuronal excitability and NMDA receptors are regulated by magnesium.^[43,44] Depression, stress, and anxiety are linked to low levels.^[45]

3.4 Zinc

Zinc affects immunological response and synaptic plasticity.^[46,47] Depression and cognitive impairment are associated with its deficiency.^[48,49]

3.5 Iron

Neurotransmitter synthesis and oxygen transport depend on iron.^[50,51] Fatigue, poor cognitive function, and mood disorders are caused by deficiencies.^[52,53]

3.6 Fatty Acids (Omega-3)

Omega-3 fatty acids affect synaptic plasticity and are structural elements of neuronal membranes.^[54,55] They enhance cognitive performance and lessen neuro-inflammation.^[56,57]

3.7 Trace Elements and Copper

Neuronal signalling and cognitive function are impacted by trace elements like copper.^[58,59]

Myelin formation, neuronal protection, and nerve signalling are all supported by micronutrients.

Table 1: Micronutrients: Function, Deficiency, Impact, Treatment.

Micronutrient	Function	Deficiency	Mental Impact	Treatment
E-complex	Neurotransmitters	Fatigue	Depression	Supplements
Vitamin D	Hormonal	Weakness	Low mood	Sunlight
Magnesium	Nerve function	Insomnia	Anxiety	Mg diet
Zinc	Synaptic signaling	Memory loss	Depression	Zinc
Iron	Oxygen supply	Fatigue	Poor focus	Iron
Iodine	Thyroid	Hypothyroid	Mood issues	Salt

4. Micronutrient Deficiencies and Mental Disorders

4.1 Depression

Depression is closely linked to deficiencies in zinc, vitamin D, folate, and vitamin B12.^[60-62]

4.2 Stress and Anxiety

Supplementing with micronutrients has been demonstrated to lower anxiety and stress levels.^[63,64]

4.3 Cognitive Disorders and ADHD

In ADHD, micronutrient interventions may enhance cognitive function and attention.^[65,66]

4.4 Neurological Conditions

Through oxidative stress and inflammation, micronutrient imbalance is linked to Parkinson's and Alzheimer's diseases.^[67-69]

5. Mechanisms Linking Micronutrients and Mental Health

Numerous biological processes, such as neurotransmitter regulation, oxidative stress reduction, immune modulation, epigenetic modifications, and gut-brain axis interactions, are involved in the relationship between micronutrients and mental health.^[70-71]

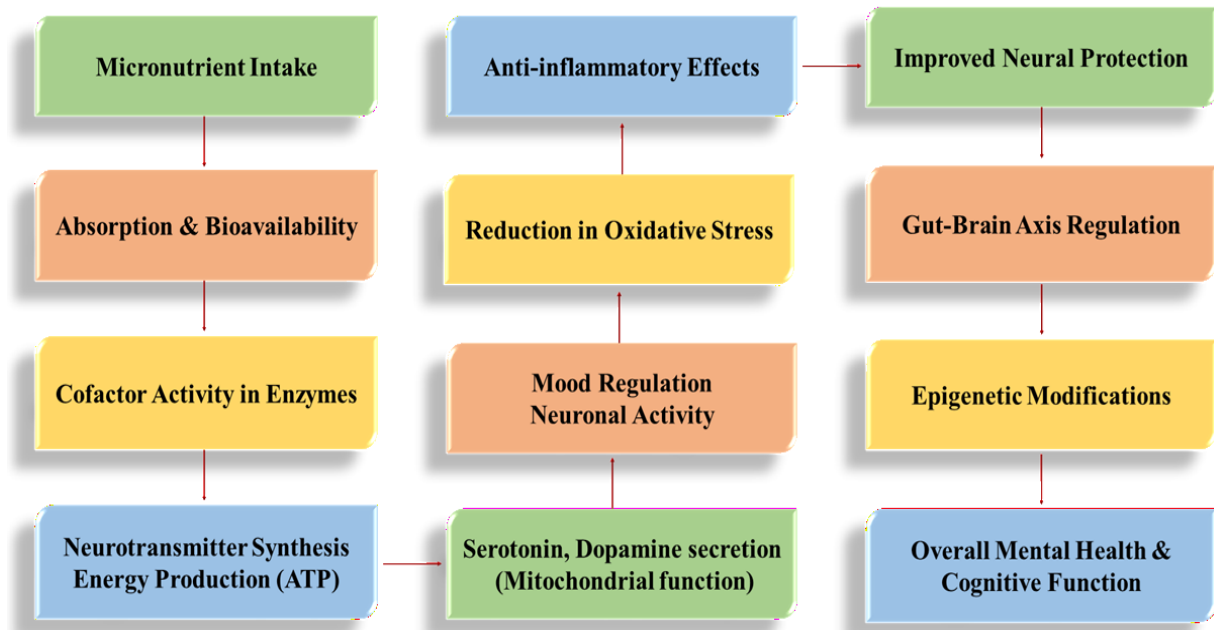


Fig. 1: Flowchart showing linkage of micronutrients with mental well-being.

Together, these circuits control neuronal integrity, emotional stability, and cognitive function.

6. Clinical implications

Clinical practice, public health initiatives, and personalised medicine are all significantly impacted by the role of micronutrients in mental health.

6.1 Diagnosis and Screening

Psychiatric assessments should include routine screening for micronutrient deficiencies, particularly iron, magnesium, vitamin B12, and vitamin D. Early detection can stop serious neurological or mental disorders from developing.^[72-75]

6.2 Supplemental Treatment

For conditions like depression, anxiety, and ADHD, micronutrient supplements can be used in addition to pharmaceutical treatment. For instance:

- B vitamins improve the effectiveness of antidepressants
- Omega-3 fatty acids help to stabilise mood.
- Magnesium lessens the symptoms of anxiety

6.3 Preventive Medical Care

Mental health issues can be prevented by ensuring sufficient intake of micronutrients through diet or supplementation. Programs for public health should concentrate on:

- Education about nutrition
- Fortification of food
- Strategies for early intervention

6.4 Customised Nutrition

Personalised micronutrient therapies are necessary due to individual differences in metabolism, genetics, and lifestyle. Nutrigenomics can assist in customising dietary advice according to personal requirements.^[76-79]

6.5 Unique Populations

Specific care is needed for some groups:

- B12 insufficiency and cognitive deterioration are more common in the elderly.
- Students and young adults: performance is impacted by stress-related inadequacies.
- Micronutrients essential for foetal brain development in pregnant women.

6.6 Restrictions and Warnings

- Excessive supplementing could be harmful.
- Medication interactions need to be taken into account.
- More RCTs are required because the clinical evidence differs.

7. CONCLUSION

Micronutrients play a fundamental role in maintaining brain health, cognitive performance, and emotional well-being. Essential nutrients such as B-complex vitamins, vitamin D, magnesium, zinc, iron, iodine, copper, and omega-3 fatty acids contribute to neurotransmitter synthesis, neuronal signaling, myelination, energy metabolism, and protection against oxidative stress and neuroinflammation. Growing scientific evidence indicates that deficiencies in these nutrients are closely associated with a wide range of mental health disorders, including depression, anxiety, attention-deficit/hyperactivity disorder (ADHD), cognitive decline, and neurodegenerative diseases. The interaction between nutrition and mental health is complex and bidirectional, with poor nutritional status potentially contributing to psychiatric symptoms and mental disorders adversely affecting dietary habits and nutrient utilization. Consequently, assessment of micronutrient status should be considered an important component of mental health evaluation and management. Dietary optimization and targeted supplementation may serve as valuable adjuncts to conventional therapeutic approaches, improving treatment outcomes and overall quality of life. Advances

in nutritional psychiatry and personalized nutrition offer promising opportunities for developing individualized interventions based on genetic, metabolic, and lifestyle factors. However, further large-scale randomized controlled trials are required to strengthen current evidence and establish standardized clinical guidelines. Overall, ensuring adequate micronutrient intake represents a practical and effective strategy for promoting mental wellness and supporting long-term neurological health.

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