IZiNCG

The potential impact of climate change on zinc nutrition

Zinc is an essential nutrient for optimal health, growth and development

Zinc is an essential nutrient for immune function, child health and development, and reproductive health (1). Within populations, infants, young children and pregnant women who consume diets with a low zinc content and/or bioavailability are at greatest risk of zinc deficiency.

An estimated 15% of the global population (1.1 billion individuals) is at risk of inadequate zinc intake (2). Based on available biochemical, food consumption and child growth data, zinc deficiency is estimated to be a public health problem[1] in 40 low- and middle-income countries (LMICs). A disproportionate number of these individuals live in countries at high vulnerability and low readiness to adapt to the negative effects of climate change (**Figure 1**).

KEY MESSAGES

- Zinc deficiency is estimated to be a public health problem in 40 low- and middle-income countries.
- Malnutrition, including deficiencies of zinc and other essential micronutrients, is considered one of the five major adverse health impacts of climate change.
- Climate change is likely to reduce the zinc content of staple crops and reduce the availability of and access to important food sources of zinc.
- Climate change is predicted to increase rates of diarrheal disease in some areas, which is likely to exacerbate the risk of zinc deficiency.
- Climate change adaptation strategies that protect zinc nutrition include large-scale food fortification and biofortification, alternative animal source foods, underutilized crops, breastfeeding, targeted supplementation for vulnerable group such as young children and pregnant women, and zinc as part of diarrhea treatment.

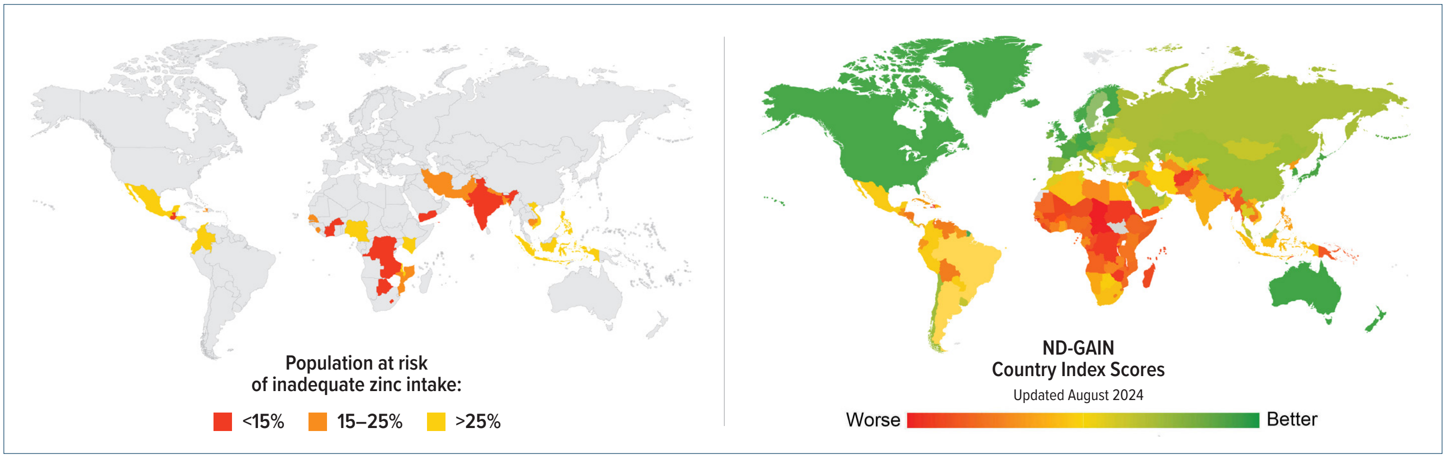

Figure 1. Estimated percentage of the population at risk of inadequate zinc intake in 40 LMICs where zinc deficiency is considered to be a public health problem[1], compared to the ND-GAIN Index score[2].

[1] Zinc deficiency was considered a public health problem in LMIICs where the percentage of the population at risk of inadequate zinc intake due to inadequate zinc in the national food supply was >25% and the prevalence of stunting among children less than 5 years of age was >20%, or where the percentage of pre-school children or women of reproductive age with low plasma zinc concentration was > 20% according to available national surveys.

[2] The ND-GAIN Index score combines the country's vulnerability to climate change (exposure, sensitivity and capacity to adapt) with a country's readiness to adapt (ability to leverage investments and convert them to adaptation actions) (3).

Climate change will negatively impact health and nutrition outcomes

Climate change caused by humans has resulted in higher temperatures across land, sea, and atmosphere, as well as increased frequency of extreme weather events such as heatwaves, extreme precipitation, droughts, and tropical cyclones. These changes are already directly affecting 3.3-3.6 billion people (4). Malnutrition is viewed as one of the five major adverse health impacts of climate change (5). By 2050, climate change is expected to cause an additional 4.8 million undernourished children and 250,000 additional annual deaths from undernutrition, malaria, diarrhea and heat stress (6).

Climate change is likely to affect nutritional status through multiple pathways and systems, including influencing people's food security, disease risk and patterns, water and sanitation environments, and choices about how to allocate time to their livelihoods and to caregiving (7,8). Importantly, climate change will not affect everyone equally. Since many LMICs already have high burdens of multiple forms of malnutrition, and fewer household-, community- and national-level resources to cope with shocks, there are justified concerns that climate change and extreme weather events may seriously slow or even reverse progress against malnutrition (9).

What do we know about the impact of climate change on zinc nutrition?

FOOD SYSTEM-RELATED IMPACTS

Decreased zinc content of staple crops

Climate change leads to increased concentrations of atmospheric carbon dioxide (CO_2), which in turn, can lower the content of zinc in important food crops. A modelling study found that an additional 138 million people — primarily residing in Africa and South Asia — will be placed at new risk of zinc deficiency by 2050 (10). Another model predicted that in the presence of increasing CO_2 concentrations, decreasing zinc and iron concentrations of crops would induce an additional 126 million disability-adjusted life years globally between 2015 and 2050 (11).

Reduced availability of and access to important dietary sources of zinc

Animal-source foods, especially meat, organ meats and shellfish, are the richest sources of dietary zinc. Despite their high phytate content limiting zinc absorption, cereals and legumes are also important sources of zinc in low- and middle-income countries due to their high consumption (12).

Projected future climate change will increasingly affect food quantity, quality, and safety, with low-income consumers, particularly women and children, most vulnerable to these effects (13). For example, droughts and other environmental consequences of climate change will result in decreased crop yields and reduced availability of livestock (14,15), and rising sea temperatures and ocean acidification will have negative impacts on seafood production (14). In addition, rising temperatures and rainfall are expected to increase food waste for perishable food, including meat and eggs (16).

Reduced agricultural and fisheries production will cause income and livelihood losses for farmers and fisherfolk, which combined with increased prices of these important sources of zinc, are likely to contribute to more people becoming at risk of inadequate zinc intakes (13–15).

OUTCOMES ASSOCIATED WITH ZINC STATUS

More diarrheal disease may exacerbate the risk of zinc deficiency

Diarrhea causes increased zinc losses, and thereby increases susceptibility to zinc deficiency (1). Demographic and Health Survey data from 43 LMICs between 2009 and 2019 showed that extreme floods, floods lasting more than two weeks, and floods preceded by drought, were associated with an increased risk of diarrhea among children among children younger than five years (17). Moreover, changes in temperature due to global climate change can and may already be increasing the incidence of bacterial diarrhea in LMICs (18).

The incidence of adverse birth outcomes will increase

Zinc is critical for normal fetal growth and development, and zinc requirements increase during pregnancy (1). Indeed, zinc deficiency during pregnancy is associated with adverse pregnancy outcomes, specifically preterm birth (19). Babies who are born too soon or too small have higher rates of morbidity and mortality due to infectious disease and impaired immunity (20). Climate change is expected to have a substantial impact on adverse pregnancy and birth outcomes. For example, a meta-analysis found the odds of stillbirth rose by 5% per 1°C increase in temperature (21), and in Pakistan, heat stress during the second trimester were associated with a higher risk of preterm birth (22).

More children under five years of age will become stunted

Zinc deficiency is associated with stunting among young children in LMICs (23). A modelling study estimated that climate change will lead to a relative increase in moderate stunting of 1–29% in 2050 compared to a future without climate change. Climate change will have a greater impact on rates of severe stunting, which are estimated to increase by 23% in sub-Saharan Africa and 62% in South Asia (24).

Zinc-specific adaptation measures

POPULATION-LEVEL APPROACHES

Scale up large-scale food fortification and biofortification

Large-scale food fortification (LSFF) with zinc alone or together with other micronutrients, led to a 24-55% decrease in the prevalence of zinc deficiency with no adverse outcomes reported (25). If LSFF of staple foods with zinc was adopted and/or optimized in all 40 countries where zinc deficiency is a public health problem, the percentage of the population at risk of inadequate zinc intake could be reduced by 50% (2).

In areas where the proportion of industrially processed of cereal flours is low, biofortification provides an alternative strategy, with trials of biofortified wheat demonstrating an increase in zinc intake in Bangladesh and Pakistan (26,27). Novel fortification vehicles such as salt and bouillon cubes may also be considered as an alternative to fortified cereal flours (28).

Explore alternative animal source foods

Many edible insects are rich sources of zinc, and land, water and energy use, and greenhouse gas emissions are generally lower for insect production compared to commonly eaten animals (29).

Support the production of underutilized and indigenous crops

Within current global food systems, only three crops (rice, maize, and wheat) contribute some 60% of calories consumed by humans (30). However, many indigenous crops have higher nutritional value than the dominant staples and concomitantly show better resilience to climate variability and shocks. For example, millet contains more zinc per 100g compared with rice, requires substantially less water to produce, and is highly tolerant to climate extremes and can be germinated to reduce its phytate content (12).

TARGETED APPROACHES — PREVENTIVE

Strengthen initiatives to promote, protect and support breastfeeding

Breastfeeding is one of the most effective ways to ensure child health and survival and is an excellent source of highly bioavailable zinc. However, contrary to WHO recommendations and despite progress over the past decade, fewer than half of all infants are exclusively breastfed for the first six months of life (32).

Micronutrient powders (MNP) and small-quantity lipid-based nutrient supplements (SQ-LNS) for extra zinc to young children

MNPs and SQ-LNS are excellent options for increasing the zinc and micronutrient intakes of children between six and 23 months of age whose complementary foods are not meeting dietary zinc requirements (33).

Increase access to Multiple Micronutrient Supplements (MMS) during pregnancy

MMS includes 15mg of zinc together with other micronutrients and reduces the risk of stillbirth, preterm birth, low birthweight and small for gestational age births (34,35). Moreover, a study conducted in Pakistan found that the negative impacts of heat on birth length were, in part, mitigated in women receiving SQ-LNS with zinc and other micronutrients before pregnancy, suggesting potential interactions between heat stress and nutritional status of the mother (22).

TARGETED APPROACHES – TREATMENT

Increase access to treatment of diarrhea with zinc and oral rehydration solution (ORS)

Treatment of childhood diarrhea with zinc and ORS is a WHO Essential Nutrition Action for improving maternal, newborn, infant and young child health and nutrition. Globally, only 15% of children have access to ORS + zinc during illness, and access is often lowest where the burden is highest (36).

About IZiNCG

IZiNCG is the International Zinc Nutrition Consultative Group whose primary objectives are to promote and assist efforts to reduce global zinc deficiency through interpretation of nutrition science, dissemination of information, and provision of technical assistance to national governments and international agencies. IZiNCG focuses on identification, prevention and treatment of zinc deficiency in the most vulnerable populations of low-income countries.

IZiNCG Secretariat

University of California San Francisco
5700 Martin Luther King Jr Way
Oakland, CA, USA 94609

secretariat@izincg.org

This brief was developed with support from the International Zinc Association

References

1. King JC, Brown KH, Gibson RS, Krebs NF, Lowe NM, Siekmann JH, et al. Biomarkers of Nutrition for Development (BOND)—Zinc Review. J Nutr. 2016 Apr;146(4):858S-885S.

2. Wessells KR, Manger MS, Tsang BL, Brown KH, McDonald CM. Mandatory large-scale food fortification programmes can reduce the estimated prevalence of inadequate zinc intake by up to 50% globally. Nat Food. 2024 Jun 19;5(7):625–37.

3. University of Notre Dame Notre Dame Global Adaptation Initiative. https://gain.nd.edu/our-work/country-index/, accessed 28 December 2024. ND-GAIN Country Index.

4. IPCC. Fifth Assessment Report. Available at: www.ipcc.ch/assessment-report/ar5/ ; 2014.

5. Romanello M, Walawender M, Hsu SC, Moskeland A, Palmeiro-Silva Y, Scamman D, et al. The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. The Lancet. 2024 Nov;404(10465):1847–96.

6. IFPRI. Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition and Sustainable Development. Washington, DC; 2015.

7. WHO. <www. who.int/news-room/fact-sheets/detail/climate-change-and-health>, accessed 23 December 2024. Climate Change.

8. IFPRI. Global nutrition report 2015. 2015.

9. Fanzo J, Bellows AL, Spiker ML, Thorne-Lyman AL, Bloem MW. The importance of food systems and the environment for nutrition. Am J Clin Nutr. 2021 Jan;113(1):7–16.

10. Headey D and VA. Extreme weather events and undernutrition: A critical but constructive review of the literature. IFPRI Discussion Paper 02236. Washington, D.C.; 2024.

11. Myers SS, Wessells KR, Kloog I, Zanobetti A, Schwartz J. Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency: a modelling study. Lancet Glob Health. 2015 Oct;3(10):e639–45.

12. Weyant C, Brandeau ML, Burke M, Lobell DB, Bendavid E, Basu S. Anticipated burden and mitigation of carbon-dioxide-induced nutritional deficiencies and related diseases: A simulation modeling study. PLoS Med. 2018 Jul 3;15(7):e1002586.

13. Gibson RS, Anderson VP. A Review of Interventions Based on Dietary Diversification or Modification Strategies with the Potential to Enhance Intakes of Total and Absorbable Zinc. Food Nutr Bull. 2009 Mar 23;30(1_suppl1):S108–43.

14. UNICEF. A Threat to Progress: Confronting the Effects of Climate Change on Child Health and Well-Being. New York; 2024.

15. Fanzo J, Davis C, McLaren R, Choufani J. The effect of climate change across food systems: Implications for nutrition outcomes. Glob Food Sec. 2018 Sep;18:12–9.

16. Godde CM, Mason-D'Croz D, Mayberry DE, Thornton PK, Herrero M. Impacts of climate change on the livestock food supply chain; a review of the evidence. Glob Food Sec. 2021 Mar;28:100488.

17. Stronger Foundations for Nutrition. An Evidence Narrative on Climate Change & Nutritious Foods. 2023.

18. Wang P, Asare EO, Pitzer VE, Dubrow R, Chen K. Floods and Diarrhea Risk in Young Children in Low- and Middle-Income Countries. JAMA Pediatr. 2023 Nov 1;177(11):1206.

19. Carlton EJ, Woster AP, DeWitt P, Goldstein RS, Levy K. A systematic review and meta-analysis of ambient temperature and diarrhoeal diseases. Int J Epidemiol. 2016 Feb;45(1):117–30.

20. Carducci B, Keats EC, Bhutta ZA. Zinc supplementation for improving pregnancy and infant outcome. Cochrane Database Syst Rev. 2021 Mar 16;3(3):CD000230.

21. Lawn JE, Ohuma EO, Bradley E, Idueta LS, Hazel E, Okwaraji YB, et al. Small babies, big risks: global estimates of prevalence and mortality for vulnerable newborns to accelerate change and improve counting. The Lancet. 2023 May;401(10389):1707–19.

22. Chersich MF, Pham MD, Areal A, Haghighi MM, Manyuchi A, Swift CP, et al. Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis. BMJ. 2020 Nov 4;m3811.

23. Shankar K, Hwang K, Westcott JL, Saleem S, Ali SA, Jessani S, et al. Associations between ambient temperature and pregnancy outcomes from three south Asian sites of the Global Network Maternal Newborn Health Registry: A retrospective cohort study. BJOG. 2023 Nov 15;130(S3):124–33.

24. Mayo-Wilson E, Junior JA, Imdad A, Dean S, Chan XHS, Chan ES, et al. Zinc supplementation for preventing mortality, morbidity, and growth failure in children aged 6 months to 12 years of age. Cochrane Database of Systematic Reviews. 2014 May 15;

25. Lloyd SJ, Kovats RS, Chalabi Z. Climate Change, Crop Yields, and Undernutrition: Development of a Model to Quantify the Impact of Climate Scenarios on Child Undernutrition. Environ Health Perspect. 2011 Dec;119(12):1817–23.

26. Tsang BL, Holsted E, McDonald CM, Brown KH, Black R, Mbuya MNN, et al. Effects of Foods Fortified with Zinc, Alone or Cofortified with Multiple Micronutrients, on Health and Functional Outcomes: A Systematic Review and Meta-Analysis. Advances in Nutrition. 2021 Sep;12(5):1821–37.

27. Jongstra R, Hossain MM, Galetti V, Hall AG, Holt RR, Cercamondi CI, et al. The effect of zinc-biofortified rice on zinc status of Bangladeshi preschool children: a randomized, double-masked, household-based, controlled trial. Am J Clin Nutr. 2022 Mar;115(3):724–37.

28. Gupta S, Zaman M, Fatima S, Shahzad B, Brazier AKM, Moran VH, et al. The Impact of Consuming Zinc-Biofortified Wheat Flour on Haematological Indices of Zinc and Iron Status in Adolescent Girls in Rural Pakistan: A Cluster-Randomised, Double-Blind, Controlled Effectiveness Trial. Nutrients. 2022 Apr 15;14(8):1657.

29. Matthias D, McDonald CM, Archer N, Engle-Stone R. The Role of Multiply-Fortified Table Salt and Bouillon in Food Systems Transformation. Nutrients. 2022 Feb 26;14(5):989.

30. Ordoñez-Araque R, Quishpillo-Miranda N, Ramos-Guerrero L. Edible Insects for Humans and Animals: Nutritional Composition and an Option for Mitigating Environmental Damage. Insects. 2022 Oct 18;13(10).

31. Bakker S, ML, EL, KD, BD, HI and RL. Food-system interventions with climate change and nutrition co-benefits; A literature review. 2021.

32. Babu S, SN, PV and MB. Expanding underutilized crops in Asia: the promise of millets for improving nutrition and sustainability. 2024.

33. UNICEF WHO. Global Breastfeeding Scorecard 2023: Rates of Breastfeeding Increase Around the World through Improved Protection and Support. New York, Geneva.; 2023.

34. Keats EC, Das JK, Salam RA, Lassi ZS, Imdad A, Black RE, et al. Effective interventions to address maternal and child malnutrition: an update of the evidence. Lancet Child Adolesc Health. 2021 May;5(5):367–84.

35. Keats EC, Haider BA, Tam E, Bhutta ZA. Multiple-micronutrient supplementation for women during pregnancy. Cochrane Database of Systematic Reviews. 2019 Mar 15;

36. Smith ER, Shankar AH, Wu LSF, Aboud S, Adu-Afarwuah S, Ali H, et al. Modifiers of the effect of maternal multiple micronutrient supplementation on stillbirth, birth outcomes, and infant mortality: a meta-analysis of individual patient data from 17 randomised trials in low-income and middle-income countries. Lancet Glob Health. 2017 Nov;5(11):e1090–100.

37. PATH. ORS and zinc. https://www.defeatdd.org/solution/ors-and-zinc/, accessed 28 December 2024.