# Household food insecurity, dietary diversity with undernutrition among children younger than five years in Indian subcontinent–a narrative review

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## Summary

**The emerging predictors of childhood undernutrition include household food insecurity (HFI) and inadequate diet diversity (DD). Geographical, socio-cultural, economic, and demographic factors contribute to HFI. Earlier, HFI was often considered an outcome of hunger and poverty leading to undernutrition. The increasing availability of data related to childhood DD and its direct association with undernutrition indicates that DD could mediate the relationship between HFI and undernutrition. This narrative review examined the association of HFI and/or DD with undernutrition in children younger than 5 years in the Indian subcontinent; and the current programmes and policies. The current evidence showed a possible association between HFI and DD either independently or together with childhood undernutrition. Until now, nutrition-specific interventions to address moderate and severe forms of undernutrition were focused, with a limited attention on nutrition-sensitive approaches to improve HFI and DD. Interventions which improve HFI and DD may be included in the existing programmes and would help address the undernutrition in children younger than 5 years.**



Keywords: Under-five children; Dietary diversity; Undernutrition; Nutritional status; Food insecurity; Indian subcontinent

## Introduction

Every child has a right to optimum nutrition for ensuring physical growth, development, and good health. Globally, 22.3% of children younger than 5 years (children under-5) are stunted and 6.8% are wasted, of which 52% of stunted and >75% of severe wasted children under-5 are from Asia.[1] Bangladesh has the highest burden of malnutrition in the Indian subcontinent.[2] On the other hand, the Indian data on children under-5 reported 35.5%, 19.3%, and 7.7% stunted, wasted, and severely wasted, respectively.[3] Similarly, Sri Lankan children had the prevalence of stunting (17.3%), wasting (15.1%) and underweight (20.5%).[4]

The UN Decade of Nutrition 2016–2025 and the Sustainable Development Goal-2 (SDG- 2) proposed to achieve the targets of World Health Assembly (2012) related to childhood stunting and wasting in children under-5 by 2025; end all forms of malnutrition by 2030 through specific strategies. These included adequate nutrition in early life years, improved diet diversity (DD) and an appropriate food system.[5] The Scaling Up Nutrition (SUN) movement and the Global Nutrition Report 2020 underscored the efforts to achieve nutrition goals at the country level.[6] Earlier, *The Lancet* Series on Maternal and Child Nutrition (2013) categorised nutrition actions into nutrition-specific and nutrition-sensitive, which required multisector convergence for planning and implementation.[7] Achieving the multisector convergence is often challenging, time-consuming and frequently delays the implementation of nutrition actions. Recently, a modified framework was proposed that categorised nutrition actions as direct and indirect health and non-health-care sector interventions, nutrition support and integration of strategies to achieve SDG-2. In the new model, household food security and access to diverse diets were placed under other sectoral strategies indirectly and directly affecting nutrition.[7] Additionally, food security and scaling up nutrition-sensitive interventions were targeted to achieve global nutrition targets. However, with no progress on food insecurity at global level, in 2022 about 29.6% of the population (2.4 billion people) were moderately or severely food insecure.[8]

Household food insecurity (HFI) and poor DD impact children predisposing them to a higher risk of undernutrition.[9] Countries from the Indian subcontinent, especially Bangladesh, Bhutan, Pakistan and Sri Lanka, experience high food price inflation due to a significant fall in agriculture production.[10] The fall in

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agriculture production exposed households to food insecurity and poor DD resulting in poor nutritional status. Undernutrition in children results from multiple national, community and individual factors (poor policy and program implementation, poor access to health care facilities, improper WASH practices, low household socioeconomic status, large household size, poor parental nutrition and education, inappropriate child-feeding practices, child's age, maternal age, gender and low exclusive breastfeeding rates).[7,9] These factors are complexly intertwined and need to be addressed to reduce the burden of undernutrition amongst children under-5.[11]

A UNICEF framework[12] was adapted to map different causes of undernutrition among children under-5 in the Indian subcontinent, and the factors were mapped at the Macro (national), Meso (community) and Micro (individual) levels (Fig. 1). Inadequate dietary intake and poor diet quality were the immediate causes of undernutrition determined by the underlying HFI and other fundamental factors (national, community and individual level) of undernutrition. All these factors contribute to childhood undernutrition and adversely influence their physical growth and development. Additionally, this exacerbates the delay in attaining SDG-2, which targets to: "End hunger and ensure access by all people, particularly the poor and vulnerable people, including infants, to safe, nutritious and sufficient food all year round by 2030".[13] Improving household food security and DD may enhance the nutritional status of children under-5 in the Indian subcontinent. The present review aimed to examine the association of HFI and/or DD with undernutrition in children under-5 from the Indian subcontinent.

## Methods

A narrative review examined the association of HFI and/or DD with undernutrition in children under-5 from the Indian subcontinent. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to prepare the review.[14]

### Information sources

An electronic search was conducted in five databases-Science Direct, PubMed, SCOPUS, EBSCO (Medline) and Web of Science, for full-text research articles published between January 2010 and May 2023. The search focused only on the articles published in the English language.

### Study identification, screening, and selection

All articles from the search were uploaded in COVIDENCE 2.0 systematic review software, Veritas Health Innovation, Melbourne, Australia.[16] RIS file format from Science Direct, Web of Science, SCOPUS, EBSCO (Medline) and PubMed file format from PubMed database was imported to COVIDENCE software. Duplicate

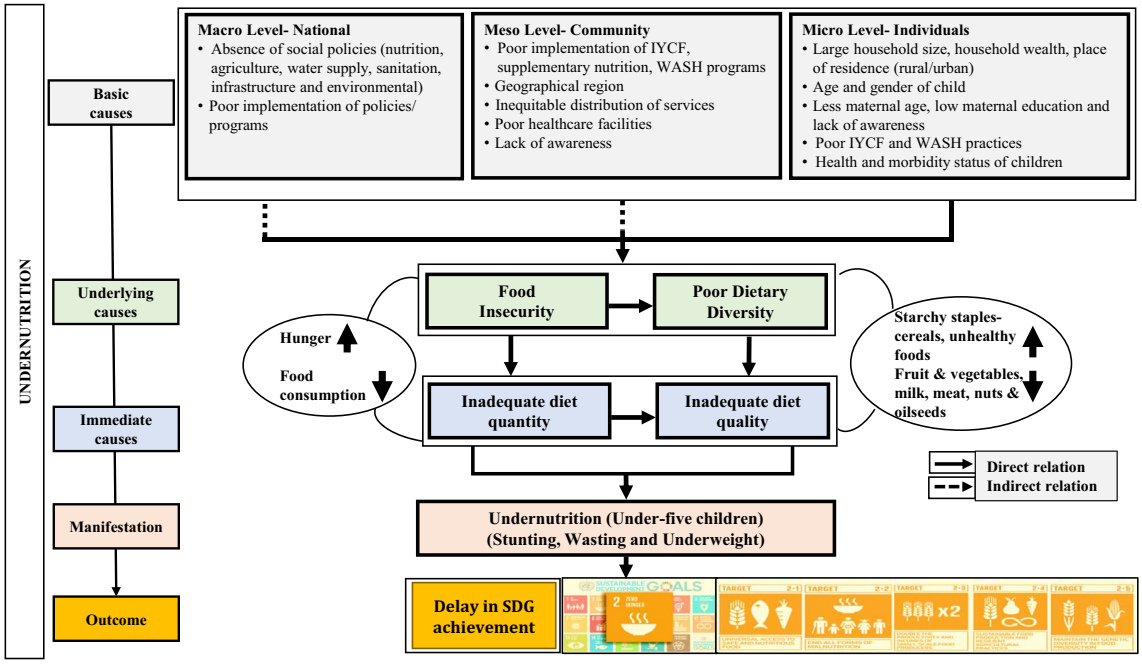


*Fig. 1:* **Conceptual framework of linkage of food insecurity and dietary diversity with undernutrition in under-5 children from the Indian subcontinent (adapted from UNICEF 2020).**[12] Under-5 children: Children younger than 5 years; IYCF: Infant and young child feeding; WASH: Water, Sanitation, and Hygiene.

articles were removed using the software. The study selection was conducted in two phases: (i) Two reviewers (SSY and HM) independently identified the relevant studies using inclusion criteria for the title and abstract screening. In case of lack of clarity or doubt, the study was retained for the next phase; (ii) Both the reviewers independently conducted full-text screening of articles for inclusion in the review. At any stage, discrepancies between the two reviewers were resolved based on the consensus of a third reviewer (KM).

### Quality check using the STROBE-M rating scale

Reporting quality of the observational studies was assessed using the Strengthening the Reporting of Observational Studies in Epidemiology- Modified (STROBE-M) rating scale.[17] Based on the scores, the articles were classified as excellent (≥85), good (70 to <85), fair (50 to <70) and poor quality (<50).

### Data extraction and management

The data extracted from the included full-text research articles were entered into the Microsoft Excel spreadsheet. The reviewers extracted the following data from the included studies: author(s), publication year, location, sample size, age, gender, mother's education, household size, household wealth, breastfeeding initiation, tools used to assess HFI and DD, and key results. All studies used validated methods such as the household food insecurity access scale (HFIAS),[18] household food security scale[19] (HFSS) and child food security scale[20] to assess food insecurity. Minimum Dietary Diversity (MDD),[21] Dietary Diversity Score (DDS)[22] and Dietary Diversity Index[23] (DDI) were used to determine the DD of children.

### Analysis

All the included studies (n = 38) were reviewed to assess the association of (i) HFI (the lack of regular access to enough safe and nutritious food due to unavailability of and/or lack of resources to obtain food for proper growth and development of body),[18] (ii) DD (the number of food items consumed from different food groups over a given time period),[24] and (iii) HFI and DD with stunting (height-for-age z-scores < −2SD), wasting (weight-for-height z-scores < −2SD) and underweight (weight-for-age z-scores < −2SD) as measures for undernutrition[25] among children under-5. Results were summarised and presented, and information on national nutrition programmes for children under-5 was extracted for all countries in the Indian subcontinent. The data for various national programs were summarised under country, program name, year of implementation, population, objectives, services, and benefits.

## Results

A comprehensive search of five journal databases (Science Direct, Web of Science, SCOPUS, EBSCO (Medline) and PubMed) generated 8030 research articles, of which 38 studies were included in preparing the present narrative review. The PRISMA flow diagram is appended below (Fig. 2).

We included 38 studies for the preparation of the manuscript. Studies from different countries included: 10 from Bangladesh, one Bhutan, 15 India, nine Nepal, one Sri Lanka and two multi-countries. The reporting quality of included studies was assessed using the STROBE-M assessment tool. Based on the scores, five studies were classified as excellent quality, 21 as good quality and 12 as fair quality (Table 2). Few studies (31.6%) were of fair category as they missed to report information on relevant dates of recruitment, exposure, follow-up and data collection; potential confounders, effect modifiers, efforts to address the potential source of bias, number of participants with missing data for variables of interest, estimates of relative risk into absolute risk for a period of time, direction and magnitude of potential bias, the role of funders for study, statement on data available online of the STROBE-M assessment tool (Supplementary File). Out of the 38 final included studies investigated: (i) 20 studied the association between HFI and undernutrition, (ii) 15 studied the association between DD and undernutrition, and (iii) four studied the association between HFI, DD with undernutrition in children under-5 from the Indian subcontinent (Table 2).

Supplementary Tables S1 and S2 present the baseline characteristics of the study participants from the 38 included studies. Overall, 20 studies represented the national, five state, one regional, nine district, two subdistrict and one village level data. One study was from urban, 12 rural, 25 both rural and urban locations. From the 38 included studies, 29 studies reported socioeconomic and demographic factors such as gender, 31 studies reported mother's education, 9 studies reported household size, 23 studies reported household wealth (quintile (%)/monthly expenses) and 11 studies reported initiation of breastfeeding within an hour of birth.

The socioeconomic and demographic characteristics of 20 studies conducted at the national level (Bangladesh = 6, Bhutan = 1, India = 5, Nepal = 5, Sri Lanka = 1 and multi-country = 2) represent data of total 5,14,888 study participants across the Indian subcontinent (Supplementary Table S1). Most studies reported either place of residence, age, gender, mother's education, household size, household wealth, and breastfeeding initiation within an hour after birth as sociodemographic factors.[26,31,35,36,41,43,50,57,58,61] Anthropometric indices studied as outcome variables were stunting/HAZ scores, wasting/WHZ scores and underweight/WAZ scores in children under-5. Undernutrition was significantly higher in children with the low educational status of mothers, large household size, poorest household wealth quintile or per capita income in the first tertile, and not being breastfed within 1 h of

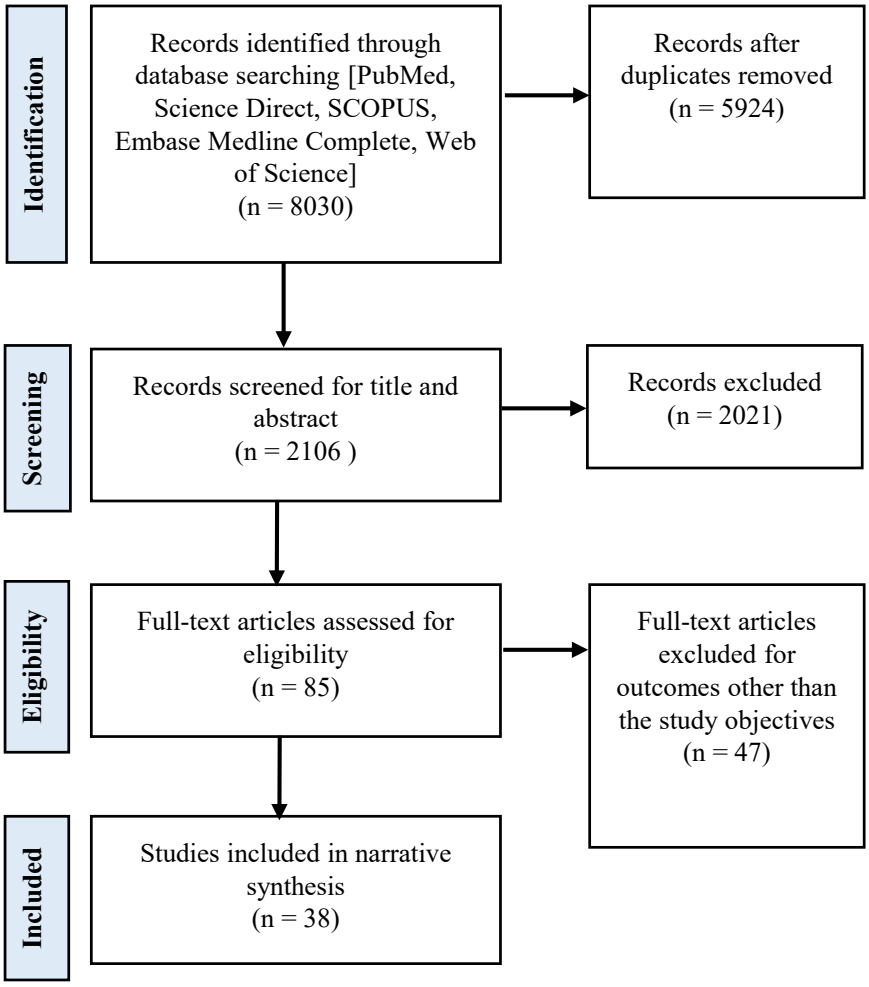


***Fig. 2:*** PRISMA flow diagram.

birth.[28,30–32,39,43,46,53,55,59,62,63] Out of seven countries, only Bhutan reported moderately low undernutrition (i.e., stunting, wasting and underweight) in under-two children. Similarly, sociodemographic factors were reported in 18 primary studies conducted at state, district, subdistrict, and village levels, representing data from a total of 2,39,782 study participants younger than five years (Supplementary Table S2). However, a few studies reported household wealth, size and breastfeeding initiation within 1 hour of birth.[27,29,33,40,47,49,52,56,60]

An in-depth study of the extracted data indicated three distinct associations of HFI and DD with undernutrition, described below.

### Association between HFI and undernutrition among children under-5 from the Indian subcontinent

Twenty studies (Bangladesh = 7, India = 6, and Nepal = 7) investigated the association between HFI and undernutrition among children under-5. Seven studies were conducted at the national level (Bangladesh = 3, and Nepal = 4) and three at the state level (India = 3). The remaining 10 studies were conducted at the district, subdistrict, or village level (Table 3).

Among different studies, four studies assessed the association between HFI and indicators of undernutrition (stunting, wasting and underweight) among 0–23 months children, i.e., one from Bangladesh, two from India and one from Nepal.[28,42,51,60] Overall, 2/4, 1/2, and 2/3 of studies have found a positive association of HFI with stunting, wasting and underweight among children aged 0–23 months, respectively. About 80% (16) studies, were on children from 6 to 59 months age group (Bangladesh = 6, Nepal = 6 and India = 4). Overall, 69.2% (9/13) studies found an association of HFI with stunting, followed by underweight 66.7% (6/9) and wasting 45.5% (5/11) among children between 6 and 59 months.

| Parameters | Inclusion | Exclusion |
|---|---|---|
| Population | Children younger than 5 years (under-5) | Children older than five years |
| Intervention | No intervention—studies that explored the association between HFI and DD with undernutrition | All other studies. |
| Comparison | The Indian subcontinent (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) | Countries other than those listed in the inclusion criteria |
| Outcomes | Undernutrition (stunting/HAZ scores, wasting/WHZ scores and underweight/WAZ scores) | Studies that reported other outcomes, including assessment of micronutrients in children under-5 |
| Study design | Observational study (cross-sectional study, case–control, and cohort study) | Experimental study designs (randomised controlled trial, quasi-experimental design), opinion articles and editorials. |

*Table 1:* **PICOS framework.**

National data from Bangladesh (Demographic and Health Survey [DHS] 2011) reported a higher prevalence of stunting (moderate to severe food insecure)-AOR (95% CI):1.38 (1.11–1.73); p = 0.004; and severely insecure- OR: 1.32 (0.89–1.94); p = 0.17) and underweight (OR: 1.31 (1.04–1.66); p = 0.024) among food insecure households of children under-5 (Table 3).[32] Other studies from Bangladesh showed similar results for children under five years.[29,33,34]

The results from Nepalese studies were mixed. An analysis of national data (NDHS-2011) showed an association between HFI and stunting (severely food insecure- AOR:1.50 (1.15–1.97); p < 0.05) and underweight (severely food insecure- AOR:1.40 (1.05–1.85), p < 0.05). A similar association was found for stunting and underweight but not for wasting.[58,59] However, the Nepal national study (primary) found no association of HFI with stunting and wasting (p > 0.05) and the DHS-2016 data showed no association with wasting (data unavailable for stunting and underweight).[53,55] Another Nepalese study assessed the effects of yearlong food sufficiency (sufficient food annually for a family from own or contracted land) on undernutrition (specific indicators were not evaluated).[54] The evidence states higher odds of undernutrition in children from the food insufficient category (OR: 4.81 (1.44–16.11); p = 0.011).[54] The results underscored the need for data on younger children (children from 0 to 23 months) to study the age-wise effects of HFI with undernutrition.

At the country level, for 17 studies, stunting was the most studied indicator of undernutrition with HFI (Bangladesh [7/7 studies] and India [6/6]), and in Nepal, both stunting and wasting were studied (4/7) (Table 3). Among the countries, stunting was the most prevalent outcome of HFI in Bangladesh 71.4% (5/7), while in India (100%, 4/4) and Nepal (66.7%, 2/3), underweight was the most prevalent outcome.

Overall, 17/20 studies showed that stunting was the most studied indicator of childhood undernutrition in the countries from Indian subcontinent. The included studies assessed either alone or together with other indicators of undernutrition (wasting and underweight). On the other hand, being underweight was the most prevalent outcome of the HFI (66.7%, 8/12), followed by stunting (64.7%, 11/17) and wasting (46.2%, 6/13).

### Association between DD and undernutrition among the children under-5 from the Indian subcontinent

Out of a total 15 studies, 12 national (Bangladesh = 2, Bhutan = 1, India = 5, Nepal = 1, Sri Lanka = 1, and multi-country = 2), one state (India = 1) and two district level (India = 2) studies investigated the association between DD and undernutrition in children under-5 (Supplementary Table S3).

Six studies i.e., five national (Bangladesh = 1, Bhutan = 1, India = 1, Nepal = 1 and multi-country = 1) and one state (India = 1) assessed the association of DD with indicators of undernutrition in 6–23 months children. Among 6–23 months of children, 3/6, 3/5, and 3/5 studies found a significant association between poor DD and stunting, wasting and underweight, respectively (Supplementary Table S3). For 0–35 months children, significant association was found between DD and all forms of undernutrition.[41] Collectively, in countries from the Indian subcontinent, the burden of undernutrition (all forms-stunting, wasting and underweight) was high among children of <24 months.[43,57,63]

Out of nine, seven national (Bangladesh = 1, India = 4, Sri Lanka = 1 and multi-country = 1) and two district studies (India = 2) assessed the association of DD (indicators: Minimum Acceptable Diet [MAD], DDS, MDD, and DDI) with undernutrition in children (age 6 ≤ 60 months) (Supplementary Table S3). Findings from the analysis of Indian National data (National Family and Health Survey [NFHS]-3, 2005–2006) on children under-5 reported that poor DDS was associated with underweight [β (SE); change%: 0.38 (0.07); 59%] and stunting [β (SE); change%: 0.43 (0.007); 54.2%].[50] However, the analysis from a comprehensive national nutrition survey (2016–18) data reported an association between MDD with all forms of undernutrition-stunting, wasting and being underweight.[46] A study that analysed NFHS-4 (2015–2016) data reported a significant association between poor DDS with wasting, stunting and underweight (p < 0.05).[41] Also, two district-level Indian studies analysed the association between

| No | Included studies | Household food insecurity | Dietary diversity | STROBE-M |
|---|---|---|---|---|
| Bangladesh | | | | |
| 1 | Sheikh et al. (2020)[26] | | √ | Good |
| 2 | Ali et al. (2019)[27] | √ | | Good |
| 3 | Mistry et al. (2019)[28] | √ | | Excellent |
| 4 | Abdullah et al. (2018)[29] | √ | | Good |
| 6 | Sarma et al. (2017)[30] | √ | | Excellent |
| 5 | Choudhury et al. (2017)[31] | √ | √ | Good |
| 7 | Chowdhury et al. (2016)[32] | √ | | Excellent |
| 8 | Ali et al. (2013)[33] | √ | | Good |
| 9 | Quddus & Bauer (2013)[34] | √ | | Fair |
| 10 | Rah et al. (2010)[35] | | √ | Good |
| Bhutan | | | | |
| 11 | Campbell et al. (2018)[36] | | √ | Fair |
| India | | | | |
| 12 | Purushottam et al. (2022)[37] | | √ | Good |
| 13 | Abedi et al. (2021)[38] | √ | | Fair |
| 14 | Pandey and Kashima (2021)[39] | | √ | Good |
| 15 | Pathak et al. (2020)[40] | √ | | Fair |
| 16 | Kim et al. (2019)[41] | | √ | Good |
| 17 | Maitra et al. (2019)[42] | √ | | Good |
| 18 | Meshram et al. (2019)[43] | | √ | Good |
| 19 | Nithya and Bhavani (2018)[44] | | √ | Fair |
| 20 | Sinha et al. (2018)[45] | √ | | Fair |
| 21 | Borkotoky et al. (2018)[46] | | √ | Fair |
| 22 | Chandrasekhar et al. (2017)[47] | √ | √ | Excellent |
| 23 | Humphries et al. (2017)[48] | √ | | Good |
| 24 | Aguayo et al. (2016)[49] | √ | √ | Fair |
| 25 | Corsi (2016)[50] | | √ | Good |
| 26 | Mukhopadhyay et al. (2013)[51] | √ | | Fair |
| Nepal | | | | |
| 27 | Dahal et al. (2021)[52] | √ | | Good |
| 28 | Nepali et al. (2020)[53] | √ | | Good |
| 29 | Paudel et al. (2020)[54] | √ | | Good |
| 30 | Shrestha et al. (2018)[55] | √ | | Good |
| 32 | Busert et al. (2016)[56] | √ | √ | Excellent |
| 33 | Lamichhane et al. (2016)[57] | | √ | Fair |
| 31 | Sreeramareddy et al. (2015)[58] | √ | | Good |
| 34 | Singh et al. (2014)[59] | √ | | Good |
| 35 | Osei et al. (2010)[60] | √ | | Fair |
| Sri Lanka | | | | |
| 36 | Perkins et al. (2018)[61] | | √ | Good |
| Multi-country | | | | |
| 37 | Harding et al. (2018)[62] | | √ | Good |
| 38 | Kim et al. (2017)[63] | | √ | Fair |

*Table 2:* **Studies estimating the association of undernutrition with household food insecurity and dietary diversity from the Indian subcontinent (n = 38).**

DD and under-5 nutritional status. A positive association of 95$^{th}$ quantile child DDS and HAZ and WAZ scores but not WHZ scores[37]; and low DDI with the WAZ scores[44] was reported.

The Bangladeshi children with high dietary diversity had lower odds of stunting (6–11 months: AOR: 0.85 (0.76–0.94); 12–23 months: AOR: 0.74 (0.69–0.79); 24–59 months: AOR: 0.69 (0.66–0.73); $p < 0.05$) across different age groups.[35] In a Sri Lankan study, DDS was positively associated with the HAZ scores ($p = 0.04$).[61] A multi-country study reported wasting in children who did not meet MDD.[62] At the country level, Bhutan

| No | Author (year) | Age (months), Sample size (n) | Undernutrition | Overall result |
|---|---|---|---|---|
| Bangladesh | | | | |
| 0–23 months | | | | |
| 1 | Mistry et al. (2018)[28] | 0–23, 6539 | Household food security versus Nutritional status<br>Stunting prevalence; p < 0.001<br>Insecure: 34.91%<br>Secure: 28.22%<br>Stunting:<br>Insecure: 1.00 (Ref)<br>Secure: CRO: 0.81 (0.74–0.88), p < 0.001<br>Stunting:<br>Insecure: 1.00 (Ref)<br>Secure: ARR[c]: 0.93 (0.85–1.00); p = 0.064 | Food security status was associated with stunting among children aged 0–23 months. |
| 6–59 months | | | | |
| 2 | Ali et al. (2019)[27] | 6–59, 6468 | Household food security versus Nutritional status<br>Stunting:<br>Food insecure: Ref<br>Food secure: AOR[c]: 0.94; p = 0.314<br>Wasting:<br>Food insecure: Ref<br>Food secure: AOR[c]: 0.95; p = 0.462<br>Underweight:<br>Food insecure: Ref<br>Food secure: AOR[c]: 0.95; p = 0.414 | No association was reported between household food security and stunting, wasting, and underweight in children aged between 6 and 59 months. |
| 3 | Abdullah et al. (2018)[29] | 6–59, 300 | Household food insecurity versus Nutritional status<br>Stunting prevalence; p = 0.005<br>No insecurity: 5%<br>Moderate food insecurity: 18%<br>Severe food insecurity: 19.7%<br>Wasting prevalence; p = 0.044<br>No insecurity: 4.3%<br>Moderate food insecurity: 6.3%<br>Severe food insecurity: 8.7%<br>Underweight prevalence; p = 0.271<br>No insecurity: 6.7%<br>Moderate food insecurity: 16.3%<br>Severe food insecurity: 19.3% | Prevalence of stunting and wasting increased with the level of household food insecurity in children aged between 6 and 59 months. |
| 4 | Sarma et al. (2017)[30] | 0–59, 7647 | Household food security versus Stunting<br>Stunting:<br>Secure: 1<br>Mildly insecure: OR: 1.18 (1.04–1.33); p = 0.01<br>Moderately insecure: OR: 1.27 (1.05–1.54); p = 0.01<br>Severely insecure: OR: 1.32 (0.89–1.94); p = 0.17 | The odds of stunting increased with the level of household food insecurity among children aged between 0 and 59 months. |
| 5 | Chowdhury et al. (2016)[32] | <60, 7568 | Food security versus Nutritional status<br>Stunting:<br>Food secure (Ref): 1.00<br>Mild food insecure: OR: 1.29 (1.12–1.48); p < 0.001<br>Moderate to severe food insecure: AOR: 1.38 (1.11–1.73); p = 0.004<br>Wasting:<br>Food secure (Ref): 1.00<br>Mild food insecure: OR: 1.02 (0.85–1.21); p = 0.864<br>Moderate to severe food insecure: OR: 1.11 (0.85–1.45); p = 0.449<br>Underweight:<br>Food secure (Ref): 1.00<br>Mild food insecure: OR: 1.28 (1.10–1.49); p = 0.002<br>Moderate to severe food insecure: OR: 1.31 (1.04–1.66); p = 0.024 | The odds of stunting and underweight increased with the level of household food insecurity among children under five years of age. |
| 6 | Ali et al. (2013)[33] | 6–47.9, 3422 | Household food insecurity versus Nutritional status<br>Stunting:<br>Mildly food insecure: AOR[h]: 1.26 (0.95–1.69); p > 0.05<br>Moderately food insecure: AOR[h]: 1.11 (0.86–1.44); p > 0.05<br>Severely food insecure: AOR[h]: 1.36 (1.05–1.76); p < 0.01<br>Underweight:<br>Mildly food insecure: AOR[h]: 1.17 (0.88–1.56); p > 0.05<br>Moderately food insecure: AOR[h]: 0.98 (0.76–1.25); p > 0.05<br>Severely food insecure: AOR[h]: 1.28 (0.99–1.65); p < 0.05<br>Wasting:<br>Mildly food insecure: AOR[h]: 1.11 (0.79–1.54); p > 0.05<br>Moderately food insecure: AOR[h]: 0.95 (0.72–1.24); p > 0.05<br>Severely food insecure: AOR[h]: 1.34 (1.02–1.75); p < 0.05 | Household food insecurity was associated in dose–response relation with stunting, underweight and wasting among children. |

(Table 3 continues on next page)

| No | Author (year) | Age (months), Sample size (n) | Undernutrition | Overall result |
|---|---|---|---|---|
| (Continued from previous page) | | | | |
| 7 | Quddus & Bauer (2013)[34] | 24–59, 310 | Child's food insecurity versus Nutritional status<br>Stunting:<br>Food secure:1<br>Food insecure: AOR[c]: 9.67 (1.88–49.7); p > 0.05<br>Underweight:<br>Food secure:1<br>Food insecure: AOR[c]: 6.82 (0.98–47.24); p > 0.05 | Children from food-insecure households have higher odds of being stunted and underweight, but the association was non-significant. |
| India | | | | |
| 0–23 months | | | | |
| 8 | Maitra et al. (2019)[42] | 0–23, 2650 | Household food security versus Nutritional status<br>HAZ:<br>Food Insecure: Rbprobit[f]: −0.02; p > 0.05<br>WHZ:<br>Food Insecure: Rbprobit[f]: 0.06; p > 0.05<br>WAZ: Food Insecure: Rbprobit[f]: 0.12; p = 0.05 | Household food insecurity increases the risk of childhood underweight with no effect on childhood stunting and wasting. |
| 9 | Mukhopadhyay et al. (2013)[51] | 0–23, 245 | Household food security versus Nutritional status<br>Underweight:<br>High/marginal food secure: 16.0%, 1.000<br>Low/very low food secure: 80.8%, AOR[g]: 12.38 (5.76–26.63); p < 0.05<br>Stunting:<br>High/marginal food secure: 10.7%, 1.000<br>Low/very low food secure: 77.6%, AOR[g]: 25.95 (10.32–65.25); p < 0.05<br>Wasting:<br>High/marginal food secure: 12.4%, 1.000<br>Low/very low food secure: 36.8, AOR[g]: 2.37 (1.14–4.93); p < 0.05 | Risk of childhood stunting, wasting and underweight significantly increased with the level of household food security in children aged between 0 and 23 months. |
| 6–59 months | | | | |
| 10 | Abedi et al. (2021)[38] | 0–59, 815 | Household food security versus Nutritional status<br>Stunting: $\chi 2 = 14.8$, df = 2, p = 0.001<br>High/marginal food secure: 39.60%<br>Low food secure: 51.90%<br>Very low food secure: 66.70%<br>Wasting: $\chi 2 = 10.23$, df = 2; p = 0.006<br>High/marginal food secure: 10.10%<br>Low food secure:17.90%<br>Very low food secure:13.30% | A positive association was seen between stunting, wasting and the level of household food security among children under five years. |
| 11 | Pathak et al. (2020)[40] | <60, 510 | Household food insecurity versus Nutritional status<br>Underweight: p < 0.000<br>Stunting: p = 0.100<br>Wasting: p = 0.001 | A positive association was seen between wasting, underweight and household food insecurity. |
| 12 | Sinha et al. (2018)[45] | <60, 2299 | Household food security versus Nutritional status<br>Stunting:<br>Households' food security status: OR: 0.831; p < 0.10<br>Wasting:<br>Households' food security status: OR: 0.968; p > 0.10<br>Underweight:<br>Households' food security status: OR: 0.728; p < 0.01 | A positive association was seen between household food insecurity, stunting and underweight, and no association was seen with wasting. |
| 13 | Humphries et al. (2017)[48] | <60, 1825 | Food insecurity versus Child anthropometry<br>HAZ:<br>Food insecurity: AOR[a]: −0.53 (−0.69 to −0.38); p < 0.001<br>HAZ:<br>Food insecurity: AOR[b]: −0.32 (−0.47 to −0.17); p < 0.001 | A positive association was reported between HAZ and food insecurity among children under five years. |
| Nepal | | | | |
| 6–23 months | | | | |
| 14 | Osei et al. (2010)[60] | 6–23, 368 | Household food insecurity versus Nutritional status<br>Stunting:<br>Household food insecurity: OR: 0.99 (0.55–1.79); p > 0.05<br>Underweight:<br>Household food insecurity: OR: 0.96 (0.49–1.88); p > 0.05 | Household food insecurity was not associated with stunting and underweight. |
| 6–59 months | | | | |

(Table 3 continues on next page)

| No | Author (year) | Age (months), Sample size (n) | Undernutrition | Overall result |
|---|---|---|---|---|
| (Continued from previous page) | | | | |
| 15 | Dahal et al. (2021)[52] | 6–59, 150 | Household food insecurity versus Nutritional status<br>Wasting (Z-score <−3SD):<br>Food Secure: Ref<br>Food Insecure: COR: 4.272 (1.454–12.549); p = 0.008 | A positive association was found between household food insecurity and severe wasting among 6–59 months age children. |
| 16 | Nepali et al. (2020)[53] | <60, 2414 | Household food insecurity versus Nutritional status<br>Wasting:<br>Mild food insecure: AOR[e]: 0.98 (0.64–1.49); p > 0.05<br>Moderate food insecure: AOR[e]: 1.13 (0.65–1.97); p > 0.05<br>Severe food insecure: AOR[e]: 1.36 (0.72–2.57); p > 0.05<br>Food secure:1 | The risk of wasting increased with the level of household food insecurity status, but the association was non-significant. |
| 17 | Paudel et al. (2020)[54] | 0–60, 426 | Food sufficiency versus Undernutrition<br>Undernutrition:<br>Sufficient: Ref<br>Not sufficient: AOR[e]: 4.81 (1.44–16.11); p = 0.011 | A positive association was found between food sufficiency for a year and undernutrition. |
| 18 | Shrestha et al. (2018)[55] | <60,<br>5307 (2013)<br>5409 (2014) | Household food insecurity versus Nutritional status<br>Stunting 2013 n (%): p > 0.05<br>No food insecurity: 983 (32.1%)<br>Mild food insecurity: 373 (37.6%)<br>Moderate food insecurity: 384 (43.1%)<br>Severe food insecurity:142 (39.8%)<br>Stunting 2014 n (%): p > 0.05<br>No food insecurity: 1336 (34%)<br>Mild food insecurity: 355 (44.7%)<br>Moderate food insecurity: 250 (49.0%)<br>Severe food insecurity:82 (46.9%)<br>Wasting 2013 n (%): p > 0.05<br>No food insecurity: 525 (17.2%)<br>Mild food insecurity: 163 (16.5%)<br>Moderate food insecurity: 185 (20.7%)<br>Severe food insecurity: 62 (17.3%)<br>Wasting 2014 n (%): p > 0.05<br>No food insecurity: 606 (15.4%)<br>Mild food insecurity:149 (18.9%)<br>Moderate food insecurity: 97 (19.1%)<br>Severe food insecurity: 28 (16.1%) | No association was found between household food insecurity and stunting or wasting. |
| 19 | Sreeramareddy et al. (2015)[58] | 0–60, 2591 | Household food insecurity versus Nutritional status<br>Stunting:<br>Food secure: 34·60% (30·28–38·92)<br>Mild food insecurity: 43·25% (37·33–49·16)<br>Moderate food insecurity: 46·41% (41·23–51·59)<br>Severe food insecurity: 50·92% (44·88–56·96) p < 0·001<br>Wasting:<br>Food secure: 10·80% (8·40–13·19)<br>Mild food insecurity: 10·21% (6·41–14·02)<br>Moderate food insecurity: 13·21% (9·48–16·94)<br>Severe food insecurity: 12·11% (8·62–15·60) p = 0·57<br>Underweight:<br>Food secure: 24·02% (19·61–28·43)<br>Mild food insecurity: 30·23% (24·24–34·22)<br>Moderate food insecurity: 33·68% (29·56–37·81)<br>Severe food insecurity: 39·82% (33·97–45·66) p < 0·001<br>Adjusted multiple linear regression with HFIAS score[d]<br>HAZ: β = −0·02; p = 0·01<br>WAZ: β = −0·01; p = 0·01<br>WHZ: β = −0·00; p = 0·67 | A positive association was found between the level of household food insecurity with stunting and underweight but not with wasting. |

(Table 3 continues on next page)

reported no association between MDD and all indicators of undernutrition.[36] Among 6-≤60 months of children, 3/7, 6/8, and 5/7 studies found a significant association between poor DD and wasting, stunting, and underweight, respectively (Supplementary Table S3).

Overall, in eight studies (Bangladesh = 2, India = 2, Nepal = 1, Sri Lanka = 1 and multi-country = 2) stunting was the most explored outcome of poor DD. Four studies (Nepal = 1, Sri Lanka = 1 and multi-country = 2) explored wasting; however, two studies (Nepal = 1, and Sri Lanka = 1) also explored underweight as an outcome

| No | Author (year) | Age (months), Sample size (n) | Undernutrition | Overall result |
|---|---|---|---|---|
| (Continued from previous page) | | | | |
| 20 | Singh et al. (2014)[59] | <60, 2335 | Food insecurity versus Nutritional status<br>Stunting:<br>Food secure (Ref)<br>Mildly food insecure: AOR[e]: 1.03 (0.77–1.37); p > 0.05<br>Moderately food insecure: AOR[e]: 1.40 (1.08–1.80); p < 0.05<br>Severely food insecure: AOR[e]: 1.50 (1.15–1.97); p < 0.05<br>Underweight:<br>Food secure (Ref)<br>Mildly food insecure: AOR[e]: 0.87 (0.63–1.20); p > 0.05<br>Moderately food insecure: AOR[e]: 1.23 (0.94–1.61); p > 0.05<br>Severely food insecure: AOR[e]: 1.40 (1.05–1.85); p < 0.05 | A positive association was found between food insecurity, stunting and underweight among children. |

AOR- Adjusted Odds Ratio, COR-Crude Odds Ratio, WAZ–Weight-for-Age z scores (Underweight), HAZ- Height-for-Age z scores (Stunting), WHZ–Weight-for-Height z scores (Wasting), OR- Odds Ratio, Ref-Reference. [a]Adjusted for age and sex. [b]Adjusted for rural residence, community wealth, whether the household was interviewed in a food-scarce month, maternal age, maternal height, maternal education, paternal education, and child age and sex. [c]Information unavailable. [d]Adjusted for sociodemographic, child and environmental factors. [e]Adjusted for other socioeconomic and demographic variables. [f]Rbprobit (Recursive Bivariate Probit) models including the interaction term on empowerment score and household food security. [g]Adjusted for child age, sex, maternal age, education, work status, residence, and wealth index. [h]Adjusted for household size, maternal age, maternal education, maternal height (only for stunting), child age, child sex, acute respiratory illness, diarrhea, and wealth index.

*Table 3:* **Association of household food insecurity with undernutrition in children under-5 from the Indian subcontinent (n = 20).**

of poor DD (Supplementary Table S3). In terms of outcomes studied, stunting was the most prevalent outcome in five studies (Bangladesh = 2, Nepal = 1, Sri Lanka = 1, and a multi-country = 1) study. In eight studies from India, underweight was most prevalent (100%) outcome of poor DD.

To summarise (collectively for both the age group), based on available literature, the association between DD and undernutrition, stunting was the most studied form of undernutrition (14/15 studies) from different countries (either assessed stunting alone or with wasting and underweight) (Supplementary Table S3). Regarding the outcome of DD, underweight was the most prevalent outcome of DD (75%, 9/12), followed by stunting (71.4%, 10/14) and wasting (58.3%, 7/12). Overall, poor dietary diversity was associated with all forms of undernutrition in children under-5 from the Indian subcontinent.

### Association of both HFI and DD with undernutrition among children under-5 from the Indian subcontinent

Out of four studies, one national (Bangladesh), two states (India = 2) and a village-level study (Nepal) showed the association of HFI and DDS with undernutrition. At the country level, in Bangladesh, HFI was significantly associated with all three undernutrition indicators and poor DD was associated with stunting (6–11 months [p = 0.012] and 12–23 months [p = 0.005]) and underweight (12–23 months) (p = 0.0001).[31] Only one study (50%, 1/2) from India found a significant association between HFI with stunting (p = 0.006).[49] Conversely, another Indian study (50%, 1/2) reported that a diverse diet protected children from stunting and being underweight.[47] HFI and DD were not associated with stunting in children under-5 from Nepal (Supplementary Table S4).[56]

Stunting was the most explored outcome for HFI (100%, 4/4) and DD (100%, 4/4). However, HFI was significantly associated with stunting (50%, 2/4), wasting (50%, 1/2), and underweight (50%, 1/2). Underweight was the most prevalent outcome (100%, 2/2) of poor DD.

To conclude, there is a shortage of information to understand the cumulative effects of HFI and low DD on the prevalence of undernutrition (stunting, wasting and underweight) in children under five.

Overall, the current evidence indicated that HFI could lead to stunting; however, poor DD could contribute to underweight and stunting in children under-5. These findings are supported by many studies conducted at the national level (52.6%) followed by the state (13.2%), district (23.7%) and subdistrict or village levels (10.5%) in the Indian subcontinent. Although the first 1000 days of life lay the foundation for physical and mental growth, limited studies were available for children under 24 months.

### Nutrition programmes for children under-5

In the Indian subcontinent, several national programs such as (Bangladesh-Bangladesh Integrated Nutrition Program [1995], Bhutan- National Nutrition Strategy and Action Plan [2021–2025], India- National Food Security Act [2013], India- Integrated Child Development Services [1975], Nepal- Multi-Sector Nutrition Plan-II [2018–2022], Nepal- National Nutrition Program [2004], Pakistan- Ehsaas' Nashonuma [2020–2023], Sri Lanka- National Supplementary Food Programme-Thriposha [1973]) are implemented to improve the nutritional status of children under-5 (Supplementary Table S5).[64–71] These programmes primarily aimed to improve the nutritional status of children under-5 through supplementary feeding programmes, fair-price

food items, service deliveries, growth monitoring of children and provision of supplements to combat micronutrient deficiencies. Implementing nutrition programmes moderately improved the child nutrition status over the last few decades in the countries. Further strengthening of nutrition education component embedded in these programmes with effective strategies to enhance food security and diet diversity of children under-5 years of age, possibly, help to accelerate the achievement of sustainable development goals.

## Discussion

A narrative review of research studies (n = 38) was prepared to examine the association of HFI and DD with undernutrition in children under-5 from the Indian subcontinent. Among the studies included, maximum 20 studies assessed the association of HFI and undernutrition, followed by DD (n = 15), and HFI and DD (n = 4). The salient results from the present review are: (i) HFI and poor dietary diversity are associated with all forms of undernutrition in children under-5 from the Indian subcontinent; (ii) Underweight was the most significant form of undernutrition among children under-5 from food insecure households as well as the children having less diversified diets, followed by stunting and wasting; (iii) DD potentially mediates the association between HFI and undernutrition in children under-5.

Also, existing HFI's association with childhood stunting (Bangladesh), indicated the presence of chronic undernutrition. A few studies used advanced statistical modelling to assess relationships between HFI and DD with undernutrition adjusting for potential confounders (education status of mothers, socioeconomic status, early breastfeeding initiation, and more). Results of this narrative review highlight that HFI and intake of a less diversified diet by children under-5 from different countries (Bangladesh, India, Nepal, and Sri Lanka) in the Indian subcontinent could predispose them to various forms of undernutrition (underweight, stunting, and wasting). The association of HFI and DD and undernutrition could be attributed to poor access and availability of nutrient-rich foods and the use of less diversified diets, resulting in decreased nutrient intakes in children and poor nutritional status.[72] A study reported that even mild HFI in early childhood influence child health in low-resource settings.[73] Further, children exposed to prolonged HFI suffer from chronic malnutrition.[74]

Poor DD circumscribes diet quality, culminating in all forms of undernutrition.[75] Recent evidence suggests that children were predisposed to multiple forms of undernutrition due to poor quality diets (vitamins and minerals deficient) consisting of monotonous starch-based staples, seasonal fruits and vegetables, fewer meat products, fish and other seafoods (17%).[76,77] Diversified diets served as a protective factor against stunting and underweight in Tanzanian children.[77] Therefore, improving DD at early life stage could prevent chronic and acute undernutrition in children.

Several studies reported an association between HFI and poor DD with childhood undernutrition[31,78]; the association remains complex and multifactorial in LMIC settings. Evidence showed the influence of macro-level, meso-level and micro-level factors that explain the underpinning mechanisms and the interrelated cascade leading to childhood undernutrition (Fig. 1). Several programmes and policies were implemented via nutrition-specific and sensitive approaches to address childhood undernutrition. Although these programmes and policies modestly addressed under-5 undernutrition, especially the severe forms of undernutrition, much more efforts, including re-strategising the programmes and procedures of assessments of undernutrition, and the delivery components, are needed to improve their nutritional status and achievement of 2030 Sustainable Development Goals (SDGs). Currently, many of these programmes address different forms of malnutrition through nutrition-specific approaches. Although a few programmes included nutrition-sensitive strategies (National Food Security Act, India; cash transfer approach and nutrition education to children, mothers, and women), there were many implementation challenges. These included poor uptake, service utilisation and non-utilisation of the foods received through the social security programs; and co-sharing of the foods and supplements provided for children with other family members.[11] Further, these programmes aimed to address moderate-severe forms of malnutrition with less scope to improve food insecurity and diet quality. Hence, there is a need to embed further approaches to improve HFI and DD that may improve undernutrition in children under-5. Overall, the present review highlights that HFI and poor DD expose the children under-5 to chronic undernutrition that hampers their overall productivity in their adult years, leading to national economic losses. Timely achievement of SDG-2 calls for urgent attention to addressing gaps in the implementation and service utilisation of programs for ensuring food security and DD.

Our review is the first to indicate a possible association of household food insecurity and dietary diversity with undernutrition (individually and in combination) in children under-5 from the Indian subcontinent. The strength of the present review is the use of appropriate search strategy that covered five databases and robust methodology used to identify and include in the review preparation. All the included studies used standard tools to assess HFI and DD. The limitations of the review are the inclusion of only observational studies, research articles published in English, and grey literature was not included in the review preparation. However, grey

### Search strategy and selection criteria

The keywords used to search were ["under-five children" OR "young children" OR "children"] AND ["dietary diversity" OR "diet diversity score" OR "diet diversity index"] AND [ "food security" OR "food insecurity" OR "HFIAS"] AND ["Bangladesh" OR "Bhutan" OR "India" OR "Maldives" OR "Nepal" OR "Pakistan" OR "Sri Lanka" OR "Indian subcontinent"] AND ["nutritional status" OR "undernutrition" OR "malnutrition" [MeSH Terms] OR "stunting" OR "wasting" OR "underweight"].

**Inclusion and exclusion criteria**

The research articles were selected based on the inclusion and exclusion criteria decided as per the set Population, Intervention, Comparison, Outcome, and Study design (PICOS)[15] framework (Table 1).

literature was referred to summarize various nutrition programs for under five children in Indian subcontinent and also to strengthen the insights in discussion section. Also, limited evidence is available to test the association between HFI and undernutrition among children aged 6–23 months; hence further studies are required for younger children from all countries. Further, due to paucity of studies from Indian subcontinent, the effects of gender differences in the association between HFI and DD was not explored. Finally, limited number of studies were available from Maldives, Bhutan, and Sri Lanka, hence the association of HFI, DD with undernutrition in these countries could not be assessed. Our study focused only on the Indian subcontinent a subsection of South Asia, hence evidence from Afghanistan is not included.

To sum up, HFI could result in poor access and availability of nutrient-dense foods, inadequate calorie intake, and use of less diversified diets. Hence, HFI can be a pivotal marker for poor dietary diversity. Additionally, poor DD mediates the association between HFI and different forms of undernutrition in under five children in the Indian subcontinent. In addition, improper implementation of national programs, delivery of low-quality food items and sharing of the food items by family members add to the poor nutritional status of children under-5.[79] Conversely, the association between the higher wasting prevalence in high-income groups in children attributed to poor quality of the diet predominantly from the ultra-processed foods.[80] This warrants the need for robust social behaviour change communication (SBCC) approach to improve feeding practices for under five children in the community. Policymakers should adopt a holistic approach to improve the nutritional status of children under-5 in the Indian subcontinent.

#### Contributors

SSY wrote the drafts of the narrative review on an association of DD with undernutrition and reviewed all drafts. SSY, HM, and PP developed the conceptual framework, search strategy, completed the screening in COVIDENCE software, reviewed the selected articles, performed the formal analysis of included studies, and conducted STROBE-M for the selected studies. HM contributed to writing drafts on the association of HFI with undernutrition, commented on methods, reviewed and finalised the final draft. PP contributed to writing drafts on the association of HFI and DD with undernutrition, commented on methodology, reviewed and finalised the draft. KM conceptualised the narrative review, supervised the review development, edited, reviewed, and approved the final draft. All authors had complete access to this review paper's data and accepted the responsibility to submit the review paper for publication.

#### Data sharing statement

The data used in this study can be obtained from the corresponding author upon reasonable request.

#### Declaration of interests

No funding was received for the preparation of the present review. We declare no competing interests.

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#### Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2024.100426.

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