



Preventing Childhood Stunting Through Integrated Life-Course Intervention Models: A Scoping Review

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ABSTRACT

Childhood stunting remains a major global public health challenge associated with chronic growth restriction beginning during pregnancy and continuing through early childhood. Its determinants include maternal nutrition, fetal growth, feeding practices, infections, caregiving, household resources, and environmental conditions. This scoping review aimed to map intervention models, delivery platforms, implementation approaches, and evidence gaps in stunting prevention across the life course, emphasizing intervention timing. The review followed established scoping review methodology and the PRISMA-ScR reporting guidelines. Literature was identified through PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library, supplemented by relevant World Health Organization reports. Eligibility criteria followed the Population Concept Context framework, focusing on children under five years, particularly during the first 1,000 days, and interventions targeting linear growth in vulnerable populations. Data were charted by intervention type, timing, delivery platform, outcomes, and implementation factors, then synthesized narratively. Twenty-nine sources met the inclusion criteria. Interventions included maternal nutrition, breastfeeding support, complementary feeding, fortified foods, water, sanitation and hygiene, social protection, and early childhood development. The evidence revealed substantial variation in intervention timing, delivery platforms, implementation strategies, and growth-related outcomes. Effectiveness appeared to depend on implementation quality, caregiver engagement, intervention intensity, and health-system and community support. The findings support coordinated nutrition-specific and nutrition-sensitive interventions beginning during pregnancy and continuing throughout the first 1,000 days. Future research should prioritize integrated delivery models, context-specific implementation strategies, and longitudinal evaluations to strengthen evidence on sustainable stunting prevention.

Keywords: Childhood Stunting, Linear Growth, Maternal Nutrition, Complementary Feeding, Nutrition-Sensitive Interventions.

ABSTRAK

Stunting pada anak masih menjadi tantangan utama kesehatan masyarakat global yang berkaitan dengan gangguan pertumbuhan kronis sejak masa kehamilan hingga anak usia dini. Faktor yang memengaruhinya meliputi gizi ibu, pertumbuhan janin, praktik pemberian makan, infeksi, pengasuhan, sumber daya rumah tangga, serta kondisi lingkungan. Scoping review ini bertujuan memetakan model intervensi, platform pelaksanaan, pendekatan implementasi, dan kesenjangan bukti dalam pencegahan stunting sepanjang siklus kehidupan, dengan penekanan pada waktu pelaksanaan intervensi. Tinjauan dilakukan berdasarkan metodologi scoping review dan pedoman pelaporan PRISMA-ScR. Literatur diidentifikasi melalui PubMed/MEDLINE, Scopus, Web of Science, dan Cochrane Library, serta dilengkapi laporan World Health Organization yang relevan. Kriteria kelayakan menggunakan kerangka Population-Concept-Context, dengan fokus pada anak berusia di bawah lima tahun, khususnya selama 1.000 hari pertama kehidupan, serta intervensi yang mendukung pertumbuhan linier pada populasi rentan. Data dipetakan berdasarkan jenis intervensi, waktu pelaksanaan, platform penyampaian, luaran, dan faktor implementasi, kemudian disintesis secara naratif. Sebanyak 29 sumber memenuhi kriteria inklusi. Intervensi mencakup perbaikan gizi ibu, dukungan menyusui, makanan pendamping ASI, pangan fortifikasi, air, sanitasi dan higiene, perlindungan sosial, serta pengembangan anak usia dini. Bukti menunjukkan variasi dalam waktu intervensi, platform pelaksanaan, strategi implementasi, dan luaran pertumbuhan. Efektivitas dipengaruhi kualitas implementasi, keterlibatan pengasuh, intensitas intervensi, serta dukungan sistem kesehatan dan masyarakat. Temuan ini mendukung intervensi gizi spesifik dan sensitif gizi secara terpadu sejak kehamilan hingga 1.000 hari pertama kehidupan. Penelitian selanjutnya perlu memprioritaskan model terpadu, strategi kontekstual, dan evaluasi longitudinal untuk memperkuat bukti pencegahan stunting berkelanjutan.

Kata Kunci: Stunting pada Anak, Pertumbuhan Linear, Gizi Ibu, Pemberian Makanan Pendamping, Intervensi yang Sensitif terhadap Gizi.

INTRODUCTION

Childhood stunting remains a persistent form of early-life growth failure and a major public health concern in low- and middle-income countries. It is defined as a height-for-age z-score more than two standard deviations below the median of the World Health Organization Child Growth Standards (de Onis & Branca, 2016; World Health Organization, 2023). Despite global progress, the burden remains high, with 150.2 million children under five stunted in 2024, alongside 42.8 million wasted and 35.5 million overweight (UNICEF, World Health Organization, & World Bank Group, 2025). These figures highlight the coexistence of multiple forms of malnutrition and reflect persistent inequalities in food systems, household resources, health services, and caregiving environments (FAO, 2025).

Stunting is not merely an anthropometric condition but a marker of cumulative biological and social adversity beginning before birth and continuing through early childhood (Black et al., 2013; de Onis & Branca, 2016). The first 1,000 days from conception to a child's second birthday are critical, as key processes such as fetal growth, breastfeeding, complementary feeding, immune development, infection exposure, and caregiver interaction are concentrated during this period (Black et al., 2013; Christian et al., 2013). Stunting is associated with poorer developmental outcomes, reduced educational attainment, lower adult productivity, and long-term health consequences (de Onis & Branca, 2016; Victora et al., 2016). Therefore, preventing stunting is not only a nutrition priority but also an investment in human capital, social equity, and population health.

Preventing childhood stunting requires more than a single intervention, as linear growth is shaped by multiple interacting pathways. These include maternal nutrition, fetal growth, infant and young-child feeding, infection exposure, environmental hygiene, caregiving quality, household food security, women's agency, social protection, and broader structural conditions (Black et al., 2013; Prendergast & Humphrey, 2014; Ruel & Alderman, 2013). Even when nutrition counselling is provided, growth faltering may persist if households lack access to nutritious foods, if infections impair nutrient absorption, or if caregivers face constraints in applying recommended practices (Keats et al., 2021).

This complexity explains why interventions may yield different outcomes across settings. Nutrition-specific strategies such as maternal supplementation, breastfeeding support, complementary feeding counselling, fortified foods, and lipid-based nutrient supplements can improve growth-related pathways, but their effectiveness depends on timing, adherence, supply reliability, baseline risk, and household food access (Bhutta et al., 2013; Keats et al., 2021). Similarly, WASH interventions have strong biological justification, yet large trials show inconsistent effects on stunting when environmental exposure reduction is insufficient (Checkley et al., 2008; Cumming et al., 2019; Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018). Thus, the key challenge lies in understanding how interventions interact across life stages, delivery platforms, and implementation contexts.

Evidence supports several intervention areas relevant to stunting prevention. Maternal nutrition and antenatal care are critical, as fetal growth restriction and preterm birth are linked to later undernutrition (Christian et al., 2013; Mridha et al., 2016). Breastfeeding promotion and support are also essential for child survival and development, with recommendations emphasizing early initiation, exclusive breastfeeding for six months, and continued breastfeeding alongside complementary feeding (Rollins et al., 2016; Victora et al., 2016; World Health Organization, 2023).

Complementary feeding is another key pathway, as children aged 6-23 months require safe, diverse, and nutrient-dense foods (World Health Organization, 2023). Education can improve feeding practices, while stronger growth outcomes are observed when counselling is combined with food provision or fortified products (Adu-Afarwuah et al., 2007; Dewey & Adu-Afarwuah, 2008). Nutrition-sensitive approaches, including agriculture, social protection, and women's empowerment, can improve enabling conditions such as food security and service access, although their effects on growth are often indirect and context-dependent (Iannotti et al., 2017; Olney et al., 2015; Ruel & Alderman, 2013).

Early childhood development interventions further contribute by enhancing caregiver interaction and developmental outcomes, though they cannot replace adequate nutrition or infection control (Attanasio et al., 2014; Yousafzai et al., 2014). Overall, while evidence supports

multiple intervention domains, it remains fragmented across sectors. This limits understanding of how interventions can be integrated across life stages and delivery systems, creating a gap in designing coordinated, scalable, and context-sensitive stunting prevention strategies.

Prior evidence syntheses have often focused on bounded questions, such as predictors among children aged 0-24 months in Southeast Asia, or on individual domains including complementary feeding, WASH, maternal nutrition, and empowerment (Dewey & Adu-Afarwah, 2008; Ruel & Alderman, 2013; Togatorop et al., 2024). Rather than claiming to be the first review of stunting prevention, this review addresses a different gap: the absence of a cross-domain map showing how intervention models align simultaneously across life-course timing, delivery platform, and implementation pathway. Its distinct contribution is an implementation-oriented synthesis that links maternal, infant, household, community, and system-level components and presents these relationships in a life-course evidence map and two author-generated conceptual frameworks. This scoping review aims to map intervention models for preventing childhood stunting by examining life-course timing, delivery pathways, evidence patterns, implementation gaps, and future research priorities.

RESEARCH METHODS

This study was conducted as a scoping review to map the breadth of evidence on childhood stunting prevention, identify key intervention models, describe implementation pathways, and highlight evidence gaps rather than estimate pooled effects. Scoping reviews are suitable for broad and complex fields because they allow examination of how evidence is distributed across populations, concepts, contexts, methods, and outcomes (Arksey & O'Malley, 2005; Levac et al., 2010). In this review, childhood stunting prevention was conceptualized as a multidimensional field involving diverse interventions implemented across the life course. The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) to promote transparency in the identification, selection, charting, and synthesis of evidence (Tricco et al., 2018).

The methodological approach was primarily guided by the framework proposed by Arksey and O'Malley, which comprises identifying the research question, identifying relevant studies, selecting studies, charting the data, and collating, summarizing, and reporting the results (Arksey & O'Malley, 2005). Methodological refinements proposed by Levac et al. were incorporated, particularly the need to clarify the purpose and scope of the review, apply an iterative approach to study selection and data charting, and provide meaningful analytical interpretation of the mapped evidence (Levac et al., 2010). The review also followed current JBI guidance for scoping reviews, including the use of the Population–Concept–Context (PCC) framework to define eligibility criteria and organize the scope of the review (Peters et al., 2024). Reporting was conducted according to PRISMA-ScR, which provides specific recommendations for transparent reporting of search, selection, data-charting, and synthesis procedures in scoping reviews (Tricco et al., 2018).

The eligibility criteria were developed using the PCC framework. The population of interest comprised children under five years of age, with particular emphasis on the first 1,000 days of life, from conception to 24 months. Studies addressing maternal, adolescent, antenatal, or fetal-growth antecedents were also considered eligible when they were relevant to the prevention of childhood stunting or subsequent linear growth failure. The central concept was intervention models for the prevention of childhood stunting or linear growth failure, including nutrition-specific interventions, nutrition-sensitive interventions, integrated delivery models, and implementation pathways. Eligible interventions included, but were not limited to, maternal nutrition, antenatal supplementation, breastfeeding protection and support, complementary feeding counselling, responsive feeding, fortified foods, lipid-based nutrient supplements, water, sanitation and hygiene (WASH), sanitation, hygiene, social protection, agriculture, food-system approaches, early childhood development, responsive stimulation, and community-based delivery models.

The contextual scope focused primarily on low- and middle-income countries and settings where childhood stunting, food insecurity, infectious disease exposure, poor environmental conditions, and health-system constraints were highly relevant. Studies conducted in other settings were considered when they provided transferable conceptual, methodological, or implementation insights relevant to stunting prevention. To capture the complexity and diversity

of evidence on stunting prevention, the review considered multiple types of sources, including randomized controlled trials, cluster-randomized trials, quasi-experimental studies, systematic reviews, scoping reviews, implementation studies, global guidelines, policy documents, and key reports from international organizations. Sources were eligible when they addressed intervention models, delivery platforms, implementation pathways, measured outcomes, or evidence gaps related to childhood stunting prevention.

The formal literature search was conducted in four major electronic databases: PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library. Additional searching included relevant global nutrition and child-health guidance and reports from the World Health Organization. The final database search was conducted on March 1, 2026. A preliminary Boolean search strategy was developed to identify evidence related to childhood stunting prevention, linear growth, intervention models, and major nutrition-specific and nutrition-sensitive pathways. The core search strategy was: (stunting OR “linear growth” OR “height-for-age” OR HAZ) AND (child OR infant* OR toddler* OR “under five” OR “under-5”) AND (prevent* OR intervention* OR program* OR trial OR “implementation model”) AND (“maternal nutrition” OR breastfeeding OR “complementary feeding” OR egg* OR “lipid-based nutrient supplement*” OR micronutrient* OR WASH OR sanitation OR hygiene OR “cash transfer” OR agriculture OR “early childhood development” OR “responsive stimulation”)*. The search strategy was adapted for each database according to its indexing system, search fields, controlled vocabulary, and syntax.

All records identified through the database searches were exported to reference management software, and duplicate records were removed before screening. Study selection was subsequently conducted in two stages. First, titles and abstracts were screened against the predefined eligibility criteria. Second, potentially eligible studies underwent full-text assessment. Title and abstract screening and full-text assessment were conducted independently and in duplicate by HVR and SW. Disagreements were resolved through discussion, and unresolved decisions were adjudicated by a third reviewer (MM). Reasons for exclusion during full-text assessment were documented. The overall selection process was presented using a PRISMA-ScR flow diagram, including the numbers of records identified, duplicates removed, records screened, reports assessed for eligibility, and sources included in the final review (Tricco et al., 2018).

Data from the included sources were charted using a structured data-extraction form developed according to the review questions and refined iteratively during the early stages of extraction, consistent with established scoping review methodology (Levac et al., 2010; Peters et al., 2024). Extracted information included author and publication year, country or region, study design, population and age group, intervention model, life-course window, delivery platform, key intervention components, comparator or control condition, outcomes measured, growth-related findings, implementation barriers, equity considerations, and key interpretations. The data-charting process focused not only on whether an intervention was associated with improved outcomes, but also on how interventions were designed, delivered, measured, and interpreted. This broader approach was considered important because the prevention of stunting may depend on intervention timing, coverage, implementation fidelity, adherence, supply reliability, caregiver behaviour, exposure reduction, and wider enabling conditions.

The findings were synthesized narratively and thematically rather than quantitatively. Evidence was organized according to life-course window, intervention model, delivery platform, hypothesized pathway, reported outcome pattern, implementation factor, and policy relevance. The synthesis characterized the included sources and mapped evidence related to maternal nutrition, breastfeeding support, complementary feeding, nutrient-dense foods and fortified products, WASH, social protection, agriculture, and early childhood development. Following data charting, recurrent intervention components, delivery platforms, implementation factors, and outcome pathways were identified and grouped across sources. Figures 2 and 3 were developed as original, author-generated conceptual displays representing the mapped categories; they were not reproduced or adapted from a single published framework and were not statistically validated. Cross-cutting implementation factors identified across the evidence included targeting, contact frequency, counselling quality, supply-chain reliability, environmental exposure reduction, equity, and measurement needs.

Formal critical appraisal was intentionally not undertaken because the primary objective of the review was to map the breadth and characteristics of heterogeneous evidence rather than estimate pooled intervention effects or assess the certainty of evidence. Accordingly, the identified evidence patterns were not used to rank comparative intervention effectiveness. A separate a priori protocol was not developed or registered because the review was initially conceived as an exploratory evidence-mapping exercise. Nevertheless, the eligibility criteria, search procedures, study-selection process, and data-charting approach are explicitly reported in this Methods section to facilitate transparency and reproducibility.

RESULTS

The formal database search was reported using a PRISMA-ScR flow diagram (Figure 1). The search identified 7,050 records from PubMed/MEDLINE, Scopus, Web of Science, the Cochrane Library, and WHO sources. After removing 2,368 duplicate records and 17 records for other reasons, 4,665 records were screened by title and abstract. Of these, 4,540 records were excluded because they did not meet the eligibility criteria. A total of 125 reports were sought for retrieval, and 4 reports could not be retrieved. The remaining 121 full-text reports were assessed for eligibility. After full-text assessment, 92 reports were excluded for reasons including wrong population or age group, lack of focus on stunting prevention or linear growth failure, absence of a relevant intervention model or implementation pathway, unsuitable setting, lack of extractable intervention evidence, duplicate or overlapping reports, and insufficient information on outcomes, delivery platform, or implementation process. Finally, 29 studies were included in the scoping review.

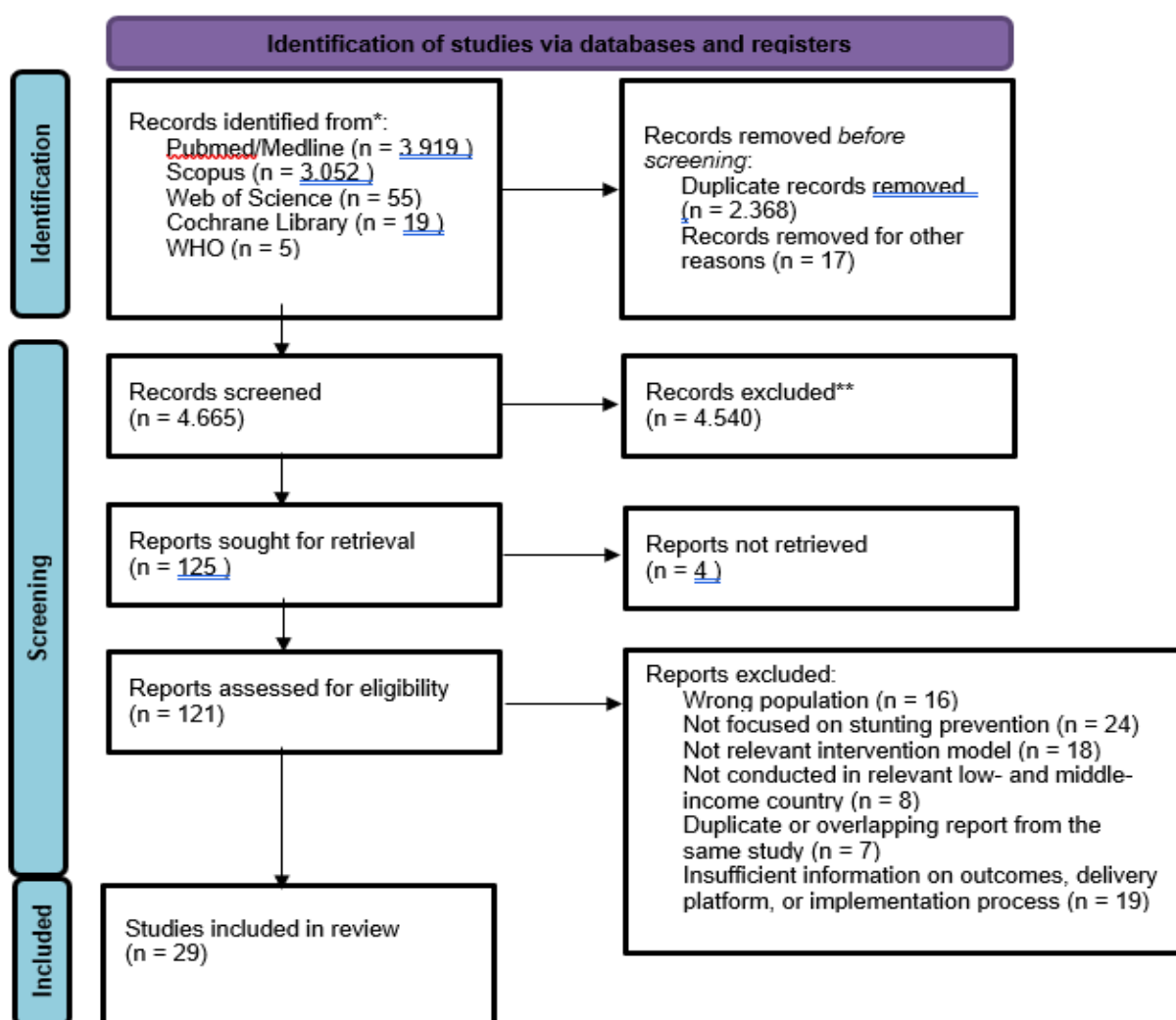


Figure 1. PRISMA.

Characteristics of Included Sources

The studies included landmark randomized and cluster-randomized trials, systematic reviews, major global reviews, and authoritative guidance relevant to childhood stunting prevention. The sources covered several low- and middle-income settings, including Bangladesh, Kenya, Zimbabwe, Ecuador, Ghana, Malawi, Pakistan, Colombia, Burkina Faso, Mali, and India. The population focus was children under five years of age, with particular attention to the first 1,000 days, including pregnancy, infancy, and the complementary feeding period.

The intervention models identified across the evidence base included maternal and adolescent nutrition, antenatal supplementation, breastfeeding protection and support, complementary feeding counselling, responsive feeding, nutrient-dense foods, fortified complementary foods, lipid-based nutrient supplements, WASH, sanitation, hygiene, agriculture-nutrition programmes, social protection, early childhood development, responsive stimulation, and community-based delivery models. Delivery platforms included antenatal care, primary health care, maternity services, community health workers, home visits, caregiver groups, agriculture extension systems, conditional cash transfer platforms, and household or community WASH programmes.

Evidence Map of Intervention Models

The 29 included sources were grouped into seven intervention-model categories: maternal and adolescent nutrition; breastfeeding protection and support; complementary feeding and responsive feeding; nutrient-dense foods and fortified products; integrated WASH-nutrition; nutrition-sensitive social protection and agriculture; and integrated nurturing care and early childhood development. These categories spanned pregnancy, early infancy, the 6-23-month complementary-feeding period, and household, community, and system-level delivery platforms (Christian et al., 2013; Dewey & Adu-Afarwuah, 2008; Ruel & Alderman, 2013).

Table 1 presents the mapped life-course window, delivery platform, reported outcome pattern, and implementation factors for each intervention-model category. Timing, delivery platform, and implementation factors were charted as characteristics of the included evidence and are interpreted in the Discussion.

Table 1. Concise evidence map of intervention models for preventing childhood stunting.

Intervention model	Life course window and delivery platform	Mapped evidence pattern	Implementation factors	References
Maternal and adolescent nutrition	Preconception to birth; antenatal, community, and social-protection platforms.	Birthweight, gestational age, fetal growth, and later undernutrition.	Baseline maternal nutrition; antenatal-care coverage; food security; supplement adherence.	(Christian et al., 2013; Haider & Bhutta, 2017; Mridha; et al., 2016)
Breastfeeding protection and support	Birth to 24 months; maternity, primary-care, and community platforms.	Breastfeeding initiation, exclusivity, continuation, illness, and early nutrition.	Skilled support; maternity protection; family support; continuity of contact.	(Rollins et al., 2016; Victora et al., 2016; World Health, 2023)
Complementary and responsive feeding	6-23 months; community health workers, caregiver groups, home visits, and growth-	Feeding practices and variable height-for-age or stunting outcomes.	Food access; contact frequency; practical skills; counselling fidelity.	(Dewey & Adu-Afarwuah, 2008; Imdad et al., 2011; Lassi et al.,

	monitoring contacts.			2013)
Nutrient-dense and fortified foods	6-23 months; household, community, and health-service platforms.	Nutrient intake and selected growth or developmental outcomes.	Acceptability; affordability; adherence; food safety; supply reliability.	(Adu-Afarwuah et al., 2007; Dewey, 2016; Iannotti; et al., 2017)
Integrated WASH-nutrition	Household and community water, sanitation, hygiene, and feeding platforms.	Mixed linear-growth findings; nutrition arms generally showed clearer growth signals.	Exposure reduction; sanitation coverage; food hygiene; animal feces; sustained uptake.	(Cumming et al., 2019; Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018)
Social protection and agriculture	Household and system platforms, including cash or food transfers and agriculture-nutrition programmes.	Food security, diet diversity, anaemia, wasting, diarrhoea, and heterogeneous direct growth findings.	Explicit nutrition pathway; women's agency and time; market and supply conditions.	(Olney et al., 2015; Ruel & Alderman, 2013)
Nurturing care and early childhood development	Early childhood; home visits, community health workers, and social-protection platforms.	Developmental outcomes; generally modest direct linear-growth effects.	Nutrition intensity; caregiver contact; service integration.	(Attanasio et al., 2014; Yousafzai et al., 2014)

Key Intervention Studies

Table 2 summarizes the design, population, and growth-related findings of key included intervention studies. In WASH Benefits Bangladesh, WASH Benefits Kenya, and SHINE Zimbabwe, nutrition arms generally reported clearer linear-growth signals than the evaluated household-level WASH arms, while combined arms did not eliminate growth faltering (Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018).

Food-based and fortified-food studies reported improvements in nutrient intake and selected growth or developmental outcomes in their trial settings (Adu-Afarwuah et al., 2007; Iannotti; et al., 2017). Maternal supplementation trials in Bangladesh and Malawi reported effects on newborn size or stunting that varied by outcome and setting (Ashorn et al., 2015; Mridha; et al., 2016).

Early childhood development trials reported improvements in developmental outcomes, while agriculture-nutrition and sanitation trials reported changes in food-security, morbidity, sanitation, or selected growth-related outcomes (Attanasio et al., 2014; Olney et al., 2015; Pickering et al., 2015; Yousafzai et al., 2014). Model-level implications from these studies are addressed in Section 4.

Table 2. Characteristics and growth-related findings of key included intervention studies.

Study or model	Design and intervention	Population/ context	Reported growth-related findings	Reference
WASH Benefits Bangladesh	Cluster-randomized trial of water,	Rural Bangladesh; children in early	Nutrition arms improved growth indicators; WASH arms provided	(Luby et al., 2018)

	sanitation, handwashing, nutrition, and combined arms.	life.	limited additional linear-growth effect.	
WASH Benefits Kenya	Cluster-randomized trial of WASH, nutrition, and combined arms.	Rural Kenya; young children.	Nutrition arms improved child growth; WASH-arm growth effects were weaker or inconsistent.	(Null et al., 2018)
Zimbabwe SHINE	Cluster-randomized factorial trial of improved WASH and infant and young-child feeding.	Rural Zimbabwe; pregnant women and infants.	Complementary feeding affected growth more clearly than WASH; combined effects did not eliminate stunting.	(Humphrey et al., 2019)
Ecuador egg trial	Randomized trial of daily egg introduction during complementary feeding.	Infants aged 6-9 months at enrolment.	Daily eggs improved linear-growth outcomes and reduced stunting in the trial context.	(Iannotti; et al., 2017)
Ghana home-fortification trial	Randomized comparison of micronutrient and fortified complementary-food strategies.	Infants receiving complementary foods.	Fortification improved nutrient intake and selected growth or developmental outcomes.	(Adu-Afarwuah et al., 2007)
Bangladesh prenatal/lactation LNS	Cluster-randomized effectiveness trial of lipid-based nutrient supplements.	Pregnant and lactating women and newborns.	Prenatal/lactation LNS reduced newborn stunting and improved birth-related growth indicators.	(Mridha; et al., 2016)
Malawi iLiNS-DYAD	Randomized trial of lipid-based nutrient supplements during pregnancy.	Pregnant women and newborns in rural Malawi.	Effects on newborn size varied by outcome and context.	(Ashorn et al., 2015)
Pakistan stimulation plus nutrition	Cluster-randomized factorial trial delivered through Lady Health Workers.	Young children and caregivers.	Responsive stimulation improved development; nutrition-related growth effects were more modest.	(Yousafzai et al., 2014)
Colombia ECD via cash-transfer platform	Cluster-randomized home-visiting trial using cash-transfer infrastructure.	Disadvantaged young children.	Home visiting improved early-childhood-development outcomes.	(Attanasio et al., 2014)
Burkina Faso agriculture-	Cluster-randomized	Women and young children.	The intervention reduced anaemia,	(Olney et al., 2015)

nutrition	agriculture, nutrition, and health behaviour-change intervention.		wasting, and diarrhoea.	
Mali CLTS sanitation	Cluster-randomized community-led sanitation intervention.	Rural Mali communities.	Sanitation-related behaviours improved; growth findings were context-specific.	(Pickering et al., 2015)
India sanitation trials	Cluster-randomized rural sanitation programmes.	Rural India.	Programmes did not consistently reduce child malnutrition.	(Clasen et al., 2014; Patil et al., 2014)

Thematic Synthesis

Maternal and Fetal-Growth Pathway

The maternal and fetal-growth pathway was the earliest life-course category in the map. Multi-country analyses linked small-for-gestational-age birth and preterm birth with later childhood undernutrition, while broader maternal and child nutrition evidence identified maternal nutritional status, adolescent nutrition, diet quality, infection exposure, and antenatal care as relevant antecedents (Bhutta et al., 2013; Black et al., 2013; Christian et al., 2013). Trials of lipid-based nutrient supplements during pregnancy reported setting-specific birth outcomes. The Bangladesh trial reported reduced newborn stunting, whereas the Malawi trial reported effects on newborn size that varied by outcome (Ashorn et al., 2015; Mridha; et al., 2016).

Breastfeeding and Early Postnatal Protection

Breastfeeding was identified as a protection-and-support model rather than a single behaviour-change message. Early initiation, exclusive breastfeeding for the first six months, and continued breastfeeding with complementary foods to two years or beyond are central to infant and young-child feeding guidance (World Health, 2023). Breastfeeding contributes to survival, immune protection, development, and early dietary security, although its effect on linear growth may be indirect through morbidity reduction and the protection of feeding adequacy (Victora et al., 2016).

Included breastfeeding sources described multi-level support components, including maternity protection, baby-friendly facility practices, skilled lactation support, protection from inappropriate commercial influence, family support, and repeated community or health-system contact (Rollins et al., 2016).

Complementary Feeding, Nutrient Density, and Responsive Care

The 6-23-month period was the central child-directed window for preventing growth faltering. During this period, breastmilk alone is no longer sufficient to meet all nutrient and energy needs, and children require safe, diverse, frequent, and nutrient-dense foods. Complementary feeding interventions can improve feeding practices, and their effects on growth tend to be stronger when education is paired with food provision, fortified products, or other nutrient inputs (Dewey & Adu-Afarwuah, 2008; Imdad et al., 2011; Lassi et al., 2013).

The Ecuador egg trial reported improved linear-growth outcomes and reduced stunting in the trial context (Iannotti; et al., 2017). The Ghana home-fortification trial reported improved nutrient intake and selected growth or developmental outcomes (Adu-Afarwuah et al., 2007). Complementary-feeding reviews mapped nutrient density, food quality, and dietary diversity as relevant intervention components (Dewey, 2016; Stewart et al., 2013).

Responsive feeding and caregiving were mapped as components connecting feeding practices, caregiver-child interaction, and development. Integrated responsive-stimulation and nutrition programmes reported stronger developmental than linear-growth effects (Yousafzai et al., 2014).

WASH, Enteric Infection, and Environmental Exposure

WASH sources reported a strong biological pathway linking diarrhoea, environmental enteric dysfunction, pathogen exposure, and linear growth (Checkley et al., 2008; Prendergast & Humphrey, 2014). However, large trials in Bangladesh, Kenya, and Zimbabwe did not consistently report reductions in stunting from the evaluated household-level WASH packages; nutrition arms generally reported clearer growth signals (Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018).

The mapped WASH components included community sanitation coverage, contamination of play and food environments, animal feces management, water recontamination, food hygiene, and sustained behaviour change (Cumming et al., 2019). Sanitation trials in Mali and India reported that uptake, coverage, and exposure reduction varied across settings (Clasen et al., 2014; Patil et al., 2014; Pickering et al., 2015). The interpretation of these findings is presented in Section 4.3.

Nutrition-Sensitive Platforms

Nutrition-sensitive platforms included social protection, agriculture, food systems, cash or food transfers, women's empowerment, community delivery systems, and health-service linkage. Reported outcomes included food security, household purchasing power, dietary diversity, women's control over resources, caregiving capacity, and service access (Ruel & Alderman, 2013).

The Burkina Faso agriculture-nutrition trial reported reductions in anaemia, wasting, and diarrhoea and changes in diet-related pathways (Olney et al., 2015). The Colombia early-childhood-development trial used conditional cash-transfer infrastructure to deliver home visits and reported improved developmental outcomes among disadvantaged children (Attanasio et al., 2014).

Life-Course Evidence Map

Table 3 maps intervention models and core measures across pregnancy, 0-5 months, 6-23 months, the household or community environment, and system-level delivery platforms.

The charted measures included birthweight, gestational age, maternal anaemia, breastfeeding indicators, dietary diversity, meal frequency, nutrient density, adherence, height-for-age z-score, stunting prevalence, morbidity, environmental exposure, sanitation coverage, fidelity, coverage, equity, and supply reliability. Policy and practice implications are discussed in Section 4.4.

Table 3. Life-course evidence map of intervention models and measures .

Life-course window	Mapped intervention models	Core measures	References
Pregnancy	Maternal nutrition; antenatal care; infection prevention; micronutrient or balanced energy-protein support; food-security support.	Birthweight; gestational age; maternal BMI and anaemia; dietary diversity; antenatal contacts; fetal-growth indicators.	(Ashorn et al., 2015; Christian et al., 2013; Mridha; et al., 2016)
0-5 months	Early initiation and exclusive breastfeeding; skilled lactation support; facility and community follow-up.	Initiation and exclusivity; illness episodes; support quality; counselling contact; service continuity.	(Rollins et al., 2016; Victora et al., 2016; World Health, 2023)
6-23 months	Diet diversity and meal frequency; responsive feeding; animal-source or fortified foods;	Diet diversity; meal frequency; nutrient density; adherence; HAZ; growth velocity; stunting	(Dewey, 2016; Dewey & Adu-Afarwuah, 2008; Iannotti; et al.,

	micronutrient powders; small-quantity LNS.	prevalence.	2017; Stewart et al., 2013)
Household/community environment	WASH; safe play; sanitation coverage; animal-feces management; food hygiene; environmental-exposure reduction.	Diarrhoea; pathogen exposure; environmental contamination; sanitation coverage; food hygiene; water recontamination.	(Checkley et al., 2008; Cumming et al., 2019; Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018)
System/platform	Community health workers; primary care; agriculture extension; social protection; food systems; home visiting.	Coverage; fidelity; contact frequency; supervision; stockouts; referral; equity; caregiver workload.	(Attanasio et al., 2014; Olney et al., 2015; Ruel & Alderman, 2013; Yousafzai et al., 2014)

Integrated Intervention Model

Figure 2 (author-generated from the included studies) presents the authors' conceptual integration of the intervention domains mapped from the included sources. Linear-growth protection from conception to 24 months is positioned at the centre, surrounded by maternal nutrition, breastfeeding and infant and young-child feeding, complementary foods, WASH and infection control, and social protection and delivery systems. The figure is a descriptive synthesis of charted categories, not a validated causal model.

The figure emphasizes that effective models combine early timing, nutrient adequacy, infection control, caregiver support, and reliable delivery. Maternal nutrition supports fetal growth and birth outcomes. Breastfeeding and complementary feeding protect early nutrition and dietary adequacy. WASH and infection control reduce environmental and enteric exposure. Social protection and delivery systems provide the enabling infrastructure needed to reach vulnerable households, maintain supply, support caregivers, and sustain intervention quality.

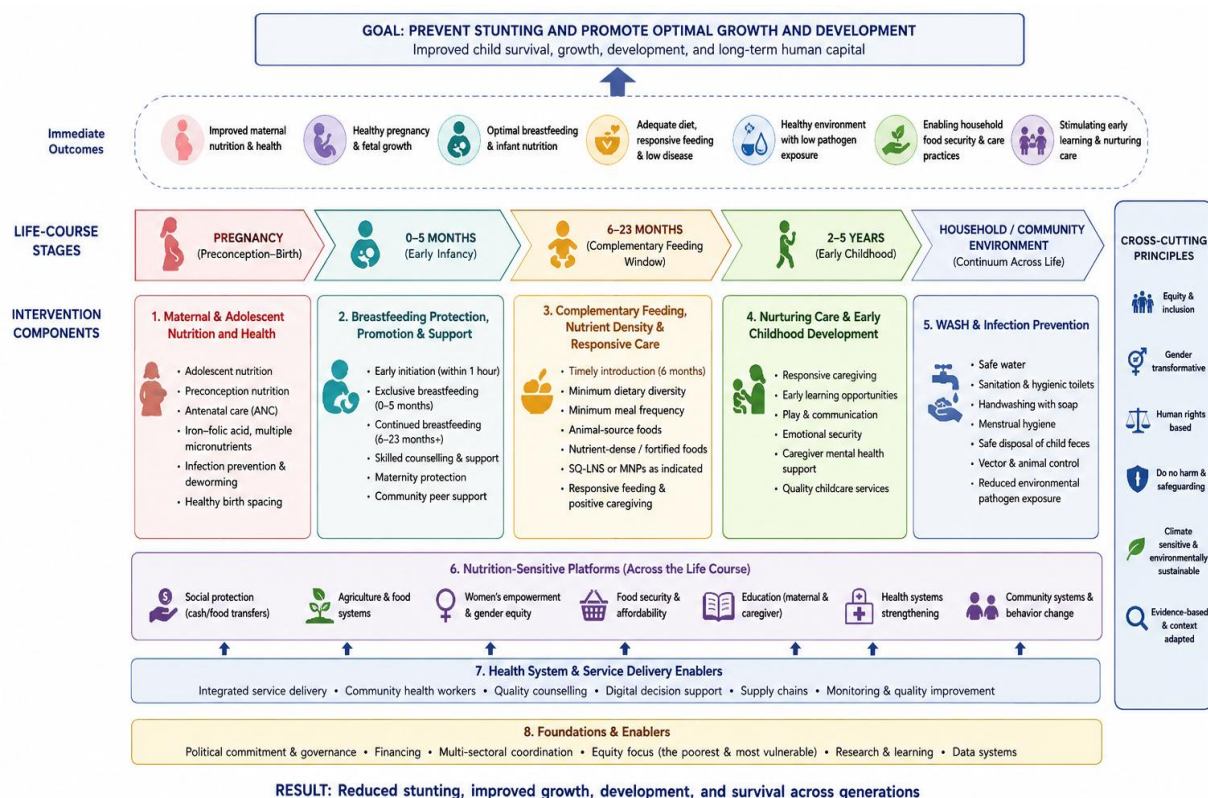


Figure 2. Integrated intervention model for childhood stunting prevention.

Implementation Pathway

Figure 3 (author-generated from the included studies) presents the authors' conceptual pathway linking risk identification, intervention inputs, caregiver or household practices, biological and environmental mechanisms, and growth outcomes. It was derived from the intervention components, implementation factors, pathways, and outcomes charted across the included sources and should be interpreted as a synthesis framework rather than a tested causal sequence.

The figure also shows four layers that must be considered together. Nutrition-specific components include antenatal care, maternal diet, breastfeeding, complementary foods, and micronutrients. Nutrition-sensitive components include WASH, cash or food transfers, agriculture, food prices, and early childhood development. Implementation levers include counselling, supply reliability, supervision, targeting, and social norms. Measurement needs include HAZ, stunting prevalence, diet diversity, morbidity, equity, and fidelity. The core message is that even a strong intervention package may fail if targeting, supply, uptake, exposure reduction, or measurement is weak.



Figure 3. Implementation pathway for stunting-prevention models

DISCUSSION

Principal Findings

The central finding of this scoping review is that childhood stunting prevention should be framed as an intervention-model problem rather than a single-intervention problem. The evidences shows that stunting is not usually prevented by one isolated input, such as counselling, supplementation, sanitation, food transfer, or early-childhood-development programming alone. Instead, prevention depends on how multiple intervention components are combined, timed, delivered, monitored, and adapted to the local pathways that produce growth faltering.

This review identified several mutually reinforcing intervention models: maternal and adolescent nutrition, breastfeeding protection and support, complementary feeding counselling, nutrient-dense foods and fortified products, WASH and infection control, nutrition-sensitive social protection and agriculture, and integrated nurturing care. These models operate through different but connected pathways. Maternal nutrition influences fetal growth and birth outcomes; breastfeeding supports early nutritional and immune protection; complementary feeding addresses diet quality during the 6-23-month period; WASH reduces infection-related growth risks; and social protection, agriculture, and early childhood development strengthen the enabling conditions for care and nutrition (Black et al., 2013; Ruel & Alderman, 2013; Victora et al., 2016).

Interpretation of Findings

The findings indicate that timing is one of the most important determinants of intervention relevance. Stunting prevention should begin before birth because fetal growth restriction, preterm birth, and small-for-gestational-age birth can influence later childhood undernutrition (Christian et al., 2013). Maternal nutrition and antenatal-care platforms therefore belong within stunting prevention, not only maternal health. After birth, breastfeeding support becomes central during the first six months, while complementary feeding, nutrient density, responsive care, and infection control become increasingly important during the 6-23-month period (Dewey, 2016; World Health, 2023).

The review also shows that targeting, delivery platform, and implementation intensity shape whether an intervention works. A technically sound intervention may have limited impact if it reaches children after the critical window, fails to reach the highest-risk households, or is delivered with insufficient frequency and quality. For example, counselling may improve knowledge but may not improve growth if caregivers cannot access nutrient-dense foods. Similarly, supplementation may be weakened by irregular supply, poor adherence, or low acceptability. WASH interventions may fail to shift linear growth if they do not sufficiently reduce pathogen exposure in water, food, soil, play spaces, or animal feces pathways (Cumming et al., 2019; Dewey & Adu-Afarwuah, 2008).

Measurement quality is also central. Stunting-prevention programmes should not measure only final anthropometric outcomes. They should also measure the pathway through which change is expected to occur. Maternal interventions require maternal diet, anaemia, antenatal-care contacts, birthweight, and gestational-age indicators. Complementary feeding interventions require dietary diversity, meal frequency, nutrient density, adherence, and responsive feeding measures. WASH interventions require exposure indicators, not only self-reported handwashing or latrine ownership. Without pathway-specific measurement, it is difficult to know whether the intervention theory was wrong, the delivery was weak, or the correct outcome was not measured.

Comparison with Existing Literature

The interpretation of this review is consistent with major global nutrition frameworks, which emphasize that maternal and child undernutrition is shaped by immediate, underlying, and structural determinants. Previous studies highlighted the importance of both nutrition-specific and nutrition-sensitive interventions, while more recent evidence updates continue to show that effective responses require intervention packages rather than isolated activities (Bhutta et al., 2013; Keats et al., 2021).

The findings also align with maternal nutrition evidence showing that prevention must begin early. Evidence linking small-for-gestational-age birth and preterm birth with later undernutrition supports the inclusion of maternal nutrition, adolescent nutrition, antenatal care, and fetal-growth protection in stunting-prevention models (Christian et al., 2013). Trials of lipid-based nutrient supplements in Bangladesh and Malawi further suggest that maternal supplementation can influence birth-related growth outcomes, although effects vary by context and baseline conditions (Ashorn et al., 2015; Mridha; et al., 2016).

The WASH evidence provides an important caution. The WASH Benefits trials in Bangladesh and Kenya and the SHINE trial in Zimbabwe found that standard household-level WASH packages did not consistently reduce stunting, while nutrition arms often produced clearer growth (Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018). This does not invalidate the

biological rationale linking enteric infection and growth faltering, which remains strong (Checkley et al., 2008; Prendergast & Humphrey, 2014). Rather, it suggests that future WASH models need more precise exposure reduction, higher community coverage, and better measurement of environmental contamination (Cumming et al., 2019).

The complementary feeding literature similarly supports the importance of nutrient density and food access. Reviews have shown that education and counselling can improve feeding practices, but stronger growth effects are more likely when families are able to access appropriate foods or fortified products (Dewey & Adu-Afarwuah, 2008). Studies from the Ecuador egg trial and Ghana home fortification trial illustrates how animal-source foods and micronutrient fortification can contribute to growth-related outcomes when they are feasible, acceptable, and delivered with adequate support (Adu-Afarwuah et al., 2007; Iannotti et al., 2017). Nutrition-related studies also support the need to connect agriculture, food systems, women's empowerment, and social protection directly to maternal and child diets, rather than assuming that poverty reduction alone will reduce stunting (Olney et al., 2015; Ruel & Alderman, 2013).

Policy and Practice Implications

Several policy and practice implications arise from this review. First, maternal nutrition programmes should be positioned as core stunting-prevention strategies. This means strengthening adolescent nutrition, preconception health, antenatal care, maternal diet quality, micronutrient supplementation, balanced energy-protein support where indicated, infection prevention, and food-security support during pregnancy.

Second, breastfeeding support systems should move beyond one-time health education. Breastfeeding protection requires maternity protection, baby-friendly facility practices, skilled lactation counselling, family support, community follow-up, and protection from inappropriate commercial influence (Rollins et al., 2016; Victora et al., 2016). Third, complementary feeding interventions should combine practical counselling with realistic food access. Programmes should support dietary diversity, meal frequency, animal-source foods, fortified foods, micronutrient powders, or small-quantity lipid-based nutrient supplements when appropriate, while considering affordability, cultural fit, food safety, and supply resilience (Dewey, 2016; Iannotti et al., 2017).

Fourth, WASH and infection-control programmes should be redesigned around exposure pathways. Rather than relying only on household water treatment, latrine promotion, or handwashing messages, future models should address community sanitation coverage, food hygiene, safe play spaces, animal feces management, water recontamination, and sustained behaviour change (Cumming et al., 2019). Fifth, social protection and food-system interventions should be nutrition-sensitive by design. Cash transfers, food transfers, agriculture interventions, and food-system policies should be linked to maternal diet, young-child diet quality, food affordability, women's time, and service use (Ruel & Alderman, 2013).

Community health-worker delivery is especially important because many stunting-prevention models require repeated contact with mothers and caregivers. However, community delivery should not be treated as a simple low-cost channel. It requires training, supervision, workload management, referral systems, commodity availability, and monitoring of counselling quality. Finally, monitoring and evaluation systems should track not only stunting prevalence and height-for-age z-scores, but also fidelity, coverage, equity, supply stockouts, dietary indicators, morbidity, environmental exposure, and caregiver burden.

Implementation quality should be treated as part of the intervention itself. A model that assumes regular counselling but delivers infrequent or low-quality contact is no longer the same model. A supplement that is delivered irregularly is not equivalent to the supplement tested in a trial. A sanitation programme with partial uptake is not a high-coverage environmental intervention. For this reason, fidelity, coverage, supervision, stockouts, counselling quality, adherence, caregiver burden, and local adaptation should be measured and interpreted as core intervention components.

This is particularly important when interventions move from controlled trials to routine systems. Trial effects often depend on conditions that may weaken during scale-up, such as close supervision, stable supply chains, motivated personnel, frequent contact, careful eligibility criteria, and high-quality monitoring. Stunting-prevention programmes should therefore include

implementation science from the beginning, so that programme failure can be distinguished from theory failure. In practice, this means documenting who was reached, how often contact occurred, whether the intervention was delivered as intended, whether caregivers could use the intervention, and whether the biological pathway actually changed.

Equity is central to stunting prevention because the burden is concentrated among poorer households, marginalized communities, food-insecure families, and populations with limited access to health, food, water, sanitation, and social protection systems; nutrition-sensitive frameworks highlight that factors such as household resources, women's empowerment, education, agriculture, food systems, and social protection influence child nutrition through indirect pathways (Ruel & Alderman, 2013). Therefore, equity-sensitive targeting should go beyond identifying high-risk children to matching intervention intensity with the severity and underlying causes of risk. This challenge is likely to intensify in contexts affected by food-price shocks, climate stress, conflict, displacement, and urban informal living, which disrupt food affordability, water security, health-service access, care time, livelihoods, and household stability. In such settings, standard intervention packages may be insufficient unless adapted to protect maternal and young-child diets, safe feeding environments, and continuity of care, and future programmes should assess not only improvements in average outcomes but also reductions in disparities between advantaged and disadvantaged groups.

Several evidence gaps remain, including the need for more comparative studies of integrated intervention models that reflect real-world constraints such as budgets, workforce, supply chains, food systems, and political priorities, since policymakers rarely implement single interventions in isolation. WASH research should shift from self-reported behaviours and infrastructure coverage toward direct or proxy measures of pathogen exposure and environmental contamination, as the limited impact of low-intensity household WASH interventions suggests the need for improved exposure models rather than abandoning environmental pathways (Cumming et al., 2019). Further research is also needed on the affordability and market resilience of nutrient-dense complementary foods, considering factors such as cultural acceptability, supply reliability, food safety, and vulnerability to price shocks (Dewey, 2016; Iannotti et al., 2017). Additionally, implementation science should be integrated into stunting research to assess factors like coverage, fidelity, supervision, stockouts, counselling quality, acceptability, caregiver workload, equity, and adaptation. Future reviews should distinguish between prevention and treatment, as prevention focuses on averting early growth faltering, while treatment may have limited capacity to reverse established deficits (de Onis & Branca, 2016). Finally, more evidence is needed from settings affected by climate stress, conflict, displacement, and urban informality, as current research often reflects stable environments, underscoring the need for adaptive intervention models that remain effective under instability.

This scoping review has several limitations. First, the search emphasized peer-reviewed publications and selected WHO sources; publication bias and the exclusion of most grey literature may therefore have favored well-known intervention models and underrepresented smaller, local, unpublished, or unsuccessful programmes. Second, restricting retrieval to PubMed/MEDLINE, Scopus, Web of Science, the Cochrane Library, and WHO sources may have introduced database-selection bias by omitting other bibliographic and regional indexes and organizational repositories. Third, language bias may be present because studies published in English or Bahasa Indonesia were eligible because these were the languages in which the review team could reliably assess the full text and extract data.

Formal critical appraisal was intentionally omitted because the objective was evidence mapping rather than evidence synthesis of comparative effectiveness or certainty. Consequently, sources with heterogeneous designs and methodological rigor contributed to the map, evidence patterns were not weighted by study quality, and the findings should not be interpreted as comparative effect estimates. A meta-analysis was not undertaken because quantitative pooling was outside the review objective.

CONCLUSION

Preventing childhood stunting requires a shift from isolated interventions to integrated, life-course models that combine nutrition-specific and nutrition-sensitive strategies delivered early particularly during pregnancy and the first 1,000 days and sustained through coordinated support

for feeding, health, caregiving, and enabling environments. Effective programmes must be context-specific, aligning intervention intensity with local drivers such as food insecurity, infection exposure, and service access, while ensuring timely delivery, adequate coverage, and strong implementation systems. Central to all efforts is a focus on equity, aiming not only to reduce overall stunting prevalence but also to close gaps affecting vulnerable populations. Future research should prioritize understanding how integrated intervention models can be effectively combined, adapted, and sustained in real-world settings.

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