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The Double Burden of Malnutrition: Coexistence of Undernutrition and Obesity in Low- and Middle- Income Countries

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Abstract

Background: The double burden of malnutrition DBM) represents a critical public health challenge in low- and middleincome countries LMICs , characterized by the simultaneous coexistence of undernutrition and overnutrition within populations, households, and individuals. Objective: To comprehensively review the epidemiology, mechanisms, health consequences, and intervention strategies for addressing DBM in LMICs. Methods: This narrative review synthesized current evidence from peer-reviewed literature, WHO reports, and international nutrition databases examining DBM prevalence, determinants, biological pathways, and policy frameworks. Results: Multiple forms of malnutrition coexist in
88% of countries globally, with highest prevalence rates in upper middle-income countries, particularly Latin America and Southeast Asia. The nutrition transition, driven by increased ultra-processed food availability and reduced physical activity, accelerates DBM emergence alongside persistent poverty-related undernutrition. Biological mechanisms include developmental programming, epigenetic modifications, and intergenerational transmission creating vulnerability to both malnutrition forms. DBM significantly increases risks for cardiovascular disease, type 2 diabetes, and reproductive complications. WHO double-duty actions, including exclusive breastfeeding promotion, maternal nutrition programs, and food system interventions, offer evidence-based solutions for simultaneous prevention of undernutrition and overnutrition. Conclusion: Addressing DBM requires integrated, multi-sectoral approaches targeting shared determinants while recognizing complex biological and social pathways underlying this dual challenge. Priority interventions should focus on early life nutrition, food environment improvements, and health system strengthening.

Keywords: Malnutrition; Obesity; Protein-Energy Malnutrition; Developing Countries; Nutritional Status; Diet; Public Health Policy

Introduction

The double burden of malnutrition DBM) has emerged as one of the most complex public health challenges facing lowand middle-income countries LMICs in the 21st century[1 2]. This phenomenon fundamentally challenges traditional malnutrition approaches by representing simultaneous coexistence of undernutrition and overnutrition within populations. Undernutrition includes stunting, wasting, and micronutrient deficiencies, while overnutrition encompasses overweight, obesity, and diet-related non-communicable diseases affecting the same populations, households, and individuals[1 2] 3 .

The World Health Organization defines DBM as "the coexistence of undernutrition along with overweight, obesity or dietrelated noncommunicable diseases, within individuals, households and populations, and across the life-course" 4 . This definition encompasses manifestations at individual (micronutrient deficiencies coexisting with excess adiposity), household (stunted children with overweight mothers), and population levels (communities exhibiting high prevalence of both malnutrition forms)[1 2] 4 .

Unlike traditional epidemiological transition models predicting linear progression from infectious diseases to chronic conditions, LMICs experience compressed morbidity transitions where both disease patterns coexist simultaneously[2 3]. This creates unprecedented challenges for health systems, policy makers, and intervention programs historically designed to address single malnutrition forms[3 5]. Understanding DBM requires comprehensive examination of epidemiological patterns, underlying mechanisms, health consequences, and evidence-based intervention strategies.

Definition and Conceptual Framework

The conceptual framework for DBM extends beyond simple coexistence to encompass complex interactions across the life course and between generations[3 4]. At individual level, DBM manifests as concurrent micronutrient deficiencies in overweight individuals, or sequential patterns where early undernutrition predisposes to later obesity development[3 6]. Household-level DBM, particularly maternal overweight with child undernutrition, represents the most studied manifestation and serves as a key surveillance indicator[7 8].

Population-level DBM reflects broader societal transitions encompassing demographic, economic, and environmental changes that simultaneously maintain undernutrition conditions while creating overnutrition-promoting environments[1

10 . This multi-level conceptualization recognizes DBM as both an outcome of complex social determinants and a risk factor for perpetuating health inequities[1 3].

Prevalence Patterns by Region

Global analyses demonstrate substantial DBM prevalence across LMICs, with considerable regional variation reflecting different nutrition transition stages and socioeconomic development[1 12]. Multiple forms of malnutrition coexist in 88% of countries globally, with 29 countries experiencing the triple burden of stunting, wasting, and overweight[9 .

Regional patterns reveal distinct epidemiological profiles[1 10]. Sub-Saharan Africa predominantly exhibits high child undernutrition rates (stunting prevalence often exceeding 30%) with emerging maternal overweight, particularly in urban areas[10] 13]. The region's DBM pattern reflects persistent poverty-driven undernutrition coexisting with lifestyle-related overweight among reproductive-age women[14].

Latin American countries demonstrate advanced nutrition transition patterns, characterized by high maternal obesity rates (frequently exceeding 60%) alongside declining child stunting[16] 17]. This reflects successful child undernutrition interventions while experiencing obesogenic environmental changes driven by ultra-processed food proliferation[11] 18].

Southeast Asian countries, including India, Bangladesh, and Indonesia, present intermediate patterns with significant intra-country variation based on development levels and socioeconomic status[12] 20]. These countries often exhibit classic household-level DBM patterns of maternal overweight coexisting with child stunting[12].

Demographic and Socioeconomic Determinants

DBM distribution within populations follows complex socioeconomic gradients differing from traditional malnutrition patterns[1 12]. Research demonstrates paradoxical distributions, with higher DBM probability in wealthier households of poorer countries and poorer households of wealthier countries[1 . This reflects differential food access and varying nutrition transition stages across socioeconomic strata[12] 21].

Educational attainment, particularly maternal education, emerges as a critical determinant with dual effects on DBM components[20] 21]. While higher maternal education typically reduces child undernutrition risk, it may associate with increased maternal overweight in settings where education

Volume 8, Issue 6; November-December 2025; Page No 420-428

correlates with reduced physical activity and enhanced processed food access[20].

Urban residence consistently associates with elevated DBM prevalence, reflecting obesogenic urban environments characterized by sedentary lifestyles, altered food systems, and enhanced ultra-processed food access[10] 20]. However, urban-rural differentials vary considerably based on development patterns, with some settings showing emerging rural DBM as economic growth extends beyond urban centers[20].

Pathophysiology and Mechanisms

Biological and Developmental Programming

The biological foundations underlying DBM involve intricate interactions between early life programming, epigenetic modifications, and metabolic adaptations creating susceptibility to both undernutrition and obesity throughout life[22]

23 . Early life undernutrition, including intrauterine growth restriction and postnatal stunting, triggers adaptive metabolic programming enhancing survival under nutrient-scarce conditions but predisposing to obesity and metabolic diseases when exposed to nutrient-dense environments[22] 24].

The "developmental origins of health and disease" hypothesis provides a mechanistic framework for understanding DBM pathways[22] 24]. Early nutritional insults permanently alter organ structure and function, metabolic set-points, and hormonal regulation systems[22] 23]. Children experiencing early growth faltering who undergo rapid catch-up growth face elevated risks for central obesity, insulin resistance, and cardiovascular disease in adulthood[23] 25].

Epigenetic mechanisms transmit nutritional experiences across generations through DNA methylation pattern and histone modification changes[22] 26]. Maternal undernutrition during pregnancy alters offspring gene expression patterns affecting metabolism, appetite regulation, and nutrient utilization[22] 24]. These epigenetic changes persist throughout life and potentially transmit to subsequent generations, creating intergenerational malnutrition susceptibility cycles[22]

23 .

Nutrition Transition and Food Systems

The nutrition transition represents the fundamental driver underlying DBM emergence in LMICs, involving shifts from traditional diets based on whole grains, legumes, and vegetables toward diets increasingly dominated by ultra-processed foods[11] 18]. These dietary changes occur alongside reduced physical activity levels and altered meal patterns creating environments conducive to continued undernutrition among vulnerable populations and emerging overnutrition across broader segments[11] 27].

Food system transformations accompanying economic development create complex environments where DBM flourishes[11] 27]. Traditional food markets are increasingly supplemented or replaced by supermarkets and convenience stores offering predominantly processed foods high in added sugars, unhealthy fats, and sodium while low in essential micronutrients[11]. Simultaneously, urbanization reduces access to fresh, diverse foods while increasing availability and marketing of energy-dense, nutrient-poor options[27] 28].

Ultra-processed foods now account for 15 30% of energy intake in middle-income countries, with sales growing rapidly[18] 19]. These foods contribute to DBM by providing excess calories promoting weight gain while failing to address micronutrient needs, particularly among populations with limited dietary diversity[18] 27]. Marketing strategies targeting children and low-income populations further exacerbate dietary transitions[11].

Intergenerational Transmission

DBM demonstrates strong intergenerational transmission patterns perpetuating malnutrition cycles across generations through biological and social pathways[23] 29]. Maternal undernutrition compromises fetal growth and increases risks of low birth weight, stunting, and micronutrient deficiencies in offspring[23] 30]. Conversely, maternal obesity associates with elevated fetal adiposity, gestational diabetes, and increased offspring obesity risk[23] 29].

The coexistence of these transmission patterns creates complex intergenerational scenarios where mothers experiencing early undernutrition but later obesity development transmit heightened risks for both undernutrition and obesity to children[23] 29]. This dual inheritance creates particularly vulnerable

Volume 8, Issue 6; November-December 2025; Page No 420-428

populations where children face elevated risks for stunting, micronutrient deficiencies, and subsequent obesity development[29] 30].

Social transmission mechanisms complement biological pathways through intergenerational transfer of poverty, food insecurity, and limited health care access[23] 30]. Families experiencing DBM often lack resources to break malnutrition cycles, as interventions addressing single malnutrition forms may inadvertently exacerbate other forms without comprehensive approaches[30].

Clinical Manifestations and Health Consequences

Immediate Health Impacts

DBM health consequences extend beyond anthropometric outcomes, encompassing immediate functional impairments affecting cognitive development, immune function, and physical capacity[31] 23]. Children experiencing DBM face compounded risks from both undernutrition and overnutrition pathways, creating unique clinical presentations challenging traditional diagnostic and treatment approaches[23] 32].

Undernutrition components, particularly stunting and micronutrient deficiencies, impair cognitive development, immune

function, and physical growth potential[34] 23]. These effects are largely irreversible if occurring during critical developmental windows, particularly the first 1000 days of life[23] 32]. Simultaneously, early exposure to obesogenic environments increases risks for rapid weight gain, insulin resistance, and metabolic syndrome development[35] 32].

The combination creates clinical presentations characterized by growth faltering alongside excessive adiposity accumulation, particularly in central body regions[23] 32]. Children may exhibit normal or elevated weight-for-height indices while experiencing stunting and micronutrient deficiencies, complicating screening and intervention approaches based on traditional anthropometric indicators[32] 33].

Long-term Disease Burden

Adults experiencing early undernutrition followed by later overnutrition development show disproportionately elevated risks for cardiovascular diseases, type 2 diabetes, and metabolic syndrome compared to those with obesity alone[36] 37]. This life-course DBM exposure pattern imposes high metabolic loads on organs with reduced functional capacity due to early developmental programming[23] 32].

Cardiovascular disease burden associated with DBM reflects complex interactions between developmental programming, metabolic dysfunction, and chronic inflammation[36] 37]. Early undernutrition compromises cardiovascular development and autonomic nervous system function, while subsequent obesity exacerbates these vulnerabilities through additional metabolic stress[36] 23]. The resulting cardiovascular risk profile often emerges earlier and proves more refractory to standard interventions[37] 23].

Metabolic complications in DBM-affected individuals typically include insulin resistance, dyslipidemia, and hypertension occurring at lower BMI thresholds than in populations without early undernutrition exposure[36] 32]. These metabolic derangements contribute to premature cardiovascular disease, type 2 diabetes, and increased mortality risks[36] 37].

Reproductive Health and Maternal Outcomes

DBM significantly impacts reproductive health outcomes, creating intergenerational perpetuation of malnutrition risks[23]

30 . Women experiencing DBM face elevated pregnancy risks including gestational diabetes, hypertensive disorders, and delivery complications[30]. The combination of micronutrient deficiencies with obesity creates unique obstetric challenges requiring specialized management approaches[30].

Maternal DBM also affects fetal development and offspring health outcomes[23] 29]. Nutrient-deficient but energy-excess maternal diets promote fetal programming patterns predisposing offspring to DBM development[29] 30]. Additionally, the inflammatory milieu associated with obesity combined with micronutrient deficiencies may impair placental function and fetal growth patterns[29] 30].

Management and Interventions

WHO Double-Duty Actions Framework

The World Health Organization developed "double-duty actions" as a strategic framework addressing DBM through integrated interventions simultaneously

Volume 8, Issue 6; November-December 2025; Page No 420-428

preventing and treating both undernutrition and overnutrition[4 39]. This approach operates at three levels: ensuring existing interventions cause no harm to other malnutrition forms; retrofitting existing programs to address multiple malnutrition types; and developing new integrated approaches from inception[4 40 .

Priority double-duty actions identified through global evidence synthesis include exclusive breastfeeding promotion, optimal complementary feeding practices, comprehensive maternal nutrition programs, well-designed school feeding initiatives, and food marketing regulations[4 41]. These interventions leverage shared biological and social determinants of malnutrition to maximize impact while minimizing resource requirements[4 39].

Implementation success depends on careful attention to intervention design, delivery mechanisms, and monitoring systems tracking multiple nutrition outcomes simultaneously[41] 42]. Programs must be designed to avoid unintended consequences, such as rapid weight gain interventions potentially promoting later obesity development, while ensuring adequate attention to both malnutrition forms[42] 43].

Policy and Programmatic Approaches

Effective DBM prevention and management requires comprehensive food system interventions simultaneously improving access to nutritious foods while restricting harmful food marketing and availability[11] 39]. These interventions encompass agricultural policies promoting nutrient-dense crop production, food safety and quality standards, fiscal policies including taxes on ultra-processed foods and subsidies for healthy foods, and urban planning approaches enhancing access to fresh food markets[11] 39].

Social protection programs represent powerful platforms for DBM prevention, particularly when designed with nutritionsensitive features addressing both food security and diet quality[44] 45]. Cash transfer programs, conditional transfers, and school feeding initiatives can incorporate nutrition objectives while maintaining poverty alleviation goals[44] 46]. Effective programs require careful attention to transfer size, targeting criteria, complementary services, and behavior change communication components[45] 47].

Food marketing regulations represent particularly important double-duty interventions, reducing children's exposure to promotions for nutrient-poor, energy-dense foods while supporting healthy option marketing[39] 48]. Implementation requires coordinated action across sectors including agriculture, trade, urban planning, and health to create food environments supporting optimal nutrition across the life course[11] 39].

Implementation Strategies

Implementing comprehensive DBM interventions requires substantial health system strengthening to address the complexity of managing multiple malnutrition forms simultaneously[42] 49]. Health workers need training to recognize DBM manifestations, counsel families on balanced nutrition approaches, and coordinate care across different programs historically designed for single malnutrition types[42] 43].

Community health worker programs represent promising platforms for DBM management, providing integrated screening, counseling, and follow-up services at household level[42] 49]. However, success requires appropriate training curricula, supportive supervision systems, and referral mechanisms linking community-based care with facility-based services[49].

Early childhood care and education settings provide critical opportunities for DBM prevention through policies establishing healthy eating patterns before preferences become entrenched[48] 50]. Comprehensive nutrition policies in childcare settings should address meal and snack quality, physical activity promotion, screen time limitations, and elimination of unhealthy food marketing exposure[48] 51].

Challenges and Future Directions

Health System Integration

DBM management complexity necessitates significant health system adaptations to integrate services traditionally delivered through separate programs[42] 49]. Current health systems often maintain distinct pathways for undernutrition and overnutrition management, creating inefficiencies and potentially conflicting recommendations for families experiencing both conditions[49].

Volume 8, Issue 6; November-December 2025; Page No 420-428

Successful integration requires comprehensive training programs for health workers at all levels, revised clinical protocols

accommodating DBM complexity, and information systems capable of tracking multiple nutrition outcomes simultaneously[42] 43]. Digital health technologies may enhance service delivery capacity and quality while reducing costs, but implementation must address digital divide issues[49].

Financing mechanisms must evolve to support integrated programming across multiple sectors and intervention types[52] 46]. Traditional nutrition financing often separates undernutrition and overnutrition interventions, creating inefficiencies and missed opportunities for synergistic impacts[52]. Blended funding mechanisms combining domestic and international resources may provide more sustainable approaches[52] 46].

Research Gaps and Priorities

Current research gaps limit optimal DBM intervention development and implementation[23] 53]. Key priorities include better understanding of biological mechanisms underlying DBM development, identification of optimal intervention timing and intensity, and development of appropriate monitoring indicators[23] 53]. Additionally, research is needed on cultural and contextual factors affecting intervention acceptability and effectiveness across diverse settings[53].

Economic evaluations comparing double-duty interventions with single-focus programs are essential for informing resource allocation decisions[52] 46]. Such evaluations should incorporate long-term health care savings from chronic disease prevention alongside immediate intervention costs[52]. Cost-effectiveness analyses must also consider differential impacts across population subgroups and potential equity implications[46].

Climate change represents an emerging research priority, as environmental changes affect both food security and diet quality in ways that may exacerbate DBM 54 23 . Research is needed to understand these complex interactions and develop climate-resilient nutrition interventions maintaining protection against both undernutrition and overnutrition under changing environmental conditions[54].

Emerging Technologies and Innovations

Precision nutrition approaches accounting for individual genetic, epigenetic, and microbiome variations may enhance DBM intervention effectiveness[55] 53]. Advances in nutrigenomics and metabolomics could enable identification of individuals at heightened risk for specific DBM pathways, allowing for targeted interventions[53]. However, these approaches must be adapted for resource-constrained settings while ensuring equitable access[53].

Digital health technologies offer promising opportunities for scaling DBM interventions while maintaining quality and reducing costs[42] 49]. Mobile health platforms can deliver personalized nutrition counseling, facilitate behavior change support, and enable remote monitoring of intervention adherence and outcomes[49]. Artificial intelligence approaches may enhance DBM risk prediction and intervention optimization[35].

Technological innovations must complement rather than replace human-centered care approaches, recognizing complex social and cultural factors influencing nutrition behaviors[49]. Implementation should prioritize reducing rather than exacerbating health inequities, ensuring technological solutions enhance access for vulnerable populations[49].

Conclusion

The double burden of malnutrition represents a fundamental challenge requiring paradigm shifts in malnutrition conceptualization, measurement, and intervention approaches. Success in addressing DBM demands integrated strategies simultaneously targeting shared determinants of undernutrition and overnutrition while recognizing complex biological, social, and environmental pathways creating vulnerability to both conditions.

Priority actions should focus on implementing evidence-based double-duty interventions, particularly those targeting early life nutrition, improving food environments, and strengthening health systems for integrated care delivery. Policy development must embrace intersectoral coordination, recognizing that DBM solutions require collaboration across health, agriculture, education, social protection, and urban planning sectors.

Volume 8, Issue 6; November-December 2025; Page No 420-428

The global nutrition community must prioritize DBM as a distinct and urgent public health challenge requiring dedicated resources, specialized technical expertise, and sustained political commitment. Only through comprehensive approaches addressing the full complexity of modern malnutrition can countries successfully navigate nutrition transitions while protecting populations from the devastating consequences of malnutrition in all its forms.

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Volume 8, Issue 6; November-December 2025; Page No 420-428

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Volume 8, Issue 6; November-December 2025; Page No 420-428

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Volume 8, Issue 6; November-December 2025; Page No 420-428