Preconception malnutrition among women and girls in south Asia: prevalence, determinants, and association with pregnancy and birth outcomes

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Summary

This review highlights the growing double burden of malnutrition among women of reproductive age in South Asia. Using nationally-representative survey data, we highlight that the prevalence of overweight now exceeds that of underweight, while anaemia remains persistently high despite intervention efforts. Underweight and anaemia are more common among unmarried women, whereas overweight is more prevalent among parous women, underscoring the need for life-stage-specific preconception nutrition programs. In our systematic review, micronutrient deficiencies vary widely between and within countries, reflecting regional disparities in nutritional status and inconsistencies in diagnostic methods. Associations of preconception underweight, overweight, anaemia and micronutrient deficiencies with health, nutrition, socio-demographic, and WASH indicators are mixed, emphasising the need for tailored, context-specific interventions. The lack of longitudinal studies limits our understanding of associations between preconception nutritional status and subsequent birth outcomes, underscoring the need for comprehensive, longitudinal studies across South Asia to inform and monitor targeted nutrition programs.

Keywords: **Nutrition; Preconception; Pregnancy planning; Adolescent; Anaemia; Micronutrient; Underweight; Overweight; Review; Demographic and health survey**

Introduction

In south Asia, most women and girls of reproductive age (WRA) have at least one form of malnutrition. Regional estimates state that over one in five WRA are underweight (BMI <18.5 kg/m2), which is the highest proportion globally,[1] while rates of overweight have increased, ranging from an estimated 20–52%.[2] Furthermore, an estimated 50% of WRA in south Asia have anaemia, meaning the region is home to more anaemic WRA than any other globally.[1] Around 75% of non-pregnant south Asian women and girls are also deficient in either iron, zinc, or folate,[3] with limited data on other micronutrient deficiencies.[1] Causes of anaemia include nutritional deficiencies of micronutrients such as iron, folate, and vitamins B12 and A, as well as non-nutritional factors such as infections, inflammation and haemoglobinopathies.[4] Malnutrition, including micronutrient deficiencies and anaemia, contributes directly and indirectly to the poor health and wellbeing of women and girls through biological, behavioural, economic, and social mechanisms, impacting their ability to engage in society through economic and social means.[5–7]

Beyond the importance of improving the nutrition of women and girls for their own right to nutrition, health and equal access to education and employment

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opportunities, malnutrition among WRA also has implications for any potential future pregnancies. South Asia is home to around half of the world's low birth weight (LBW) infants and wasted children (low weight-for-height, and almost 40% of stunted children (low height-for-age), both of which are associated with preconception underweight.[8,9] Anaemia before and during pregnancy has been associated with poor fetal growth, post-partum haemorrhage, and maternal death.[10,11] Micronutrients such as zinc and vitamins A and D are essential for fetal skeletal growth and development,[12–14] while iodine regulates fetal metabolism and brain development, with iodine deficiency being the most common preventable cause of intellectual disability worldwide.[15] The nutritional status of WRA around the time of conception impacts the development of the placenta, vital fetal organs and fetal microbiome, and affects fetal epigenetic programming, which are associated with lifelong health and disease.[16–18] As these important developmental stages occur before pregnancy detection, intervening to improve the nutritional status of WRA as part of antenatal care may be too late to improve maternal and fetal outcomes. This problem is exacerbated further in south Asia, where the majority of women do not have their first antenatal appointment in the first trimester.[19] Therefore, it is important to ensure WRA are micronutrient replete before becoming pregnant, during the 'preconception period', in order to support early fetal development, as well as to improve their own health and wellbeing.[16,17]

There remains a lack of consensus among stakeholders regarding the definition of the 'preconception period', which is broadly understood as the period of time for a reproductive age woman (15–49 years) during which changes can be made to achieve desired health outcomes in preparation for pregnancy.[20] This may differ depending on the outcome; while three months may be sufficient time to improve micronutrient status through supplementation before pregnancy, the time required to establish new dietary behaviours to improve dietary intake is highly variable and may take several years.[20] Definitions also differ depending on whether an individual- or population-level perspective is taken, and whether definitions focus on pregnancy-intention or take a life-course approach.[21,22] Taking a population-level approach to preconception addresses malnutrition among all non-pregnant women and girls of reproductive age (defined by the WHO and United Nations as 15–49 years[23,24]), as most of this population will have the potential to become pregnant in future, whereas an individual-level approach can tailor services to people depending on whether or not they are planning to get pregnant.[20]

It is important to establish an evidence base on the prevalence and determinants of malnutrition, including anaemia and micronutrient deficiencies, to inform the development of policies and programs to address malnutrition of all forms during the preconception period. While a recent review has highlighted the burden of underweight and short stature regionally, data were not available from all south Asia countries, and the review did not consider overweight, anaemia or micronutrient deficiencies.[1] Furthermore, while the evidence base exploring associations between nutritional status of women during pregnancy and low birth weight is well established,[25–27] there is limited evidence on the association between preconception nutritional status and birth outcomes.[22,28,29] This is crucial to determine the potential for preconception nutritional programmes to improve birth outcomes across the region.

In this paper, we estimate the prevalence and determinants of underweight, overweight, short-stature, anaemia, and micronutrient deficiencies among married women of reproductive age in south Asia using the last two rounds of nationally-representative survey data. We also report prevalence estimates and determinants analyses from the published literature. Determinants are presented in line with Partap et al.'s conceptual framework for determinants of preconception health: health, nutrition, socio-demographic, and water, sanitation and hygiene (WASH) domains (Fig. 1).[30] We also calculate estimates for the prevalence of underweight, overweight, short-stature and anaemia among different preconception groups (unmarried, married nulliparous and married parous) using nationally-representative survey data. Lastly, we summarise the published literature available on associations between preconception nutrition and birth outcomes, such as LBW, preterm birth, and small for gestational age (SGA) in south Asia.

For this paper, preconceptual women are defined as those aged 15–49 years, consistent with standard definitions from the World Health Organization (WHO) and the United Nations.[23,24] These definitions are widely adopted in global public health research to ensure consistency and comparability across regions and studies.[20,31] Preconceptual women are identified irrespective of marital status, gravidity, or pregnancy intention, provided they are not currently pregnant and have not undergone sterilization.

For the literature review component, studies including participants as young as 10 years were included due to the broader definitions of women of reproductive age (WRA) in the literature, including ranges such as 10–49, 13–35, 14–35, and 14–49 years. Adolescence (10–19 years) is an important time for healthy lifestyle habit forming and education on the importance of preconception health.[32] Nutritional, educational, and health-related interventions initiated in early adolescence can improve future pregnancy outcomes, reduce the burden of maternal and neonatal complications, and contribute to broader health and economic gains.[33] This is particularly relevant in the South Asian context due to the high prevalence of child marriage.

We recognise and respect that adolescents may not view their health through a preconception lens, raising ethical considerations as considering them such. However, addressing their health and nutrition is critical within a population-based approach to preconception and indeed for their broader wellbeing and health across the life course, regardless of their reproductive role or intentions. Furthermore, this inclusive approach ensures that critical evidence is not excluded, ensuring that policies and programs can be informed by the best available evidence.

Full details of the methods are provided in Supplementary File 1. First, we used data from the two (where available) most recent rounds of data from Demographic Health Surveys (DHS) or National Nutrition Surveys (NNS) to estimate the prevalence of underweight, overweight/obesity, short-stature and anaemia among married preconceptual women in south Asia and explore how these have changed over time. Where data access was not possible, we extracted prevalence estimates from NNS reports (Supplementary File 1, Table S1). We undertook logistic regression modelling to explore determinants of these malnutrition indicators. As some surveys included married women only, we calculated the prevalence of underweight, overweight/obesity, short-stature and anaemia among married women only across all surveys, to improve comparability. To explore how nutritional status differs across the preconceptual life course, we also calculated the prevalence of underweight, overweight/obesity, short-stature and anaemia among subgroups of preconceptual women: (i) Unmarried girls/women aged 15–49 years (where available; including nulliparous never married, divorced, widowed and separated women), (ii) Married nulliparous girls/women aged 15–49 years, and (iii) Married parous girls/women (who have delivered at least one baby) aged 15–49 years. Sample characteristics are reported in Supplementary File 5.

Second, as data on anaemia was only available at two timepoints in three countries and micronutrient deficiencies are not routinely collected in DHS or NNS, we undertook a systematic review to synthesise evidence from the published literature on the prevalence and determinants of anaemia and micronutrient deficiencies among WRA in south Asia. We had planned to undertake a meta-analysis to calculate pooled estimates for the prevalence of anaemia and other micronutrient deficiencies regionally, however this was not possible due to the high level of heterogeneity in the method of obtaining clinical sample (e.g. venous or capillary blood sample), method of measuring haemoglobin and other micronutrient concentrations, and cut-offs used to diagnose anaemia and other micronutrient deficiencies, as well as sample characteristics (e.g. age). Journal articles

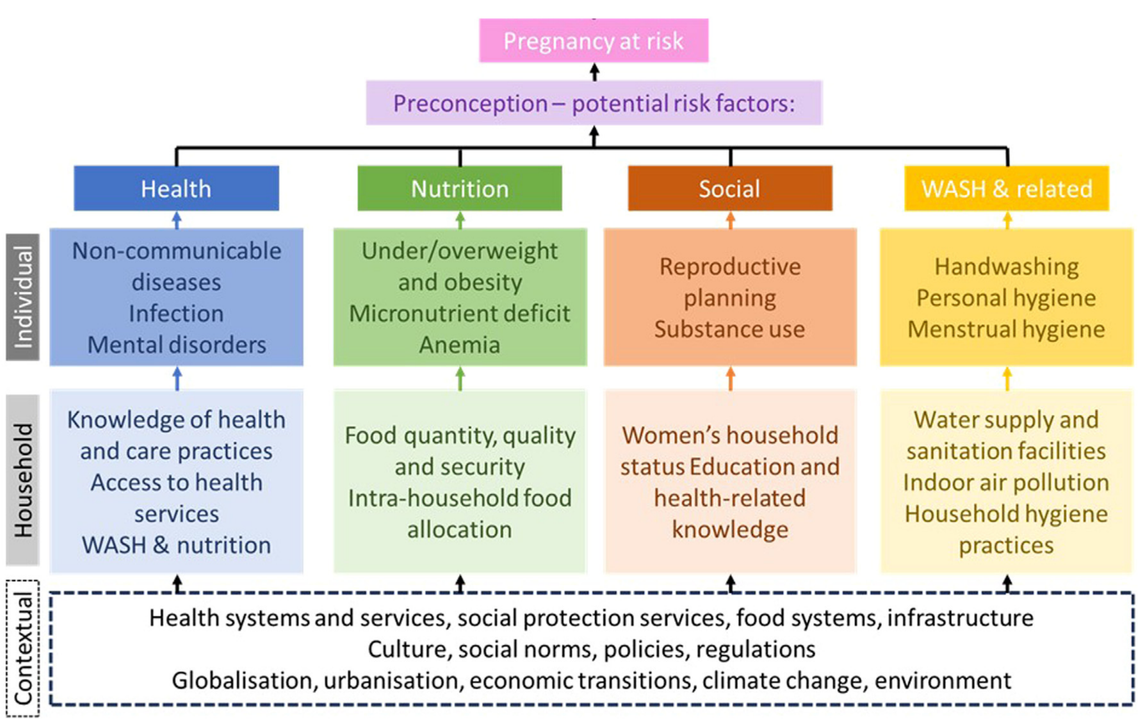

Fig. 1: *Conceptual framework organising individual, household, and contextual determinants for preconception health, updated from Partap et al.'s systematic review.*[30]

(including PRISMA diagram) are summarised in Supplementary File 5 and 6.

Third, to explore the evidence on associations between malnutrition indicators and pregnancy and birth outcomes, we reviewed the regional literature on associations between preconception nutrition and low birth weight and other outcomes of maternal and neonatal nutritional status.

Search strategy

One author (FM) searched Ovid (Medline, EMBASE, and Global Health), Web of Science, Global Index Medicus, and Cochrane Library databases on 12/09/2023 to identify studies in English which collected data since the year 2000. Search terms included free text and Medical Subject Headings (MeSH) terms, or equivalent, under the themes of "Preconception period", "Nutrition", and "South Asia". Search strategies are presented in Supplementary File 4. Additional resources from reference lists of the included studies were identified using forward and backward citation searching [93], and by searching the websites of state, national, and international organisations.

Prevalence of preconception malnutrition

Our analysis of nationally-representative survey data reveals a growing double burden of malnutrition among preconception women in South Asia, as the prevalence of overweight (ranging from 29.0% to 57.8%; Fig. 2) now surpasses that of underweight (4.6%–15.7%) among married women. Our analysis also shows that short stature remains an issue, particularly in India and Bangladesh (11.5% and 10.7%, respectively), pointing to persistent concerns about early childhood malnutrition and its long-term effects. These findings aligns with the region's dietary transition.[34,35] Urbanisation, migration, and increased availability of ultra-processed foods, even in rural areas, have driven higher intakes of fats, sugars, and calories, contributing to worsening nutritional status.[36,37] Furthermore, labour out-migration has reduced women's engagement in agriculture even in rural areas, leading to a more sedentary lifestyle.[38]

Anaemia, a significant public health concern in South Asia, shows wide variation in prevalence across countries. Our estimates among married women from national survey data are alarmingly high, ranging from 28.9% in Nepal to 63.3% in the Maldives, with little to no improvement over time (Fig. 2d). For instance, anaemia prevalence has remained stagnant in India (53.2% in 2015–16 to 54.0% in 2019–21), has increased marginally in Bangladesh (26.0% in 2011–12 to 28.9% in 2019–20), and has declined by 7.4 percentage points in Nepal. This suggests that current programmatic efforts, such as weekly IFA supplementation for adolescent girls, are not sufficient to address this public health concern.[39]

Anaemia estimates from our systematic review of the published literature highlight even greater variability, with the prevalence estimates ranging from 9.1% in younger women in Bangladesh to 96.5% among adolescents in India (Fig. 3a; full data extraction tables in Supplementary File 8 and 9). This range reflects variation in nutritional status as well as heterogeneity in study population characteristics (e.g. age and education level) and methods of diagnosing anaemia, including the type of blood sampled (capillary versus venous blood), method of determining Hb concentration, and cut-offs to diagnose anaemia. The heterogeneity in methods of diagnosing anaemia between studies prevented meta-analysis and makes comparison of estimates between countries and sub-country regions unfeasible, a key limitation of our systematic review.

Importantly, our systematic review found that iron deficiency anaemia (IDA) varies regionally, from 2.4% to 43%, both from Sri Lanka but using different diagnostic cut-offs, indicating the need for more standardised diagnostic criteria (Fig. 3b). Estimates for IDA appear relatively high in India and low in Bangladesh. Our systematic review supports regional findings that iron deficiency contributes to around 50% of anaemia cases,[46] highlighting the importance of addressing deficiencies of other micronutrient involved in the production of erythrocytes and Hb, like folate and vitamin B12, which contribute to other forms of anaemia.[4] More research on the burden of anaemia from different aetiologies is required to inform locally tailored programmatic action to address anaemia.[4,41,42,47,48]

Micronutrient deficiencies are another critical aspect of malnutrition among women in South Asia, with our systematic review highlighting notable disparities between and within countries. Low serum ferritin, a marker of iron deficiency, for example, is common in India (31.3–87.7%) but much lower in Bangladesh (5.9–7.1%; Fig. 4a). Part of this discrepancy can be attributed to variations in sample demographics and serum thresholds used for diagnosis (either <15 or <12 μg/L). For example, the lowest prevalence of low serum ferritin (5.9%) is observed in among married, nulliparous women aged <40 years (using cut-off <12 mg/L), whilst the highest prevalence (87.7%) is observed among women aged 14–35 years (using cut-off <15 mg/L; Fig. 4a).

Estimates from our systematic review for serum folate deficiency, by contrast, are highest in Sri Lanka (42–52.5%) and Pakistan (50.8%), and lower in India (1.3–7.9%) and Bangladesh (13–29%; Fig. 4b). However, when examining red blood cell (RBC) folate deficiency, prevalence remains high in India (22.2–79.3%) and Bangladesh (76.1%). These patterns highlight the complexity of micronutrient deficiencies and underscore the need for more consistent measurement protocols.

Though estimates for vitamin A deficiency were low in studies from some countries like Nepal and

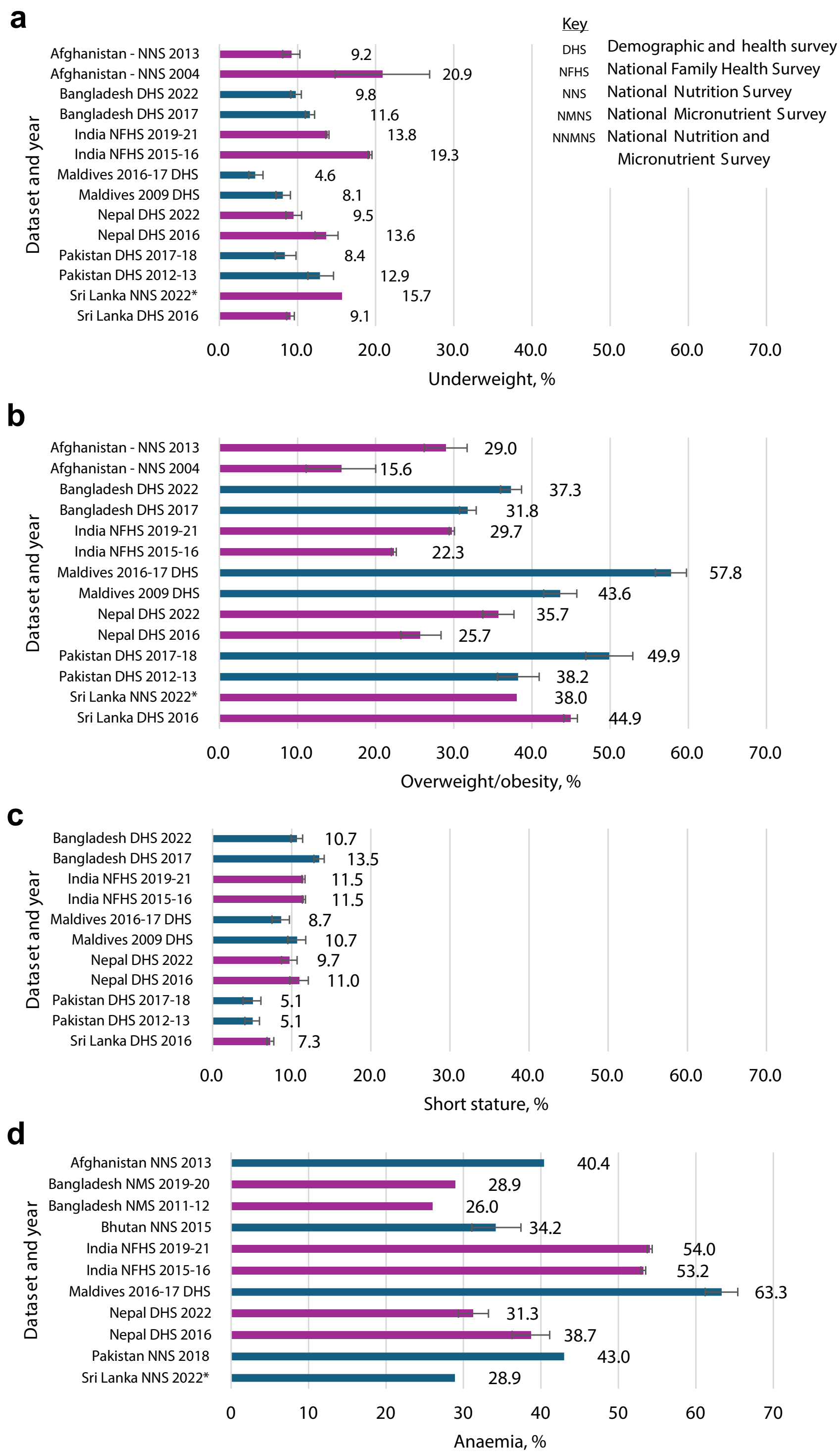

***Fig. 2:** Prevalence of underweight, overweight, short stature, and anaemia among married** women from nationally-representative surveys, organised by country and year of publication.* a) Underweight prevalence, b) Overweight/obesity prevalence, c) Short-stature prevalence, d) Anaemia prevalence. DHS, demographic and health survey; NFHS, National Family Health Survey; NNS, National nutrition survey; NMNS, National micronutrient survey; NNMNS, National nutrition and micronutrient survey. Error bars represent 95% confidence intervals. *Sri Lanka NNS 2022 age range 18–40, other countres 15–49. **Afghanistan 2013 does include unmarried women, and reports for Afghanistan NNS 2004, Bangladesh NNS 2011–12 or 2018–19, Pakistan NNS 2018 or Sri Lanka NNS 2022 do not report whether estimates include unmarried women or not. Underweight BMI<18.5 kg/m^2, Overweight/obesity BMI ≥ 25 kg/m2, short stature <145 cm, anaemia Hb < 12 g/d.

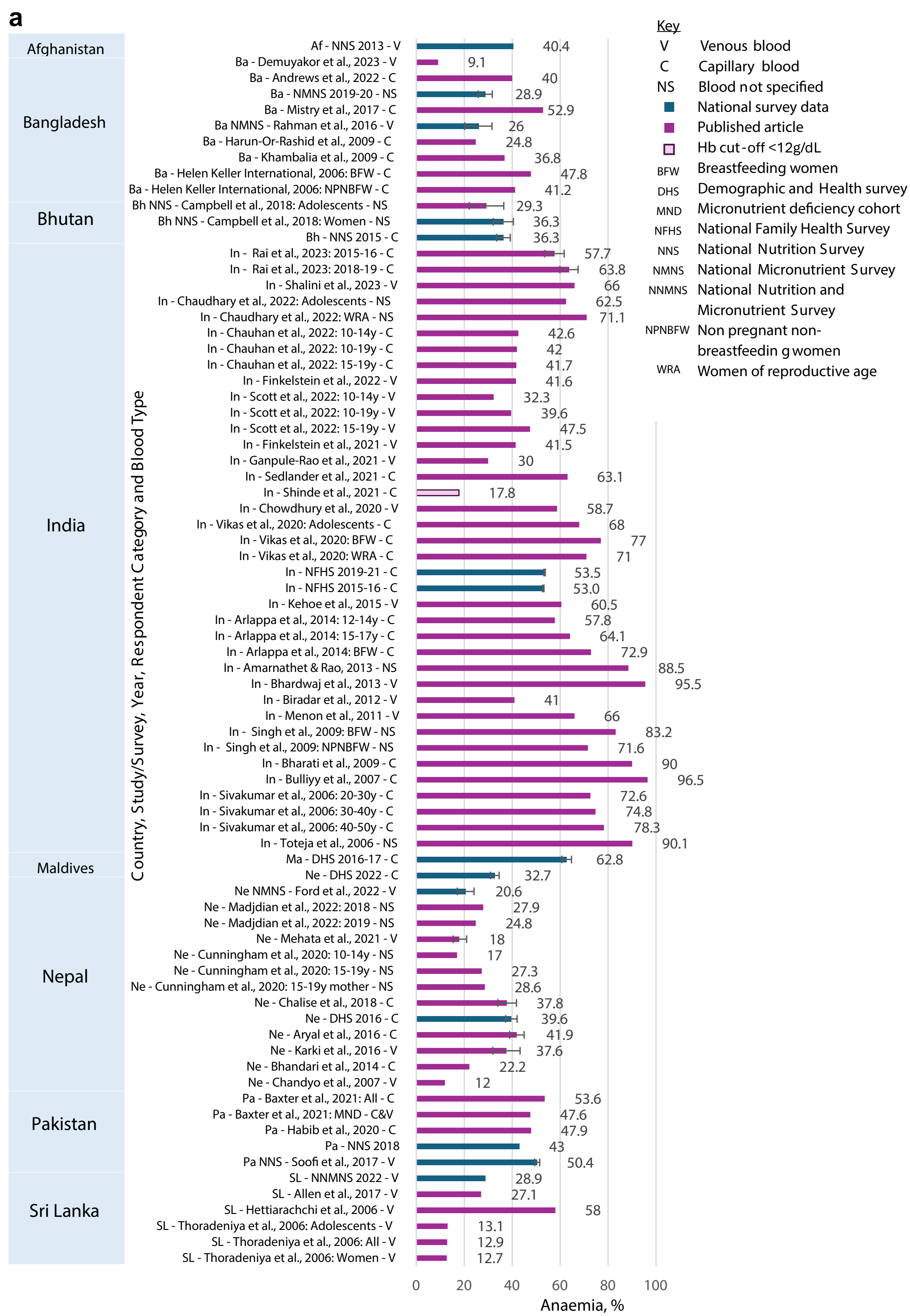

Fig. 3: Anaemia prevalence as reported by the included studies and from nationally-representative surveys where available, organised by country and year of publication. a) Anaemia prevalence: Ba, Bangladesh; BFW, breast-feeding women; Bh, Bhutan; DHS, demographic and health survey; In, India; Ma, The Maldives; MND, Micronutrient deficiency cohort; Ne, Nepal; NFHS, National Family Health Survey; NNS, National nutrition survey;

b

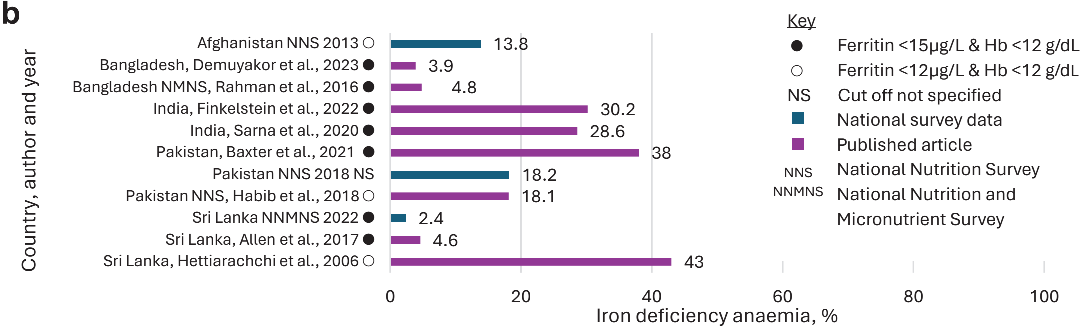

Fig. 3: Continued.

Bangladesh (1.8–5.3%), studies from Pakistan report a higher prevalence (31.8–40.8%; Fig. 4c), with a marked disparity between reproductive-age women and adolescents. All studies from our systematic review show at least one in five potential preconception women are deficient in Zinc, however the limited number of studies and heterogeneity in thresholds for diagnosis prevents cross-country comparison (7 cut-offs over 12 studies; Fig. 4d). The limited number of studies on vitamin B12 deficiency points to similarly diverse results, with one study from India reporting a low prevalence (2.6%) compared to other Indian studies showing a higher burden (27%–56.4%; Fig. 4e). Studies on iodine deficiency report similar prevalences in Bangladesh (29.6%–38.4%), yet large differences in prevalence across India (4.1%–88.3%; Fig. 4f), which could be due to differences in demographics or deficiency cut-offs. These high prevalences are surprising given the large-scale salt iodisation campaigns across the region.[49]

Our systematic review highlights vitamin D deficiency as a key concern, with six of seven studies reporting that over two thirds of women were deficient, and the NNS from Afghanistan reporting that 95.5% of women are deficient (Fig. 4g). While estimates from the review appear to have reduced over time in India, they remain high in Pakistan and Afghanistan, both predominantly Muslim countries where most women wear clothing minimising skin exposure to the sun. Addressing these issues requires promoting micronutrient-rich diets and safe sun exposure through social and behaviour change efforts, and food fortification programmes.[50,51]

A key limitation of our systematic review is the use of different methods and cut-offs to determine micronutrient deficiencies between studies, making comparisons between studies difficult. Regional coverage of micronutrient surveys among women of reproductive age with standardised methodologies is required to obtain a more comprehensive understanding of the nutritional status of women and girls during the preconception period, including micronutrient levels and deficiencies.

When comparing our estimates of malnutrition using nationally-representative survey data across subgroups of preconceptual women, underweight is most common among unmarried women and least common among married parous women in all countries apart from Pakistan (Table 1). Overweight is most common among married parous women in all countries ($p < 0.05$). In India, short stature is most common among unmarried women, whereas in Bangladesh, the Maldives, Nepal and Sri Lanka the prevalence of short stature is highest among married parous women, likely reflecting their older age and reduced undernutrition over time. Anaemia is most common among unmarried women in Bhutan and Nepal and married parous women in India and the Maldives (Table 1).

These significant variations in underweight, overweight and anaemia by preconception life-stage, and the

NMNS, National micronutrient survey; NNMNS, National nutrition and micronutrient survey; NPNBFW, Non-pregnant non-breast-feeding women; Pa, Pakistan; SL, Sri Lanka; WRA, women of reproductive age. Blood type specified in label: C; capillary blood, V; venous blood, NS; blood type not specified. For graphs presenting anaemia prevalence by blood type, refer to Supplementary File 9. Anaemia generally determined using serum haemoglobin (Hb) concentrations or haematocrit. *Hb cut-off <12 g/dL, or <10 g/dL in one study—Shinde et al., 2021 (indicated by a lighter coloured bar with border).[40] For studies including girls aged 10–11 years a cut-off of <11.5 g/dL was used for these participants.[41–45] Error bars represent 95% confidence interval for DHS/NFHS data, or standard deviation where reported by the included studies. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. b) Iron-deficiency anaemia prevalence: IDA, iron-deficiency anaemia; NNS, National nutrition survey; NNMNS, National nutrition and micronutrient survey. IDA estimated from combined low Hb and ferritin: Hb < 12 g/d and ferritin <15 (●) or <12 μg/L (○). Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies.

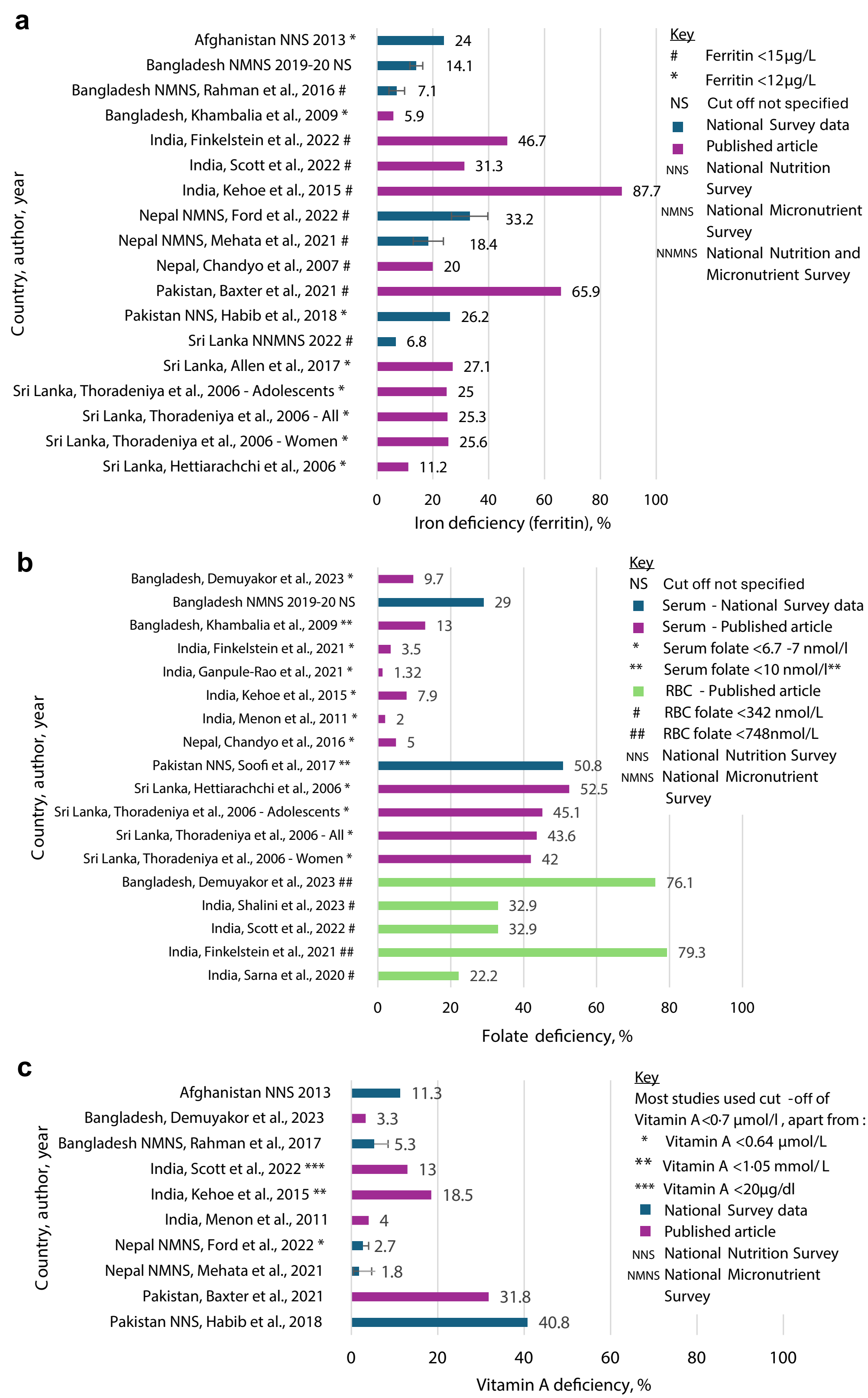

***Fig. 4:** Prevalence of micronutrient deficiencies, as reported by the included studies, organised by country and year of publication.* a) Iron deficiency determined using serum ferritin <15# or <12* µg/L, NS: cut-off not specified. NNS, National nutrition survey; NMNS, National micronutrient

difference in associations between countries, underscore the need for tailored nutrition programs.[52] Regional guidelines advocate for regular BMI screening and targeted lifestyle interventions, especially during preconception, to address malnutrition and its associated risks, such as increased C-section rates.[53,54] Implementing routine BMI and fertility intention screening, along with personalised weight-management and dietary counselling, is essential for improving the health of WRA preconceptually.

Determinants of preconception malnutrition

Tables 2 and 3 present determinants of anaemia and micronutrient deficiencies, respectively, from our own analysis of nationally-representative survey data, as well as the results from studies reporting multivariate associations from our systematic review. Adjustment for our analysis can be found in Supplementary File 1. All review studies adjusted for age and education, with most also accounting for wealth, caste/religion, and area of residence. Many included occupation, dietary intake, and household factors. Some adjusted for health factors (BMI, anaemia, infections) and healthcare utilisation (ANC visits, supplementation). Most studies selected covariates using theory, while others used stepwise methods.

Health-related factors

The lack of preconception health indicators in national surveys and limited evidence on the association between health-related factors and anaemia and micronutrient deficiencies in the studies from our systematic review makes it challenging to draw broad conclusions (Tables 2 and 3). In a study from Pakistan, long or heavy menstrual periods and lack of contraceptive use are associated with anaemia, but no studies explored associations with other micronutrient deficiencies. Recent infections are associated with anaemia and zinc deficiencies in studies from Pakistan and Nepal, respectively. Notably, health facility usage has no consistent association with anaemia, further complicating our understanding of its determinants. Further research using a standard set of health-related indicators is required.

Nutrition related factors

Nutrition-related factors also show mixed relationships with anaemia and micronutrient deficiencies in the systematic review (Tables 2 and 3). While a higher BMI generally correlates with lower anaemia prevalence, adherence to iron-folic acid (IFA) supplementation is only associated with lower anaemia in two of seven studies, with two studies finding that IFA supplementation is associated with higher anaemia. This raises questions about the effectiveness of regional IFA supplementation programs.[55–58] Meat consumption and micronutrient-rich diets generally correlates with reduced in anaemia and vitamin A, zinc, and vitamin B12 deficiencies in the included studies, but not iron or folate deficiencies. This underscores the importance of incorporating behaviour change components which promote the consumption of diverse, locally available diets alongside supplementation and food fortification efforts.[50,51,59–62] Dietary recommendations should also address the low bioavailability of micronutrients and dietary fibre in vegetarian diets, prevalent in south Asia.[63] The lack of information on preconception supplementation and dietary intake from nationally-representative surveys prevents our own analysis of these indicators. Our systematic review also found that increased food security also correlates with a reduced prevalence of anaemia and iron deficiency, highlighting the importance of

survey; NNMNS, National nutrition and micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. b) Folate deficiency determined as serum folate <6.7–7 nmoL/l* or <10 nmoL/l**, or RBC folate 151 ng/mL (342 nmol/L; conversion factor: 2.266)# or <748 nmol/L##, NS: cut-off not specified. NNS; National nutrition survey, NMNS; National micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple or green bars represent estimates from published studies. c) Vitamin A deficiency cut-off: <0.7 μmoL/l, apart from three studies using <0.64 μmol/L*, <1.05 mmoL/l**, or <20 μg/dL***. NNS, National nutrition survey; NMNS, National micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. d) Zinc deficiency cut-offs included <10.1 μmoL/l* (<10.7 μmol/L fasting), <60 μg/dL**, <80 μg/dl***, <9.3–11.3 μmol/L# (depending on time of day and fasting status), <66–74 μg/dl ## (depending on time of day and fasting status), <59–66 μg/dL ### (depending on time of day and fasting status), and <9.95 μmol/L (<650 μg/L) ####. NS: cut-off not specified. NNS, National nutrition survey; NMNS, National micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. e) B12 mostly deficiency defined as <150 pmol/L (equivalent to <203 pg/mL), or <148 pmol/L*, NS: cut-off not specified. NNS; National nutrition survey, NMNS; National micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. f) BFW, breast-feeding women; In, India; NPNBFW, Non-pregnant non-breast-feeding women. Iodine deficiency: urinary iodine concentration <100 mg/L*, <50 μg/L**, or <15 ppm#, NS: cut-off not specified. NNS, National nutrition survey; NMNS, National micronutrient survey; NNMNS, National nutrition and micronutrient survey; NPNBFW, Non-pregnant non-breast-feeding women. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies. g) Vitamin D deficiency was defined serum 25(OH)D <20 ng/mL (equivalent to 50 nmoL/l)* or <25 ng/mL** (cut-off missing from one paper***), NS, cut-off not specified; NNS, National nutrition survey; NMNS, National micronutrient survey. Blue bars represent data from nationally-representative surveys, whereas purple bars represent estimates from published studies.

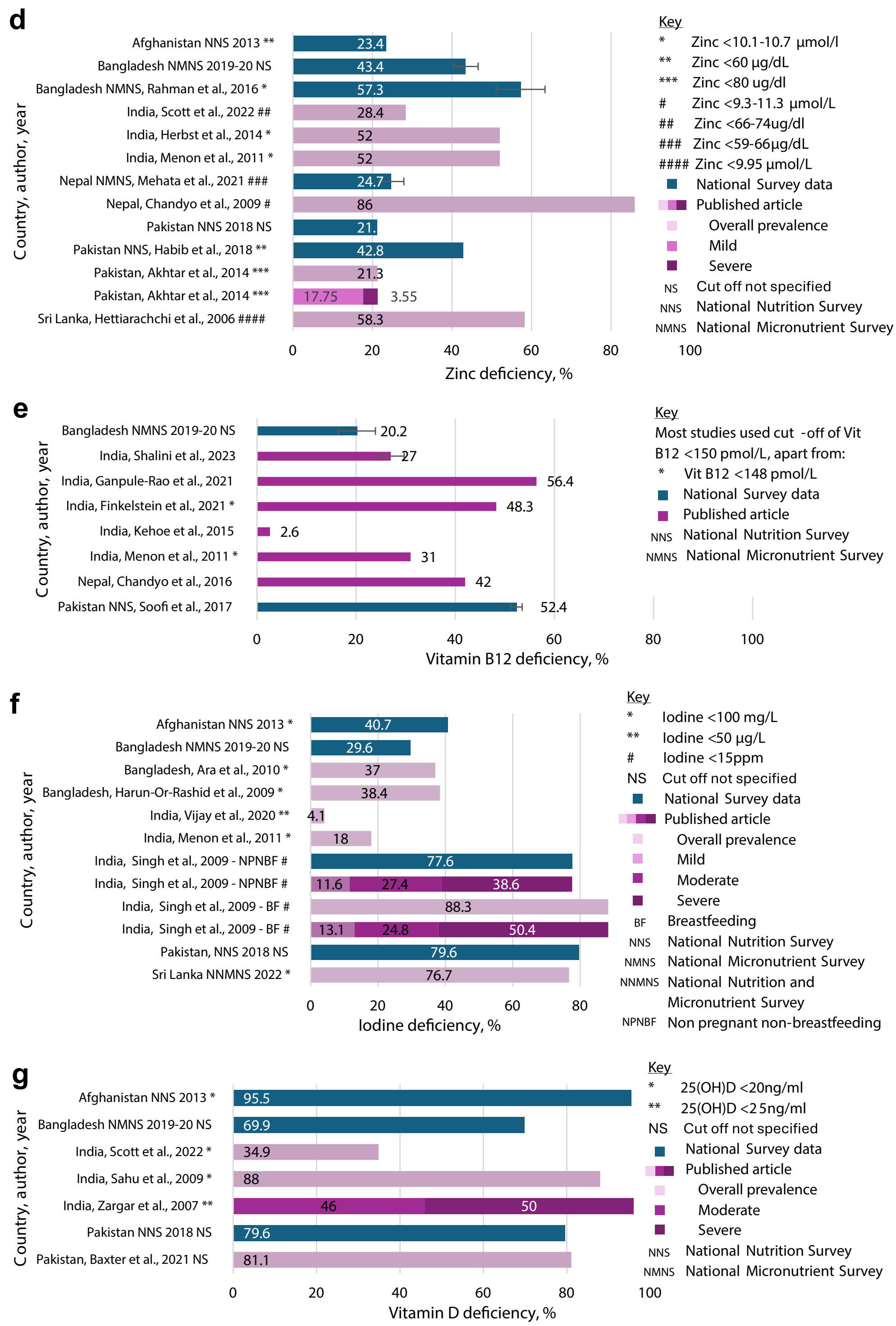

Fig. 4: Continued.

	Underweight	Overweight	Short stature	Anaemia
	Bangladesh 2022			
n	17,653	17,653	17,655	Missing
Married, parous	9.1	38.6	10.8	
Married, nulliparous	14.2	28.1	7.5	
	p<0.0001	p<0.0001	p=0.6514	
	Bhutan 2015			
n				3,893
Married, parous	Missing	Missing	Missing	29.21
Married, nulliparous	Missing	Missing	Missing	37.25
Unmarried	Missing	Missing	Missing	40.1
	India 2019-21			
n	515,573	515,573	497,838	516,224
Married, parous	13.4	30.6	11.4	54.5
Married, nulliparous	16.5	24.3	11.7	50.5
Unmarried	32.1	14.1	12.4	52.6
	p<0.0001	p<0.0001	p<0.0001	p<0.0001
	Maldives 2016-17			
n	6,417	6,417	6,426	6,212
Married, parous	3.5	60.7	8.8	63.1
Married, nulliparous	10.4	44.0	5.6	61.0
Unmarried	27.6	24.1	5.8	61.1
	p<0.0001	p<0.0001	p=0.0014	p=0.4829
	Nepal 2022			
n	6,253	6,253	6,209	6,254
Married, parous	9.0	37.5	9.6	31.2
Married, nulliparous	13.7	21.3	9.2	30.1
Unmarried	25.0	9.6	8.5	37.2
	p<0.0001	p<0.0001	p=0.5520	p=0.0009
	Pakistan 2017-18			
n	3,895	3,895	3,899	
Married, parous	8.5	51.2	4.6	Missing
Married, nulliparous	7.5	42.6	7.8	Missing
	p=0.7626	p=0.0335	p=0.0226	
	Sri Lanka 2016			
n	16,528	16,528	16,536	
Married, parous	8.54	46.13	7.33	Missing
Married, nulliparous	12.92	35.7	6.3	Missing
	p<0.0001	p<0.0001	p = 0.0029	

Table 1: The prevalence of underweight, overweight, short-stature, and anaemia among women during the preconception period calculated using the most recent nationally representative survey data, including heat maps in which a darker colour represents a higher prevalence.

Country	Study	HEALTH: Heavy/long menstruation	Depo-Provera use	Recent infectious disease	Health facility use	Hemoglobinopathy	NUTRITION: Higher BMI	IFA adherence	Increased food security	Meat intake	Other dietary intake	Other food supplements	Regular exercise	Zinc deficiency	Vitamin A deficiency	Vitamin D deficiency	Ferritin deficiency	Vit B12 deficiency	Folate deficiency	SOCIODEMOGRAPHIC: Increasing education	Increasing wealth	Employment	Town/region	Rural (vs urban)	Caste, ethnicity or religion	Older age	Married (vs unmarried)	No children or unmarried#	Wants (more) children##	Higher gravida	Shorter birth interval	Media exposure	Nutrition knowledge	Improved sanitation
	Bhutan NNS, 2015																			↓	NS			NS										
	India NFHS, 2019-21																			↔	↓			↑	Y			↓	↓					
	India NFHS, 2015-16																			↓	↓			↑	Y			↓	↑					
	Maldives DHS, 2016-17																			NS	↓			↓				↓	NS					
	Nepal DHS, 2022																			↓	↑			NS	Y			↑	↑					
	Nepal DHS, 2016																			NS	↑			NS	NS			↑	↑					
Bangladesh	Andrews et al., 2022									NS	↓																							
Bangladesh	Rahman et al., 2016								↓	↓	NS			NS	↑		↑		↑		NS			NS						NS				
Bhutan	Campbell et al., 2018 - Adolescents								NS	NS	NS										NS	Y		NS		↑								NS
Bhutan	Campbell et al., 2018 - 15-49y				NS			NS												↓	NS		Y	NS		↑	↓			↑				↓
India	Chauhan et al., 2022						NS	↑												↓	NS	NS	Y	↓	Y	↑	NS					↓		
India	Scott et al., 2022					↑		NS		↓				NS	NS	NS	↑	NS	↓	NS	NS					↑						NS		NS
India	Chowdhury et al., 2020						↓													↓	NS	NS				NS								
India	Shanbhag et al., 2016							↓												↓														
India	Menon et al., 2011									NS	NS														Y									
India	Bharati et al., 2009																			↓			Y	↓	Y		↑							
India	Bulliyy et al., 2007						↓													↓	↓		Y			↓								
Nepal	Ford et al., 2022							↑							↑		↑								Y	↑								NS
Nepal	Chandyo et al., 2007		↓																	NS		Y				NS				↓				
Pakistan	Habib et al., 2020	↑		↑	↓		NS	NS		↑	Y	↑	↓							↓						NS							NS	↓
Pakistan	Soofi et al., 2017						↓	↓	↓	↓	Y									↓	NS	Y	Y	NS		↑				↑	NS			NS
		1	1	1	2	1	5	7	3	7	6	1	1	2	3	1	3	1	2	16	14	5	5	12	8	10	3	5	5	4	1	2	1	6

↓ (with light purple) Reduced prevalence (statistically significant, $p < 0.05$), ↑ (with dark purple) Increased prevalence (statistically significant, $p < 0.05$), Y (with mid-purple) Non-ordinal association with prevalence (statistically significant, $p < 0.05$), ↔ Association of multiple directions (statistically significant, $p < 0.05$), NS No association ($p \geq 0.05$). *Employment generally - not specifically unskilled, **Pucca (cement and brick) = less prevalent. *** Green leafy veg intake = lower prevalence, #No children or unmarried (ref = married parous), ##Wants (more) children or undecided (ref = wants no more children). Bhut, Bhutan; DHS, Demographic and Health Survey; Ind, India; Mal, The Maldives; NFHS, National Family Health Survey; NNS; National Nutrition Survey, Pak; Pakistan. All studies adjusted for age and education, with most also accounting for wealth, caste or religion, and area of residence. Many included occupation, dietary intake, and household factors. Some adjusted for health factors (BMI, anaemia, infections) and healthcare utilisation (ANC visits, supplementation). Most studies selected covariates using theory, while others used stepwise methods.

Table 2: **Summary of multivariate associations between anaemia and potential determinants, as calculated from national survey data and reported by the included studies, organised into health, nutrition, sociodemographic and WASH domains, as per Partap et al.'s review of preconception interventions.[28]**

addressing the wider food environment to ensure the availability and affordability of micronutrient-rich diets.

Socio-demographic factors

Our analysis of nationally-representative survey data as well as estimates from our systematic review highlight that socio-demographic factors, including education, household wealth and rural-urban residence, strongly influence malnutrition patterns (Tables 2–4). In most countries, higher education correlates with a lower prevalence of underweight, anaemia, short stature and IDA, but a higher prevalence of overweight and vitamin D deficiency, underscoring the double-edged sword of socioeconomic development. While associations between wealth and anaemia in the national survey data demonstrate mixed results, most studies find no significant association with anaemia. However, increased wealth is associated with reduced iron and zinc deficiencies. Residing in a rural area is associated with increased short-stature, underweight and vitamin A deficiency, whereas an urban residence is associated with increased overweight and vitamin B12 deficiency. Associations between anaemia and wealth and rural/urban residence differ between countries, reflecting unique regional dynamics. An older age is generally associated with an increased risk of anaemia, but not other micronutrient deficiencies, indicating that other factors than age alone are likely responsible for micronutrient deficiency.

WASH related factors

Two of six studies from our systematic review report that improved access to sanitation is associated with reduced anaemia. No studies report an association between WASH-related factors and other micronutrient deficiencies, demonstrating the need for more robust research to clarify the relationship between WASH and preconception malnutrition.

Associations between preconception nutrition and pregnancy/birth outcomes

In our systematic review, we identified three studies exploring associations between preconception nutrition and pregnancy/birth outcomes. All three explored preconception BMI as the exposure, despite us designing our searches to identify papers exploring associations between multiple forms of preconception malnutrition,

Indicator	Country	Paper	Reports good health	Recent infection	Higher BMI	IFA adherence	Increased food security	Meat intake	Other dietary intake	Anaemia	Vitamin A deficiency	Vit B12 deficiency	Folate deficiency	Increasing education	Increasing wealth	Employment	Town/region	Rural (vs urban)	Caste, ethnicity	Older age	Higher gravida	Shorter birth interval	Nutrition knowledge	Improved sanitation
			HEALTH		NUTRITION									SOCIODEMOGRAPHIC										
IDA	Pakistan	Baxter et al., 2021												↓										
IDA	Pakistan	Habib et al., 2018			↓	↓	↓			↑											↑	↑		
Ferritin deficiency	Bangladesh	Rahman et al., 2016					↓			NS	NS	↑	↑	NS	↓			NS			↑		NS	
Folate deficiency	India	Menon et al., 2011						NS	Y										NS					
Folate deficiency	Nepal	Chandyo et al., 2016			NS			NS		NS						NS				NS				
Folate deficiency	Pakistan	Soofi et al., 2017			NS	NS	NS	NS	Y					NS	NS	Y	Y	NS		NS	↑	NS		NS
Vit A deficiency	Bangladesh	Rahman et al., 2017																↑						
Vit A deficiency	India	Menon et al., 2011						↓	Y										NS					
Zinc deficiency	Bangladesh	Rahman et al., 2016					NS	↓	Y	↑				NS	↓	NS		NS		NS				
Zinc deficiency	India	Menon et al., 2011						NS	Y										NS					
Zinc deficiency	Nepal	Mehata et al., 2021		↑	↓								↓	NS	↓					NS				
Vit B12 deficiency	Nepal	Chandyo et al., 2016			NS			↓		NS						↓				↑				
Vit B12 deficiency	Pakistan	Soofi et al., 2017			↑	NS	NS	NS	NS					NS	NS	NS	Y	↓		NS	↓	NS		NS
Vit D	Pakistan	Baxter et al., 2021	↓											↑		↓								

↓ (with light purple) Reduced prevalence (statistically significant, $p < 0.05$), ↑ (with dark purple) Increased prevalence (statistically significant, $p < 0.05$), Y (with mid-purple) Non-ordinal association with prevalence (statistically significant, $p < 0.05$), ↔ Association of multiple directions (statistically significant, $p < 0.05$), NS No association ($p \geq 0.05$). *Employment generally–not specifically unskilled, **Pucca (cement and brick) = less prevalent. *** Green leafy veg intake = lower prevalence, #No children or unmarried (ref = married parous), ##Wants (more) children or undecided (ref = wants no more children). Ba, Bangladesh; BMI, body mass index; CRP, c-reactive protein; IDA, iron deficiency anaemia; IFA, iron and folic acid; In, India; Ne, Nepal; Pa, Pakistan; RBC, red blood cell; vit D, vitamin D. All studies adjusted for age and education, with most also accounting for wealth, caste or religion, and area of residence. Many included occupation, dietary intake, and household factors. Some adjusted for health factors (BMI, anaemia, infections) and healthcare utilisation (ANC visits, supplementation). Most studies selected covariates using theory, while others used stepwise methods.

Table 3: **Summary of multivariate associations between micronutrient deficiencies (iron-deficiency anaemia and ferritin, folate, zinc and vitamins A, B12, and D deficiencies) and potential determinants, as reported by the included studies, organised into health, nutrition, sociodemographic and WASH domains, as per Partap et al.'s review of preconception interventions.**[28]

including underweight, overweight, anaemia and micronutrient deficiencies (Supplementary File 1 and 11). All took place in Southern India with sample sizes <700. Selvam and colleagues[54] is the only study which reports significant associations between increased preconception BMI and increased birth weight and gestational weight gain during pregnancy. Gudipally and colleagues[53] find significant associations between preconception BMI and gestational diabetes and hypertensive disorders during pregnancy, but not LBW or preterm birth. Differences may be explained by population characteristics, as Gudipally and colleagues include all married women, whereas Selvam and colleagues restricted their inclusion criteria to primigravida women with no underlying comorbidities. Abdulla and colleagues[64] find no association between preconception BMI and SGA (Supplementary File 11).

In our systematic review, we identified no regional studies which examine the association of anaemia or micronutrient deficiencies with birth outcomes. While some studies from other Asian countries report associations between anaemia and LBW,[65,66] results were inconsistent.[67] As we explore in more detail in our review of preconception nutrition interventions in South Asia, nutritional interventions during the preconception period have demonstrated mixed effects and are most effective when delivered as complex interventions through multiple channels to address health, nutrition, socio-demographic and WASH determinants.[30,68–70] The burden of preconception malnutrition also differs between countries, highlighting the importance of locally-tailored studies which intervene well before conception to allow sufficient time to optimise nutrition status.[30,69] Given the high burden of anaemia, micronutrient deficiencies, and LBW in south Asia,[71] large-scale, longitudinal studies among non-pregnant WRA are needed to track how nutritional status changes over time, and the extent to which this influences birth outcomes such as LBW.

Knowledge gaps and recommendations

Our analysis of nationally-representative survey data and systematic review highlight several key knowledge gaps which lead to important recommendations for improving research and interventions on preconception nutrition and health in South Asia.

There is limited evidence on anaemia and other micronutrient deficiencies from Afghanistan, Bhutan, and the Maldives. Additionally, micronutrient deficiency data is not routinely collected through large-scale, nationally-representative surveys like DHS or standardised in NNS, hindering regional comparisons. Therefore, large scale national surveys should prioritise the

Country and data set		Underweight						Overweight						Short stature					
		Increasing education	Increasing wealth	Rural (vs urban)	Ethnic/religious group	No children or unmarried#	Wants (more) children##	Increasing education	Increasing wealth	Rural (vs urban)	Ethnic/religious group	No children or unmarried#	Wants (more) children##	Increasing education	Increasing wealth	Rural (vs urban)	Ethnic/religious group	No children or unmarried#	Wants (more) children##
Bangladesh	2014 DHS	↓	↓	↑	Y	NS	↑	↑	↑	↓	NS	↓	↓	↓	↓	NS	NS	NS	NS
	2017 DHS	↓	↓	↑	NS	↑	↑	↑	↑	↓	NS	↓	↓	↓	↓	↑	NS	NS	NS
India	2015-16 NFHS	↓	↓	↑	Y	↑	↔	↑	↑	↓	Y	↓	↓	↓	↓	↑	Y	NS	NS
	2019-21 NFHS	↔	↓	↑	y	↑	↑	↓	↑	↓	Y	↓	↓	↓	↓	↑	Y	↑	↑
Maldives	2016-17 DHS	↑	↓	NS		↑	↑	↓	↑	↑		↓	↓	↓	NS	NS		↓	NS
Nepal	2016 DHS	↓	↓	↓	Y	↑	↑	NS	↑	↓	Y	↓	↓	↓	↓	NS	Y	NS	NS
	2022 DHS	↓	↓	NS	Y	↑	↑	↑	↑	↓	Y	↓	↓	↓	↓	↑	Y	NS	NS
Pakistan	2012-13 DHS	NS	↓	↑	Y	NS	↑	NS	↑	↓	Y	↓	↓	↓	NS	↑	Y	NS	NS
	2017-18 DHS	NS	↓	↑	Y	NS	NS	NS	↑	NS	Y	↓	↓	↓	NS	NS	Y	↑	NS
Sri Lanka	2016 DHS	NS	↓	↑	NS	↑	↑	↑	↑	↓	Y	↓	↓	↓	↓	↑	Y	↑	NS
Total # studies reporting indicator		10	10	10	9	10	10	10	10	10	9	10	10	10	10	10	9	10	10

↓ (with light purple) Reduced prevalence (statistically significant, $p < 0.05$), ↑ (with dark purple) Increased prevalence (statistically significant, $p < 0.05$), Y (with mid-purple) Non-ordinal association with prevalence (statistically significant, $p < 0.05$), ↔ Association of multiple directions (statistically significant, $p < 0.05$), DHS, Demographic and Health Survey; NFHS, National Family Health Survey; NNS, National Nutrition Survey; NS, No association ($p \geq 0.05$). #No children or unmarried (reference category = married parous), ##Wants (more) children or undecided (reference category = wants no more children). For tables reporting model coefficients, refer to Supplementary File 10.

Table 4: **Summary of significance and direction of associations between potential determinants and preconception underweight, overweight, and anaemia using nationally representative survey data.**

collection of micronutrient data in Afghanistan, Bhutan, and the Maldives.

There is a large variation in how studies define reproductive age and determine anaemia and micronutrient deficiencies. The studies reviewed used a wide range of age groups (including 15–49, 13–35, 18–30, 10–49, 15–40, <40, ≥15, ≥20, 14–35, 14–49, 15–23, 18–40, and 18–49 years), methods of blood sample collection (venous vs. capillary), diagnostic techniques (Hemocue, cyanmethemoglobin, Shali's, Sysmex, or haematocrit methods), and cut-off points for deficiencies, leading to inconsistent and incomparable results. There is an urgent need for standardised guidelines across the region to harmonise definitions, data collection methods, and diagnostic criteria. This standardisation would allow for more accurate comparisons between countries and better understanding of trends over time and in response to interventions.

Our analysis highlights how most available data is cross-sectional, limiting the ability to assess changes in malnutrition and its determinants over time. This prevents an understanding of how nutrition evolves through the life-course or in response to interventions. The Maldives, for example, has the highest anaemia prevalence regionally, but trends cannot be determined because there is only data from one time point. Longitudinal studies are essential to track changes in nutritional status over time, identify causal relationships, and assess the impact of interventions on malnutrition in preconception women. These should be incorporated into national survey programs.

Despite the global evidence base on the association between factors like reproductive health, WASH practices and health behaviours and anaemia and micronutrient deficiencies, the evidence base on these associations is limited within South Asia. Future research should focus on exploring the relationship between reproductive health, WASH practices, and health behaviour with preconception nutrition outcomes. This will better inform the development of nutrition-sensitive interventions.

The association between preconception nutrition and birth outcomes represents a stark evidence gap regionally, which limits the development of evidence-based programming to improve maternal and child health. Further studies should address this gap, to guide preconception and maternal health programs and policies effectively.

Conclusion

Our study highlights the significant and multifaceted burden of preconception malnutrition in South Asia, characterised by overweight surpassing underweight in prevalence alongside widespread anaemia and micronutrient deficiencies (particularly vitamin D) with substantial inter-country and subpopulation variation. The lack of standardised methods for diagnosing anaemia and micronutrient deficiencies hinders meaningful comparisons regionally. When comparing by preconception subgroup, consistent patterns in BMI suggest underweight is more common among unmarried women and overweight is more common among married parous women, whereas anaemia patterns vary between countries, underscoring the need for subgroup-specific, context-sensitive nutrition programs. Age, education, wealth, and urban/rural residence are key socio-demographic determinants of malnutrition, while dietary intake, food security, and BMI also influence anaemia and micronutrient deficiencies. The mixed evidence of the association between IFA supplementation and anaemia highlights the necessity for tailored nutrition strategies and enhanced food environments. We demonstrate the limited evidence on associations between preconception BMI and birth outcomes and an absence of research linking preconception anaemia or micronutrient deficiencies to such outcomes, underscoring the urgent need for large-scale, longitudinal studies in South Asia to guide effective interventions.

We identify three key priorities. First, as the profile of malnutrition differs by preconception group, regular screening of nutritional status starting around puberty (BMI, anaemia, and micronutrient deficiencies) and fertility intention among reproductive age women with tailored nutrition counselling pathways will be important to address socio-demographic disparities in malnutrition. Second, regional guidance is required to harmonise definitions, diagnostic criteria, and data collection methods for micronutrient deficiencies during the preconception period to enable evidence-based policymaking. Third, large-scale, longitudinal surveys and programme monitoring data sets with standardised data collection are required across south Asia, particularly in underrepresented countries and areas, to strengthen the evidence base on associations between preconception nutrition, women's health and birth outcomes and to inform policy action.

Contributors

FM, NS, VS and ZM designed and planned the study. FM undertook the data analysis for the analysis component (supported by RV) and FM and NS undertook the screening and data extraction for the review component. FM wrote the first manuscript draft in close collaboration with NS, with contributions from DS and VS on later drafts. RC, ZM, JH, CB, MN, RV and US contributed to interpretation of the findings and editing of the manuscript.

Data sharing statement

No primary data was collected for this study and all information is available in the public domain. Data extraction tables can be made available by individual request.

Declaration of interests

Co-authors VS and ZM are employees of UNICEF Regional Office for south Asia (RoSA) which funded this study. Other authors have no conflicts of interest. DS is supported by the National Institute for Health and Care Research (NIHR) through an NIHR Advanced Fellowship (NIHR302955) and the NIHR Southampton Biomedical Research Centre (NIHR203319). The authors declare no other conflicts of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2025.100573.

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