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The Dual Burden of Anaemia and Stunting in Children under Five in Nigeria: Shared Determinants and Public Health Implication

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Abstract

Anaemia and stunting frequently coexist among children under five and share socioeconomic, maternal, environmental, and health-related determinants, yet they are often investigated separately. This study examined their shared determinants and spatial distribution in Nigeria using nationally representative Nigeria Demographic and Health Survey data from 9,562 children under five. Anaemia was defined as haemoglobin concentration below 11 g/dL, while stunting was defined as a height-for-age z score below −2 according to the World Health Organization child growth standards. A Bayesian shared component model jointly analyzed spatial variation across Nigeria's 36 states, decomposing it into shared and condition-specific components while accounting for individual, household, and environmental covariates. Greater household wealth and maternal education at primary, secondary, or higher levels were associated with lower odds of anaemia, stunting, and their co-occurrence. Improved water sources, sanitation facilities, and maternal antenatal care were also associated with lower risk, whereas rural residence and inadequate household amenities were associated with greater vulnerability. Spatial analysis identified a high shared burden in several northern states, including Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, and Borno, while most southern states exhibited comparatively lower joint risk. These findings demonstrate overlapping socioeconomic and geographic patterns in childhood anaemia and stunting and support addressing both conditions

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through coordinated interventions. The study contributes spatial evidence for integrated, geographically targeted policies that strengthen maternal education, improve household socioeconomic conditions, expand access to quality healthcare, and enhance water, sanitation, and hygiene infrastructure.

Keywords: Anaemia; Stunting; Bayesian Shared Component Model; Spatial Analysis; Nigeria

Introduction

Anaemia and stunting remain two of the most pressing public health challenges affecting children in low-and middle-income countries (UNICEF, 2021). Despite global progress in reducing childhood morbidity and mortality, these conditions continue to compromise child growth, development, and survival, particularly in sub-Saharan Africa and South Asia (WHO, 2020). Anaemia, defined by low haemoglobin concentration, is a multifactorial condition often resulting from nutritional deficiencies (especially iron, folate, and vitamin B12), infections such as malaria and helminthiasis, and chronic inflammation (Kassebaum et al., 2014; Stevens et al., 2022). It impairs oxygen transport, leading to fatigue, poor cognitive function, weakened immunity, and increased risk of mortality in young children and pregnant women (WHO, 2025). Stunting, characterized by low height-for-age, reflects chronic undernutrition and recurrent infections during the critical first 1,000 days of life (Mulyani et al. 2025).

Beyond physical growth failure, stunting is strongly associated with impaired neurodevelopment, reduced school performance, diminished economic productivity, and heightened risk of chronic diseases in adulthood (Soliman et al., 2021).

Both anaemia and stunting share overlapping determinants, including inadequate dietary intake, food insecurity, poor maternal health, low birth weight, limited access to healthcare, and exposure to unhygienic environments (Sahiledengle et al., 2023). Their coexistence reflects cumulative biological and social deprivation. Emerging evidence suggests that chronic inflammation and environmental enteric dysfunction may simultaneously impair iron metabolism and linear growth, reinforcing the interrelationship between the two conditions (Victora et al., 2021).

For instance, stunted children are more likely to suffer from anaemia due to cumulative nutritional deprivation and increased susceptibility to infections, while anaemia can contribute to growth faltering by impairing cellular metabolism and immune defence (Onyango et al., 2019; Harding et al., 2018). The dual burden of anaemia and stunting thus represents a vicious cycle with far-reaching implications for child health and national development.

Globally, an estimated 148 million children under five are stunted, while over 40% experience some form of anaemia, with the highest prevalence observed in sub-Saharan Africa (UNICEF/WHO/World Bank, 2021). Despite various interventions, ranging from micronutrient supplementation and food fortification to infection control and maternal health programs, progress has been slow and uneven (WHO, 2020; Keats et al., 2021).

The consequences of the dual burden extend beyond health. Stunted and anaemic children are less likely to achieve optimal educational outcomes, more prone to reduced economic productivity in adulthood, and at greater risk of intergenerational transmission of malnutrition (Gautam et al., 2025).

The Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being), highlight the urgency of addressing malnutrition in all its forms (United Nations, 2015). However, while anaemia and stunting are often studied separately, evidence on their joint distribution, shared risk factors, and spatial clustering remains limited. Such knowledge is critical for designing integrated interventions that maximize health outcomes and resource efficiency (Garrett & Natalicchio, 2011; Osendarp et al., 2021).

This study, therefore, aims to investigate the burden and interrelationship of anaemia and stunting among children under five, with attention to their shared determinants and spatial distribution. Understanding these dynamics will not only strengthen the evidence base for child nutrition policies but also contribute to targeted strategies that address multiple forms of undernutrition simultaneously, ultimately reducing the cycle of poor growth, ill health, and socioeconomic disadvantage.

Data Source

This study utilized secondary data obtained from the Nigeria Demographic and Health Survey (NDHS), a nationally representative household survey conducted by the National Population Commission (NPC) in collaboration with Inner City Fund (ICF), an

international research and consulting organization. These surveys used a stratified two-stage cluster design where the first stage involved selecting clusters from a list of enumeration areas, which served as the primary sampling units. Clusters were selected with a probability proportional to their size. The second stage involved systematic sampling of households from the list of households in each cluster, with an equal number of households selected from the clusters. The selected households were visited and interviewed by trained staff.

Study Variables

The child's haemoglobin (Hb) concentration was measured using a portable HemoCue analyser, and children were considered anaemic if their Hb level is under 11 g/dl after adjusting for altitude, in line with World Health Organization (WHO) recommendations (World Health Organization, 2011). Stunting was assessed using height-for-age measurements, with children classified as stunted if their height-for-age Z-score (HAZ), based on the WHO Child Growth Standards, is below **-2** standard deviations from the reference median (World Health Organization, 2006).

Methods

The shared component model (SCM) was originally proposed by Knorr-Held and Best (2001) to jointly model the spatial variation of rates of several diseases with common risk factors. The SCM allows for the underlying risk surface of the diseases to be decomposed into two: shared and disease-specific variation. The SCM has been used in a wide variety of applications, such as identifying shared spatial patterns among chronic-related preventable hospitalizations (Macharia et al., 2022), for joint spatial modelling of related childhood conditions such as anaemia and malaria across several African countries (Roberts & Zewotir, 2022), and for joint modelling of brain cancer incidence and mortality rates in two regions in the north of Spain (Etxeberria et. al., 2018). Recently, the SCM was used to identify crime-general and crime-specific hotspots in a region in Canada (Law et. al., 2020). The SCM is typically used when interest is in the relative risk of two or more diseases in a particular region, where regional-level covariates can be incorporated in the model. In this case, the response represents the disease counts for the state. In this study, however, we consider the SCM to model the probability, π_{ijk}, of child j residing in district i having anaemia $(k = 1)$ or stunting $(k = 2)$. Thus, we make use of logistic regression models given by

$$logit(\pi_{ij1}) = \alpha_1 + x'_{ij1}\beta_1 + \vartheta u_i + v_{i1}, \quad (1)$$

$$logit(\pi_{ij2}) = \alpha_2 + x'_{ij2}\beta_2 + \frac{u_i}{\vartheta} + v_{i2}, \quad (2)$$

Where $\alpha_k, k = 1, 2$, are the disease specific intercepts; β_k is the vector of regression parameters corresponding to the covariates x'_{ijk} for the k^{th} disease, where such covariates comprise of child-level, household-level and environmental factors; u_i is the disease-general shared spatial component common to both disease; and v_{ik} is the disease-specific spatial component which captures the spatial patterns that deviate from the shared spatial component. Both the shared and specific spatial components were based on all 36 states across Nigeria. The parameter ϑ is referred to as the partitioning weight and allows for a different odds gradient of the shared component.

Note that the weighted shared component and the disease-specific component add up to 100% of the spatial variation for each disease. The advantage of our approach to the SCM is that it enables one to explore the individual and household risk factors for each disease. Thus, such risk factors are well accounted for in the model. Figure 2 presents a schematic representation of the shared component model for this study. The shared component captures the spatial pattern common to both diseases, where ϑ allows each disease to have a unique association with this spatial pattern. A value of ϑ close to one indicates that anaemia and stunting have a similar magnitude of association with the shared spatial pattern, whereas a smaller positive value of ϑ indicates that anaemia has a weaker association with the shared spatial pattern compared to stunting (Law et. al., 2020). It should be noted that estimating a partitioning weight (ϑ) for one disease and assigning the inverse to the second disease improves model identifiability compared to estimating separate partitioning weights for each disease (Knorr-Held et.al., 2001; Law et.al., 2020). In addition, only one parameter needs to be estimated, rather than two. Each of the shared and disease-specific spatial components, u_i and v_{ij}, can be decomposed as follows:

$$u_i = u_{str_i} + u_{unstr_i},$$

$$v_{ij} = v_{str_{ij}} + v_{unstr_{ij}},$$

Where u_{str_i} and $v_{str_{ij}}$ are spatially structured effects and u_{unstr_i} and $v_{unstr_{ij}}$ are the random heterogeneity (spatially unstructured) effects. These spatial effects are due to

unmeasured factors that have not been controlled for in the model, where such factors may be common among neighbouring states (and thus contribute to the structured spatial effect) or specific to a district (and thus contribute to the unstructured spatial effect)

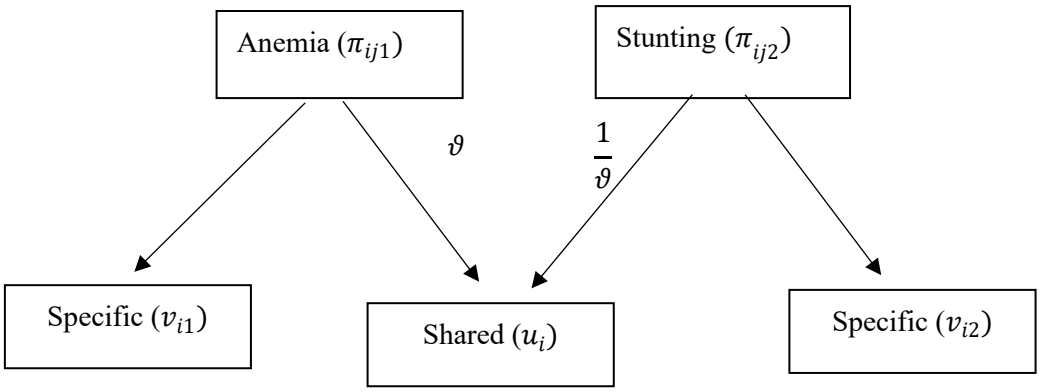


Fig. 1: A schematic diagram of the shared component model

All of the maps created were based on the results of this study and made use of shapefiles freely available from the DHS Program's Spatial Data Repository (https:// spatialdata.dhsprogram.com/ boundaries).

Results

Table 1: Socio-demographic background of the respondents

Characteristics	Frequency (Percentage)
Wealth Index	
Poorest	4,250 (44.45)
Poorer or middle	3,000 (31.37)
Richer or richest	2,312 (24.18)
Place of Residence	
Rural	6,602 (69.04)
Urban	2,960 (30.96)
Child's Gender	
Male	5,154 (53.90)
Female	4,408 (46.10)
Mother's Education	
No education	3,602 (37.67)
Primary	2,008 (21.00)
Secondary	2,060 (21.54)
Higher	1,892 (19.79)

Characteristics	Frequency (Percentage)
Wealth Index	
Toilet facilities	
No	6,501 (67.99)
Yes	3,061 (32.01)
Water source	
Unimproved	5,948 (62.20)
Improved	3,614 (37.80)
Child had a fever in the last 2 weeks.	
No	6,472 (67.68)
Yes	3,090 (32.32)
Child had a cough in the last 2 weeks	
No	7,205 (75.35)
Yes	2,357 (24.65)
Time of antenatal visit	
None	4,268 (44.64)
1-3 times	3,581 (37.45)
4 times and above	1,713 (17.91)
Total	9,562 (100%)

Table 1 presents the frequency distribution of the 9,562 under-five children included in the study. A majority of the children, 6,602 (69.04%), resided in rural areas, and approximately 54% were male. Regarding household wealth status, children from the poorest households constituted the largest proportion, accounting for 4,250 (44.45%), followed by those from poorer or middle-income households with 3,000 (31.37%). Children from richer or richest households represented the smallest group, with 2,312 (24.18%). In terms of mothers' education, the largest proportion of mothers had no formal education (3,602; 37.67%), whereas only about 19% (1,892) attained higher education. Access to basic amenities was limited, as only 37% of households had access to improved drinking water sources and 32% had toilet facilities.

Additionally, 32% of the children experienced fever in the two weeks preceding the survey, while 24% reported cough. Mothers with no antenatal care visits constituted the largest group, followed by those with one to three visits, whereas mothers with four or more visits were the least represented.

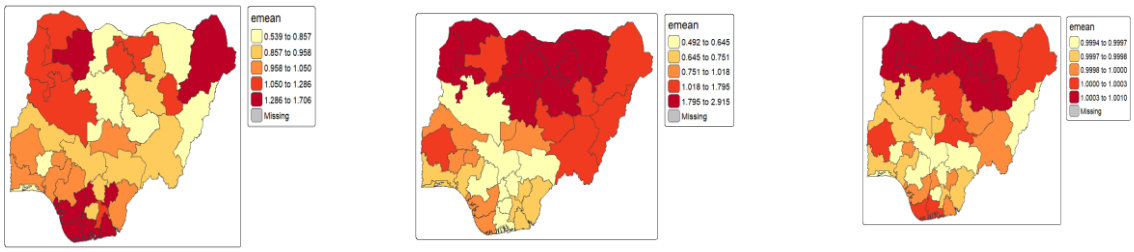
Table 2: The Odds Ratio estimates of the covariate effects and 95% Credible Intervals

Variables	Anaemia		Stunting		Anaemia & Stunting	
	OR	95%CI	OR	95% CI	OR	95% CI
Wealth Index						
Poorest (Ref. Cat.)	1.000		1.000		1.000	
Poorer or Middle	0.824	0.697,0.869	0.934	0.889,1.204	0.910	0.773,0.956
Richer or Richest	0.734	0.624,0.929	0.802	0.846,1.007	0.833	0.715,0.922
Place of Residence						
Rural (Ref. Cat.)	1.000		1.000		1.000	
Urban	0.834	0.859,1.047	0.900	0.944,1.206	0.822	0.754,0.957
Mother's Education						
No Education (Ref. Cat.)	1.000		1.000		1.000	
Primary	0.874	0.793,0.964	0.803	0.703,0.915	0.863	0.754,0.963
Secondary	0.852	0.748,0.972	0.761	0.598,0.719	0.847	0.749,0.957
Higher	0.742	0.654,0.838	0.705	0.566,0.705	0.800	0.733,0.940
Child's Gender						
Male (Ref. Cat.)	1.000		1.000		1.000	
Female	0.879	0.826,0.936	0.977	0.892,1.068	0.899	0.878,0.118
Toilet Facilities						
No (Ref. Cat.)	1.000		1.000		1.000	
Yes	0.989	0.785,0.978	0.990	0.923,1.045	0.972	0.871,0.953
Water Source						
Unimproved (Ref. Cat.)	1.000		1.000		1.000	
Improved	0.961	0.847,0.931	0.864	0.824,1.034	0.942	0.829,0.910
Child had a fever in the last 2 weeks	1.000		1.000		1.000	
No (Ref. Cat.)	1.003	0.933,1.203	0.905	0.923,1.251	0.910	0.802,1.033
Yes						
Child had cough in the last 2 weeks	1.000		1.000		1.000	
No (Ref. Cat.)	0.925	0.831,1.084	0.853	0.816,1.039	1.020	0.868,1.105
Yes						
Time of antenatal visit						
None (Ref. Cat.)	1.000		1.000		1.000	
1-3 times	0.824	0.823,1.034	0.934	0.728,0.934	0.810	0.823,1.138
4 times and above	0.723	0.652,0.946	0.718	0.622,0.843	0.602	0.734,0.973

Table 2 presents the estimated odds ratios for anaemia, stunting, and their shared effect (anaemia and stunting) for the linear covariate effects, along with the corresponding 95% credible intervals. The results indicate that children of mothers with primary, secondary, or higher education had lower odds of being anaemic or stunted compared with those whose mothers had no formal education. Estimates for the household wealth index show a significantly reduced likelihood of stunting and of the shared outcome among children from poorer or middle-income households.

Female children were less likely to be anaemic or stunted than their male counterparts, whereas children residing in rural areas had higher odds of experiencing both anaemia and stunting. Lack of access to toilet facilities was associated with increased odds of stunting. Children who experienced cough in the two weeks preceding the survey were more likely to be stunted but less likely to be anaemic.

Furthermore, compared with mothers who had no antenatal care visits, those who attended one or more visits had lower odds of anaemia and of the combined outcome of anaemia and stunting.



Anemia (part a) Stunting (part b) Shared effects (part c)

Fig 2: Maps of Nigeria showing the specific and shared spatial effects

The posterior estimates of the spatial effects are presented in Figure 1, illustrating the disease-specific spatial patterns for anaemia (part a), stunting (part b), and their shared spatial effects (part c).

For anaemia, the spatial distribution indicates a pronounced concentration of high risk among children in several northern states, notably Borno, Yobe, Bauchi, Kano, Katsina, Jigawa, Sokoto, and Kebbi, as well as in selected Niger Delta states, particularly Rivers and Bayelsa. Moderate anaemia risk is observed across Kaduna, Niger, and Kogi, extending into parts of the South-West, including Oyo, Ogun, and Osun. In contrast, lower anaemia risk is evident in Lagos, Ekiti, Anambra, Imo, Abia, Enugu, and Ebonyi, suggesting relatively favourable conditions in these states.

In the case of stunting, states with elevated risk are predominantly located in northern Nigeria, including Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, and Borno. Children residing in these states exhibit a substantially higher likelihood of stunting compared with the national average. Moderate stunting risk is observed in Bauchi, Gombe, Adamawa, Niger, Kaduna, Plateau, Benue, and Kogi, as well as in parts of the South-East, indicating intermediate levels of vulnerability. Conversely, lower stunting risk is evident across most

southern states, including Lagos, Ogun, Oyo, Osun, Ekiti, Ondo, Anambra, Imo, Abia, Enugu, Bayelsa, Rivers, Akwa Ibom, and Cross River.

The shared spatial effects reveal a clear co-occurrence of high risk for both anaemia and stunting among children in Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, and Borno, highlighting a pronounced joint disease burden in these states. Intermediate levels of co-occurrence are observed in Kaduna, Niger, Bauchi, Gombe, Adamawa, Plateau, Benue, and Kogi, as well as parts of the South-South region. In contrast, the joint burden of anaemia and stunting appears considerably lower in most southern states, including Lagos, Ogun, Oyo, Osun, Ekiti, Ondo, Anambra, Imo, Abia, Enugu, Bayelsa, Rivers, Akwa Ibom, and Cross River.

Discussion

This study provides comprehensive evidence on the dual burden of anaemia and stunting among children under five in Nigeria by examining their shared determinants and spatial distribution using a shared component modelling framework. The findings highlight that anaemia and stunting are not isolated nutritional conditions but are deeply interconnected and shaped by overlapping socioeconomic, maternal, environmental, and geographic factors. The observed patterns underscore persistent inequalities in child health outcomes and emphasize the need for integrated, context-specific public health interventions.

Consistent with previous research, household socioeconomic status emerged as a central determinant of childhood nutritional outcomes. Children from poorer households and those residing in rural areas were more likely to experience stunting and the combined outcome of anaemia and stunting. This aligns with extensive evidence showing that poverty constrains access to adequate food, healthcare, and hygienic living conditions, thereby increasing children's vulnerability to chronic undernutrition (Marume et al., 2025; Addae et al., 2024). The stronger association observed between household wealth and stunting, compared to anaemia alone, reflects the chronic and cumulative nature of growth faltering, which is particularly sensitive to long-term deprivation and food insecurity (Patriota et al., 2024).

In contrast, the weaker association between wealth and anaemia highlights the multifactorial aetiology of anaemia in early childhood. Beyond dietary iron deficiency,

anaemia is influenced by infections such as malaria, helminth infestations, and chronic inflammation, all of which are prevalent in low-resource settings (Kassebaum et al., 2014; Stevens et al., 2022). This complexity reinforces the importance of addressing both nutrition-specific and nutrition-sensitive factors when designing anaemia control programs.

Maternal education consistently demonstrated a strong protective effect against anaemia, stunting, and their joint occurrence. Children born to mothers with primary, secondary, or higher education had significantly lower odds of adverse nutritional outcomes compared to those whose mothers had no formal education. This finding corroborates earlier studies indicating that maternal education improves health knowledge, childcare practices, utilization of preventive health services, and household decision-making power (Smith & Haddad, 2015; Cunningham et al., 2017). Educated mothers are more likely to adopt appropriate infant and young child feeding practices, seek timely healthcare, and maintain hygienic environments, all of which are critical during the first 1,000 days of life, a period that strongly determines both linear growth and micronutrient status (Dewey & Begum, 2011).

Environmental conditions, particularly access to improved water sources and sanitation facilities, were also important determinants, especially for stunting and the joint outcome. Poor water, sanitation, and hygiene (WASH) conditions increase children's exposure to repeated infections and environmental enteric dysfunction, which impair nutrient absorption and contribute to growth faltering and micronutrient deficiencies (Prendergast & Humphrey, 2014; Humphrey et al., 2019). These findings reinforce the growing consensus that nutrition interventions must be integrated with WASH improvements to achieve sustainable reductions in childhood undernutrition.

Maternal health service utilization, as reflected by antenatal care attendance, was another significant protective factor. Children whose mothers attended one or more antenatal care visits had lower odds of anaemia, stunting, and their joint occurrence compared to those whose mothers had no antenatal visits. Antenatal care provides critical opportunities for nutritional counselling, iron and folic acid supplementation, malaria prevention, and early identification of maternal health risks that can affect foetal growth and child health outcomes (World Health Organization, 2016; Keats et al., 2021). These results highlight antenatal care as an essential entry point for interventions aimed at preventing both anaemia and stunting.

The spatial analysis revealed pronounced geographic clustering of anaemia and stunting, with a substantial shared burden concentrated in northern states such as Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, and Borno. These states have long been characterized by high poverty levels, food insecurity, low female education, limited access to healthcare services, and a high burden of infectious diseases, including malaria (National Population Commission & ICF, 2019; World Bank, 2020). The presence of a strong shared spatial pattern suggests that anaemia and stunting are driven by common contextual and structural factors in these regions, reinforcing the argument that addressing these conditions separately may lead to fragmented and less effective interventions.

In contrast, most southern states exhibited a lower joint burden of anaemia and stunting, reflecting relatively better socioeconomic conditions, higher maternal education levels, improved infrastructure, and greater access to health and nutrition services. However, the presence of intermediate shared risk in parts of the North-Central and South-South regions indicates that vulnerability to the dual burden extends beyond the traditionally high-risk northern zones. This finding underscores the importance of subnational analyses and geographically targeted interventions that account for local contexts rather than relying solely on national averages.

Methodologically, the use of the shared component model represents a key strength of this study. By jointly modelling anaemia and stunting, the approach allows for the decomposition of spatial variation into shared and disease-specific components while simultaneously accounting for individual- and household-level covariates. This framework has been successfully applied in previous studies examining co-occurring health outcomes and provides valuable insights into common underlying risk structures (Orunmoluyi et al., 2022; Agasa et al., 2024; Law et al., 2020). The findings from this approach offer strong empirical support for integrated policy responses to childhood undernutrition.

Conclusion

The coexistence of anaemia and stunting among children in Nigeria calls for a strategic shift toward coordinated and equity-oriented policies that deliberately target the most vulnerable populations and high-burden regions. Addressing this dual burden is essential not only for enhancing child survival, growth, and cognitive development but also for disrupting the intergenerational transmission of undernutrition and strengthening long-

term human capital formation and national development. The findings highlight an urgent need for multisectoral, integrated, and spatially targeted interventions that concurrently tackle poverty alleviation, female education, access to quality maternal health services, food and nutrition security, improvements in water, sanitation, and hygiene (WASH), as well as effective prevention and control of childhood infections.

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