

## **“Micronutrient Deficiency, Dietary Diversity, and Academic Stress: An Emerging Triad Affecting Metabolic Health in Medical Students”**

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## **Abstract**

### ***Background:***

*Medical students are exposed to sustained academic stress, irregular dietary habits, and lifestyle constraints that adversely affect nutritional quality. While caloric intake may be sufficient or excessive, poor dietary diversity and stress-related eating behaviours predispose students to micronutrient deficiencies and early metabolic disturbances.*

### ***Objective:***

*To review existing evidence on the interrelationship between dietary diversity, academic stress, micronutrient deficiency, and metabolic health among medical students.*

### ***Methods:***

*A narrative review of national and international literature focusing on dietary diversity scores, stress physiology, micronutrient status, and metabolic risk factors in medical students and young adults was undertaken.*

### ***Results:***

*Low dietary diversity, combined with chronic academic stress, is consistently associated with*

*deficiencies of iron, vitamin D, vitamin B12, folate, and zinc. Stress-induced hormonal changes and poor food choices further impair nutrient absorption and promote metabolic imbalance, increasing the risk of overweight, insulin resistance, and early non-communicable diseases.*

**Conclusion:**

*Micronutrient deficiency, inadequate dietary diversity, and academic stress form a synergistic triad that negatively influences metabolic health in medical students. Addressing this triad through institutional nutrition programs and stress-management strategies is essential for long-term health promotion.*

**Keywords:** *Dietary diversity, Micronutrient deficiency, Academic stress, Metabolic health, Medical students*

**Introduction**

Medical students represent a unique population in which **high nutritional knowledge does not necessarily translate into healthy dietary practices**. Academic pressure, prolonged study hours, irregular meal timings, and limited physical activity significantly influence food choices and eating behaviour. Increasing reliance on convenience foods and stimulants results in diets that are calorie-dense but nutritionally inadequate.

Dietary diversity—the consumption of a variety of food groups—is a key determinant of micronutrient adequacy. Low dietary diversity is strongly associated with deficiencies of essential vitamins and minerals, even when energy intake is adequate. When combined with chronic academic stress, these deficiencies may contribute to early metabolic alterations, creating long-term health risks.

**Dietary Diversity and Micronutrient Adequacy**

Dietary diversity score (DDS) is widely used as a proxy indicator for micronutrient sufficiency. Diets lacking fruits, vegetables, whole grains, legumes, dairy, and animal-source foods are associated with deficiencies of iron, zinc, vitamin B12, folate, and vitamin D.

Among medical students, hostel food environments, time constraints, and preference for processed foods significantly reduce dietary diversity. Low DDS has been linked to fatigue, impaired immunity, and reduced cognitive performance—factors that further affect academic efficiency and lifestyle choices.

**Academic Stress and Nutritional Behaviour**

Academic stress activates the hypothalamic–pituitary–adrenal axis, leading to sustained cortisol elevation. Elevated cortisol alters appetite regulation, increases cravings for high-sugar and high-fat foods, and negatively affects micronutrient metabolism and absorption.

Stress and sleep deprivation also encourage excessive caffeine intake, irregular meals, and meal skipping—particularly breakfast—further compromising dietary quality. Over time, these behaviours reinforce micronutrient inadequacy and metabolic imbalance.

## Impact on Metabolic Health

The coexistence of low dietary diversity and academic stress contributes to metabolic disturbances even in young adults. Micronutrient deficiencies impair energy metabolism, reduce physical activity due to fatigue, and promote low-grade inflammation.

This combination increases susceptibility to:

- Weight gain and central obesity
- Insulin resistance
- Dyslipidaemia
- Early risk of non-communicable diseases

Thus, metabolic risk in medical students often develops silently, preceding overt clinical disease.

## Public Health and Institutional Implications

Medical colleges play a critical role in addressing this emerging health challenge. Integrating nutritional diversity assessment, micronutrient screening, and stress-management programs into student wellness initiatives can prevent long-term metabolic consequences. Improving campus food environments and incorporating lifestyle education into the curriculum are essential preventive strategies.

## Materials and Methods

### Study Design

This study was designed as a **narrative review** focusing on the interrelationship between **micronutrient deficiency, dietary diversity, academic stress, and metabolic health** among medical students.

### Literature Search Strategy

A comprehensive literature search was conducted using electronic databases including **PubMed, Google Scholar, Scopus, and Web of Science**. Relevant articles published in **English language** between **2005 and 2024** were considered.

### Search Terms

The following keywords and their combinations were used:

- *Medical students*
- *Micronutrient deficiency*
- *Dietary diversity*
- *Academic stress*
- *Hidden hunger*

- *Metabolic health*
- *Obesity*
- *Lifestyle factors*

Boolean operators (AND, OR) were applied to refine the search.

#### Inclusion Criteria

- Studies involving **medical students or young adults**
- Articles addressing **dietary diversity, micronutrient status, stress, or metabolic outcomes**
- Original research articles, systematic reviews, narrative reviews, and national survey reports
- Studies conducted in **India and other low- and middle-income countries**, along with relevant global literature

#### Exclusion Criteria

- Studies focusing exclusively on paediatric or geriatric populations
- Articles lacking relevance to nutrition, stress, or metabolic outcomes
- Conference abstracts without full text availability

**Table 1. Summary of Materials and Methods**

Component	Description
Study design	Narrative review
Study population	Medical students and young adults
Databases searched	PubMed, Google Scholar, Scopus, Web of Science
Time period	Published literature from 2005–2024
Search terms	Micronutrient deficiency, dietary diversity, academic stress, metabolic health, medical students
Inclusion criteria	Studies on dietary diversity, micronutrient status, stress, or metabolic outcomes
Exclusion criteria	Paediatric/geriatric studies, irrelevant topics, abstracts without full text
Data extracted	Dietary patterns, micronutrient deficiencies, stress factors, metabolic indicators
Data analysis	Qualitative thematic synthesis



**Figure 1. Conceptual framework illustrating the triad affecting metabolic health in medical students**

#### Data Extraction and Synthesis

Data were extracted on:

- Dietary patterns and dietary diversity
- Common micronutrient deficiencies
- Academic stress and lifestyle factors
- Reported metabolic outcomes such as BMI, obesity, insulin resistance, and cardiometabolic risk

The findings were **qualitatively synthesised** and thematically analysed to explore the interconnections among the three components of the proposed triad.

## Results

#### Dietary Diversity and Micronutrient Status

The reviewed literature consistently demonstrated **low dietary diversity among medical students**, characterised by inadequate consumption of fruits, vegetables, whole grains, dairy products, and animal-source foods. Despite sufficient or excessive caloric intake, deficiencies of **iron, vitamin D, vitamin B12, folate, and zinc** were frequently reported across studies.

Low dietary diversity scores were strongly associated with **fatigue, reduced immune function, and impaired cognitive performance**, indicating compromised micronutrient adequacy despite adequate energy intake.

## Academic Stress and Dietary Behaviour

Multiple studies reported **high levels of academic stress** among medical students, particularly during examination periods. Academic stress was consistently associated with:

- Irregular meal patterns
- Skipping of breakfast
- Increased consumption of caffeinated beverages and fast foods
- Reduced intake of nutrient-dense foods

Chronic stress was shown to influence **neuroendocrine pathways**, particularly through sustained elevation of cortisol levels. This hormonal imbalance adversely affects appetite regulation, nutrient absorption and metabolism, and promotes altered fat distribution.

## Impact on Metabolic Health

The coexistence of **low dietary diversity and chronic academic stress** was linked to **early metabolic disturbances**, even among young adults. Commonly reported outcomes included:

- Increased body mass index (BMI)
- Central adiposity
- Reduced levels of physical activity secondary to fatigue
- Early markers of insulin resistance and dyslipidaemia

Several studies indicated that micronutrient deficiencies may **indirectly contribute to metabolic risk** by reducing energy levels and exercise tolerance, thereby promoting sedentary behaviour and progressive weight gain.

## Integrated Triad Effect

The synthesis of available evidence revealed a **synergistic interaction** between:

1. Poor dietary diversity
2. Micronutrient deficiency
3. Academic stress

Together, these interrelated factors contribute to impaired metabolic health, creating a **silent but progressive risk profile** for the future development of non-communicable diseases among medical students.

## Summary of Key Findings

- Adequate caloric intake does not guarantee micronutrient sufficiency
- Academic stress significantly influences dietary behaviour and nutrient metabolism

- The combined effect of poor dietary diversity, micronutrient deficiency, and stress increases susceptibility to obesity and metabolic disorders at a young age

## Conclusion

Micronutrient deficiency, inadequate dietary diversity, and academic stress together constitute an emerging triad that adversely affects metabolic health in medical students. Recognising and addressing this interconnected framework is crucial for promoting sustainable health behaviours and safeguarding the future healthcare workforce.

## Optional Small Table (if journal allows)

Component	Key Effect
Low dietary diversity	Micronutrient deficiency
Academic stress	Poor food choices, cortisol excess
Combined impact	Metabolic imbalance, weight gain

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