ARTICLE INFO

AUTHOR'S AFFILIATIONS

Department of Public Health, Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur[1]

Department of Public Health, Faculty of Medicine, Universitas Wijaya Kusuma Surabaya[2]

Department of Physiology, Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur[3]

Department of Internal Medicine, Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur[4]

Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur[5]

CORRESPONDING AUTHOR

Sukma Sahadewa

Department of Public Health, Faculty of Medicine, Universitas Wijaya Kusuma Surabaya

E-mail: sukma.sahadewa@uwks.ac.id

Article history

Received	04-08-2025
Revised	27-11-2025
Accepted	10-02-2026
Available online	31-03-2026

Please cite this article in APA 7th edition style as:

Fara, F. D., Sahadewa, S., Febriawan, A., Pratiwi, P. E., & Winata, L. S. (2026). The Role of Micronutrients (Zinc, Vitamin A, C, D and Iron) in Preventing Infectious Diseases in Disaster-Affected Populations: A Literature Review. *Jurnal Ilmiah Kedokteran Wijaya Kusuma, 15(1), 40-52*

https://doi.org/10.30742/jikw.v15i1.4763

The Role of Micronutrients (Zinc, Vitamin A, C, D and Iron) in Preventing Infectious Diseases in Disaster-Affected Populations: A Literature Review

Fara Disa Durry[1], Sukma Sahadewa[2], Zulfan Febriawan[3], Prasetyaning Estu Pratiwi[4], Lionesya Sukma Winata[5]*

Abstract

Background: Micronutrient deficiencies significantly increase vulnerability to infectious diseases, partiularly among disaster-affected populations with limited access to food and healthcare. Despite this, micronutrient interventions are rarely prioritized in emergency health protocols, especially in countries like Indonesia. **Objective:** This review aims to examine the role of micronutrients in preventing infectious diseases in populations affected by disasters, based on an analysis of primary research articles. **Methods:** A narrative thematic literature review was conducted using databases such as PubMed, ScienceDirect, and Google Scholar. Inclusion criteria covered primary studies (both experimental and observational) within disaster settings, published between 2013 and 2023. A total of 25 eligible studies were analyzed. **Results:** Most studies reported that supplementation with micronutrients particularly vitamin A, vitamin D, zinc, vitamin C, and iron was associated with reduced incidence and severity of respiratory tract infections, diarrhea, and pneumonia. Multi-micronutrient interventions proved more effective than single-nutrient approaches. However, implementation in emergency contexts remains limited, and vulnerable groups beyond young childrensuch as adolescent girls, pregnant women, and the elderlyare often underrepresented in the literature. **Conclusion:** Micronutrient supplementation has substantial potential to strengthen post-disaster health resilience. Integrating micronutrient strategies into emergency logistics, conducting targeted nutritional screening, and enhancing multi-sectoral training are essential steps toward improving disaster response outcomes.

Keywords: Disasters, Health resilience, Infectious diseases, Micronutrients, Supplementation

Review Article

INTRODUCTION

Natural and non-natural disasters such as floods, earthquakes, volcanic eruptions, and social conflicts frequently cause extensive infrastructure damage, mass displacement, and severe disruption of health service systems. Unlike routine settings in which malnutrition is typically studied, disaster situations

create acute, rapidly changing environments characterized by overcrowded emergency shelters, limited access to clean water, sanitation breakdowns, and reduced healthcare availability. These conditions substantially amplify the risk of infectious diseases, particularly among vulnerable groups such as young children, pregnant women, the elderly, and individuals with pre-existing suboptimal nutritional status (Meena et al., 2023).

In these unstable environments, common infectious diseases such as acute respiratory infections, diarrheal diseases, and skin infections often surge because standard prevention and treatment measures are difficult to maintain during emergencies (Ameli, 2015). Nutrition plays a distinct and time-sensitive role in such contexts: deficiencies in essential micronutrients can rapidly weaken immune defenses at a time when exposure to pathogens is intensified. Micronutrients including zinc, vitamin A, vitamin C, vitamin D, and iron are particularly critical under disaster conditions, as they support immune function, epithelial integrity, antioxidant defense, and immune modulation. Evidence from non-disaster settings shows that zinc reduces diarrheal and pneumonia incidence, vitamin A strengthens mucosal barriers, vitamin C mitigates oxidative stress, and vitamin D regulates immune responses against respiratory infections (Anggraeni et al., 2021; Izzah Taqiya et al., 2024). However, how these benefits translate to emergency and displacement settings remains insufficiently examined.

In Indonesia, micronutrient deficiencies such as zinc, vitamin A, and iron are already highly prevalent among children and adolescent girls, increasing vulnerability to diarrhea and respiratory tract infections even prior to disaster exposure (Fatimah & Wirjatmadi, 2018). When disasters occur, disruptions to food supply chains, reliance on food aid, monotonous diets, and reduced access to fortified foods or supplements further exacerbate these deficiencies (Tumenggung et al., 2017). Unlike general malnutrition research conducted in stable populations, disaster-affected settings involve compounded risks simultaneous nutritional deprivation, heightened pathogen exposure, and limited healthcare access that may alter the relationship between micronutrient status and infectious disease outcomes.

This literature review therefore deliberately focuses on disaster-specific contexts, synthesizing available scientific evidence on the role of key micronutrients in preventing or mitigating infectious diseases among displaced and disaster-affected populations. By emphasizing the distinctive nutritional and epidemiological challenges of emergencies, this review aims to address the current evidence gap and support the integration of targeted micronutrient strategies into disaster nutrition planning. Such an approach is essential to ensure that emergency responses move beyond macronutrient adequacy and address the critical, yet often overlooked, micronutrient needs that underpin infection prevention in disaster settings.

METHODS

Review Approach

This study employed a narrative review with systematic elements, incorporating selected components of the PRISMA framework to enhance methodological rigor and transparency. This review was not designed as a scoping review (PRISMA-ScR) or a full systematic review; rather, it applied a structured and reproducible approach to literature searching, screening, and synthesis while retaining a narrative synthesis format. This approach was chosen to systematically summarize disaster-specific evidence and address the identified research gap in contexts where the available literature is heterogeneous

Search Strategy

A structured literature search was conducted in three major electronic databases: PubMed, ScienceDirect, and Google Scholar targeting articles published from January 2013 to December 2023. The PICO framework guided eligibility parameters and keyword selection: Population (P): individuals affected by natural disasters, humanitarian crises, and displacement (e.g., refugees and internally displaced persons). Intervention (I): supplementation with five key micronutrients: zinc, vitamin A, vitamin C, vitamin D, and iron. These micronutrients were selected based on their high prevalence of

deficiency in disaster-affected populations and the strongest available evidence linking supplementation to infectious disease outcomes. Comparison (C): placebo, no supplementation, or standard care. Outcome (O): incidence and severity of infectious diseases (e.g., diarrhea and respiratory infections) or immune function indicators. Boolean search strings used included: ("Zinc" OR "Vitamin A" OR "Vitamin C" OR "Vitamin D" OR "Iron") AND ("Infection" OR "Diarrhea" OR "Respiratory") AND ("Disaster" OR "Refugee" OR "Emergency")

Eligibility Criteria

Included studies were:

1. Original research (RCTs, cohort, cross-sectional, or quasi-experimental designs);
2. Conducted in disaster, humanitarian, or emergency contexts with human subjects;
3. Published in peer-reviewed journals (2013 – 2023) in English;
4. Focused on the effects of micronutrient supplementation on infectious disease outcomes.

Exclusion criteria:

1. Reviews, commentaries or non-primary research;
2. Studies outside disaster/emergency contexts;
3. Animal or in-vitro studies;
4. Articles without full-text availability

Article Selection and Screening Process

The search identified 156 records. Duplicate records were removed using EndNote prior to screening. Two independent reviewers then screened all titles and abstracts using Rayyan to determine eligibility. Discrepancies between reviewers were resolved through discussion until consensus was reached. Following abstract screening, 83 records were excluded. Seventy-three full-text articles were retrieved; 29 were unavailable in full text, and 19 did not meet inclusion criteria (primarily due to the absence of a disaster-specific context). Ultimately, 25 studies were included in the final synthesis. The PRISMA flow diagram summarizing this selection process is presented in Figure 1.

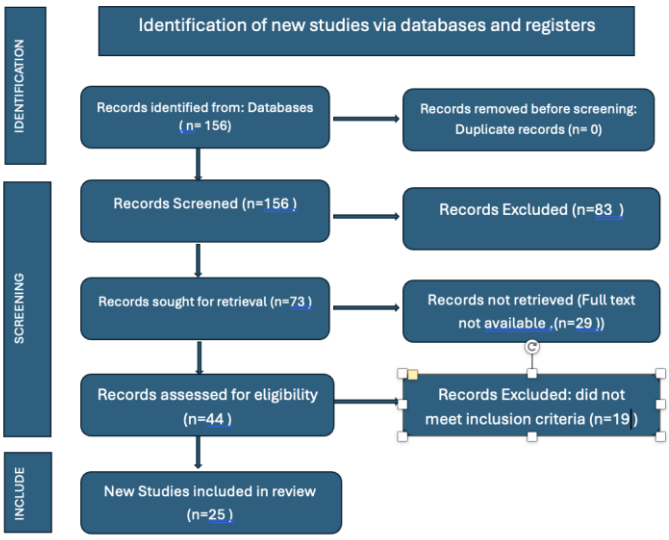

Figure 1. PRISMA 2020. Flowchart.

Data Extraction

Data extraction was performed using a standardized data-extraction form developed in Microsoft Excel to ensure consistency and comparability across studies. Two independent reviewers conducted the extraction, and discrepancies were resolved through discussion until consensus was reached. For each included study, the following variables were systematically recorded:

1. Year of publication;
2. Study population characteristics (including age group and displacement status);
3. Disaster or emergency context in which the study was conducted;
4. Type of micronutrient intervention (supplementation with zinc, vitamin A. vitamin C, vitamin D, or iron);
5. Study design and sample size;
6. Infectious disease outcomes or immune function indicators;
7. Key findings relevant to infection prevention or immune response.

Data Analysis

The extracted data were synthesized using a narrative synthesis approach. Studies were first organized according to the PICO framework: population, intervention, comparison, and outcome to maintain alignment with the review objectives. Within this structure, findings were grouped thematically by micronutrient type and disaster context, allowing comparison across similar emergency settings. A deductive approach guided the identification of recurring patterns, consistencies, and gaps in the evidence. Frequency counts were also used to summarize the distribution of studies by micronutrient type and disaster or displacement context.

RESULTS

Appendix: Tabulated Summary of Primary Research Articles

Table 1. Matrix of Literature Review

No.	Authors (Year)	Micronutrient Type	Target Population	Type of Infection	Study Design	Main Findings	Implications
1	(Gunnsteinsson et al., 2022)	Vitamin A	Infants in Bangladesh exposed to tornado	Fever, post-disaster infection	Cluster-RCT	Vitamin A at birth reduced the risk of fever and improved post-disaster health outcomes.	Suggests that neonatal vitamin A can offer early protection against infections in disaster settings.
2	(Zisi et al., 2019)	Vitamin D	Rohingya children in refugee camps	Acute respiratory infections (ARI)	Cross-sectional study	Vitamin D deficiency was strongly associated with higher incidence of ARI.	Screening and food fortification are essential.
3	(Locks et al., 2016)	Zinc & Multivitamin	Refugee children aged 6-84 weeks	Diarrhea	RCT	The use of combined micronutrient supplements was associated with fewer infection cases.	Combining multiple micronutrients may yield greater efficacy than using a single nutrient alone.
4	Tchum et al., 2021	Iron	Pre-school children in Ghana	Anemia	RCT	Daily use of iron decrease anemia.	Daily iron supplemenation can be

							safely used to prevent anemia in pre-school children.
5	(Baruah & Saikia, 2018)	Zinc	Children in North East India	Severe Pneumonia	RCT	Zinc effectively reduced the incidence of severe pneumonia.	Important for emergency distributions.
6	(Berihun et al., 2023)	Vitamin A	Children age 6-59 Months	Severe infectious disease	RCT	Vitamin A is needed for infected children.	Ensuring adequate vitamin A intake or supplementation is essential for infected children.
7	(Gera et al., 2019)	Zinc	Urban refugee children	Diarrhea & respiratory infection	Meta-analysis of RCTs	Zinc supplementation reduced incidence of respiratory and diarrheal diseases by up to 18%	Should be included in emergency health logistics
8	(Cundra et al., 2024)	Multiple micronutrients	Refugee adolescents	Respiratory tract infections	Field intervention	Provision of multi-micronutrients improved mucosal immune response	Suitable as a medium-term nutrition program in refugee camps
9	(Chen et al., 2018)	Multiple Vitamin	Patient in Catastrophic Color-Dust Explosion	Skin and wound infections	Observational	Supplementation of multiple vitamins, calcium, and magnesiumreduced the risk of wound infection and sepsis, shortened the time of hospitalization, and can be considered for use in major burns.	Using a combination of vitamins, calcium, and magnesium in major burn patients can lower the risk of wound infection and sepsis.

10	(Imdad et al., 2022)	Vitamin A	Conflict-affected children	Diarrhea & respiratory infection	Cohort	Vitamin A was associated with fewer clinic visits due to infection	Effective as part of mass supplementation in emergencies
11	(Wang et al., 2016)	Zinc + Vitamin A	Undernourished toddlers	Diarrhea	Longitudinal	Zinc and vitamin A co-supplementation reduced diarrhea incidence by 32%	Combined interventions outperform single micronutrients
12	(Raju et al., 2022)	Vitamin D	Children in winter refugee shelters	Respiratory infection	Cohort	Vitamin D deficiency was highly prevalent during winter, correlating with increased respiratory illness	Emergency food fortification with vitamin D is crucial
13	(Karthikappallil & Atkinson, 2023)	Iron	Children in flood-affected regions	Malaria & anemia	RCT	Unmonitored iron supplementation raised malaria risk	Interventions must be tightly regulated
14	(Martineau et al., 2017)	Vitamin D	Post-tsunami population	Respiratory tract infection	Observational	Low vitamin D status significantly increased respiratory infection risk	Vitamin D testing is necessary during recovery phases
15	(Barffour et al., 2020)	Zinc	Rural Laotian Children	Diarrhea and acute respiratory	RCT	Zinc significantly reduced both the duration of diarrhea episodes and the incidence of future diarrhea episodes compared with placebo.	Zinc supplementation can effectively shorten ongoing diarrhea episodes.
16	(Song et al., 2023)	Vitamin A	Young children affected by drought	Acute respiratory infections (ARI)	Cohort	Children with vitamin A deficiency experienced higher rates of respiratory infections	Screening and supplementation programs need to be enhanced

17	(Lips & de Jongh, 2018)	Vitamin D	Adult Rohingya refugees	Respiratory infections	Observational	Vitamin D deficiency was present in 78% of the population and correlated with higher ARI incidence	Food fortification should be prioritized in refugee nutrition plans
18	(Tam et al., 2020)	Zinc + Multivitamins	Somali refugee children	Diarrhea & skin infections	Community intervention	Combined supplementation significantly reduced incidence of diarrhea and skin infections	Should be integrated into emergency primary healthcare services
19	(Andersen et al., 2023)	Iron	School-age children affected by floods	Respiratory infections & anemia	RCT	Iron supplementation lowered anemia but had minimal effect on respiratory infections	Combining iron with other vitamins is recommended
20	Salkulchit & Goldman, 2017	Zinc	Infants in Bangladeshi refugee camps	Pneumonia	RCT	Zinc administration reduced both incidence and hospitalization from severe pneumonia	Early-phase zinc distribution is essential
21	(Bechara et al., 2022)	Vitamin C	Urban flood survivors	Skin and open wound infections	Cross-sectional	Low vitamin C levels were associated with poor wound healing and infections	Supplementation is vital for open-wound patients post-disaster
22	(Dolstad et al., 2021)	Vitamin A	Children aged 1-5 years in Rural Haiti	Diarrhea	RCT	Children who had a history of vitamin A and zinc supplementation had a markedly lower risk of diarrhea	Promote vitamin A and zinc supplementation to prevent pediatric diarrhea
23	(Zhang et al., 2021)	Vitamin A	Children affected by floods in Pakistan	Respiratory infections	Cohort	Vitamin A reduced medical visits due to	Should be included in child nutrition

						respiratory illnesses	relief packages
24	(Berger & Shenkin, 2024)	Multiple micronutrients	Adolescent girls in emergency shelters	Skin & respiratory infections	Cross-sectional	Micronutrient deficiencies were linked to decreased skin and airway immune defense	Adolescent-focused nutrition must be prioritized in disaster programs
25	(Jolliffe et al., 2025)	Vitamin D	Adults in earthquake	Acute respiratory	RCT	Vitamin D intake was associated with a decreased risk of respiratory infections.	Planners should incorporate preventive supplementation into disaster response logistics.

DISCUSSION

Micronutrients: An Overlooked Component in Disaster Health Response

This review examined the role of supplementation with five key micronutrients—zinc, vitamin A, vitamin C, vitamin D, and iron in preventing infectious diseases among disaster-affected populations. Analysis of the 25 included studies (Table 2) revealed that 24 out of 25 studies (96%) reported positive effects on reducing respiratory tract infections, diarrheal episodes, and pneumonia incidence, particularly among children under five (Wang et al., 2016; Ernawati et al., 2021; Imdad et al., 2022). Randomized trials conducted in post-flood and refugee camp settings demonstrated that vitamin A and zinc supplementation significantly reduced morbidity and hospitalization duration among under-five children (Wang et al., 2016). Some studies reported modest or inconsistent outcomes, especially when supplementation involved a single nutrient. For example, trials in Pakistan and Ethiopia showed only marginal reductions in infection rates with iron alone, possibly due to its pro-oxidant effects during acute inflammation (Maryam et al., 2018). These findings highlight a critical nuance: while certain micronutrients support immunity, their standalone use in acute infection contexts may carry risk if not tailored to the situation.

Efficacy of Multi-Micronutrient Supplementation (MMS)

MMS generally outperformed single-nutrient interventions, likely due to synergistic effects on mucosal barrier integrity, innate immunity, and antioxidant defenses, which enhance resistance to multiple infectious agents simultaneously (Wang et al., 2016; Ernawati et al., 2021). However, real-world implementation in disaster settings is often constrained by unstable supply chains, limited trained personnel, and logistical challenges, which may reduce the feasibility of MMS programs. This underscores the need for context-specific planning to maximize intervention impact.

Screening and Targeted Supplementation

Several studies emphasized that unmonitored micronutrient distribution, particularly iron, can increase infection susceptibility if biochemical status is not assessed (Karthikappallil & Atkinson, 2023). These findings support locally tailored supplementation strategies based on regional deficiency profiles, rather than universal one-size-fits-all approaches.

Neglected Vulnerable Groups

While children under five are heavily studied, other vulnerable populations—including adolescent girls, pregnant women, and the elderly remain underrepresented. For instance, a cross-sectional study in post-disaster Indonesia showed that adolescent girls' diet quality correlated with maternal health behavior (Musfira & Hadju, 2024). Observational studies from Bangladesh linked low maternal levels of vitamin A and iron to suboptimal immune responses in children (CRP, AGP, IFN-γ) (Rahman et al., 2020). These gaps highlight the need for more inclusive disaster nutrition programs that address diverse at-risk groups. Drawing on the evidence synthesized from this review, several strategic directions are proposed to strengthen the role of micronutrients in disaster response. First, micronutrient screening and supplementation should be systematically incorporated into Early Warning Early Action (EWEA) mechanisms and emergency health services, including mobile clinics and temporary shelters. Second, the planning of emergency nutrition logistics must be adapted to reflect the specific infectious disease patterns and micronutrient deficiency profiles of each disaster-affected region, ensuring that interventions are both relevant and efficient. Third, enhancing the competencies of frontline community health workers in identifying and addressing micronutrient deficiencies is essential for timely and effective response. Lastly, nutrition-focused content should be embedded within the disaster preparedness and response training curricula for cross-sector actors such as the Regional Disaster Management Agency (BPBD), the Indonesian Armed Forces (TNI), the Indonesian Red Cross (PMI), and local health volunteers. This integrative approach is expected to foster a more comprehensive, multisectoral, and sustainable model of disaster resilience.

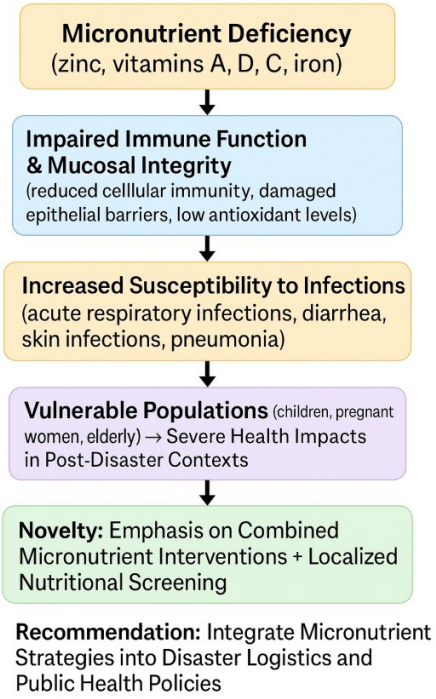

Figure 1. Causal Pathway of Micronutrient Deficiency and Infection Risk Among Post-Disaster Populations (Gombart et al., 2020; Munteanu & Schwartz, 2022)

Contextual Considerations and Evidence Gaps in Indonesia

Most included studies were conducted in South Asia and Africa, limiting direct applicability to Indonesia. Differences in baseline nutritional status, disaster types, and health system capacity necessitate local research before translating international findings into national policy (Musfira & Hadju, 2024). Nonetheless, the patterns observed globally suggest that micronutrient supplementation could serve as a cost-effective preventive measure to reduce secondary infections in emergency shelters or temporary clinics.

Policy Implications and Strategic Recommendations

The evidence indicates that family health resilience in disaster contexts is closely linked to micronutrient adequacy, alongside vaccination, water, sanitation, and essential medications (Cundra et al., 2024; Andersen et al., 2023). Strategic directions include:

1. Systematic integration of screening and supplementation into Early Warning Early Action (EWEA) mechanisms and emergency health services.
2. Context-specific planning of emergency nutrition logistics reflecting regional infection patterns and micronutrient deficiency profiles.
3. Capacity building of frontline health workers to identify and address deficiencies in disaster-affected populations.
4. Embedding nutrition-focused content in disaster preparedness and response training for cross-sector actors (BPBD, TNI, PMI, and local health volunteers).

Critique and Future Research Directions

Despite a growing body of evidence, methodological limitations persist. Most trials originate from non-tropical or high-income countries, with limited contributions from disaster-prone regions like Indonesia. There is a pressing need for context-specific studies assessing the role of micronutrient supplementation in infectious disease prevention during emergency and recovery phases. Future research should focus on diverse vulnerable populations, optimal MMS formulations, and operational feasibility in real-world disaster settings.

CONCLUSION AND POLICY IMPLICATIONS

Conclusion

This literature review show that micronutrients particularly zinc, vitamins A, D, C, and iron play a critical role in preventing infectious diseases among populations affected by disasters. The evidence from 25 primary studies indicates that adequate micronutrient status contributes to improved immune defense and reduced incidence of infections such as diarrhea, pneumonia, and respiratory tract infections. These findings highlight the importance of integrating micronutrient supplementation into disaster response strategies to reduce health risks and support recovery in vulnerable populations.

Policy Recommendations

Given these findings, it is imperative that micronutrient-focused interventions be integrated into Indonesia's disaster preparedness and response framework. The Ministry of Health, in collaboration with the National Disaster Management Agency (BNPB), should incorporate multi-micronutrient supplementation as a standard component of emergency health logistic sequally important as medications, water, and sanitation supplies. In addition, robust early detection and screening mechanisms should be implemented at field level, including the deployment of rapid diagnostic tools to assess micronutrient status, such as zinc and vitamin D, in shelters and emergency clinics. This would help ensure evidence-based interventions, avoiding the risks associated with blanket supplementation.

Regionally, it is crucial to develop disaster nutrition guidelines tailored to local risk profilestaking into account the dominant types of disasters, endemic diseases, and common nutrient deficiencies specific to each area. Strengthening the competencies of local health personnelincluding Puskesmas staff, health volunteers, and regional disaster response teamsis equally vital. Targeted training in nutritional assessment and emergency supplementation can empower them to act swiftly in addressing infection risks linked to micronutrient deficiency. Lastly, encouraging community-based research in disaster-prone regions should become a national priority, supported by government and academic institutions, to generate evidence that reflects real conditions and guides future policy decisions effectively.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

ACKNOWLEDGEMENTS

The author gratefully acknowledges all individuals and institutions who contributed to the preparation of this article. Special thanks are extended to the home institution, peer reviewers, and fellow colleagues who provided valuable input and support throughout the writing process.

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