Original Article

Hidden hunger and child undernutrition in South Asia: A meta-ethnographic systematic review

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Background and Objectives: South Asia hosts the largest proportion of undernourished children in the world. Hidden hunger and undernutrition continue to be a major global health concern in the region. A systematic review looking at factors and drivers for hidden hunger and child undernutrition was undertaken. **Methods and Study Design:** This review was conducted using the 2020 Preferred Reporting Items for Systematic reviews and Meta-Analysis guidelines. Five computerized databases were searched: CINAHL, EMBASE, PubMed, PsycINFO and Scopus, in addition to various grey literature sources. **Results:** A total of 3601 articles were retrieved from databases and 25 studies from grey literature, 98 studies met our inclusion criteria. Included studies were assessed for quality by validated tools. A Meta-ethnographic narrative approach was used to analyse the findings. The most commonly reported factors for child undernutrition were maternal education, poor dietary diversity and rural residence. **Conclusions:** Based on findings we propose a model to mainstream context specific nutrition behavioural change along with nutrition specific and sensitive interventions aimed at targeting gender, social and cultural factors and norms. Findings from the review add to the extant literature of child undernutrition to inform policy and program.

Key Words: child undernutrition, hidden hunger, South Asia, stunting, wasting

INTRODUCTION

There are four forms of undernutrition: wasting (low weight for height), stunting (height deficit for age), underweight (weight deficit for age), and deficiencies in vitamins and minerals (also known as hidden hunger).[1] Undernourished children can have poor school performance and lower productivity as adults, with an increased likelihood of being obese and developing associated chronic diseases such as cardiovascular disease, diabetes and cancer in adulthood.[2,3] Further, the cycle of undernutrition can be transmitted through generations as an undernourished female is more likely to have undernourished children.[4]

Undernutrition in children is a major public health concern in low- and middle-income countries (LMICs) with long term impact on children's growth, survival and development.[5] While stunting, wasting and underweight are the most common form of undernutrition in children, hidden hunger also known as deficiencies of essential vitamins and minerals, especially iron, zinc, iodine and vitamin A affect almost one-third of the world's population.[6] Many LMICs have high prevalence of different forms of undernutrition along with micronutrient deficiencies.[7] South Asia has the highest burden of child undernutrition and micronutrient deficiencies globally. South Asian countries of India (39%) and Pakistan (44%) continue to have high national stunting prevalence over the 40% threshold. Critical levels of wasting are also prevalent in South Asian countries of Bangladesh (>20%), India (16%) and Pakistan (12%).[8] In addition, micronutrient deficiencies of Iron deficiency anaemia, vitamin A and zinc, are each of global significance in the region.[9,10] More than 40% children under 5 years of age are anaemic,[6] 44-50% of preschool children are affected by Vitamin A deficiency (VAD)[11] and there inadequate zinc intake in the region, as compared with other LMICs.[12]

Unravelling child undernutrition in South Asia remains complex, but the United Nations International Children's Emergency Fund (UNICEF) conceptual framework allows to better understand the potential determinants of child undernutrition.[13] UNICEF framework suggests an interplay of multiple factors at immediate, underlying, and basic levels that affect nutrition in children, instead of a linear or causal approach. Research suggests immediate factors include maternal factors (education, short stature,

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Manuscript received 13 July 2022. Initial review completed 11 August 2022. Revision accepted 22 September 2022.
doi: 10.6133/apjcn.202212_31(4).0014

poor nutrition health before and during pregnancy)[14-22] and child factors (illness, age, inappropriate feeding practices, including poor diet during the 1000 days of life and illness). Household factors include (household wealth index, family size and place of residence)[23-28] and access and utilisation of services (health service utilisation and water and sanitation).[14,21] The basic causes look at creating an enabling environment that highlight structural processes with political, financial and social factors and household access to resources.[1,29]

At present there is no study that uses meta-ethnographic approach to analyse and understand the factors associated with child undernutrition to identify priorities for action. While majority of published studies are quantitative, there is limited triangulation of these findings with qualitative research and grey literature. This gap makes it hard to link evidence to concerted regional practice and policy. This review brings together information for prioritised action in the region and develops a model to inform policy and practice.

This systematic review assessed child undernutrition, including stunting, wasting, underweight and micronutrient deficiencies of iron, vitamin A, and zinc, identify its driving factors and priorities across the eight countries of South Asia. It appraises, synthesises, and summarises published work on child undernutrition in South Asia. It contributes to the evidence required to prioritize actions directed at the immediate, underlying and basic determinants of child undernutrition, informing region-specific program and policy for reduced undernutrition in the region.

METHODS

This systematic was registered with PROSPERO, reference CRD42018112696.[30] The protocol has been published in BMC Systematic Reviews.[31] Variations to the review from the protocol are: the review is informed by the 2020 PRISMA reporting guidelines,[32] instead of 2015 guidelines. The search was updated to 1 March 2021 from 1 September 2019. Lastly, this review did not assess the overall quality of the body of evidence using the GRADE approach.[33] GRADE approach is best suited for intervention studies while the majority of studies included in this review were cross-sectional studies.

Search strategy

The methods of the review are described in detail in the protocol.[31] We briefly outline the methods below. Five databases were searched: CINAHL, EMBASE, PubMed, PsycINFO and Scopus. Additionally, grey literature was searched from websites of key organisations working on undernutrition in South Asia, including of: 3ie impact assessment, Action Against Hunger, Alive and Thrive, Bills and Melinda Gates Foundation (BMGF), Department for International Development (DFID), International Food and Policy Research Institute (IFPRI), Nutrition International, Save the Children, UNICEF, World Bank, World Health Organisation (WHO). Forward-citation searches, reference lists of relevant papers were reviewed, and Google Scholar was searched in conclusion. Search terms used to undertake the search are provided in the protocol[31] and as Supplementary table 1.

Inclusion and exclusion criteria

Studies that measure or assess determinants of child undernutrition in a South Asian country were considered. This review looked at different forms of child undernutrition including stunting, wasting and being underweight and micronutrient deficiencies of iron, vitamin A and zinc.[31] This review considered both published and unpublished literature.[34,35] It focused on children under the age of 5 years in South Asia. South Asia region is as categorised in the United Nations geographical regions including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.[36] The search included both qualitative and quantitative studies. All quantitative study types were considered, along with qualitative and mixed-methods studies. Unpublished grey literature search included programme and evaluation reports and working papers. Editorials, dissertations and theses, conference abstracts, opinion pieces, books and book reviews were excluded.[37] Studies published between January 2000 to 01 March 2021 and those published in English were included. Studies conducted in and after the year 2000 were considered as this was the beginning of the Millennium Development Goals (MDGs), and hence it aids in tracking the progress of the region in line with the MDGs.[38]

This review focused on child undernutrition including stunting, wasting and underweight in children with a Z-score below minus two standard deviations (-2 SD) from the median of the World Health Organisation (WHO) reference population.[39,40] Anaemia measures in children aged 6-59 months were haemoglobin <110 g/L, moderate anaemia of haemoglobin 70-99 g/L and severe anaemia of haemoglobin <70 g/L.[41] Vitamin A deficiency, including both serum retinol concentrations <10 μg/dL and subclinical vitamin A deficiency (serum vitamin A <20 ug/dL) were considered.[42,43] Zinc deficiency was considered as recommended by the International Zinc Nutrition Consultative Group.[44,45]

Study selection process

All studies from the search were imported into EndNote, where duplicates were identified and removed. Studies were screened through a three-step process: (i) screening of titles to remove any irrelevant studies; (ii) screening of abstracts to confirm eligibility and relevance; and (iii) screening of full texts for final inclusion. This process was undertaken independently by the first author (NW), and any doubts were resolved by discussion with the other two researchers. Data from included studies were collected in a data extraction table, Table 1 and 2. This process was undertaken independently by the first author (NW) and random sample of 10% of studies was assessed by the senior author (AR). Any discrepancies were resolved with discussion.

Assessment of methodological quality

Final studies shortlisted in the review were assessed for methodological quality prior to inclusion in the review. Critical Appraisal Skills Programme (CASP) tools were used to assess the methodological quality of qualitative studies,[46] randomised controlled trials[47] and case-control studies.[48] CASP tool is widely accepted and used to as-

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
Academic literature - Journal articles							
1	Ackerson LK & Subramanian SV, 2008, India[104]	14552, 12-35 months	IDA, stunting, wasting, underweight	Domestic violence experienced by mothers			8
2	Adhikari RP et al., 2020, Nepal[121]	3158, 0-59 months	Stunting, under-weight and wast-ing	Low socio-economic status, caste	Regional disparity	Low socio-economic status, caste	7
3	Agarwal S, Srivastava A, 2009, India[61]	124385, 0-59 months	IDA, stunting, wasting, under-weight	Mother's no education, low household wealth index, poor socio-economic status	Low household wealth index, poor socio-economic status	Mother's no education, low household wealth index, poor socio-economic status	8
4	Aguayo VM, Badgaiyan N & Dzed L, 2017, Bhutan[129]	2028, 0-23 months	Wasting		Child's age (0–11 months, sex (males), regional disparities, poor feeding practic-es, inadequate complementary feeding		6
5	Aguayo VM, Badgaiyan N & Paintal K, 2015, Bhutan[62]	2085, 0-23 months	Stunting	Child's age (12–23 months), sex (male), re-gional disparities, low household wealth index, ANCs (<3 check-ups), mothe''s no education			6
6	Aguayo VM, Nair R, Badgaiyan N & Krishna V, 2016, India[28]	2561, 0-23 months	Stunting	LBW, inadequate feeding practices, poor die-tary diversity, mother's nutrition & height (<145 cm), without access to improved sanitation			8
7	Ahmed AS, Ahmed T, Roy SK, Alam N & Hossain MI, 2012, Bangladesh[110]	8,885, 0-24 months	Stunting, wasting and underweight	Sex (male)	Sex (male), not vaccinated against mea-sles, not consuming iodised salt	Sex (male)	7
8	Ahsan S, Mansoori N, Mohiuddin SM, Mubeen SM, Saleem R & Irfanullah M, 2014, Pakistan[63]	304, 6-59 months	Stunting	Mother's no education, family size (>5 mem-bers), pregnancy >4 times, child mortality in last 6 months, absence of breastfeeding and no child immunisation			7
9	Akram R, Sultana M, Ali N, Sheikh N & Sarker AR, 2018, Bangladesh[16]	6540, 0-59 months	Stunting	Child's age (36 -47 months), low household wealth index, place of residence (rural) sex (male), mother's low education, low maternal BMI, children suffering from diarrhea			8
10	Alam MA et al, 2017, Bangladesh[64]	689, 6-24 months	Stunting	Child's age (>12 months), maternal undernutri-tion, mother's low education (<5 years), con-sumption of untreated drinking water, low household wealth index			8/12 (case control)
11	Ali SS, Karim N, Billoo AG & Haider SS. 2005, Pakistan[65]	400, 0-36 months	Stunting, wasting and underweight	Mother's no education	Mother's no education (primary level)	Mother's no education (pri-mary level)	5

ANC: Ante-natal check-ups; MUAC: Mid-Upper Arm Circumference; LBW: Low Birth Weight; SBA: Skilled Birth Attendant.
†Quality Assessment (QA):
Majority of studies are cross-sectional other study designs are mentioned in the QA column,
Cross-sectional studies assessed on a score of 8 (0-3: low quality, 4-5: medium quality and 6-8: high quality)
Case -control studies assessed on a score of 12 (0-4: low quality, 5-8: medium quality; 9-12: high quality)
Mixed methods assessed on a score of 5 (0-1: low quality, 2-3: medium quality, 4-5: high quality)
Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
12	Alom J, Quddus MA & Islam MA, 2012, Bangladesh[92]	6150, 0-59 months	Stunting, wasting and underweight	Child's age (>6 months), regional disparities, father's no education, father's occupation (working in agriculture were more likely, low household wealth index	Child's age (>6 months), mother's low education, breastfed children	Child's age (>12 months) increased with age, regional disparities, father's no education, low household wealth index, breastfed children	6
13	Baig-Ansari N, Rahbar MH, Bhutta ZA & Badruddin SH, 2006, Pakistan[66]	399, 6-18 months	Stunting	Sex (female), household food insecurity, mother's no education, large family size			8
14	Best CM, Sun K, de Pee S, Bloem MW, Stallkamp G & Semba RD, 2007, Bangladesh[108]	77 678 HHs, 0-59 months	Stunting, underweight, and wasting	Parental tobacco use	Parental tobacco use	Parental tobacco use	8
15	Budhathoki SS, Bhandari A, Gurung R, Gurung A & Kc A, 2020, Nepal[67]	0-59 months	Stunting	Low household wealth index, regional disparity, mother's education, small at birth, mother's tobacco use, no ANC visits, children no breastfed			7
16	Chandrasekhar S, Aguayo VM, Krishna V & Nair R, 2017, India[115]	2630 HH, 6-23 months	Stunting, underweight, and wasting	Food insecurity, dietary diversity	Food insecurity	Food insecurity, dietary diversity	8
17	Choudhary TS et al, 2019, India[128]	18898, 0-59 months	Wasting		Child's age (<12 months), LBW, nonutilisation of govt. nutrition services, feeding practices, seasonality - more in summer and monsoon		8
18	Choudhury N et al, 2017, Bangladesh[170]	10291, 0-23 months	Stunting, underweight, and wasting	Sex (male), child's age (increased with age), mothers low BMI, mother's no education, household food insecurity			8
19	Chowdhury F, Chisti MJ, Hossain MI, Malek MA, Salam MA & Faruque ASG, 2011, Bangladesh[109]	13555, 0-59 months	Stunting, underweight, and wasting	Father's tobacco use, low socio economic status	Father's tobacco use, low socio economic status	Father's tobacco use, low socio economic status	8
20	Chowdhury TR, Chakrabarty S, Rakib M, Saltmarsh S & Davis KA, 2018, Bangladesh[133]	17133, 0-59 months	Underweight and severe underweight			Mother's no or low education, father's no or low education, low household wealth index, child's age (>12 months), regional disparities, household consumption of iodized salt	6
21	Conway K et al, 2020, Nepal[107]	0-59 months	Stunting	regional disparities, socioeconomic inequalities, parent's level of education, maternal nutrition, sanitation practices (open defecation), maternal and newborn healthcare			5/5 (mixed-methods)

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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
22	Corsi DJ, Mejía-Guevara I, Subramanian SV, 2015, India[69]	26,842 (stunting); 27,483 (underweight), 6-59 months	Stunting and underweight	Short maternal stature, mother's no education, low household wealth index, poor dietary diversity, maternal underweight		Short maternal stature, mother's no education, low household wealth index, poor dietary diversity, maternal underweight	8
23	Cunningham K et al, 2019, Nepal[116]	1402, 6-24 months	Stunting	Place of residence (rural), women empowerment in agriculture, poor Water Sanitation and Hygiene (WASH) facilities and practices, poor dietary diversity			8
24	Keshav D & Montakarn C, 2020, Nepal[117]	366, 0-59 months	Stunting, underweight, and wasting	Number of children in a family using same cooking pot, mother's age at last delivery, contraceptive use, feeding practices	Sex (male)	Mother's occupation, postnatal check-up, postpartum intake of vitamin A capsule, uses of contraceptives, consumption of alcohol during pregnancy	5
25	Das SR et al, 2020, India[122]	580, 6-72 months	Stunting, underweight, and wasting	Low socio-economic status	Child's age (6-36 months), religion (hindu), mother's low education	Religion (muslim), LBW, mother's low education	4
26	Dhami MV et al, 2019, India[70]	13548, 6-8 months	Stunting	Poor feeding practices, mother's no or low education, low household wealth index			8
27	Das J et al, 2015, Bangladesh[120]	16 948, 0-59 months	Stunting, underweight, and wasting	Presence of under-5 siblings	Presence of under-5 siblings	Presence of under-5 siblings	8
28	Deshmukh PR, Sinha N & Dongre AR, 2013, India[93]		Stunting	Child's age, father's no or low education, fathers' occupation, low household wealth index, no consumption of Vit-A supplement in last 6 months, having anaemia			6
29	Di Cesare M, Bhatti Z, Soofi SB, Fortunato L, Ezzati M & Bhutta ZA, 2015, Pakistan[71]	33 638, 0-59 months	Stunting, underweight, and wasting	Socioeconomic inequities, regional disparities, maternal factors: low height, underweight, education (<10 years), low household wealth index, household food insecurity	Socioeconomic inequities, regional disparities, maternal factors: low height, underweight, education (<10 years), low household wealth index, household food insecurity	Socioeconomic inequities, regional disparities, maternal factors: low height, underweight, education (<10 years), low household wealth index, household food insecurity	8
30	Dinachandra Singh K, Alagarajan M & Ladusingh L, 2015, India[127]	0-59 months	Wasting		No access to sanitation toilets (open defecation), unhygienic storage of drinking water, education of household head, mothers exposed to mass media, underweight mothers, place of residence (remote areas)		8

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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality).

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
31	Dorsey JL, Manohar S, Neupane S, Shrestha B, Klemm RDW & West KP Jr, 2018, Nepal[72]	4,853, 0-59 months	Stunting	Child's age (increased with age), maternal height (<145 cm), underweight mothers (<45 kg), thin mothers (MUAC <22.5), mother's no education, household size, head of household gender (female), community-level factors: agriculture households less likely to have stunted children & community infrastructure less developed (lacking paved roads, markets, or hospitals) more likely			8
32	Farooq R et al, 2020, Pakistan[134]		Underweight			Place of residence (rural), mother's low education, low household wealth index, number of children born to women, poor sanitation facility, child's age (18-32 months)	8
33	Fenske N, Burns J, Hothorn T & Rehfuess EA, 2013, India[73]	12 176, 0-24 months	Stunting	Child age and sex (male), low household wealth index, mother's low or no education, low maternal BMI, being born as a twin or multiple birth was associated with stunting			8
34	Gautam S et al, 2017, Nepal[123]	150, 0-59 months	Wasting		High prevalence in urban, mother's low or no education, backward caste, occupation (labourer), child's age (25-36 months), high birth order, feeding practices (children who were not fed colostrum)		5
35	Harding KL, Aguayo VM & Webb P, 2018, South Asia[124]	252797, 0-59 months	Wasting		Younger children (0 to 5 months), low BMI (<18.5 kg/m^2), higher birth order, sex (male), mother's no education, short maternal stature, lack of improved water source, low household wealth index		6
36	Harding KL, Aguayo VM & Webb P, 2018, South Asia[6]	62509, 0-59 months	Stunting and wasting	LBW, children aged 0 to 23 months not breastfed within the first hour post-partum, those who were provided pre-lateral feeds, aged 0 to 5 months not exclusively breastfed. Poor minimum diet diversity & minimum adequate diet	LBW, children aged 0 to 23 months not breastfed within the first hour post-partum, those who were provided pre-lateral feeds, aged 0 to 5 months not exclusively breastfed. Poor minimum diet diversity & minimum adequate diet		8

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Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
37	Hasan MT, Soares Magalhaes RJ, Williams GM & Mamun AA, 2016, Bangladesh[75]	28 941, 0-59 months	Stunting, underweight, and wasting	Mother's low education (primary or less)	Mother's low education (primary or less)	Mother's low education (primary or less)	8
38	Hasan M et al, 2019, Bangladesh[74]	296, 0-24 months	Stunting	Low dietary diversity <5 food groups, mother's no education, maternal short stature, low household wealth index			12/ 12 (case-control)
39	Hoq M et al, 2019, Bangladesh[112]	Qual: 75, Quant: 147, 0-59 months	Stunting, underweight, and wasting	Inappropriate feeding practice, high birth order, high number of family members, illness in the last 2 weeks and access to hygienic latrine	Inappropriate feeding practice, high birth order, high number of family members, illness in the last 2 weeks and access to hygienic latrine	Inappropriate feeding practice, high birth order, high number of family members, illness in the last 2 weeks and access to hygienic latrine	5/5 (mixed-methods)
40	Hossain S et al, 2020, Bangladesh[76]	10875, 0-59 months	Stunting, underweight, and wasting	Lower in female children, higher educated mothers, wealthier families, mother had received prenatal care, and the bigger size of the child during birth	Lower in female children, higher educated mothers, wealthier families, mother had received prenatal care, and the bigger size of the child during birth	Lower in female children, higher educated mothers, wealthier families, mother had received prenatal care, and the bigger size of the child during birth. Place of delivery: delivered at health facility	7
41	Huda TM, Hayes A, El Arifeen S, & Dibley MJ, 2018, Bangladesh[77]	5,911 in 2004 & 965 in 2014, 0-59 months	Stunting	Household economic status, maternal and paternal education, improved health-seeking behaviour of the mothers, sanitation, fertility, and maternal stature			7
42	Meshram II et al, 2019, India[83]		Stunting, underweight, and wasting	Regional disparities, low dietary diversity, low caste, mother's no education, lower socio-economic status, mother's history of morbidity and hygiene, not having access to sanitation toilets and separate kitchen	Regional disparities, low dietary diversity, low caste, mother's no education, lower socio-economic status, mother's history of morbidity and hygiene	Regional disparities, low dietary diversity, low caste, mother's no education, lower socio-economic status, mother's history of morbidity and hygiene, not having access to sanitation toilets and separate kitchen	6
43	Mostafa KSM, 2011, Bangladesh[97]	6058, 0-59 months	Stunting	Low household wealth index, low maternal BMI (thinner mother), place of residence (rural), father's no education, no access to toilet facilities, child's age (increased with age), higher birth order			8
44	Khan S et al, 2019, Pakistan[78]	3071, 0-59 months	Stunting, underweight, and wasting	Place of residence (rural), mother's no education, consanguineous marriage, poor household wealth, mother's height (<145 cm)	Mother's no education	Place of residence (rural), poor household wealth index, consanguineous marriage, sex (male), mother's low or no education, mother's height (<145 cm), maternal BMI (<18.5), child's small size at birth	8

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Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
45	Khatri RB, Mishra SR, Khanal V & Choulagai B, 2015, Nepal[135]	280, 0-59 months	Underweight			Sex (female), younger mothers (<24 years), having daily bath protective factor	6
46	Khatun W et al, 2019, Bangladesh[102]	28,123, 0-59 months	Stunting and wasting	Mother's short height (<145 cm)	Mother's short height (<145 cm)		8
47	Kim R, Mejía-Guevara I, Corsi DJ, Aguayo VM & Subramanian SV, 2017, South Asia[79]	18,586, 6-23 months	Stunting	Mother's short height (<145 cm), low household wealth index, mother's no education, low maternal BMI (< 18.5 kg/m^2), poor dietary diversity, immunisation, mother's young age at marriage, poor feeding practices			8
48	Kim R et al, 2019, India[80]	140,444, 6-59 months	Stunting, underweight, and wasting	Mother's short height, mother's no education, low maternal BMI, low household wealth index & air quality	Mother's short height, no mother's education, low maternal BMI, lower household wealth index & air quality, poor access to sanitation, unsafe stool disposal, poor dietary diversity, <4 ANC visits absence of SBA	Low maternal BMI, mother's short height, low household wealth index, no mother's education & poor dietary diversity	8
49	Mahmood T et al, 2020, Pakistan[81]	25067, 0-59 months	Stunting	Child's age (increased with age, sex (male) higher birth order (second or higher), parent's no education, lack of sanitation facilities, low household wealth index			8
50	Meshram II et al, 2012 India[94]	1751	Underweight and stunting	Low household wealth index		Mother's no education (no education), mother's suffering from morbidities	6
51	Meshram II et al, 2015, India[82]	5457, 0-12 months	Stunting, underweight, and wasting	Poor feeding practices, low socioeconomic status, mother's no education of the mother, poor hygienic practices, LBW			8
52	Meshram II, Laxmaiah A, Gal Reddy C, Ravindranath M, Venkaiah K & Brahmam GN, 2011, India[98]	805, 0-36 months	Stunting, underweight, and wasting	Child's age (higher >24 months vs <12 months)		Child's age (higher >24 months vs <12 months), low household wealth index	8
53	Mistry SK et al, 2019, Bangladesh[84]	6539, 0-23 months	Stunting	Sex (male), LBW, mother's low or no education, age at first pregnancy, maternal nutrition, regional disparities, place of residence (rural), low socio-economic status, food insecurity, poor access to sanitary latrine and toilet hygiene condition			8

ANC: Ante-natal check-ups; MUAC: Mid-Upper Arm Circumference; LBW: Low Birth Weight; SBA: Skilled Birth Attendant
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Mixed methods assessed on a score of 5 (0-1: low quality, 2-3: medium quality, 4-5: high quality)
Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
54	Mondal D & Paul P, 2020, India[95]	29,558, 0-59 months	Stunting, underweight, and wasting	3 or less ANC visits, smaller children, LBW (<2.5 kgs), child's age (increased with age- >12 months more at risk), sex (male), higher birth order (second or higher), younger mothers more (under 25 years), parent's no education, low household wealth index	Intimate partner violence (physically abused mothers), smaller children, LBW (<2.5 kgs), sex (male), higher birth order (second or higher), younger mothers (under 25 years), parent's no education, low household wealth index	3 or less ANC visits, smaller children, LBW (<2.5 kgs), child's age (increased with age- >12 months more at risk), sex (male), higher birth order (second or higher), younger mothers more (under 25 years), parent's no education, low household wealth index, place of residence (rural)	8
55	Murarkar S et al, 2020, India[113]	2929 mothers and 3671 children, 0-59 months	Stunting, underweight, and wasting	Place of residence (urban slums & rural), higher birth order (second or higher)	Place of residence (urban slums & rural), exclusive breast feeding, acute diarrhea	Place of residence (urban slums & rural), low household wealth index, sex (male), exclusive breast feeding, mother's low education	8
56	Nepali S et al, 2020, Nepal[126]	2414, 0-59 months	Wasting		Food insecurity, place of residence (rural), mother's no education		8
57	Karkuki Osguei N & Mascie-Taylor CGN, 2019, Nepal[90]	3630, 0-59 months	IDA, stunting, wasting, underweight	Mother's no education, regional disparities, religion & ethnicity, access to sanitation, low household wealth index	Regional disparities, religion	Mother's low or no education, religion & ethnicity, regional disparities, low household wealth index	6
58	Paul P et al, 2019, India[103]	80539, 0-59 months	IDA, stunting, wasting, underweight	Age at marriage (<18 years)	Age at marriage (<18 years)	Age at marriage (<18 years)	8
59	Rah JH, Cronin AA, Badgaiyan B, Aguayo VM, Coates S, & Ahmed S, 2015, India[119]	10 364, 34 639 and 1282, 0-23 months	Stunting	Access to sanitation toilets, mother's/caregiver's reported hygiene practices, sanitation and drinking water conditions			8
60	Rahman A & Chowdhury S, 2007, Bangladesh[85]	5333, 0-59 months	Stunting	Mothers low (primary) or no education, household wealth (dependent on fathers education level), mother's media exposure, number of under-5 children, place of delivery (at home more at risk), child's age (>1 year), birth order, months of breast-feeding, birth size, mother's BMI, mother's height, age of household head, measles vaccine, supplementation of diet with liquids, regional disparities			5
61	Rahman MM, Saima U & Goni MA, 2015, Bangladesh[105]	0-59 months	Stunting, underweight, and wasting	Mother's autonomy in household decisions	mother's autonomy in household decisions	mother's autonomy in household decisions	8

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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
62	Rahman MS, Howlader T, Masud MS & Rahman ML, 2016, Bangladesh[111]	7530, 0-59 months	Stunting, underweight, and wasting	Low birth weight	Low birth weight	Low birth weight	8
63	Rahman MHU et al, 2020, India[86]		Stunting, underweight	Poor sanitation practices (open defecation), mother's no education, higher maternal age (40-49 years), religion and backward caste, poorest household wealth index		Poor sanitation practices (open defecation), mother's no education, higher maternal age (40-49 years), religion and backward caste, poorest household wealth index	8
64	Raihan MJ et al, 2017, Bangladesh[131]	10478, 0-59 months	Wasting		Lower socio-economic status, poor water, sanitation & hygiene		8
65	Saeed Q, Shah N, Inam S & Shafique K, 2017, Pakistan[87]		Stunting, underweight	Maternal depression, mother's low or no poor education, unemployment, and low household wealth index		Maternal depression	8
66	Saha KK et al, 2009, Bangladesh[118]	1343, 1-24 months	Stunting, underweight	Household food insecurity		Household food insecurity	8
67	Saleemi MA, Ashraf RN, Mellander L & Zaman S, 2001, Pakistan[171]	1236, 0-60 months	Stunting	Duration of breastfeeding, mother's short height, LBW, history of stunting			11/12 (case control)
68	Sarma H et al, 2017, Bangladesh[88]	7647, 0-59 months	Stunting	Household food insecurity, place of delivery (delivered at home more at risk) low household wealth index, mother limited exposure to mass media, child's age (12-23 months), smaller than average size of child at birth, parents' low (primary) or no education			6
69	Saxton J et al, 2016, India[114]	1227, 6-24 months	Stunting	Protective agent: cooking outdoors rather than indoors, birth spacing >/=24 months, and hand-washing with a cleansing agent. Risk factor: higher birth order, repeated diarrhoeal infection			8
70	Shah SM, Selwyn BJ, Luby S, Merchant A & Bano R, 2003, Pakistan[89]	1878, 0-36 months	Stunting	Mother’s no education, father’s low income, overcrowded houses			7

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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with under-weight	Quality assessment†
71	Shroff M, Griffiths P, Adair L, Suchindran C & Bentley M, 2009, India[106]	821, 0-36 months	Stunting	Mother's autonomy (overall decision making, permission to travel, attitude towards domestic violence and financial autonomy)			5
72	Singh A, Singh A & Ram F, 2014, Nepal[100]	2335, 0-59 months	Stunting, underweight, and wasting	Household food insecurity, low maternal BMI (<18.5 kg/m^2)	Household food insecurity, low maternal BMI (<18.5 kg/m^2)	Household food insecurity, low maternal BMI (<18.5 kg/m^2)	8
73	Singh GCP, Nair M, Grubesic RB & Connell FA, 2009, Nepal[99]	443, 6-36 months	Stunting, underweight	Child's age (>12 months), low maternal BMI, backward class (Dalit), low household wealth index		Low maternal BMI, child's age (>12 months), higher birth order, low household wealth index, backward caste (Dalit), parent's low education (<6 years), low Vitamin A treatments, poor participation in nutrition pro-grams	7
74	Tariq J, Sajjad A, Zakar R, Zakar MZ & Fischer F, 2018, Pakistan[101]	984, 0-24 months	Stunting, underweight and wasting	Mother's low BMI, mother's low access to in-formation, high birth order, consanguineous marriages, father's low education, place of resi-dence (rural), poor sanitation facilities, low vita-min A consumption	Children not breastfed	Mother's low BMI, mother's low access to information, high birth order, consanguineous marriages, father's low educa-tion, place of residence (rural), poor sanitation facilities, low vitamin A consumption	8
75	Tiwari R, Ausman LM & Agho KE, 2014, Nepal[19]	2380, 0-59 months	Stunting	Low household wealth index, small size of baby, breastfed more than 12 months			8
76	Wali N et al, 2020, South Asia[59]	564518, 0-59 months	S Stunting	Mothers no education, mothers' short height (<150 cm)			8

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†Quality Assessment (QA):
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Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 1. Study characteristics for child undernutrition- stunting, wasting and underweight (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
GREY literature							
1	IFPRI, 2020, India[172]	NA	Stunting	Mother's low BMI (<18.5 kg/m^2), access and utilisation of health and nutrition services, low socio-economic status, access to sanitation facilities, mother's no education, inadequate diet			6
2	IFPRI, Gujarat, 2021, India[173]	NA	Stunting	Mother's low (18.5 (<kg/m^2), poor feeding practices (delayed and inadequate complementary feeding), low socio-economic status			6
3	IFPRI, Tamil Nadu, 2021, India[174]	NA	Stunting	Mother's low (<18.5 (kg/m^2), poor feeding practices (delayed and inadequate complementary feeding), low socio-economic status			6
4	UNICEF, 2015, India[151]		Stunting, vit. A, IDA	Mother's short height, low household wealth index, maternal underweight, failure to meet children's minimum dietary diversity, mother's no education, low age at marriage			6
5	World Bank, 2017, India[175]	NA	Stunting	Mothers age (<18 years and >35 years), low household wealth index			6
6	World Bank, 2017, Bangladesh[176]	NA	Stunting	Mothers age (<18 years and >35 years), low household wealth index			6
7	World Bank, 2017, Bhutan[177]	NA	Stunting and anaemia	Maternal anaemia, poor nutrition and care amongst women, poor quality & access to services			6

ANC: Ante-natal check-ups; MUAC: Mid-Upper Arm Circumference; LBW: Low Birth Weight; SBA: Skilled Birth Attendant
†Quality Assessment (QA):
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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality).

Table 2. Study characteristics of micronutrient deficiencies of vitamin A, iron and zinc

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
Academic literature - Journal articles							
1	Ackerson LK & Subramanian SV, 2008, India[104]	14552, 12-35 months	IDA, stunting, wasting, underweight		Domestic Violence experienced by mothers		8
2	Agarwal S & Srivastava A, 2009, India[61]	124385, 0-59 months	IDA, stunting, wasting, underweight		Place of residence (urban)		8
3	Arlappa N et al, 2011, India[149]	8777, 36-59 months	VAD	Lower socio-economic status, poor dietary diversity & prolonged dietary deficit, child's age (increases with age)			8
4	Arlappa N, Laxmaiah A, Balakrishna N, Harikumar R & Brahmam GN, 2008, India[150]	8646	VAD	Backward caste (scheduled tribe), mother's no education, no access of sanitary toilets			8
5	Bharati S, Pal M, Chakrabarty S & Bharati P, 2015, India[138]	35 591, 6-59 months	IDA		Child's age (6-23 months), regional disparities, place of residence (rural), parents no education		8
6	Dey S, Goswami S & Dey T, 2013, India[146]	10137, 0-59 months	IDA		Place of residence (rural), religion (hindu >mus-lims), women with multiple children, mother's no education & mother's young age at marriage, sex (male)		6
7	Habib MA et al, 2016, Pakistan[139]	7138, 0-59 months	IDA		Child's age (<24 months), maternal anaemia, household food insecurity, place of residence (rural), sex (male)		8
8	Harding KL, Aguayo VM, Namirembe G & Webb P, 2018, Nepal and Pakistan[130]		IDA		Maternal anaemia		6
9	Khan JR, Awan N & Misu F, 2016, Bangladesh[140]	2171, 6-59 months	IDA		Child's age (<24 months), maternal anaemia, malnourished child, source of drinking water, low household wealth index, regional disparities		8
10	Laxmaiah A et al, 2013, India[141]	71591 for VAD, 3,291 for IDA	IDA, VAD	Backward community (other Backward castes, scheduled caste & schedule tribes), parent's no education, limited access to sani-tary toilets, child's age (<3years)	Child's age (>3-5 years), no access to sanitary toilets		8
11	Nair KM, Fernandez-Rao S, Nagalla B, Kankipati RV, Punjal R, Augustine LF, Hurley KM, Tilton N, Harding KB, Reinhart G, Black MM, 2016, India[145]	476 (6-12 months), 316 (29-56 months)	IDA		Maternal anaemia, young age (29-35 months), low birth weight, poor dietary diversity		10/11 (Random-ised-control trial)

†Quality Assessment (QA):
Majority of studies are cross-sectional other study designs are mentioned in the QA column,
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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality)

Table 2. Study characteristics of micronutrient deficiencies of vitamin A, iron and zinc (cont.)

S. No	Author, year	No of children (N), age	Outcomes	Factors associated with stunting	Factors associated with wasting	Factors associated with underweight	Quality assessment†
12	Nguyen PH et al. 2018, India[147]	245 346, 6-59 months	IDA		Lower maternal education, coverage of Nutrition and Health Interventions, poor socioeconomic status, poor sanitation, low meat & fish consumption		8
13	Osguei NK & Mascie-Taylor CGN, 2019, Nepal[90]	3630, 0-59 months	IDA, stunting, wasting, underweight		Regional disparities		6
14	Paul P et al, 2019, India[103]	80539, 0-59 months	IDA, stunting, wasting, Underweight		Child marriage (<18 years)		8
15	Rahman S et al, 2017, Bangladesh[152]	1266, 6-59 months	VAD	Inadequate dietary intake of vitamin A, poor dietary diversity, particularly leafy vegetables			8
16	Siegel EH, Stoltzfus RJ, Khatry SK, LeClerq SC, Katz J & Tielsch JM, 2006, Nepal[142]	569, 4 –17 months	IDA		Age & caste		6
17	Sharma U & Yadav N, 2019, India[144]	365, 48-60 months	IDA and zinc deficiency		Undernourished children (stunted, underweight & wasted)	Undernourished children (stunted, underweight & wasted)	5
18	Yusuf A et al, 2019, Bangladesh[143]	2231, 6-59 months	IDA		Maternal anaemia, undernourished children, younger children (<24 months), low household wealth, regional disparities		
Grey literature							
1	IFPRI, 2018, India[148]		IDA		Inadequate dietary diversity (intake of iron-rich foods), poor sanitation		6
2	UNICEF, South Asia, 2015[151]		Stunting, Vitamin A deficiency, IDA		Low household wealth index, lower maternal education, poor quality diets		6
3	World Bank, 2017, Bhutan[178]	NA	Stunting and anaemia	Maternal anaemia, poor nutrition and care amongst women, poor quality & access to services			6

†Quality Assessment (QA):
Majority of studies are cross-sectional other study designs are mentioned in the QA column,
Cross-sectional studies assessed on a score of 8 (0-3: low quality, 4-5: medium quality and 6-8: high quality)
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Randomised control trials assessed on a score of 10 (0-3: low quality; 4-6: medium quality, 7-10: high quality)
Grey Literature assessed on a score of 6 (0-2: low quality, 3-4: medium quality; 5-6: high quality).

sess the quality of different study designs.[49-51] Cross sectional studies were assessed by JBI tool.[52] Mixed methods studies were assessed by the MMAT mixed methods appraisal tool by Pluye and colleagues.[53] Grey literature was appraised with the AACODS tool that looks at authority, accuracy, coverage, objectivity, date and significance.[54] All studies were appraised as having high, medium or low quality. The quality of all studies was independently appraised by the first author (NW) and a random sample of 10% of studies was assessed by the senior author (AR). Any discrepancies were resolved with discussion.

Data synthesis

This review used a meta-ethnographic approach to synthesise data,[55] an increasingly recognised approach to synthesise qualitative and quantitative studies.[56,57] Meta-ethnographic approach has evolved that allows interpretation of findings to develop models to inform policy and practice.[57] This approach enables to identify relationships between and across various factors associated with child undernutrition and identify priorities, leading to creation of new models and theories.[58] The meta-ethnographic approach involved 4 stages: (i) identifying metaphors and common findings; (ii) determining how the study findings were related: even though the number of studies was large (n=98), commonalities were identified; (iii) reciprocal translation of studies; and (iv) synthesizing translations which form a line of argument and produce a model (Figure 1) for the description of findings.

We did not undertake a meta-analysis and report the pooled estimate for the effect of each factor on undernutrition across all sub-regions. This is because, firstly, the factors were measured differently in each study. Secondly, meta-analysis depicts effect size and may not necessarily provide models to inform policy decisions. Our recent studies estimate the effect sizes[59,60] and the present study complements them with the development of a model. Lastly, this review summarises studies over a period of 20 years (2000-2021) where different WHO reference values have been used for measuring stunting, wasting and underweight, pre and post 2007 estimates.[39, 40] Thus, reporting an estimate for the pooled effect would misrepresent the impact of the factors on child nutrition.

RESULTS

A total of 3601 articles were retrieved from eight databases. After the removal of duplicates, 3003 articles were retained. Screening of titles and abstracts resulted in the inclusion of 281 articles. The abstract review led to the inclusion of 155 articles. The full texts for the remaining 155 articles were reviewed, and 86 deemed eligible for final inclusion. Another 4 articles were included from other sources through manual search of the bibliographic references of the retained articles. Additionally, a grey

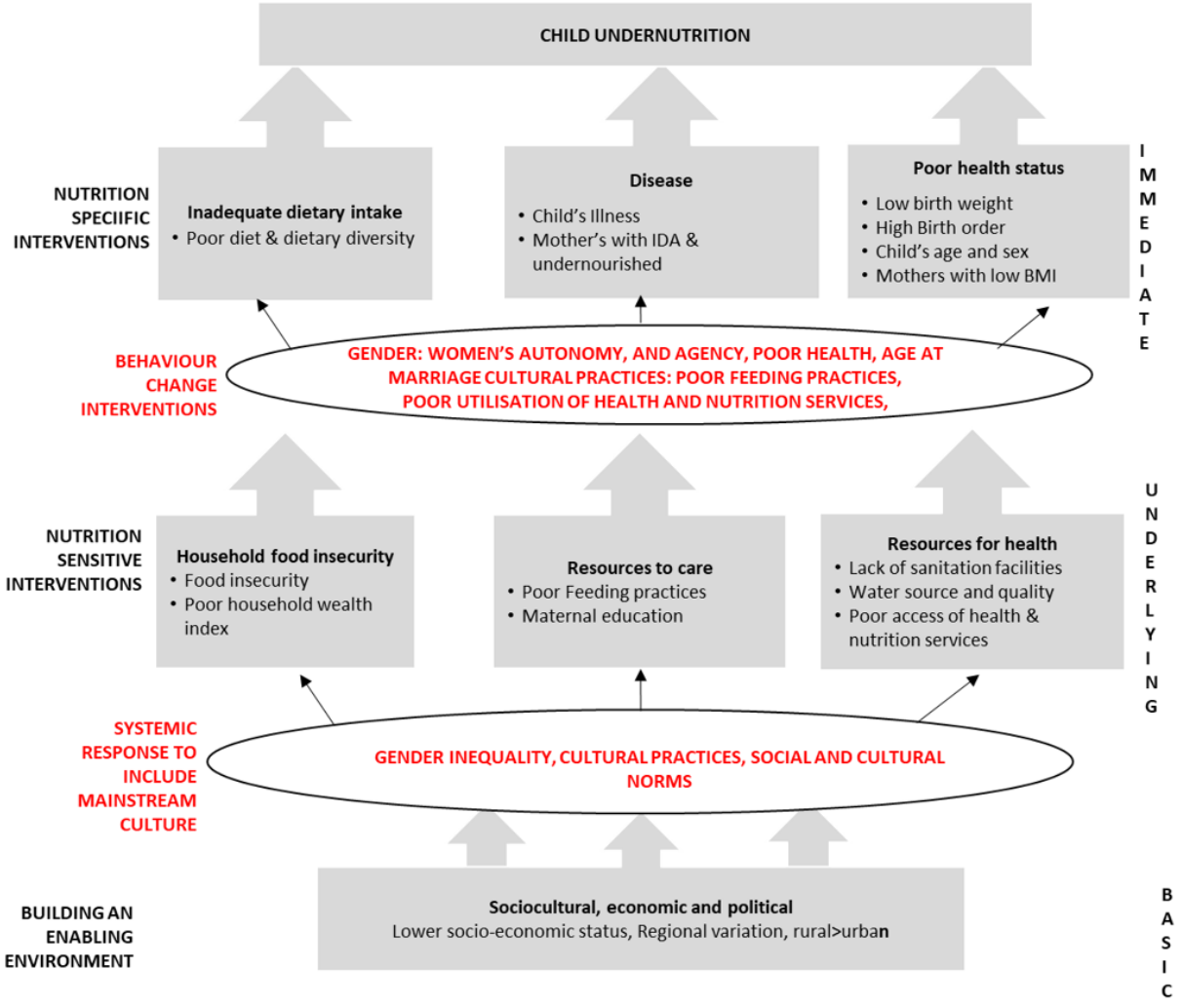

Figure 1. Child undernutrition in South Asia: a new conceptual framework.

literature search, including screening of organisation websites, provided 25 reports. Full-text screening of the reports led to the exclusion of 17 reports. Therefore, total of 90 articles and 8 reports were included in the review, as shown in Figure 2. Most studies included were quantitative, highlighting the prevalence and drivers, determinants, correlations, and risk factors of child undernutrition.

Study characteristics

Majority of studies were cross-sectional (N=84), three case-control studies, two mixed methods studies and one randomised control trial. Grey literature reports design included a combination of quantitative methods and mixed methods. Majority of studies were conducted in Bangladesh and India, and this review found no studies conducted in Maldives. Stunting was the most researched indicator, followed by wasting and underweight. Eighteen studies reported on Iron deficiency anaemia, five on Vitamin A deficiency and only one study on zinc deficiency. Quality of most studies reported was medium or high.

Overall, the most reported factor associated with all forms of child undernutrition were maternal education, poor maternal nutrition, child's age and sex, low household wealth and socioeconomic status, rural residence, poor dietary diversity and poor access to sanitation. Table 3 provides a snapshot of the most common factors across all studies. Table 1 and 2 provide study characteristics. However, there were some variances according to the type of child undernutrition, and these are detailed below.

Stunting

The most reported factors associated with child stunting were: maternal education - mothers with primary or no education,[16,31,61-90] low household wealth index[62,64,67,69-74,76-81,86-89,91-97] and children aged >12 months.[16,62,64,68,72,73,81,84,85,88,92,93,95,97-99] Children of mothers who had low Body Mass Index (BMI) <18.5 kg/m^2,[16,68,73,79,80,85,97,99-101] short stature <145 cm,[31,69,71,72,75,77-80,85,91,102] were under 25 years of age 95 and older mothers over 40-49 years86 were more likely to be stunted.

Other maternal factors associated with child stunting were a limited exposure to media,[85,88,101] young age at marriage,[79] younger mother's <18 years,[103] history of morbidity,[83] maternal depression[87] and those who experienced domestic violence.[104] Mothers who received three or less antenatal care check-ups had higher odds of having stunted children.[62,67,73,76,95] Mothers who delivered their babies at home were at higher risk.[85,88] Children whose mothers participated in making all household decisions were less likely to be stunted.[105,106] Improved health-seeking behaviour of mothers resulted in decreased

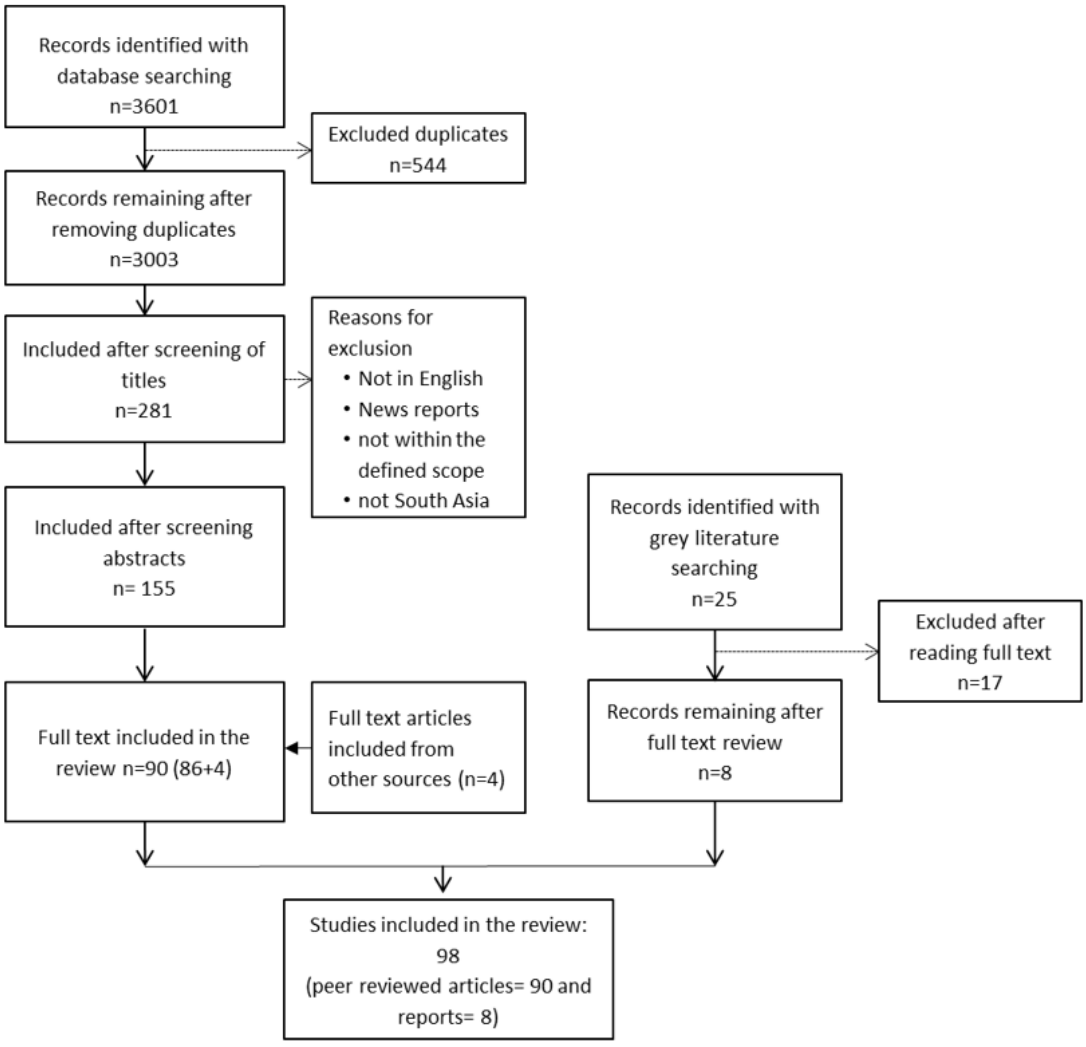

Figure 2. Study selection flow chart.

Table 3. Relation between reported factors associated with child undernutrition across literature

Associated factors	Stunting (N=51)	Wasting (N=39)	Underweight (N=39)	Vitamin A deficiency (N=5)	Iron deficiency (N=18)	Zinc deficiency (N=1)
No mother's education	‡	‡	‡	‡	§	
No father's education	¶		¶			
Poor maternal physical health[†]	¶	¶	¶		‡	
Low BMI (<18.5 kg/m^2	§	§	§			
Maternal short stature <145 cm	§	¶				
Re Child age <12 months		§			‡	
Child age >12 months	‡		§	‡		
Being male	¶	‡	§		§	
Being female	¶					
Low birthweight	¶	¶	¶		¶	
Small at birth	¶	¶				
Higher birth order (second or more)	§	¶	§			
Low household wealth	‡	¶	‡		§	
Poor access to sanitation	§	¶	§	‡		
Food insecurity		¶	¶		¶	
Poor dietary diversity	¶	¶	¶	‡	§	
Inadequate feeding practices	¶	¶	¶			
Lower socioeconomic status	§	¶	¶	‡		
Rural place of residence	¶	¶	¶		‡	‡

[†]Undernourished/anaemia.
[‡]High association – high association of the factor reported with child undernutrition by more than 30% of studies.
[§]Moderate association- moderate association of the factor reported with child undernutrition by 15-30% of studies.
[¶]Low association- low association of the factor reported with child undernutrition by less than 15% of studies.

child stunting.[77,107]

Children of fathers with higher education had decreased odds of being stunted.[77,81,85,92,93,97,101] Parental factors associated with child stunting were low literacy levels of both parents,[95,107] tobacco use[67,108,109] and those who were married consanguineously.[78,101]

Male children were more likely to be stunted than female children[16,68,73,76,78,101,110] except for a few studies that highlight females as more likely to be stunted.[66,81,95] Children who had low birth weight,[82,84,91,95,111] were small at birth,[67,76,85,88,95,96] had higher birth order,[73,81,85,95,97,101,112-114] were born as a twin or multiple births[73] and those who were ill[16,112,114] were more at risk of being stunted. Full vaccination of a child was a protective factor against stunting.[79,85]

Poor feeding practices were associated with child stunting, such as inadequate feeding, delayed introduction of complementary foods,[62,70,79,82,85,112] poor dietary diversity,[69,74,79,83,115,116] children not fed colostrum and introduced with other foods immediately after birth,[117] absence of breastfeeding,[63,67] and breastfeeding for more than 12 months.[96]

Household factors included household food insecurity,[66,68,84,88,100,115,118] household poor access to toilets,[77,81-84,86,90,91,97,101,107,112,116] poor access to safe drinking water,[64,119] and poor hygiene practices.[91,114] Cooking outdoors rather than indoors was a protective agent against child stunting,[114] while poor air quality in households[80] and not having a separate kitchen83 were reported risk factors. Large families with a size of >5 members,[63,66,72,112] the presence of under-5 siblings[85,120] and overcrowded houses[89] were more likely to have stunted children.

They were regional disparities in the prevalence of stunting,[62,67,83,85,90,92,107] with those living in certain regions,[16,84] rural areas[16,71,78,84,97,113,116] and urban slums[113] more likely to be stunted. Those children belonging to lower socioeconomic status[61,71,83-85,107,121,122] and backward caste[86,90,99,121,122] had higher odds of stunting.

Wasting

Most reported factor associated with child wasting was maternal education, where educated mothers with secondary or higher education were less likely to have wasted children when compared with mothers with no education.[65,68,71,76,78,80,83,92,95,123-126] Lower education of household heads was also associated likelihood of child wasting.[127] Mothers with low BMI<18.5 kg/m^2 [68,71,80,100,124,127] and short stature <145 cm[80,102,124] were more likely to have wasted children. Other maternal factors associated with child wasting were age <25 years,[95,127] early marriage <18 years,[103] mothers working as labourers,[123] history of morbidity and poor hygiene[83] and those who experienced domestic violence.[95,104] Protective factors to child wasting were mothers who were exposed to mass media,[127] received prenatal care,[76,80] accessed health and other services[128] and participated in making all household decisions.[105]

Child related factors significantly associated with wasting were younger age <6 months,[68,92,122-124,129] male sex,[68,76,95,110,117,124,128,129] low birth weight,[76,95,111,124,128] higher birth order,[95,112,123] illness in the last 2 weeks,[112,113] not vaccinated[110] and having multiple siblings.[112,120,123]

Household related factors associated with wasting were: food insecure households,[68,71,100,115,126] poor air quality,[80] low household wealth,[71,76,80,95,130] poor sanitation facilities,[80,112,127,132] and lack of improved water source.[127,130]

Poor feeding practices associated with wasting included not giving colostrum,[123] given pre-lacteal feeds in the first days of life[101,129,129] and inadequate diet and diversity.[80,83,112,119,129] Breastfed children were more likely to be wasted.[92,132]

They were geographical differentials and disparities in prevalence of wasting,[71, 83, 90, 121, 129] with those living in remote and rural[113,126,127] and in urban slums[123] more at risk. Populations of lower socioeconomic status[61,71,83,131] and vulnerable minorities were at risk of being wasted.[83,90,122,123]

Underweight

The most reported factor associated with underweight was maternal education, where children of mothers with secondary or higher education were at low risk of being underweight when compared with mothers with no or primary education.[61,65,68,69,71,75,76,78,80,82,83,86,90,94,95,99,113,133,134] Other maternal factors included low maternal BMI <18.5 kg/m^2,[68,69,71,78,80,99-101] maternal age of 40-49 years[86,136] and under 25 years of age.[95] Mothers with a history of co-morbidities[83,94] and those married at young age <18 years were more likely to have underweight children.[103] Uneducated fathers were also more likely to have underweight children.[68,95,99,101,133]

Child related factors associated with underweight included older age >12 months,[68,92,95,98,99,133,134] male sex,[68,76,78,95,110,113] low birth weight <2.5 kgs[82,95,111] and higher birth order of second or more.[95,99,101,112]

Households with low socioeconomic status,[71,82,83,121] low and lowest wealth index[69,71,76,78,80,82,90,92,95,98,99,113,133,134] and those belonging to vulnerable populations including backward castes[99,121] and certain religious backgrounds[86,90,122] had underweight children. Food insecure households[68,71,100,115,118] and those with poor dietary diversity[69,80,83,115] had underweight children. Breastfed children were more likely to be underweight[92,113] and those with poor and suboptimal feeding practices.[82,112] Poor hygiene practices and inadequate sanitation access,[83,101,112,134] open defecation,[86] and not taking a daily bath[82,135] were contributing factors to underweight in children.

They were geographical differentials in the prevalence of underweight,[71,78,83,90,92] with those residing in rural areas[78,95,101,134] and urban slums[113] more at risk. Access and utilisation of health services acted as a protective agent against underweight, mothers who delivered at a health facility,[76,92] had received prenatal care[76,78,95] and consumed Vitamin A supplements.[99, 101, 117]

Children whose mothers participated in making all household decisions[105] and in nutrition programs[99] were less likely to be underweight. Other contributing factors to underweight included maternal depression,[87] mother's low access to information, consanguineous marriage,[136] presence of under-5 siblings,[120] large family size,[112] father's smoking or tobacco use in the house[108,109] and domestic violence experienced by mothers.[104]

Iron deficiency anaemia (IDA)

Younger children aged <24 months[137-142] and undernourished children,[139,142,144]especially those stunted[130] were more likely to be anaemic. Maternal factors included anaemic mothers,[78,130,138,142,144] mothers with limited or no education[138,146,147] and early marriage <18 years.[103,145]

Households with poor dietary diversity with low intake of iron-rich foods such as green leafy vegetables (GLVs) and animal source foods,[3,146,147] food insecure households,[139] low household wealth index,[3,137,139,142,146] limited access to drinking water[140] and sanitation facilities[140,146,147] were associated with IDA. There were regional disparities in the prevalence of anaemia with those living in rural areas,[3,90,137,139,142,145] urban slums[61] and vulnerable populations[141,145] at higher risk. Other factors associated with IDA were domestic violence experienced by mothers,[104] being a male child,[138,145] low birth weight[144] and poor coverage of nutrition and health interventions.[146]

Vitamin A deficiency

Lower socioeconomic and backward communities were at higher risk of Vitamin A deficiency (VAD).[148-150] Poor dietary diversity with low intake of animal-source foods and leafy vegetables[148,150,151] and prolonged dietary deficit[148] caused VAD. VAD increased with age, which was higher amongst 3 to 5 years compared to 1 to 3 years.[140, 148]Children of illiterate parents were VAD[140,148,150] and those living in households with limited or no access to sanitary latrines.[140,149]

Zinc deficiency

There was only 1 study from India that reported on factors associated with zinc deficiency, common factors reported were poor nutritional status of children, wasted and stunted children were three times more likely to be zinc deficient and rural residence.[143]

A new conceptual framework to understand priorities

This review highlights priorities across factors associated with child undernutrition. These factors have been consistently reported in the literature across the last two decades. Based on the UNICEF framework, these priorities can be categorised into immediate, underlying, and basic factors. The most commonly reported findings that need to be prioritised are: **Immediate factors:** child's age, sex and poor nutrition status, poor maternal health, poor dietary diversity; **Underlying factors:** maternal low or no education, low household wealth index, poor water and sanitation; and **Basic factors:** rural residence, low socioeconomic status.

Our review describes a gap in the literature, and Figure 1 highlights the addition of gender, cultural norms and practices and social factors at various levels of the UNICEF framework with a need for targeted culturally appropriate interventions. While research has been successful in identifying the factors at immediate – individual level and underlying – household level there is a further need to understand the persistence of certain factors from a cultural lens. Factors such as maternal education, poor dietary diversity, poor women's autonomy and agency, poor maternal health, poor utilisation of available services and poor Water Sanitation and Hygiene (WASH). This framework highlights gender as a cross-cutting issue and as a fundamental aspect of social and cultural norms at the level of basic causes. It is also embedded in patriarchal cultural practices across South Asia that impact women's overall participation, agency and autonomy, utilisation of services for herself and her children – at the level of underlying causes. The level also points out other cultural feeding practices that impact child undernutrition.

DISCUSSION

South Asia continues to be the epicentre of child undernutrition, with the largest population of undernourished children in the world. This review brings together literature from academic sources and grey literature to understand the key factors and priorities associated with different forms of child undernutrition and hidden hunger in South Asia. The review findings identify factors at immediate, underlying, and basic level for child undernutrition. While identifying these factors has been significantly useful to address and design appropriate interventions, there is a further need to understand the persistence of certain factors over decades. Factors such as maternal education, poor feeding practices, dietary diversity, poor maternal health, poor utilisation of available services including WASH and health. Based on the findings, we identified the social-cultural factors and norms that need to be targeted to improve behaviours and attitudes of societies, households and individuals and promote gender equality. The review proposes a systemic response to mainstream gender, social-cultural factors and norms at the basic level factors. We propose the need for context specific nutrition behaviour change interventions, Figure 1, with the aim to address the social-cultural factors along with nutrition specific and sensitive interventions. Smith and Haddad (2015) highlight the importance of addressing cultural factors in reducing child undernutrition in South Asia and further the importance of addressing gender in the region.[4]

Maternal education was one of South Asia's most consistent factor of child undernutrition. Research in LMICs suggests that high maternal education translates into greater health care utilization, adoption of modern medical practices and greater female autonomy, which influences health-related decisions for improved child nutritional outcomes.[152,153] Additionally, parental education plays a key role in a family's income, access to resources, proper nutrition and food security.[153] South Asia has the highest school dropout ratio in the world, often females are unable to complete their education due to socioeconomic reasons. Reasons highlighted for high school dropouts are poor WASH facilities, girls often need to support with family responsibilities such as housework or caring for younger siblings, girls are also taken out of school once they reach puberty to protect their honour.[154] In addition, due to the patriarchal culture in the region if families must choose between educating a son or a daughter, the son is often preferred.[155]

Low maternal BMI <18.5 kg/m^2 was associated with stunting, wasting and underweight in children, a finding consistent with research across LMICs.[152] Low BMI in mothers can lead to intrauterine intergenerational trans-

mission of undernutrition giving infants high risk of low birth weight and being small for gestational age.[132,152] Anaemic mothers were more likely to have children with iron deficiencies, this could be due to poor maternal health and nutrition, poor access to iron and micronutrient-rich foods due to low household wealth, all of which can impact the iron stores of the newborn.[156,157] Poor women's health reflects the social and cultural factors that lead to her poor health from childhood to adolescence to motherhood.[4,155] An undernourished female is more likely to have undernourished children in their first 1,000 days post conception, transmitting the cycle of undernutrition through generations.[4]

This review also highlights low birth weight and being small for gestational age as risk factors for stunting, wasting, underweight and IDA. Short maternal stature (<145 cm) was a reported factor associated with stunting, wasting, underweight and IDA in children. Research shows an association between maternal height and child undernutrition, specifically stunting and wasting. A study in 54 low-income countries showed that every one-centimetre increase in maternal height reduced the risk of wasting among children <5 years.[158] Maternal height is a useful marker for assessing intergenerational linkages in child's health before or immediately after birth with lasting influence over a few years.

A child's age and sex were consistent factors associated with child undernutrition and micronutrient deficiencies. Stunting and underweight in children increased with age>12 months; Vitamin A deficiency was more common in older children aged 3 to 5 years as compared to younger children. This finding concurs with other research in South Asia.[159,160] This may be explained as an effect of breastfeeding transition when breastfeeding gradually declines with the child's age coupled with poor or limited complementary feeding and dietary diversity. Additionally, as children can move around and are independent, they are more exposed to contaminated foods and drinking water from unimproved resources, which can lead to childhood diseases. However, wasting and IDA were more common in younger children <24 months. This finding is consistent with research, that shows child's age to be positively associated with haemoglobin concentration[157] and that wasting prevalence significantly reduced with age.[161] This can be explained as the first 1000 days from conception to two years of are at a critical window with high nutritional needs, requiring a high intake of quality and nutrient rich foods for children over 6 months.

Male children were reported to be more stunted, wasted, underweight and anaemic as compared to female children. This finding is contrary to research in South Asia that highlights females to be more undernourished than males due to the patriarchal culture of male preference.[155] However, research in LMICs highlights male are more undernourished, reasons for this need to be further explored but some preliminary results reveal female preference in some cultures and biological reasons that make male more vulnerable than females.[162]

Household wealth was positively associated with child undernutrition status and IDA, where children born in poor households were more likely to be undernourished and anaemic than those in middle income or rich households. Households with low income tend to spend less on proper nutrition and children born in such households are more susceptible to growth failure and illnesses.[152] Food insecurity and inadequate dietary diversity were associated with child undernutrition, possibly due to low household wealth.[163]

Households with poor access to improved toilets and drinking water were reported to be associated with undernutrition in children. Lack of safe water and sanitation can cause recurrent infectious diseases such as diarrhoea and repeated episodes of infections can lead to compromised immunity resulting in undernutrition.[164] The nutrition sensitive intervention's focus on WASH interventions has helped improve access to WASH and countries working toward achieving the Sustainable Development Goals (SDGs) has enabled 'sustainable access' by addressing discrimination and inequalities across populations of all ages.[165] However, poor sanitation and hygiene practices continue to be a major constraint in women's overall health and well-being. Lack of proper toilets, sanitation and hygiene are also a major cause of low school attendance for adolescent girls across South Asia. The social stigma and taboo across sanitation and hygiene further make it harder to navigate the barriers for improved outreach of overall WASH for women.[154]

Poor feeding practices included cultural practices such as introducing pre-lacteals and not giving colostrum and other factors such as prolonged duration of breastfeeding for more than 12 months. Inadequate complementary foods were identified as contributing factors to stunting, wasting and underweight. Research in developing countries highlights the importance of adequate and timely feeding for children to fulfil their additional nutrient requirements, with an emphasis to introduce complementary foods at 6 months of age in addition to breastmilk. This is important to ensure optimal growth and development in children, failing which can have irreversible and irreparable damage.[166] Poor dietary diversity was also associated with child undernutrition and micronutrient deficiencies, consistent with research that highlights the importance of dietary diversity and consumption of fruits and vegetables for wholesome nutrition.[163] Research in the region further points out that only 40% of food supply in the region is comprised of non-staples, such as meats, fruits and vegetables, resulting in poor diet quality.[4]

The present study has several strengths and limitations. It has the strength of a systematic review based on a comprehensive search of the existing literature, including academic and grey literature on child undernutrition in South Asia. It looks at multiple forms of child undernutrition, including stunting, wasting, underweight and micronutrient deficiencies of vitamin A, iron and zinc. All study designs were included in the review search. Most studies reported were of medium or high quality. This review highlights the need to address the gender, sociocultural factors and norms that can improve the health of women and children in societies. However, this study had some limitations. This review did not undertake a meta-analysis and report the pooled estimate for the effect of each factor on undernutrition across all sub-regions; this is because the factors were measured differently in each study, while meta-analysis depicts effect size and may not

necessarily provide models to inform policy decisions. Secondly, while this review summarized the individual causes and some of the underlying causes of undernutrition, it does not address any of genetics, birth defects, and early food allergies or reactions that may contribute to failure to thrive.

Conclusions and implications

The study highlights the need to mainstream gender, social-cultural factors and norms at the basic and underlying level and emphasises the need for context specific nutrition behavioural change interventions along with nutrition specific and sensitive interventions and enabling environments.[167] Study findings could enrich the policy discourse about the Sustainable Development Goals (SDGs), especially Goal 2: 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture'.[168] There are synergies available to work with Goal 5: 'achieve gender equality and empower all women and girls, to improve women's role in reducing child undernutrition'. It further highlights the need to unpack and understand the cultural and social factors that act as barriers to child undernutrition and consider the role of gender inequality in child undernutrition. Adopting multipronged strategies and target behaviour change would strengthen efforts directed towards the WHO global nutrition targets by 2025.[169]

ACKNOWLEDGEMENTS

The study is part of the primary author's doctoral dissertation with the School of Social Sciences at Western Sydney University, Australia.

AUTHOR DISCLOSURES

The authors declare no conflict of interest. This research received no external funding.

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Supplementary table 1. Search terms used to undertake the search

Child preschool [MeSH/Subheading] OR infan [MeSH] OR under-five* OR preschool* OR paediatr* OR bab** *AND* *Child malnutrition [MeSH/Subheading] OR Malnutr* [MeSH/Subheading] OR undernutr* [MeSH/Subheading] OR underweight [MeSH/Subheading] OR malnourish* OR undernourish* OR stunt* OR wast* OR "acute malnutrition" OR chronic malnutrition" OR "micronutrient malnutrition" OR "micronutrient deficiency" OR "vitamin A deficiency" OR "iron deficiency" OR "iron deficiency aneamia" OR Anaemia OR "zinc deficiency"* *AND* *Caus* [MeSH/Subheading] OR Factor* OR determinant* OR correlate* OR "risk factor" OR multifactorial caus*OR priorit** *AND* *"South Asia*" or "Southern Asia*" or Afghan* or Bangladesh* or Bhutan* or India* or Maldives or Nepal* or Pakistan* or Sri Lanka**