World Nutrition, June 2026;17(2): 216-221
DOI: https://doi.org/10.26596/wn.2026172216-221

WORLD NUTRITION
The Official Journal of the World Public Health Nutrition Association
Journal homepage: https://www.worldnutritionjournal.org
ISSN: 2041-9775

Commentary

"Food as medicine": Maximizing nutrition in antimicrobial resistance mitigation

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Article History
Received: January 07, 2026
Reviewed: February 04, 2026
Revised: May 14, 2026
Accepted: June 05, 2026
Published: June 30, 2026

Citation
Akintunde D.M., Adam S.A.Y., Akintunde O.O., Odeh G.E., & Ayinde J.B. (2026). "Food as medicine": Maximizing nutrition in antimicrobial resistance mitigation. *World Nutrition*, 17(2), June, 216–221. https://doi.org/10.26596/wn.2026172216-221

Academic Editor
Ted Greiner, PhD

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Highlights/Key Messages

- Antimicrobial resistance is a global health crisis
- Malnutrition increases the chances of infections and AMR in SSA
- Nutrition initiatives have a potential AMR mitigation role, yet are unexplored
- Funded epidemiological research/clinical trials are required to confirm this
- Nutrition as a mitigation strategy should be included in AMR research agendas

Background
Antimicrobial resistance (AMR) is a growing global health threat, with sub-Saharan Africa (SSA) disproportionately affected. In 2021, SSA recorded about 923,000 AMR-associated and 209,000 AMR-attributable deaths. Key drivers include antibiotic misuse, weak water/sanitation/hygiene (WASH) systems, poor infection prevention and control (IPC), limited diagnostics, and fragile health systems. Nutrition remains an underexplored but potentially critical lever for AMR mitigation.

Objective
This perspective examines how improved nutrition could reduce AMR burden in SSA by strengthening host defenses, lowering infection risk, and decreasing unnecessary antibiotic use.

Methods
We conducted a comprehensive literature search across PubMed, Medline, Google Scholar, DOAJ, Semantic Scholar, and African Journals Online. Using MeSH and free-text terms for "nutrition", "malnutrition", and "antimicrobial resistance" with Boolean operators, we identified original studies and reviews linking between malnutrition and AMR in SSA.

Results
Malnutrition impairs immunity, disrupts gut barrier function, and alters the gut microbiome, increasing susceptibility to infection and colonization by multidrug-resistant organisms. Malnourished children are routinely prescribed antibiotics, further driving resistance. Conversely, diets rich in fiber, micronutrients, and fermented foods - common in traditional African diets - support a healthy microbiome, enhance colonization resistance, and reduce AMR gene carriage. Micronutrients such as zinc, iron, vitamin A, and vitamin D are vital for immune function and barrier integrity. To mitigate AMR through nutrition, promoting nutrient-dense, locally available foods and fermented products to strengthen immunity and gut health; advancing food fortification, dietary diversification, and food safety to reduce infection burden; scaling nutrition-sensitive and nutrition-specific interventions for high-risk groups, including malnourished children; and strengthening behavior change communication may proof effective.

Conclusion
Optimizing nutrition offers a practical, low-cost approach to lowering infection rates and antibiotic use in SSA. Policymakers and partners should adopt a multi-sectoral approach that embeds nutrition in AMR strategies, leverages traditional diets, and strengthens existing nutrition initiatives to reduce AMR and advance Sustainable Development Goals.

Keywords: nutrition, antimicrobial resistance, mitigation, multi-drug-resistant organisms, Sub-Saharan Africa

Introduction

Antimicrobial resistance (AMR) is a global health crisis, especially in sub-Saharan Africa (SSA). AMR complicates the treatment of sepsis, leading to death or disability (IHME, 2024). In 2021, 1·14 (1·00–1·28) million deaths were directly attributable to AMR, and another 4·71 million (4·23–5·19) were associated with AMR globally. In Sub-Saharan Africa, 923 (732–1110) thousand and 209 (161–257) thousand were associated with and attributable to AMR, respectively. 58·9% (54·8–63·0) of the attributable AMR mortality occurred in children younger than 5 years in Western sub-Saharan Africa. About 39 million people are expected to die from AMR globally between 2025 and 2050. (Naghavi et al., 2024) Misuse and overuse of antibiotics, lack of access to water, sanitation, and hygiene (WASH) facilities, inadequate infection prevention and control (IPC) in healthcare settings, and insufficient access to diagnostics, in addition to socioeconomic disparities, weak healthcare systems, and insufficient pharmaceutical regulation, have been shown to be key drivers of AMR in SSA (Sartorius et al., 2024).

Nutrition might play a role in AMR burden reduction, especially in the SSA, preventing diseases and minimizing antibiotic use among humans and animals. It affects critical functions required for host defense and disease resistance (Holowka et al., 2023). Malnutrition among children remains a global challenge driven by interrelated factors, including inadequate nutrition, poverty, and societal disparities (Morales et al., 2023). Sub-Saharan Africa bears a particularly high burden of undernutrition, accounting for an estimated 55.2 million stunted children and 10.2 million wasted children (Holowka et al., 2023). Improving nutrition may help reduce susceptibility to diseases requiring antibiotic treatment, as enhanced nutritional status strengthens immune responses and lowers infection rates (Morales et al., 2023). Malnourished children are especially susceptible to infections due to a weak immune system, and poor treatment response can increase their exposure to various antibiotics. Hence, appropriate and optimal nutrition will reduce this exposure, thereby potentially playing a role in reducing AMR (Holowka et al., 2023; Morales et al., 2023). Micronutrients, including zinc, iron, vitamin A, and vitamin D, are also essential for supporting immune responses and maintaining the body's protective barriers against infection (FAO, 2020). This perspective paper aims to highlight the potential role of nutrition in addressing AMR in SSA.

Methods

A comprehensive literature search was conducted using PubMed, Medline, Google Scholar, Directory of Open Access Journals, Semantic Scholar, and African Journals Online. We combined MeSH and free terms, "nutrition", "malnutrition," and "antimicrobial resistance", with necessary Boolean Operators including AND, OR, and NOT. We searched the literature for evidence linking malnutrition and antimicrobial resistance in SSA, including original studies and reviews. Articles consulted are mostly from SSA. Articles not written in English were excluded. We also searched for and included relevant WHO policy documents or reports. We synthesized the documented impact of malnutrition/nutrition on AMR development and spread primarily in SSA.

Impact of Undernutrition on Infectious Disease Burden and AMR

Undernutrition weakens host immunity, increasing susceptibility to infections and the risk of multidrug-resistant organism (MDRO) infections. Studies demonstrate that deficiencies in essential nutrients substantially modulate immune function (Holowka et al., 2023; Morales et al., 2023). In addition, it alters intestinal barrier function and can lead to environmental enteric dysfunction, characterized by epithelial dysfunction, malabsorption, chronic intestinal inflammation, and a vicious cycle of worsening malnutrition (Holowka et al., 2023). Figure 1 describes a conceptual framework for the interconnection between malnutrition and AMR.

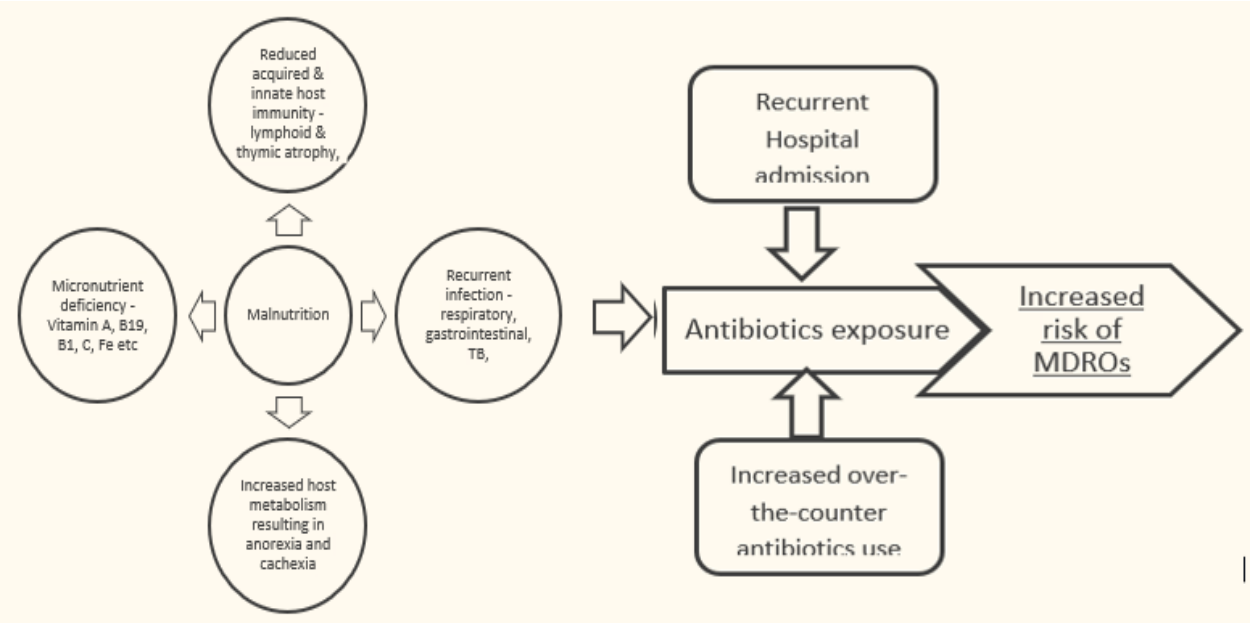


Figure 1. Conceptual Framework linking malnutrition and the risk of AMR (Adapted from Andreas et al 2018)

The elevated risk of intestinal-derived bacterial infections in malnourished children, together with the bidirectional relationship between infection and nutritional decline, underpins the WHO guidelines recommending routine antibiotic treatment for severe acute malnutrition (Holowka et al., 2023; Slöcker-Barrio et al., 2025). However, widespread antibiotic use in this vulnerable population also potentially increases the risk of MDRO infections (FAO, 2020)). Emerging evidence suggests that malnourished children may be intrinsically predisposed to MDRO colonization and infection even without prior antimicrobial exposure (Holowka et al., 2023).

Diet plays a central role in shaping the gut microbiome. With adequate dietary intake, the intestinal microbiome is dominated by Firmicutes and Bacteroidetes, among which beneficial bacteria support epithelial health, nutrient absorption, and barrier integrity (Morales et al., 2023; Rinninella et al., 2019). A key protective mechanism is colonization resistance, whereby the resident microbiota inhibits the growth of pathogenic enteric bacteria such as *Enterobacterales, Clostridioides difficile*, and *Enterococcus*. Its importance is highlighted by the rapid expansion of intestinal MDRO populations following antibiotic exposure (Holowka et al., 2023). Although MDROs may be benign colonizers at low levels, increased intestinal abundance often precedes bloodstream infections, as observed with Extended Spectrum Beta-Lactamases and Carbapenem-resistant Klebsiella pneumoniae in intensive care units and among transplant patients (Holowka et al., 2023).

Interventions promoting traditional African diets are relatively low-cost strategies to promote microbiota-mediated MDRO colonization resistance (Holowka et al., 2023; Morales et al., 2023). Evidence from healthy adults shows that high-protein, low-fiber diets increase AMR gene density and MDRO-associated taxa (Holowka et al., 2023), thereby increasing the risk of shedding/spread and endogenous infections. High-fiber diets reduce resistance genes and favor the proliferation of protective anaerobes (Holowka et al., 2023; Morales et al., 2023). Though varying by region and culture, traditional local African diets generally consist of whole grains, vegetables, fruits, legumes, and lean protein sources, which are high in fiber and low in saturated fats, micronutrient-rich, and contain phytochemical elements like phenols (Matsinkou Soh et al., 2023). These improve gut function, decrease plasma cholesterol levels, and have anticarcinogenic, antioxidant, anti-inflammatory, and antifungal properties, as well as other preventive qualities (Matsinkou Soh et al., 2023). They are also essential in preventing chronic diseases such as diabetes mellitus (DM) and cancers, conditions that can also depress immunity. In addition, they are also useful in maintaining good glycemic control in the dietary management of DM. These findings support dietary therapy as a promising approach to mitigate MDRO risk (Holowka et al., 2023; Matsinkou Soh et al., 2023).

Potential Nutrition Strategies for AMR Mitigation

Promotion of Nutrient-rich Local African foods

Improving diets thus provides a practical and complementary way to reduce AMR in SSA, though approaches vary across regions due to poverty and varying levels of food insecurity resulting from active conflict, drought, among others (FAO, 2020). Encouraging the consumption of nutrient-rich local foods such as legumes, whole grains, fruits, vegetables, and traditional fermented products can strengthen immune function and reduce the risk of infections that often require antimicrobial treatment. Focusing on locally available foods also improves affordability and cultural acceptance, making healthy eating easier to sustain over time. Promoting prebiotic and probiotic consumption may potentially contribute to AMR mitigation by supporting gut health (Markowiak & Ślizewska, 2017). Prebiotics and probiotics, found in fiber-rich foods like whole grains and tubers and fermented foods such as yogurt and fermented cereals, respectively, affect the gut microbiota composition and its metabolic function (Markowiak & Ślizewska, 2017; Rinninella et al., 2019). A healthy gut microbiome can reduce the growth of harmful bacteria and limit the spread of AMR genes within the gut (Rinninella et al., 2019; Slöcker-Barrio et al., 2025). Prebiotics resist digestion in the upper gut, fermentation by intestinal microbiota in the colon, and selectively stimulate the growth of probiotics. They may also modulate lipid metabolism, enhance calcium absorption, and subsequently affect the immune system and bowel function (Markowiak & Ślizewska, 2017). Probiotics help maintain a balanced gut environment and counteract the growth of pathogenic intestinal microbiota that can be ingested from contaminated food and water (Slöcker-Barrio et al., 2025). They do this by antagonism through the production of antimicrobial substances, competition with pathogens for adhesion to the epithelium and for nutrients, immunomodulation of the host, and inhibition of bacterial toxin production. They may also form a protective barrier, preventing pathogenic bacteria from colonizing the epithelium (Markowiak & Ślizewska, 2017; Slöcker-Barrio et al., 2025).

Promotion of Food Safety & Diet Quality

Advancing food fortification and dietary diversification programs can reduce infection burdens, thereby reducing dependence on antimicrobials and supporting a more comprehensive response to AMR (Mosha et al., 2018). Micronutrients, including vitamin A, β-carotene, folic acid, vitamin B12, vitamin C, riboflavin, iron, zinc, and selenium, play immunomodulatory roles and affect both an individual's vulnerability to infection and the progression and outcome of disease (Chiabi et al., 2018). Deficiency leads to lower immune function and increased susceptibility to infections, potentially necessitating antibiotic use. In addition, promoting food hygiene through safe food handling, storage, and processing, as well as hand hygiene, may reduce foodborne infections. Fewer infections may reduce the need for antibiotics in humans (Chiabi et al., 2018).

Nutrition-Sensitive and Nutrition-Specific Health System Interventions

Advancing nutrition-sensitive interventions, which address the underlying determinants of fetal and child nutrition and development, such as homestead food production, biofortification, support to income generation, family planning, nutrition education (in school settings), deworming, iron and folic acid supplements in adolescents, pre-natal nutrition optimization, and malaria intermittent preventive treatment in pregnancy will serve to improve maternal and child nutrition and reduce antibiotics use (Abdullahi et al., 2021; Mosha et al., 2018). In addition, the promotion of nutrition-specific interventions, including breastfeeding, complementary feeding, vitamin A supplementation, preventive and therapeutic zinc, balanced energy protein supplementation, and high-energy ready-to-use therapeutic food in malnourished children, serves to reduce low birth weight, wasting, and stunting, and increase breastfeeding practice, with resultant strengthening of immunity, reduced infection, thus lowering the need for antibiotic use (Abdullahi et al., 2021; Chiabi et al., 2018; de Hoop et al., 2025; Mosha et al., 2018). Nutrition-sensitive and -specific interventions should also target high-risk groups, including malnourished children, people living with HIV/AIDS, and older adults, who have higher infection rates and antibiotic exposure. Nutrition rehabilitation reduces this burden.

Nutrition- sensitive and specific interventions are most effective when paired with behavior change communication initiatives that disseminate nutrition and public health information, especially to women. Such campaigns enhance awareness of the value of a balanced diet, dietary diversity, safe food preparation methods, optimal infant and child feeding practices, especially in the first 100days of life, and appropriate health-seeking behaviors, thereby amplifying health and nutrition benefits. Continuing education on the link between nutrition, immunity, and AMR will help reduce the demand for antibiotics, including inappropriate use for viral infections (de Hoop et al., 2025; Mosha et al., 2018; Nair et al., 2016).

Integration of Nutrition into AMR Action Plans

The Quadripartite organizations -- WHO, FAO, the World Organization for Animal Health, and the United Nations Environment Programme (UNEP) – have advocated for nutrition as a key mitigative strategy to strengthen AMR prevention. This includes the transformation of agrifood systems to significantly reduce AMR while optimizing animal health and welfare (WHO et al., 2024). However, this recommendation is targeted only at animal health and agrifood systems, not at human health, in the updated Global Action Plan on AMR (WHO et al., 2026). We suggest that nutritional considerations for infection prevention should not be limited to animal health but should also include human health.

Challenges and Opportunities

Adequate nutrition, which involves both micro- and macronutrients, is severely hampered by food insecurity in SSA. According to the 2025 FAO report, inflation and high food prices are major drivers, leading to hunger and malnutrition in already vulnerable population groups, including children, women, low-income households, and rural dwellers.(FAO, 2020). In fragile and conflict settings of SSA, conflict remains a major driver of food insecurity (Gebrihet & Gebresilassie, 2025). The destruction of farmland and irrigation infrastructure, coupled with the displacement of farming communities, severely disrupts agricultural production and reduces food availability, thereby tipping families into cycles of poverty and food insecurity (FAO, 2025; Gebrihet & Gebresilassie, 2025). Food insecurity results in reduced access and inadequate food intake, thereby increasing susceptibility to various infections and necessitating the use of antimicrobials (whether self-medicated or prescribed), thereby increasing the risk of AMR (FAO, 2020, 2025). Political instability and lack of political will are directly or indirectly linked to increased AMR, especially as government policies affect food production and availability (Otaigbe & Elikwu, 2023).

Despite the challenges that nutrition, as an AMR mitigation strategy, may face, integrating nutrition into AMR policies is essential in SSA. Actions such as those contemplated in the Decade of Action on Nutrition and the Sustainable Development Goals 2030, as well as those implemented through regional initiatives and programs such as Accelerate Nutrition, may provide guidance on mitigating AMR through nutrition (WHO, 2017, 2025). Interventions that improve dietary practices (especially among children, adolescents, pregnant and breastfeeding women and the elderly) including nutritional counselling and rehabilitation at all levels of care will ensure that patients and caregivers have the necessary information to prevent/reduce infections, decrease recovery time, and lower re-infection risk, consequently decreasing antibiotic use and the risk of developing resistance in the SSA -- where there is often limited diagnostic capacity(FAO, 2025). National and sub-national governments must strengthen the implementation of multi-sectoral policies that promote optimal nutritional practices, thereby maximizing locally available food resources to build the body's immune system and reduce the need for antibiotics (Holowka et al., 2023; Matsinkou Soh et al., 2023; Unger et al., 2019).

Conclusions and Recommendations

Nutrition is a potentially important yet neglected player in reducing the AMR burden, boosting immune function, preventing disease, and reducing the need for antimicrobials. A well-nourished body is better equipped to defend against infections, potentially lowering reliance on antibiotics. Improving nutrition could indeed be key to reducing disease susceptibility and antibiotic use. Sub-Saharan Africans must maximize the cultivation and consumption of existing nutritious traditional foods and support nutrition initiatives in the fight against AMR. Communities should promote local African diets above refined foods, especially the now widely promoted ultra-

processed foods, for healthy living. Nutrition interventions have not adequately emphasized how to utilize and maximize local, affordable diets for healthy living. We also suggest that policymakers, in partnership with relevant local voluntary organizations and United Nations agencies working on nutrition-related efforts in SSA, should strengthen their current efforts to reduce malnutrition to the barest minimum using a multi-sectoral approach to achieve the Sustainable Development Goals (Mpiira & Okello, 2020). Mothers of under-fives should be taught how to maximize nutrition using locally available food resources for children's growth and development, from breastfeeding to complementary feeds, to prevent infection and reduce antibiotic use, especially in the first 1000 days of life.

Author Contributions

DMA conceptualized the research. SAYA, OOA, GEO, and BJA wrote the original draft with routine critical reviews and additions by DMA. DMA and SAYA responded to reviewers' comments. All authors then critically reviewed the following versions. All authors have read and approved the final version of the paper and its submission and have given consent for publication.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

Meta AI was used for brainstorming while working on the outline of this paper

Acknowledgements

None

Data Availability Statement

All relevant data are available within the manuscript

Funding

This is independent research that has received no funding from any individual or organization.

Conflict of Interest

The authors have no conflict of interest to declare.

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