NUTRITION LITERATURE REVIEW REPORT

1. SUMMARY

In the past two decades, Nepal has seen a sustained reduction in stunting; in fact, Nepal has been identified globally as an exemplar country in this regard [1]. However, not only is the latest prevalence of stunting at 32 percent still concerning, but progress has slowed since 2011. Furthermore, progress has been unequal - favoring children of wealthier households and those of dominant ethnicities [2,3]. Geographical disparity is also a major challenge. Trends in other nutrition indicators, such as wasting, micronutrient deficiencies, and obesity, however, are less impressive. Rates of wasting have gone largely unchanged and go as high as 17.6% in Karnali province with a national average of 12% [4]. Nepal is also experiencing the dual burden of malnutrition: while low stature, thinness, and micronutrient deficiencies among women of reproductive age and adolescent girls continue to pose a significant health risk within the country, now there are more women of reproductive age who are overweight or obese than those who are underweight [5].

In this literature review, we summarized 373 publications on the causes of malnutrition among children, women, and adolescent girls, as well as the most effective interventions to address it, in Nepal and globally. We focused this summary on the lessons learned we gleaned from these studies:

Paying attention to women's nutrition throughout her life cycle. One of the most salient findings throughout this literature review is the importance of supporting women at every stage of life. The status of maternal nutrition and child nutrition at birth were consistently identified as important determinants of various forms of early childhood malnutrition [6–11]. Poor maternal nutrition before and during pregnancy lead to poor birth outcomes. Low maternal body mass index (BMI), low maternal stature, and inadequate dietary diversity are among the top factors associated with wasting, stunting, and underweight in young children. Moreover, the prevalence of malnutrition and poor diet quality amongst women of reproductive age and adolescent girls are concerning. Only about half of women of reproductive age consumed minimum dietary diversity and consumed legumes, let alone nutrient-rich animal source foods, such as meat and eggs [5,12,13]. To our knowledge, there are currently limited interventions aimed towards women during the preconception period [14,15], and we recommend an expansion of this approach.

Care for women and gender equity at the center. Newly married women and young mothers in Nepal are exposed to various vulnerabilities that stem from gender inequity and have been found to compromise their nutrition and that of their children. These vulnerabilities include unfair intra-household food allocation, unequal household division of tasks, and consequently high time-burden for young mothers, the limited say women have over their own reproductive decisions and high prevalence of adolescent marriage and of gender-based violence (GBV). Interventions that promote women's decision-making in these various domains and engage family members, such as mothers-in-law and husbands, to reconsider traditional roles and practices related to care for women and children are needed [16].

Addressing inequities is imperative. It is important to note that the reduction of stunting in Nepal has been unequal, and currently, stunting is concentrated among children of households experiencing multiple forms of deprivation [2,3,17]. This inequality in nutritional status could be traced

back to not only inequality in immediate factors (e.g., children in these households are less likely to be exclusively breastfed and meet minimum adequate diet for their complementary feeding), but also in underlying and contextual factors (e.g., women from these households are more likely to experience gender-based violence or experienced forced child marriage, less likely to attend ANC, etc.). Future interventions need to not only target but be designed for the context in which the most vulnerable populations live. For example, the current investment to address this inequality, an unconditional cash transfer program called The Child Grant, has birth registration as a registration requirement, which adds another layer of complexity for overburdened local officials and recipients, and therefore increases barriers for those who are most in need of the grant [18]. More rigorous evaluation and research on how to improve the adoption of these grants by those who need them would be useful.

Continue and refine successes in direct interventions in the health sector. Nepal's success in strengthening their community-based primary health care system, such as female community health volunteers, integrated management of acute malnutrition, health mothers' groups, integrated management of childhood illness, etc., deserve celebration. However, the nutrition content of health services is generally weak. For example, while the number of facility-assisted births has risen, this has not yet translated to improved rates of early initiation of breastfeeding and reduction of pre-lacteal feedings. Despite passing the Breastmilk Substitutes (BMS) Act, awareness and enforcement of the act are lacking. Data on the coverage of other vital interventions, such as delayed cord clamping and kangaroo care for pre-term babies, is also unclear. Moreover, while attendance in at least four antenatal care visits is high, the quality of nutrition counseling at these visits still needs improvement. Further, attendance in post-natal care is still low.

Agriculture. Despite its enormous potential, growth in the agriculture sector was found to be too low and volatile through our findings to be large enough to have significantly impacted stunting [19]. To address this, expansion of demand-driven agricultural research and extension activities, improvement of agriculture infrastructure (markets, agro-processing facilities, etc.), and increased access to longer-term credit are needed. Participation in nutrition-sensitive agriculture (NSA) interventions is dependent upon access to adequate land and water and, therefore, can be unequal according to age, caste, gender, household wealth, access to resources, training, and education [20]. To specifically provide support for smallholder farmers, increased attention towards currently underutilized indigenous crops and provision of climate-smart agriculture technologies and practices were recommended [19,21–23]. Reduction of post-harvest losses and improved food safety measures are also needed in the Nepal food system.

Water, Sanitation, and Hygiene (WASH). Results from Nepal reaffirm the primacy of addressing WASH to address child malnutrition. It is important to recognize that existing global literature on the impact of WASH interventions on nutrition indicators is mixed. Three randomized control trials of unprecedented scale in Kenya, Zimbabwe, and Bangladesh found no effect of their comprehensive WASH interventions on stunting. These results suggest that further interventions to reduce fecal-oral contamination may be needed. One example of such an exploration is the creation of an infant and young child play space: a clean, safe environment in which babies and infants can freely play that avoids key fecal transmission routes. Further, more work can be done to improve water quality. One study found that only five percent of water samples collected around remote hilly areas of Nepal met WHO's guidelines for microbial safety of drinking water at the point of consumption.

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2. INTRODUCTION

Suaahara II is a large-scale, multi-sectoral, community-based nutrition initiative that is uniquely integrated, as the project pairs behavior modification activities and essential nutrition actions with evidence-based interventions in maternal, newborn and child health; family planning; water, sanitation and hygiene; and kitchen gardening and poultry farming in 42 of 77 districts of Nepal. Suaahara II is scheduled to end in 2023.To ensure the follow-up nutrition activity incorporates the latest evidence, **we conducted a comprehensive literature review on the causes of malnutrition, as well as the most effective interventions to address it in Nepal and globally.**

In this document, we will first describe our literature search strategy and describe the current nutrition status among Nepal's women and children. We will then review what is known on the various determinants of childhood and maternal malnutrition and their trends in Nepal. Following this, we will discuss direct and indirect nutrition interventions in health and other sectors.

2.1. Literature search strategy

This literature review summarizes the existing literature on [1] determinants of maternal and child malnutrition in Nepal and [2] interventions that accelerate reductions in malnutrition globally. This review pays particular attention to interventions that address chronic and acute under-nutrition in young children, adolescent girls, and women of reproductive age. This includes the identification of knowledge gaps that require further investigation to better explore barriers and facilitators towards optimal Maternal Infant and Young Child Nutrition (MIYCN) practices and determine the best strategies to reach different target audiences. The outline for this review will follow the framework proposed in 2020 to accommodate new findings in the subject [1].

This literature review considered the following:

1. All articles listed in PubMed that cited two articles from the 2013 Lancet series in Maternal and Child Nutrition [2,3], and either summarized global learning or was conducted in Nepal and South Asia,
2. Relevant publications from Feed the Future's Nutrition Innovation Lab [4] and Innovation Lab for the Reduction of Post-Harvest Loss [5],
3. Suaahara annual reviews, annual reports, and related publications, and
4. Articles recommended by various topical experts we interviewed.

Since this review focused on the latest evidence, we excluded articles that were published before 2013.We included all studies from Nepal and South Asia. Papers based on other regions will only be included if there is no article from Nepal or South Asia or if they are a review (narrative or systematic) of a specific topic. Finally, this review does not include documents of current policies in Nepal; these documents are being reviewed in a different exercise.

3. NUTRITION STATUS

First, we reviewed the trends of various forms of malnutrition in women and children in Nepal using nationally representative data from Nepal's Demography and Health Surveys (NDHS), Multiple Indicator Cluster Survey (MICS), and the Nepal National Micronutrient Status Survey.

3.1. Stunting and wasting

Nepal has seen an impressive, sustained reduction in stunting in the past 2 decades (Figure 1); in fact, Nepal has been identified as an exemplar country in this regard [6]. This matters because linear growth retardation and stunting are associated with undesirable short-, medium-, and long-term outcomes, including delayed child development / poor neurodevelopment [7,8], leading to lower school achievement and reduced earnings, reduced physical strength and work capacity [9], contributing to adult noncommunicable diseases and increased mortality [10,11], and undesirable birth outcomes in the next generation [12]. However, not only is the latest prevalence of stunting at 32% still concerning but also progress has slowed since 2011. Furthermore, progress has been unequal, favoring children of wealthier households and those of dominant ethnicities [13].

Wasting remains a cause for concern; there has been no decrease in the prevalence of wasting throughout the years. This is concerning not only because wasting is associated with premature death but also with delayed development in the social-emotional domain [8]. It is also worth noting that, unlike some other countries in South Asia, the prevalence of childhood overweight is still quite low (2.8%) [14].

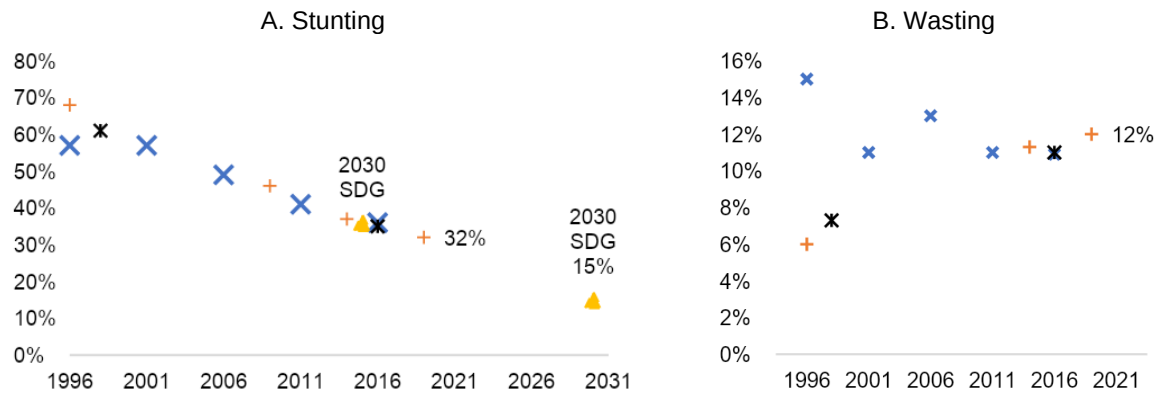

Figure 1: Prevalence of stunting (panel A) and wasting (panel B) amongst children agreed 6-59 months old according to Nepal Demographic Health Survey (NDHS) 1996-2016 (blue), Multiple Indicator Cluster Survey (MICS) 2010-2019 (orange), and Nepal National Micronutrient Status Survey (NNMSS) 2016 (black). The Yellow dashed line is the 2030 Sustainable Development Goal (SDG).

3.2. Nutrition status at birth

Birthweight is a predictive indicator of potential neonatal death and of malnutrition if the child survives. Low birth weight, especially low birth size for gestational age, is a major factor for stunting

Table 1: Prevalence of poor birth outcomes according to the 2016 Nepal Demographic Health Survey [15] and the 2007 WHO Global Survey [16]

Variables	NDHS	WHO
Low birth weight	12%	12.6%
Preterm birth		9.4%
Small for gestational age		34.9%
Maternal assessment		
Very small	5%	
Smaller than average	12%	
Average	83%	

[17–20] and wasting [20]. Similarly, pre-term birth is associated with reductions in both cognitive and motor scores [21].

While it is notably lower than the rest of South Asia [22], the prevalence of low birth weight still indicates a high rate of poor birth outcomes in Nepal. Moreover, it is notable that this rate has not gone down much since 2007, a finding that is also brought up by the NDHS analysis [15].

3.3. Micronutrient deficiencies

Table 2: Prevalence of micronutrient deficiencies among children 6-59 months old according to the Nepal National Micronutrient Status Survey [23]

Variables	
Anemia (Hb<11.0 g/dL)	19.1%
Iron deficiency (Ferritin <12 µg/L)	27.6%
Iron-deficiency Anemia	10.6%
Vitamin A deficiency	4.2%
Zinc deficiency	20.7%
RBC Folate deficiency	1%

The 2016 NNMSS found a high prevalence of iron and zinc deficiencies in the country [23]. This matters because childhood anemia is associated with impaired cognitive development and, possibly, motor development [24].

On the other hand, DHS analyses and the micronutrient survey found that iodine deficiency is well controlled through iodine fortified salt [15]. Similarly, vitamin A deficiency is no longer a significant public health problem.

Some studies explore the prevalence of deficiencies of other micronutrients amongst Nepalese children. One study explored the prevalence of vitamin B12 and folate deficiencies due to their association with megaloblastic anemia, poor growth, increased infection, and irreversible neurological damage to the developing brain [25–27]; they have also been found to be associated with cognition [28] and linear growth [29] among Nepalese children. Further findings include that 30.2% of

children were vitamin B12 deficient, while RBC folate deficiency was not a problem [30]. Similarly, one study explored the prevalence of vitamin D insufficiency due to its role in bone health and beyond. The study found a low prevalence of vitamin D insufficiency among Nepalese infants despite high rates of vitamin D insufficiency among their mothers [31]. It is important to note, however, that these analyses were done using cross-sectional data of 500 households, and therefore, its relevance is unclear.

4. DETERMINANTS

We reviewed twelve articles (published in 2016-2020) on determinants of various forms of malnutrition using nationally representative data (Table 3). One study reported on the top 10 factors related to stunting, wasting, and underweight in various countries [32]; we reported on their findings of Nepal. One study analyzed the proportion of contributing factors on stunting in 2016 [33], while three others analyzed the proportion contributed by various factors to the reduction of stunting over time [13,34,35]. We also reviewed analyses on determinants for stunting [36–38], wasting [20], and anemia[39,40].

Table 3: Summary of determinants

Determinants		Stunting								Wasting		Underweight	Anemia	
		(32)	(33)	(13)	(38)	(34)	(35,41)	(36)	(42)	(32)	(20)	(32)	(39)	(43)
Basic														
Household characteristics	Wealth	#2	72%	9.0%	X	12%	28%	X	X					
	Size				X									
	Caste or ethnicity		-1.2%											X
Maternal characteristics	Education	#5	1.1%	12.2%	X	11%	14%	X	X	#6	X	#7		
	Employment							X						
	Smoking							X						
	Age at marriage								X					
Paternal characteristics	Education		2.9%	12.5%		3%	6%							
Environmental	AE Zone				X			H, M					H	
	Seasonality										X		X	
Underlying														
Household WASH	Sanitation facility	#3				7%				#4		#3	X	
	Open defecation		3.9%	12.3%			14%							
	Unsafe stool disposal	#6								#10				
	Unsafe water	#8				0%	1%					#10		
Other HH environment	High indoor pollution									#5		#4		
Health services	ANC coverage, <4 ANC visit	#10	1.9%	14.0%		3%	16%	X				#9		
	Delivered at health facility		1.6%			11%								
	Vaccination coverage					6%			X					
	Iodized salt									#3				
	Vit A coverage	#9										#9		

Immediate															
Breastfeeding	Breastfeeding practices		0.2%	8.1	X			X				X			
Child's diet	Poor dietary diversity			6.3%					X		#1			#6	
Child's illness		#7			X						#7, #8, #9			#5	X
Maternal characteristics	Short stature	#1		19.3%	X	4%			x					#2	
	Low BMI	#4	12.3%		X				X		#2	X		#1	
	Diet														
	Birth spacing, fertility			3.4%			4%								X
	Anemic														X
Child's characteristics	Small at birth		2.6%					X				X			
	Birth order		8.6%									X			
	Birth month											X			
	Other forms of malnutrition				X										X

Maternal nutrition, child's nutrition at birth, infant and young child feeding practices, household water and sanitation, maternal education, and household wealth consistently were repeatedly found to be important factors for various forms of malnutrition. Moreover, multiple studies noted that stunting was concentrated among children of households experiencing multiple forms of deprivation, including poor child diets, low levels of maternal education, and household poverty [44], and therefore addressing inequalities to be key in future efforts in reducing malnutrition [45].

Below we will discuss various other determinants that have been found to be important.

4.1. Immediate: Intergenerational transfer

Since all the nutrients a child receives from their conception to six months of life come directly from their mothers, the nutritional status of women before, during, and after pregnancy affects their own well-being and has long-lasting impacts on the survival, growth, and development of their children [46].

4.1.1. Women's nutrition status before pregnancy, women of reproductive age

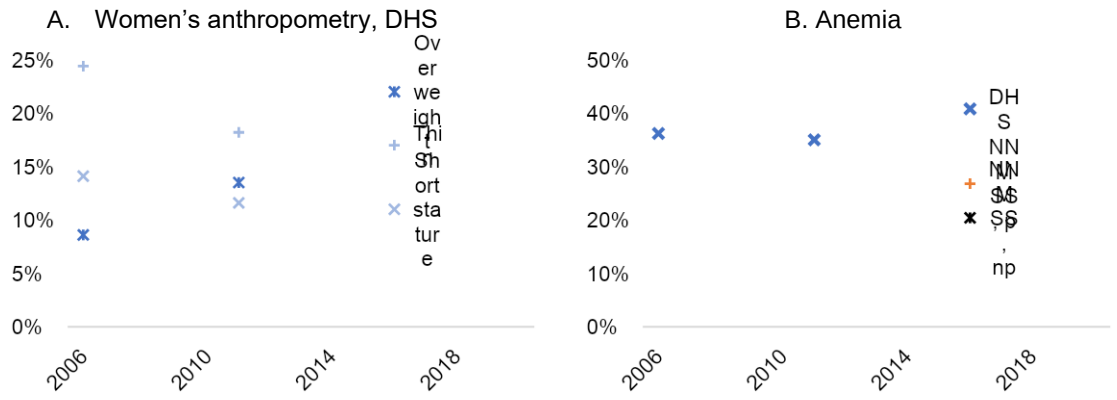

Figure 2: Panel A depicts the prevalence of women aged 15-49 years old who were thin (BMI<18.5), short stature (<145 cm), and overweight from the 2006, 2011, and 2016 NDHS. Panel B depicts the prevalence of any anemia amongst women aged 15-49 years old (<12.0 g/dL for non-pregnant women; 11.0 g/dL for pregnant women) from the 2006, 2011, 2016 NDHS and the 2016 NNMSS.

From NDHS [15], we found that there has been a slight decrease in the prevalence of mothers who are underweight (BMI<18.5) or with short stature (<145 cm) even though the rate of progress has slowed down between 2011 and 2016. On the other hand, the prevalence of women who are overweight continued to increase such that as of 2016, it has passed that for underweight. This, coupled with the finding of a high prevalence of consumption of sweet foods (76%) [23] and high rate of hypertension (17%) among women aged 15-69 years old, may signal further complications during pregnancy. In fact, a 2020 study found an association between women's obesity with their likelihood of experiencing miscarriage [47]. Fortunately, currently in Nepal, the prevalence of double burden of malnutrition at the household level is still very low (1.54%) [48].

Table 4: The prevalence of micronutrient deficiencies among non-pregnant women 15-49 years old according to the Nepal National Micronutrient Status Survey

Variables	
Iron deficiency	18.7%
Iron-deficiency Anemia	14.2%
Vitamin A deficiency	3.0%
Zinc deficiency	24.3%
RBC Folate deficiency, megaloblastic anemia (<226.5 mmol/L)	4.5%
RBC Folate lower than recommended level to prevent neural tube defects (906 mmol/L)	89.6%

Micronutrient deficiencies continue to be a problem. The prevalence of anemia has increased over the years. This is not ideal because women who are short, thin, anemic, or gain inadequate weight during pregnancy are more likely to suffer adverse birth outcomes, e.g., low birth weight and preterm delivery [49,50], which are persistent problems in Nepal. We found two studies assessing the risk factors of anemia in non-pregnant women of reproductive age using data from NDHS [51] and the NNMSS [52]. The use of hormonal contraceptives was also found to be important in both studies. Appropriate birth spacing allows mothers' bodies to build iron reserves that are needed during pregnancy. House characteristics related to increased infection, such as using wells as a water source [51] and having dirt floors [52], were also found to be a risk factor.

About a quarter of women in Nepal had a zinc deficiency. Zinc is an essential trace element with a key role in the immune system and DNA synthesis, cellular division, proliferation, and growth [53,54]. Zinc is also required during pregnancy for optimal growth and development of the fetus, along with maternal tissue expansion [55]. Poor maternal zinc status has been associated with negative pregnancy outcomes, including spontaneous abortion, congenital malformation, low birth weight, and preterm delivery [56,57].

While RBC Folate deficiency is relatively uncommon, its levels in 90% of Nepalese women were not adequate to avoid neural tube defects, a common but complex congenital malformation resulting from the failure of the neural tube closure during embryogenesis [58]. An adequate level of RBC Folate of all women is especially important since the process to avoid neural tube deficiency happens early in pregnancy, likely before most women became aware of their pregnancy.

Only about half (48.8% according to NNMSS, 50.2% according to NDHS) of reproductive age women in Nepal consumed the minimum dietary diversity. Moreover, only a quarter consumed meat, and 10% consumed eggs. In their survey of women 15-49 years old from 9 districts[59], Bhandari et al. state that the majority of women relied too heavily on cereal to meet their caloric needs. Less than 50% of women in any of the three agroecological zones consumed legumes/pulses and any category of animal-sourced foods at least once a day. This poor diet might be due to the limited availability and affordability of nutritious foods. A 2016 study in 3 villages found that models of the commonly-consumed lowest cost diet lack sufficient vitamin B12, riboflavin, and calcium in the mountains; B6, B12, calcium, and iron in the hills; vitamin A, calcium, and iron in the terai [60]. Adding fish to the diets of women in mountain and hill areas and increasing dark green leafy vegetable consumption in all zones was recommended as the most cost adequate way to improve their diet.

4.1.2. Women's nutrition status before pregnancy, adolescent girls

Table 5: The prevalence of undernutrition and micronutrient deficiencies among adolescent girls aged 10-19 years old according to the 2016 Nepal National Micronutrient Status Survey [23] or Suahaara II Annual Survey as published in their adolescent health [61]

Variables	NNMSS 2016	Suaahara 2018
Stunting	32.1%	
Wasting	23.3%	
Underweight		18.6%
Anemia	20.5%	28.6%
Iron deficiency	18.0%	
Iron-deficiency Anemia	7.0%	
RBC Folate deficiency, megaloblastic anemia (<226.5 mmol/L)	6.1%	
RBC Folate lower than recommended level to prevent neural tube defects (906 mmol/L)	95.8%	

Similar to that of their adult counterpart, the nutrition status of adolescent girls in Nepal is concerning. About one third were stunted, about one quarter was too thin, about one fifth was anemic, and 96% RBC Folate was lower than the recommended level to prevent neural tube defects. Their diet was also poor. NDHS 2016 found that, among girls 15- 19 years of age, only 46% met minimum dietary diversity (had at least 5 out of 10 food groups), while NNMSS 2016 found that only 43% of 10-19-year-old non-pregnant girls did so. There is also currently a lack of interventions to address this poor nutrition status. A recently published study found that only a few adolescent girls

have any exposure to nutrition information in the prior month and that most adolescents never took Iron Folic Acid (IFA) supplements [61].

Nutritional status of adolescent girls is important for childhood nutrition for two reasons. First, adolescents undergo a critical period of growth and development when about half of adult body weight and 15 to 20 percent of adult height have been attained. There is even some evidence suggesting that "catch-up" growth is possible during adolescence if nutrition is adequate. This not only causes adolescents to be particularly vulnerable to undernutrition but also increases the vulnerability of pregnancy and breastfeeding during adolescence due to competition for nutrients between the mother and fetus, marking this period as critical to promote intergenerational health [61]. The percentage of babies born with low birth weight is highest (16%) among mothers under age 20 [15]. A longitudinal observational study observing 60,742 deliveries in Nepal found that compared to adult mothers, adolescent mothers had higher odds of experiencing prolonged labor, preterm birth, and of having a baby being small for gestational age [62]. Secondly, adolescent pregnancy is common in Nepal. Nearly a quarter (23%) of mothers in Nepal give birth before 18 years of age, while about half have given birth by the age of 20 [63].

Table 6: The prevalence of anemia and iron deficiency among pregnant women aged 15-49 years old according to the 2016 Nepal National Micronutrient Status Survey [23]

Variables	
Iron deficiency	26.8%
Iron-deficiency Anemia	7.8%
Vitamin A deficiency	5.1%

4.1.3. Women's nutrition during pregnancy

Women's nutrition status during pregnancy, unsurprisingly, is also poor. More than one-quarter of pregnant adult women had iron deficiency, while one in twenty had vitamin A deficiency. This is important because inadequate diet during pregnancy can affect fetal development and growth in the short term, subsequent growth and cognitive development in the medium term, and the risk of chronic disease in the longer term. This is especially relevant in resource-poor settings, such as in Nepal, in which women may enter pregnancy with multiple micronutrient deficiencies [64]. Iron deficiency in pregnant women can lead to anemia in their offspring, and a mother's vitamin A deficiency can lead to children's night blindness and increased risk of infection.

Despite its importance, the diet of pregnant women in Nepal is still poor. Data from Nepal conforms with the global findings on pregnant women who consumed predominately plant-based diets: that they have inadequate micronutrient intakes and little dietary diversity [65]. Animal source food consumption during pregnancy in Nepal is low: only 14%, 30%, and 34% of pregnant women consumed eggs, milk products, and meat, fish, or poultry, respectively [15]. Moreover, a recent panel study that followed 200 women over 18 months found that being pregnant or recently giving birth was not associated with improvement in any eating practices [66].

While there are some findings surrounding cultural practices of "eating down" (eating less during pregnancy for fear of delivering a large baby and enduring long, painful labor) and some concerns regarding the impact of spicy foods on a baby's health and comfort, most women reported structural barriers, such as seasonal variation and high cost, as reasons why they were not able to consume nutrient-rich foods during pregnancy [67,68]. The Suaahara II program Third Annual Survey (2019) indicates that the program has been tackling this problem well. The knowledge that pregnant women should consume more food than usual increased from 72% to 81% ($p<0.01$) among household heads and from 86% to 91% ($p<0.01$) among mothers. In practice, the percentage of pregnant women that consumed more food than usual increased from 48% to 61% ($p<0.01$) in 2019. The individual dietary diversity score among mothers increased from 4.1 to 4.4 ($p<0.01$), while the percentage of mothers meeting the minimum dietary diversity (5 out of 10 groups) increased from 36% to 45% ($p<0.01$) between 2017 and 2019.

4.1.4. Women's nutrition status during lactation

We did not find major studies on the current status of maternal nutrition during lactation in Nepal or South Asia. One small study found that iron deficiency is uncommon among lactating women in urban Nepal, despite a high risk of inadequate dietary iron intake [69]. This lack of evidence is notable since lactating women require nutrients in increased amounts in comparison to non-pregnant women, including vitamins A, E, B6, B12, choline, folate, iodine, lutein and zeaxanthin, zinc, omega-3 fatty acids, as well as increased amounts of fiber and protein [70].

Table 7: Proportion of women using any method of family planning according to the 2016 Demographic Health Survey [15]

Variables	
Using any method of family planning, currently married women	53%
Using modern method of family planning, currently married women	43%
Using modern method of family planning, girls 15-19 years old	15%
Want to but not using contraception, currently married women	24%

4.1.5. Family planning

Unmet needs in family planning and pregnancy spacing are a common problem in Nepal. Only 43% of currently married women use modern methods of family planning. Moreover, more than one-quarter of women who gave birth in the last five years became pregnant within 24 months of giving birth, and 52% had an unmet need for family planning within 24 months postpartum. [71]

Family planning allows for sufficient time between pregnancies and therefore enables women's bodies to recover their nutritional stores and muscle tone from previous pregnancies [72], in addition to many other proposed causal mechanism [73]. The evidence between pregnancy spacing and reduced risks for stunting is well documented. A study pooling 153 NDHS surveys across 61 countries

conducted between 1990 and 2011 found that birth intervals of less than 12 months and between 12 and 23 months were associated with 1.09 and 1.06 the risks for stunting, respectively, as compared to a 24- to 35-month interpregnancy interval [74]. Another found decreases in child height at age 1 among children who are born within three years of an older sibling [75]. In fact, family planning and pregnancy spacing might partially explain the inequities in stunting we currently found in Nepal [33]. For example, in 2016, the total fertility rate was highest in the poorest wealth quintile at 3.2 compared to 1.6 in the richest quintile. Moreover, significantly higher rates of unmet need for family planning were found among rural and hill residents and Muslims than in other groups [76].

Despite the clear evidence between pregnancy interval and stunting, the evidence on the role of short interpregnancy intervals on adverse birth outcomes, such as preterm birth and small for gestational age, have been mixed. Some studies found their role to be negligible after applying family fixed effects (as in only comparing children from the same families) [77,78], while some others find, such associations remain [79,80]. Similarly, the relationship between birth spacing and maternal nutritional status has been mixed. Only two of five studies reviewed reported an increased risk of maternal anemia [73,81], and only four of eight studies reviewed positive association with maternal anthropometric status [81]. The reviews pointed out apparent methodological limitations and therefore suggested further studies before making conclusions for this association. In contrast, evidence of an association between family planning and both short pregnancy intervals and child mortality are well-documented [82–84]. This association holds even after applying family fixed effects, even though the association considerably attenuates with the socioeconomic status of the family [84,85].

Adolescent girls have even poorer access to and knowledge of family planning compared to adult women. Only 15% to 20% of girls aged 15-19 used modern methods of family planning [15,61]. A study on adolescent girls by the Suahaara team found that about one-third of the young adolescent girls have any knowledge on family planning methods, while accurate knowledge of healthy timing and spacing of pregnancies and births was low overall [61].

4.2. Immediate: Burden of disease

4.2.1. Child's illness

Table 8: The prevalence of child's illnesses according to the 2016 Demographic Health Survey [15], the 2016 Nepal National Micronutrient Status Survey [23], and the 2019 Multiple Indicator Cluster Survey [86]

Variables	NDHS	NNMSS	MICS
Fever	21%	36.5%	20.6
Cough		38.3%	
Acute respiratory infection	2%		2.1%
Diarrhea	8%	19.6%	9.7%
Had H. *pylori* in stool sample		19.7%	
Suffering from Soil Transmitted Helminths		11.9%	

According to NDHS, between 2006 and 2016, the prevalence of diarrhea and symptoms of acute respiratory infection (ARI) among under-5 children declined by 4% and 3%, respectively, while the prevalence of fever increased by 4% (Figure 3) [87]. NNMSS, on the other hand, found a much higher prevalence of these illnesses. (Table 8). Suaahara II's Third Annual Survey Report found a somewhat higher incidence in diarrhea cases among children 0-2 years old (12.4%) than among all children under 5 years of age (9.5%). Regardless, these rates are still too high, given their consequences on child health and nutrition status.

4.2.2. Environmental enteric dysfunction (EED).

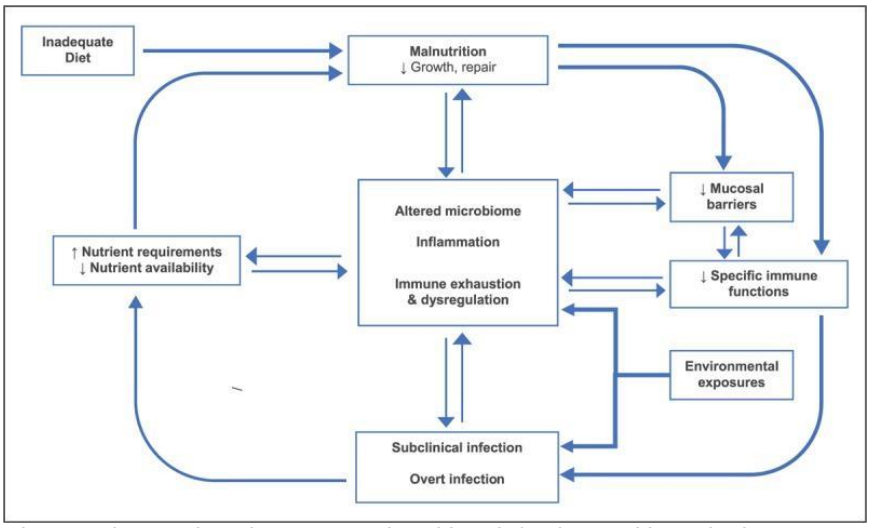

Figure 3: interactions between malnutrition, infection and intestinal dysfunction as illustrated by Walson et al. . [88]

Moreover, the 'vicious-cycle' between nutrition and infection is evolving to a more nuanced understanding of the roles of the environment, burden of exposure to pathogens because of crowding or poor water and sanitation, gut microbiota, chronic intestinal inflammation, mucosal barrier loss, and immune function [88,89]. Although diarrhea is a common manifestation of infection within the gut, many children experience significant intestinal dysfunction after fecal contamination, even in the absence of overt diarrheal disease. This led to poor absorption, local intestinal inflammation, and increased bacteria across the gut surface. This phenomenon is called environmental enteric dysfunction (EED).

EED is an alarming global health concern, especially given its high prevalence and demonstrated association with poor growth outcomes in young children living in low- and middle-income countries, even though most data seems to be from sub-Saharan Africa [90–92]. Studies in Nepal found that the effects of EED on growth faltering in young children were small but statistically significant [93]. The causal mechanism between EED and growth faltering is still being studied, however, with the strongest evidence for systemic inflammation [94]. Significant strides have been made in linking environmental exposure to enteric pathogens and toxins with EED and in understanding the multifactorial mechanisms underlying this complex condition [95]. However, this has not led to a better understanding of how to protect children in Nepal beyond minimizing contact with fecal contamination.

4.2.3. Malaria and anemia

We also found extensive studies on the relationship between anemia and malaria treatments [96–99] and preventions [99,100]. However, due to the marked decrease in malaria incidence in Nepal [101], we will not discuss this in detail.

4.3. Immediate: Child's dietary intake

4.3.1. Breastfeeding

Table 9: Prevalence of optimal breastfeeding according to the 2016 Demographic Health Survey [15], the 2016 Nepal National Micronutrient Status Survey [23], and the 2019 Multiple Indicator Cluster Survey [86]

Variables	NDHS	NNMSS	MICS
Ever breastfed, 6-23 months		97.9%	98.7%
Early initiation of breastfeeding	55%	66.8%	41.7%
Given pre-lacteal feeds	29%		
Exclusive breastfeeding, 0-5 months	66%	66%	62.1%
Continued breastfeeding at 1 year	98%	94.3%	95.5%
Continued breastfeeding at 2 years	89%	83.4%	87.6%
Currently bottle-fed	13%	11.3%	

While there have been steady improvements in early initiation of breastfeeding, lack of pre-lacteal feeding, and exclusive breastfeeding in Nepal over the last 25 years, there is still room for improvement [102]. While most in Nepal receive colostrum, less than half received early initiation of breastfeeding [103]. Almost a third of children were given pre-lacteal feeds [15,103]. Moreover, only two-thirds of children 0-5 months were exclusively breastfed, and there were a three percentage point decrease in exclusive breastfeeding (EBF) practices between 2011 and 2016 [104]. Similarly, a facility-based study in the Mid-western and Eastern regions found that only 23. Two percent of infants were exclusively breastfed until 6 months [105]. The rate of partial breastfeeding was higher with inadequate knowledge on the duration of exclusive breastfeeding or late initiation of breastfeeding, or perceived breastfeeding problems.

This is important because a systematic review found that, compared to infants who initiated breastfeeding ≤1 hour after birth, infants who initiated breastfeeding 2–23 hours and ≥24 hours after birth had a 1.33 and 2.19-fold greater risk of neonatal mortality, respectively [106]. Moreover, neonates who were not exclusively breastfed have almost 4 times higher risk of infection-related mortality than exclusively breastfed neonates, and the provision of pre-lacteal feeds increased a child's likelihood of being wasted (RR=1.10) and severely wasted ([102]. Moreover, a case-control study [14] in Nepal looked at maternal profiles and social determinants of severe acute malnutrition (SAM) in children under five years of age and found exclusive breastfeeding practices as one of the two most important contributing factors to decrease SAM. The high prevalence of wasting in infants aged 0 to 5 months in South Asia calls for greater support to early breastfeeding initiation and exclusive breastfeeding during the first six months after birth [20].

4.3.2. Complementary feeding

Table 10: Prevalence of optimal complementary feeding according to the 2016 Demographic Health Survey [15], the 2016 Nepal National Micronutrient Status Survey [23], and the 2019 Multiple Indicator Cluster Survey [86]

Variables	NDHS	NNMSS	MICS
Timely initiation of complementary foods, 6-8 months	84%	79.4%	
Had minimum dietary diversity, 6-23 months	47%	45.8%	39.7%
Had minimum meal frequency, 6-23 months	71%	77.3%	68.9%
Has minimum acceptable diet, 6-23 months	36%	38.0%	31.0%
Had consumed food rich in vita A	63%		
Had consumed food rich in Iron	35%		

In Nepal, only 36% of children aged 6-23 months old consumed a minimum acceptable diet, as recommended by WHO [104]. This is mostly driven by the fact that only 44% of children consumed minimum dietary diversity. In addition to overall diets, poor consumption of animal source foods (ASF) by children 6-23 months of age also deserves attention. Only 27%, 22%, and 16% of them consumed meat, eggs, and milk products in the previous day [15]. A study in Nepal that tracks children's consumption over time found that, even in populations with better overall complementary feeding dietary indicators, consumption of iron and vitamin-A rich foods was irregular [107].

This poor diet has clear consequences on child growth and development. The steepest drop in mean height-for-age z-scores in NDHS occurred between 7 and 18 months old, during the complementary feeding period [13]. Poor complementary feeding practices, especially inadequate dietary diversity and meal frequency, have also been found to be associated with stunting [42] and wasting [20], respectively, and micronutrient deficiencies. Moreover, in analyses using data from multiple countries (39 to 185 countries per study), ASF consumption has been associated with decreased stunting [108–110]. This association between ASF consumption and stunting is stronger if more ASF types are consumed [111].

Analysis of the 2016 NDHS data found that children with the following characteristics to be more likely to consume a minimum adequate diet: older age, having a mother with a diverse diet, educated, and were exposed to TV/radio health and nutrition program, living in a household with good WASH indicators, living in middle or richer household wealth quintile, residence in Terai ecological zone or in Province 4 (Gandaki Province), and rural residence. On the other hand, being born with low birth weight and being part of a minority caste and ethnic group was associated with a lower likelihood to meet a minimum adequate diet. Additionally, one study found that Nepalese children with perceived LBW are also fed less diverse diets, which may stem from beliefs that they are too weak to ingest some types of food [112]; similar findings have been reported in Pakistan [113].

Consumption of unhealthy snack foods and beverages is an emerging issue in urban areas. A cross-sectional survey conducted in a representative sample of 745 primary caregivers of children aged 12–23 months in Kathmandu Valley found that unhealthy snack foods and beverages (USB) contributed 25% of children's total energy intake [114]. This is an issue because the consumption of unhealthy snack foods/beverages by children is associated with an inadequate intake of micronutrients.

Compared to low USB consumers, high USB consumers had lower dietary intakes of 12 nutrients and were at greater risk of inadequate intakes for 8 nutrients. Consumption of unhealthy snack foods and beverages is also associated with poor child growth (lower mean length-for-age z-score). Notably, children from the poorest households had significantly higher odds of high USFB consumption, whereas children whose caregivers were of upper caste/ethnicity or had achieved tertiary education had lower odds of consumption than other children [115].

4.3.3. Feeding during childhood illnesses

Harmful feeding practices during childhood illness are a concern in South Asia. An analysis of survey data and review of research in South Asia found that while most children continue to be breastfed when they become sick, up to 49% of sick children are breastfed less frequently than usual [116]. Moreover, up to 75% of caregivers restrict the frequency, quantity, or quality of foods fed to sick children. Common reasons given by caregivers for these practices include concerns that a sick child cannot digest breastmilk or some food types, that the breastmilk has become harmful to the child, and that the child has no appetite or refuses to feed. The study also found evidence that feeding advice and counseling by health workers to caregivers of sick children are inadequate and, in some cases, detrimental. Suaahara II Third Annual Survey found that knowledge and practices on feeding a sick child were poor all three years of the project. There was no progress between 2017 and 2019 on household heads and mothers' knowledge to give more food to a sick child.

4.4. Underlying: Household food security

Table 11: Prevalence of food insecurity according to the 2016 Demographic Health Survey [15] and the 2016 Nepal National Micronutrient Status Survey [23]

Variables	NDHS	NNMSS
Food secure	48%	59.1%
Mildly food insecure	20%	15.8%
Moderately food insecure	22%	18.1%
Severely food insecure	10%	7%

4.4.1. Household food security

Nepal ranks 79th out of 113 countries in the Global Food Security Index [117]; 41% of the population experiences food insecurity (15.8% mild, 18.1% moderate, and 7% severe) [23]. According to the 2016 NDHS, about 56% of all women of reproductive age and 76% of Dalit women of reproductive age had experienced food insecurity [118]. Analyses of the association between household food security and child nutritional status in Nepal and the rest of South Asia, for the most part, found a positive association between the two [119–122]. One study in the mid-west Surkhet, Nepal, found that children from households experiencing food insecurity have 4.26 times the odds of being stunted than those from food-secure homes [121]. However, the true extent of food security's impact on early childhood undernutrition at the national level is difficult to analyze due to the lack of good quality data related to food insecurity in Nepal [13]. Food affordability is a problem. A study that modeled the lowest cost diet commonly eaten in 3 Nepalese communities found that it lacks key nutrients [60], while the cost

of minimally nutrient adequate diets is between 34% and 57% household food expenditure, which is very high [123].

4.4.2. Household agriculture

In Nepal, agriculture contributes almost one-third of the total GDP and provides employment to 74% of the economically active population. Two reviews on determinants of progress in stunting in Nepal found that low productivity and a lack of competitiveness in the agriculture market have continued to present challenges to significant progress in poverty reduction and overall food security being attributed to agricultural growth in Nepal [13,34]. Despite its enormous potential, growth in the agriculture sector (3.5% per year between 2001 and 2011) was found to be too low and volatile to have significantly impacted stunting [124].

The agriculture sector is identified as a nutrition-sensitive sector due to its potential to improve household food security, dietary quality, income, and women's empowerment [125]. However, most studies on the household level we found in this topic have been focused on one pathway by which household agriculture might impact: production diversity. A recent systematic review found that production diversity and livestock ownership are consistently associated with dietary diversity, while their association with child's nutritional status is weaker [126]. A longitudinal modeling study also found that increased total dietary energy availability was significantly associated with reduced stunting rates [127]. Findings from Nepal align with these global results. Analysis of a nationally-representative dataset from 2013-2014 found that a child's diet is associated with the composition of farm production, especially for fruits and vegetables, dairy, and egg [128]. Moreover, a decomposition analysis of three rounds of the Nepal Living Standard Survey (NLSS) found that agriculture-related changes explain at least 16% of the improvement in child's diet [129]. A study also found that women who own ponds are more likely to eat fish [130]. Meanwhile, an analysis of the 2011 NLSS found no significant relationship between a household's total agricultural diversity and either HAZ or stunting [131].

The relationship between production diversity and dietary diversity, unsurprisingly, depends on the degree of a household's reliance on its own production. Dietary diversity is less associated with production diversity in households that are wealthier [128,132], have a higher degree of commercialization [131], have better access to food markets [133–135], receive public assistance [135], or engage in temporary migration [135]. Similarly, this relationship was more evident among older preschool children than infants since older children are more likely to rely on household foods [128,132]. On the flip side, engagement in agriculture was found to protect against food insecurity and malnutrition in peri-urban settings [136], indicating that diversification of food and income sources is key. Similarly, owning cultivable land and participant's unemployment status was significantly associated with increased odds of dietary monotony in women [137].

Other pathways between agriculture and nutrition, such as the relationship between nutrient availability in soil and nutrition deficiencies in children's diet, are understudied. One preliminary study found an association between zinc concentration in soil and stunting and anemia prevalence in the area [138].

For further discussion on nutrition-sensitive agriculture, find them under 'indirect intervention – other sectors. '

4.5. Underlying: Access to health services

4.5.1. Antenatal care

Table 15: Women's access to health services according to the 2016 Demographic Health Survey [15] and the 2016 Nepal National Micronutrient Status Survey [23]

Variables	NDHS
HH within 30 minutes of a government health facility	49%
Received ANC from a skilled provider (women who gave birth in the past 5 years)	84%
Deliveries took place in health facility	57%
Receive postnatal care check within 2 days of delivery	57%

Antenatal care (ANC) aids in the reduction of maternal and neonatal mortality [139]. Nepal has made notable progress in maternal care, with increases in the number of women attending four or more ANC visits, as recommended by the WHO. The Maternity Incentive Scheme (MIS) and the Aama program have had positive influences on these rates of attendance [33]. Since the 1980s, there has been a commitment from government and development partners to support maternal care programs, and there have been increased efforts to reform health systems and increase the accessibility of health services [140]. Increased accessibility and utilization of maternal health services have positively impacted growth outcomes in Nepal over the last several decades [141,142] and particularly as they relate to increased immunization [141,143–145] and the provision of ANC [35,146–148]. Quality of ANC services threatens gains made in access and utilization. Only 17% of health facilities in Nepal offered high-quality ANC services in 2015 [33], and performance in maternal nutrition programs in low- and middle-income countries are poor [149]. Access to ANC and maternal care drives improvements in breastfeeding in the lower socioeconomic quintiles [150], which, along with complementary feeding practices, are important for child nutrition and growth [112].

4.5.2. Health-seeking behavior

Table 12: Prevalence of behaviors related to care and feeding of sick children according to the 2016 Demographic Health Survey [15]

Variables	NDHS
Taken to health facility or provider for advice or treatment	64%
Given more food or liquid than usual	32%

Over the decade, treatment or advice-seeking practices from the health facilities or providers for diarrhea, symptoms of acute respiratory infection (ARI), and fever showed significant improvement. However, families of children from poor households were less likely to seek treatment or advice from health facilities or providers. Household heads' knowledge that a sick child should be taken to a health facility or FCHV, however, increased from 57% in 2017 to 76% in 2019 ($p<0.01$); maternal

knowledge increased similarly from 54% in 2017 to 71% in 2019 (p<0.01) (Table 4.8). There was no significant change in sick child feeding.

4.6. Underlying: Household environment

In a systematic review of the literature, the environmental risk factors that have been associated with stunting that included 71 articles, in the final analysis, foodborne mycotoxins, a lack of adequate sanitation, dirt floors in the home, poor quality cooking fuels, and inadequate local waste disposal were consistently found to be associated with an increased risk of childhood stunting [151].

4.6.1. Household water

On the surface, Nepal did not seem to have a water security problem, as 95% of households in Nepal have access to improved sources of drinking water [15]. However, further inspection revealed that only 40% of the population has this within 30 minutes of a round trip. Moreover, this does not seem to guarantee water quality, especially in remote hilly areas of Nepal. A study that collected and tested samples from participating household's main drinking water source and from the container used for drinking water transport and storage [152]. They found that the majority of water samples tested in this study were contaminated with E. coli (93.6 and 95.3%, respectively) and total coliform bacteria (99.4 and 98.8%, respectively). Only five percent of water samples at the point of consumption met the WHO's guidelines for microbial safety of drinking water. Lastly, using wells as a water source was also found to be a risk factor for anemia in children.

There is a call to measure household water security beyond water availability. Household water insecurity, or the inability to access and benefit from adequate, reliable, and safe water, is widely recognized as a threat to human health and well-being. With the introduction of a new indicator to measure overall household water insecurity [153], there is a renewed attention on the many pathways between household water security and child nutrition, such as competition with food security on household resources and women's time and energy [154]. There is also emerging evidence on a household's water security complicated relationship with breastfeeding [155] and child's dietary diversity [156].

4.6.2. Household sanitation and hygiene

Only half used improved sanitation facilities [15]. A study found that 31.5% of children in the Eastern region of Nepal were infected with intestinal parasites [157]. Parasitic infections were significantly associated with not using soap after defecation, the habit of thumb sucking, and not wearing sandals. A study in remote hills area found a higher rate: 51.1% of children were suffering from parasitic intestinal infections (mostly various helminth species and *Giardia intestinalis*), and 52.2% had other waterborne illnesses [152].

In Nepal, unimproved sanitation is among the top 4 causes of stunting, wasting, and underweight in young children in Nepal [32]. A lack of adequate sanitation, dirt floors in the home, and inadequate local waste disposal are associated with an increased risk of childhood stunting [151,158]. Living in an area with open defecation also more than doubled the odds of an adolescent girl to have anemia [40]. Another study found that nutritional deficiency (being either stunted, wasted, or underweight) was negatively associated with handwashing after cleaning a baby's bottom and cleanliness of caregiver's hands and positively associated with keeping animals inside the house overnight and the presence of

total coliforms in the drinking water source [152]. Diarrhea was positively associated with an intermittent water supply and the presence of a mud floor and negatively associated with cleanliness of the toilet and the cleanliness of children's hands.

4.6.3. Household air pollution

Table 13: Prevalence of household air pollution-related to care and feeding of sick children according to the 2016 Demographic Health Survey [159]

Variables	NDHS
Smoking inside homes	46.0%
No separate kitchen room	49.8%
Use of polluting fuels for cooking	74.8%
The proportion of children living in houses with natural floors (earth/sand or dung)	98.4%

Despite a moderate decrease, household air pollution in Nepal continues to be very high, and since women do most household work, including cooking, women and children are the ones exposed to household air pollution [160]. Use of unclean cooking fuel [151,161], absence of separate kitchens [121,161], and exposure to environmental tobacco smoke [161] have been found to be associated with stunting in South Asia and Nepal. The effects start in utero, with mothers using biofuel for household energy (wood and dung) at an increased risk of delivering small-for-gestational-age infants [162]. Using the 2016 NDHS, a study also the use of polluting cooking fuel and the absence of a separate kitchen to be associated with childhood pneumonia [36]. The association between being born in low caste (Dalits) and stunting and wasting were modestly attenuated when controlling for household air pollution [163]. This means exposure to household air pollution partly explained the caste-ethnic difference in undernutrition among children in Nepal.

4.6.4. Foodborne mycotoxin

Exposure to mycotoxins through the diet is widespread in resource-constrained areas of the world, such as Nepal, where 94% of the population is exposed [164], even though the severity in Nepal is lower than what is found in sub-Saharan Africa [165]. Nevertheless, infants whose mothers were exposed to aflatoxin during pregnancy showed a higher risk of being born SGA [165], even though association with stunting is not observed [166]. It is also important to note that mycotoxin exposure is associated with EED [167]. A critical finding across all studies was the lack of association with either wealth or education of the household. Furthermore, nearly all households in these studies report purchasing some of their food, implying contamination of the food supply at the market level and the need to consider strategies for intervention that go beyond those focused on household production. While many other factors contribute to poor pregnancy outcomes, ubiquitous dietary exposure to mycotoxins represents a public health concern that cannot be ignored.

4.7. Basic: Women's education

The impacts of women's education on HAZ and stunting in Nepal have been widely supported in the literature [35,37,38,141,147,168]. In addition to the association with stunting, wasting, underweight, and childhood anemia, maternal education is associated with quality of complementary feeding, likelihood to take IFA supplements, more nutrition knowledge, child getting all basic vaccinations [15], and food security [118].

4.8. Basic: Gender equity

Nepal has an undercurrent of pervasive, patriarchal social structures and a deep-rooted ethnic caste system woven into the fabric of an otherwise rich, diverse cultural heritage, restricting progress in all major development sectors [169]. However, evidence on the relationship between measures of gender equity and child nutrition is inconclusive since most work on this topic has not been rigorous [170,171]. Higher-quality studies showed more consistently positive associations between income equity and food security. Evidence is limited on other exposure-outcome pairings [170–172]. Findings from the five studies done in Nepal [173–177] are similar to global findings. Gender equity impacts child nutrition in the following manners:

4.8.1. Unequal food allocation

A study found that newly married women had poor diet quality, and most ate fewer high-quality foods important for pregnancy in their marital, compared with natal, home [66]. This explains the poor maternal nutritional status since about half of newly married women are pregnant within 1 year of marriage. Interestingly, the highest inequity occurred in households experiencing severe or unexpected food insecurity, and also in better-off, high caste households, whereas poorer, low caste but not severely food insecure households were more equitable. Food allocation also varied regionally and seasonally [178].

4.8.2. Decision making

More than half of currently married women participate, either by themselves or jointly with their husband, in decisions regarding their own health care, making major household purchases, and visits to their family or relatives. Thirty-eight percent (38%) participate in all three decisions, while 28% do not participate in any of the decisions. About half of currently married women (52%) with cash earnings decide independently on how their earnings are used [15], even though husband and wife disagree on the level of female autonomy in money decisions but agree on non-economic decisions [179]. This might be due to low asset ownership by women. Only 8% and 11% of women (as compared to 19% and 21% of men) own a house and land, respectively [15].

What might be more important, however, is a women's decision-making power about her own health and that of her children. This matters because maternal decision-making input had a small but positive and significant association with some health-seeking behaviors, such as receiving at least 4 antenatal care visits, attendance at Growth Monitoring and Promotion (GMP) in the 6 months prior to the survey, and Health Mothers' Group (HMG) attendance, but not with receiving at least 3 postnatal care visits or delivering in a health institution [15,180]. Decision-making control was directly associated with exclusive breastfeeding [181]. This includes women's decision-making power on their use of contraception. High women's autonomy [182,183] and more equitable gender attitudes in the

household are associated with the use of contraceptives. Currently, 23.7% of married women wanted to use contraception but did not [184]. Given the importance of birth spacing and family planning for nutrition (see sections about this topic above), women's decision making on contraception matters for child nutrition.

4.8.3. Lack of time

Time is a key input to nutritional outcomes, insofar as it shapes practices around food consumption, child feeding, and childcare, all of which traditionally fall within women's domain in most societies [185]. This unequal household task allocation has been acknowledged globally as particularly important [186–188]. This unpaid "re-productive work" encompasses a variety of tasks, including food preparation, feeding of young children, breastfeeding, child social stimulation and monitoring, collecting and/or treating water, collecting cooking fuel, managing household (and children's) hygiene, and sanitation, and accessing health services, such as antenatal care, regular health checkups, child vaccinations, health, and nutrition information, and government food and nutrition programs. Both quantity (time spent) and quality (nature of the activities) of care matter. This is important because women's time is under stress. In a study of 3 Asian and 2 African countries, Nepali women have the heaviest work burdens, spending about 11 h a day in total on productive and re-productive work compared to men's 8 h [185]. Another Nepal study found 6.7±3.3 hours of physical labor a day for adolescent mothers [61].

4.8.4. Maternal mental health

There is increasing recognition of the importance of maternal mental health on child nutrition [189,190] and sustainable development in general [191]. For example, maternal depression during pregnancy is associated with fewer prenatal care visits [192] and poor birth outcomes [193,194]. Moreover, postnatal maternal depression has been linked to poor breastfeeding practices and other caregiving practices [195]. Consequently, studies have linked maternal depression to developmental delays [196,197]; a 2017 meta-analysis found that children whose mothers were depressed to have a 4.2 lower cognitive score at 6-8 weeks postpartum compared with those whose mothers were not [50]. This is also true regarding nutrition status: a systematic review of longitudinal studies found that children of depressed mothers had a higher chance of being underweight and stunted in the first year of life [198]. Moreover, maternal mental health's bidirectional association between health and household food insecurity is well-documented [199].

However, it is important to remember that this is an emerging topic; findings in this topic are mostly based on observational findings that heavily rely on cross-sectional analyses. There is emerging evidence on how to effectively engage with this topic in a nutrition-sensitive context [200], but the results were still preliminary. Moreover, a recent finding using Suahaara data found that maternal and paternal depression, while associated with maternal underweight, was not associated with children's anthropometric status or dietary diversity [201]. This indicates that the dynamics of maternal mental health are likely complex.

4.8.5. Male out-migration

In Nepal, international migration is a highly gendered phenomenon. Compared to global figures, where women make up about half of the world's migrant population, 90% of Nepalese migrants are

men. It is also quite common. In a sample of women with small children, about a third of households were female-headed, mostly due to male out-migration [185]. Many of these men migrate alone to earn wages abroad while their families stay behind. A recent paper reported results of in-depth interviews and focus group discussions on its impact on food security [37]. Migration can benefit households that stay behind through remittances, which help cover basic expenses, and by facilitating access to loans and credit, and alleviating anxiety about having enough to eat. In fact, another study found migration to be associated with higher child dietary diversity [202]. However, migration can also come at a high cost [37]. Men report undignified, unsafe, and difficult working conditions in India, while women bear additional childcare, fieldwork, and housework responsibilities. Limited male agricultural labor also hampers agricultural productivity and increases households' reliance on markets to meet basic needs.

4.8.6. Other aspects of gender equity

One example is how women's empowerment has been found to mitigate the effect of low production diversity [177] on the child's dietary diversity. An analysis of Suahaara data found that empowered women are more likely to practice proper household WASH behavior [203], which translated into higher child LAZ. Low women's empowerment is also associated with delayed initiation of breastfeeding, pre-lacteal feeding, and not being exclusively breastfed [102]. Social participation was positively associated with exposure to IYCF information, which in turn was related to the early initiation of breastfeeding and dietary diversity [181].

Gender-Based Violence (GBV) is a problem in Nepal. Approximately 44% of Nepali women had experienced at least one of the four types of intimate partner violence (IPV). Analysis of women's nutritional status and IPV found associations between physical violence and overweight status and controlling behaviors with anemia [204]. Two studies from India found a significant association between GBV and child nutrition in South Asia [205,206].

4.9. Basic: Household wealth

Wealth is also seen to impact early initiation of BF, exclusive BF, dietary diversity, vitamin A and deworming, mother's diet, low birth weight, safe disposal of stools [15]. Poverty reduction and wealth accumulation were seen as determinants for improvements in stunting outcomes in Nepal across both our quantitative and qualitative findings and are supported widely in the existing literature [35,141,146].

4.10. Basic: Inequities

It is important to note that the reduction of stunting in Nepal has been unequal, and currently, stunting is concentrated among children of households experiencing multiple forms of deprivation. For example, the fastest reduction in stunting occurred within the highest quintile of wealth (7pp annualized decline as compared to 0.5pp) [13,207]. Analysis of 2016 Nepal Demographic Health Survey data also found households in the mid and far-west hills and mountain areas in Karnali Pradesh and Sudurpashchim Pradesh provinces, in the low-wealth quintile, or from socially excluded caste and ethnic groups are more likely to experience stunting [208].

This is determined not only by immediate factors (e.g., children in these households are less likely to be exclusively breastfed and met minimum adequate diet for their complementary feeding) but also by underlying and societal factors (e.g., women from these households are more likely to experience gender-based violence, less forced child marriage, health service utilization, etc.). For example, children of some ethnicities, e.g., other Terai ethnicities and Muslims, are 2-3x more likely to have anemia than Brahmins [43]. Only 28% of Terai/Madhesi Dalit women consumed minimum dietary diversity, compared to 62.4% amongst Hill/Brahmin. There is also a strong association between ethnicity and food insecurity [118]. Further, Dalit women were most likely to be food insecure, even after accounting for factors such as education and wealth. They were 82, 85, 89, and 92% more vulnerable to food insecurity than Muslims, Brahmin/ Chhetri, Terai Indigenous, and Hill Indigenous populations, respectively.

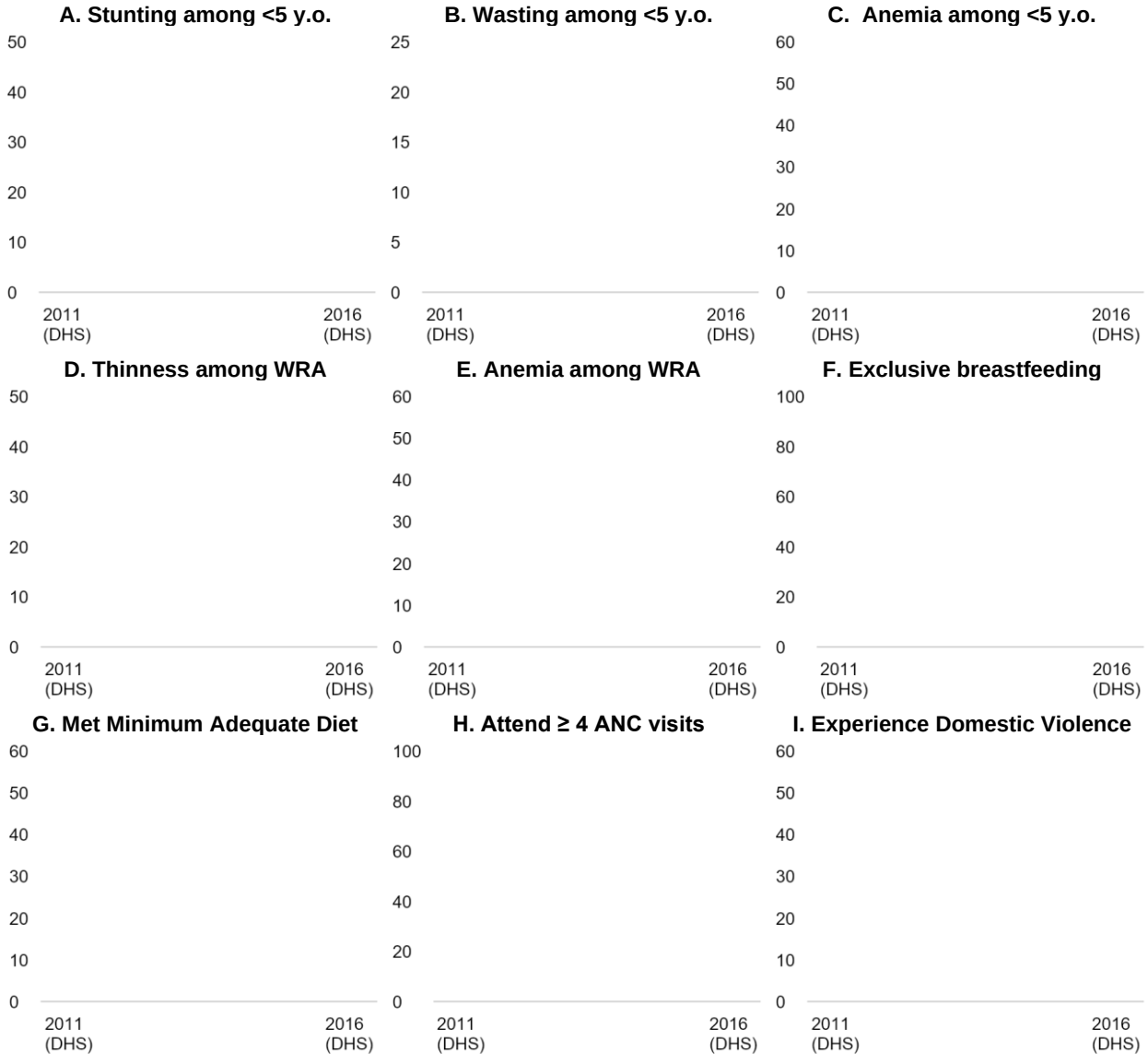

Figure 4: Various indicators related to maternal and child's health by various ethnic groups according to the 2016 NDHS further analysis [208] or own calculation (for wasting)

Relatedly, the Terai zone also showed poor achievements in various indicators relevant to child undernutrition: the proportion of those with micronutrient deficiencies [23], practice of pre-lacteal feeding, the proportion of children meeting minimum adequate diet, odds of anemia [15,40], underweight amongst women, and women's dietary diversity especially regarding consumption of eggs, vitamin-A fruits and vegetables, and dark green leafy vegetables. Unsurprisingly, the proportion of child wasting and underweight is highest in Terai (12% and 33%, respectively) [15]. Moreover, Province 2, which includes most of the Terai plain land in Nepal, has poor indicators despite having fewer challenges related to geographic constraints, access to health facilities, and the retention of health workers. 14% of children under 5 years of age in Province 2 have moderate or severe acute malnutrition [86]. The province has the highest proportion of children given pre-lacteal feeds, the lowest proportion of children meeting the minimum adequate diet, and the lowest proportion of children receiving vitamin A supplementation, deworming, and immunization. Moreover, the province has the highest proportion of women of reproductive age who are short in stature, thin, or experiencing intimate partner violence. They also have the lowest score of nutrition knowledge and a low rate of safe stool disposal.

4.11. New: Covid-19

COVID-19 impacted many determinants discussed earlier, including food security, gender based violence, and reproductive health in general, and therefore served as further pressure that highlights existing vulnerabilities and inequities. Rural communities in particular face food security challenges, reflecting the absence of policies to support food production [209], including raised food insecurity rates and lack of access to adequate meal sizes and nutrients [210,211]. The fact that many households rely on markets for their food highlights a potential risk of deepening vulnerability, given that the COVID-19 crisis has resulted in broader losses of income in Nepal. This could be further exacerbated when households' food stocks are depleted, affecting those with existing vulnerabilities as well as other parts of the population that would be normally less vulnerable [209]. Nutrition should thus be a core component of the COVID-19 response plan [212].

Gender-based violence is also impacted, with an increase in domestic violence rates, particularly for women and young girls, which can be addressed using education and dissemination of public information [213]. Reproductive health is impacted through the closure of services leading to lack of care and contraception for women, resulting in increased unsafe abortions, stillbirths, and maternal mortality and decreases inequality of care [214–216]. COVID-19 has also increased the gap in maternal mental health issues, along with health care services, emphasizing the need for mental health care [217,218].

4.12. New: Climate change

Food security and malnutrition in Nepal are highly sensitive to climate risks through access to markets and agriculture-related income, highlighted by the effects of flooding and droughts [219]. Nepal is considered to be one of the countries in the world that is most vulnerable to climate change, being ranked as the fourth most climate-vulnerable country in the world by the World Bank in 2011.

Climate change and environmental conditions are also associated with childhood stunting, and its effects on nutrition can be exacerbated by socioeconomic, agricultural, and demographic factors [145,220,221]. In particular, there are links between extreme precipitation and drought with worse child nutrition [222]. The causal links between childhood undernutrition are limited and draw on secondary data, supported by nutrition resilience following the 2015 earthquake in Nepal [223,224]. However, predictions on the future impact of climate change on food security demonstrate that the availability of food will present from local to global levels [225]. Proximity to towns is found to buffer the impact of seasonal variation on child growth [135]. Research on forest environmental income demonstrates that low-income populations with limited access to resources face greater negative consequences due to climate change. These groups are not significantly benefited by current services, proposing that environmental justice be addressed in future climate-related interventions [226,227].

5. INTERVENTIONS

5.1. Direct interventions | Health sector

5.1.1. Supplementation to women

5.1.1.1. Before pregnancy

Preconception care includes any intervention provided to women of childbearing age before pregnancy to improve the health and nutrition outcomes of women, newborns, and children. There have been calls to intervene at this stage, particularly regarding diet and nutrition [228]. We found only one such intervention: The Women First trial, which compared the provision of protein, energy, and micronutrient supplementation 3 months before conception, during pregnancy, or not at all [229]. Children of women who were given supplementation before conception was found to be 44%, 24%, and 26% less likely to experience stunting, wasting, and SGA, respectively [230], even though these results were not statistically significantly different when compared to the results of supplementation during pregnancy. A systematic review of the effectiveness of such an intervention is in progress [231]. Inclusion of such an approach is recommended.

5.1.1.2. During pregnancy

Pregnancy requires a healthy diet that includes an adequate intake of energy, protein, vitamins, and minerals to meet maternal and fetal needs. While ideally, good maternal nutrition should be achieved through adequate diets for pregnant women, micronutrient supplementation is generally necessary.

Table 14: Maternal supplementation coverage according to the 2016 Demographic Health Survey [15] and the 2016 Nepal National Micronutrient Status Survey [23]

Variables	NDHS	NNMSS
Taken iron and folic acid tablets during last pregnancy		90.8%
Taken at least 180 iron tablets during last pregnancy	42%	77.2%
Taken deworming tablet during last pregnancy	69%	59.0%
Taken iron tablets during last post-partum period		57.0%
Taken vitamin A capsule during last post-partum period		46.0%

In their review of systematic reviews, Campos Ponce et al. found single micronutrient supplementation, especially iron and folic acid (IFA), to be an effective approach, especially to reduce deficiency of said micronutrients [232]. Overall, they did not find IFA supplementation to have an impact on stunting. However, even though analyses from data in Nepal found that increased IFA supplementation indeed reduces stunting [147] and even reduce neonatal mortality [233]. Nepal has successfully expanded its coverage of iron-folic acid (IFA) supplementation: 90.8% of women took

IFA tablets during their last pregnancy. This was done through the mobilization of female community health volunteers [234,235]. However, more work on this is still needed: the proportion of women who took at least 180 tablets during pregnancy is much lower.

Zinc supplementation has been found to increase zinc concentrations and height for age z-scores in children under five. Moreover, calcium supplementation through ANC was found to be feasible and effective in aiding the prevention of preeclampsia and eclampsia, with coverage, compliance, and acceptability among pregnant women suggesting the ability to be scaled up throughout Nepal [236].

WHO recently updated its recommendation on the provision of multiple micronutrient (MMN) supplementation during pregnancy due to their slight benefits on birth outcomes (low birth weight, small-for-gestational-age, and possibly preterm births) compared to IFA supplementation alone [237,238], while there is no evidence of additional benefit in child mortality. There is no evidence for a reduction in anemia using MMN supplementation alone [239]. Combining education on use of a variety of nutrient-dense local foods supplemented with MMN would aid in achieving optimal maternal nutrition [240].

The body of evidence on the effectiveness of program approaches to improve the coverage of maternal nutrition interventions in South Asia is very small and largely focused on only iron folic acid and calcium supplementation [149]. Program approaches that were effective in improving intervention coverage addressed barriers at multiple levels and had several common features: use of formative research and client assessments to inform the design of program approaches and actions; community-based delivery platforms to increase access to services; engagement of family members, as well as pregnant women, in influencing behavioral change; actions to improve the capacity, supervision, monitoring, and motivation of front-line service providers to provide information and counseling; and access to free supplements.

For pregnant women, energy and protein supplementation modestly increased maternal weight [241,242] and improved birth outcomes among children [243]. However, there has been limited national-level protein-energy supplementation for women and adolescent girls likely because they are expensive and challenging to implement compared with other efficacious interventions [241,244].

5.1.2. Interventions for newborns

WHO's 2016 Standards for improving the quality of maternal and newborn care in health facilities' quality of care statement includes nine components of the process of care [245]. Three of these are nutrition-specific: neonate's cord clamped 1 min after birth, neonatal skin-to-skin contact with mother after birth; and breastfeeding within 1 h of birth.

5.1.2.1. Delayed cord clamping

Delayed cord clamping, clamping the umbilical cord 1-3 minutes after birth, allows blood flow between the placenta and neonate to continue, which may improve iron status in the infant for up to six months after birth and has been found to be an effective intervention for reducing anemia in early life [232]. This may be particularly relevant for infants living in low-resource settings with reduced access to iron-rich foods. WHO recommends delayed umbilical cord clamping (not earlier than 1 min after birth) for improved maternal and infant health and nutrition outcomes [246].

In a randomized clinical trial carried out at a tertiary hospital in Kathmandu, 540 newborns were randomized to delayed umbilical cord clamping (>3 minutes) or early clamping no later than 1 minute [247]. A delay in cord clamping resulted in a significant reduction in the prevalence of anemia by 9% at 8 months of age and 8% at 12 months of age. By extending umbilical cord clamping to longer than 3 minutes after birth, infants in low-resource settings experience less anemia, which may have positive effects on health and development.

5.1.2.2. Skin-to-skin contact and Kangaroo Mother Care

Mother-infant separation post-birth is common. In standard hospital care, newborn infants are held wrapped or dressed in their mother's arms, placed in open cribs or under radiant warmers. In contrast, skin-to-skin contact (SSC) begins ideally at birth and should last continually until the end of the first breastfeeding. SSC involves placing the dried, naked baby prone on the mother's bare chest, often covered with a warm blanket. Having early contact may also help keep babies warm and calm and improve other aspects of a baby's transition to life outside the womb [248,249]. Further benefits of SSC include increasing rates and success of breastfeeding [250], along with infant physiological stability in the transitional period post-birth and post-cesarean section and premature newborns, babies born with low birth weight [73,248,251,252]. In 2016, Nepal's Every Newborn Action Plan (NENAP) set a target to reduce neonatal mortality rate (per 1000 live births) to 11 and stillbirth (per 1000 total births) to 13 by 2035.increase the proportion of all premature newborns receiving Kangaroo Mother Care (KMC) to 35% by 2035 from the 0% coverage at the time [236,253]. However, the current rate of KMC coverage is unclear.

5.1.3. Supplementation for children

Table 15: Children's health services according to the 2016 Demographic Health Survey [15] and the 2016 Nepal National Micronutrient Status Survey [23]

Variables	NDHS	NNMSS
Participated in growth monitoring in the last months	18.4%1	8.1%
Consumed a vitamin A capsule during last campaign	86%	92.1%
Consumed a deworming tablet during last campaign, 12-59 months	76%	87.3%
Consumed Baal Vita micronutrient powder in the last 7 days		2.0%
Received all basic vaccinations, 12-23 months	78%	

5.1.3.1. Micronutrient powders

Micronutrient powders (MNP), a mixture of vitamins and minerals enclosed in single-dose sachets that are stirred into a child's portion of food immediately before consumption, are one of the few available interventions to address the nutritional causes of anemia and fill important nutrient gaps in

children [254]. Home fortification with MNP reduced anemia by 31% and iron deficiency by 51% in infants and young children when compared with no intervention or placebo. In Nepal, children's MNP intake quarters the odds of having anemia while there is evidence of a significant impact on growth [43]. It is important to note, however, only 2% of children were reported to consume MNP in 2016 [23].

Effective delivery and long-term sustainability of MNP interventions remain a complex challenge [255]. A paper reviewing various countries' experience in delivering MNP found that community-based distribution channels have generally shown higher coverage and, when delivered as part of an infant and young child feeding approach, may provide additional benefit given their complementarity. They found while diverse experiences delivering MNP exist, and although no one-size-fits-all approach emerged, well-established delivery platforms, community involvement, and social behavior change communication (SBCC) centered designs tended to have more success. A review on strategies to promote MNP found that negative experiences with health care providers or inconvenience at the time that micronutrient powder (MNP) use is initiated discourage future MNP use [256]. The review then recommended that SBCC should include counseling about potentially challenging side effects so that caregivers are prepared to work through them.

5.1.3.2. Other types of micronutrient interventions

We also found multiple articles on the efficacy of other types of supplementations on Hb and Anemia. Commercial iron fortification and supplementation are associated with increases in iron levels and, therefore, reductions in anemia [232,240,257]. Multivitamins alone showed indistinguishable effects on increases in Hb and reductions in anemia from iron supplementation alone [258]. When iron and micronutrient supplements were integrated, larger changes in Hb concentrations were seen [259]. Similar results in increasing Hb levels were seen through providing Vitamin B supplements [260], Vitamin C supplements [258], and Vitamin E supplements for preterm infants and infants with very low birth weight [261]. Vitamin A supplementation for pregnant women was associated with a reduced risk for anemia [262]. However, zinc supplementation for children demonstrated no difference in Hb rates [263–265]. Note: Biofortification of crops is addressed in section 5.4.1.1.

5.1.3.3. Supplementary feeding

A systematic review on the impact of supplementary feeding found an impact on child's height, height-for-age z-score (stunting), and Hb levels (anemia), but not on weight-for-height z-score (wasting) [266]. The analysis also found evidence of leakage. Children only benefited 36% of the energy in the supplement compared to 85% when supplementary feeding is done at home, as compared to 85% when supplementary feeding is done at day-care or feeding centers.

5.1.4. Growth monitoring program

Growth monitoring and promotion (GMP) includes the routine measurement of a child's weight and length/height, the assessment of a child's growth adequacy, growth-informed counseling, and remedial action, if necessary. When implemented correctly, GMP programs have provided the opportunity for early diagnosis and treatment of undernutrition and increased mothers' knowledge of proper infant and young child feeding [267,268]. In 2016, only a small proportion of children participated in GMP (c. f. Table 15). A mixed-method analysis found that this is due to beneficiaries' perceptions of the relative non-importance of GMP and the knowledge and skill of frontline workers

[267]. They also found variation in GMP utilization by maternal age, education, and residency (alone, nuclear or extended), as well as household socio-economic well-being and rurality. They recommended further exploration on the implementation of improved GMP protocols and to evaluate facility-level implementation barriers.

5.1.5. Promotion and support for appropriate feeding

5.1.5.1. Baby-Friendly Hospital Initiative

The Baby-friendly Hospital Initiative (BFHI) is a key component of the World Health Organization/United Nations Children's Fund Global Strategy for Infant and Young Child Feeding [269]. A narrative review summarizing 58 reports, including nine based on three RCTs, found that adherence to the BFHI Ten Steps has a positive impact on short-, medium-, and long-term breastfeeding outcomes. Moreover, there is a dose-response relationship between the number of BFHI steps women are exposed to and the likelihood of improved breastfeeding outcomes (early BF initiation, exclusive breastfeeding at hospital discharge, breastfeeding duration, and EBF duration). Finally, community support (step 10) appears to be essential for sustaining breastfeeding impacts of BFHI in the longer term. A 2019 World Bank analysis found that Nepal showed a weak implementation of the Ten Steps in both public and private hospitals [270]. Despite passing a Breastmilk Substitutes (BMS) Act, awareness and enforcement of the act are lacking. Moreover, mothers lacked the support they need during antenatal or postnatal periods, especially in cesarean deliveries.

5.1.5.2. Breastfeeding promotion

A scoping review summarizing evidence on the effectiveness of interventions to support optimal breastfeeding in five countries in South Asia [271] found that single and combination breastfeeding interventions delivered within or across multiple implementation environments (health facility, community, and home/family) were effective in improving breastfeeding practices. Programs and interventions that reached women and their families beginning during pregnancy and with repeated exposure were more likely to improve breastfeeding outcomes. Interventions focused on short duration, irregular frequency, inappropriate timing, poor coverage, and targeting were likely to have no impact. Reported barriers to breastfeeding promotion in Nepal include acceptability of traditional feeding practices, priests' advice, prelacteal feeding and discarding colostrum, mother-in-law's opinion; availability and accessibility through lack of information, low access to media and health services, and misperception, support, belief about milk insufficiency, and involvement of mothers in decision making. [272]

5.1.5.3. Age-appropriate complementary feeding practices

An analysis of experience from Alive & Thrive's behavior change interventions to improve complementary feedings in 4 countries, including Bangladesh, resulted in five lessons learned [273]. They include the importance of selecting a few priorities complementary feeding behaviors to focus on, addressing underlying determinants (including food access) and key influencers of those behaviors, testing concepts, recipes, messages, tools for feasibility/acceptability and clarity, selecting program channels to achieve desired coverage, intensity, and scale, and sustaining exposure for at least 2 years while continually monitoring and adjusting the program.

5.1.6. Management of acute malnutrition

Globally, a recent systematic review comparing integrated community-based management of acute malnutrition, such as community-based mobilization, screening, follow-up, counseling, and education found limited evidence either way on whether such an approach improves screening, identification, and management of SAM and MAM [274]. After an extensive pilot evaluation process in 2009-2012 and active collaboration between UNICEF and the ministry of health from 2012-2020, Integrated management of acute malnutrition (IMAM) has been scaled up in Nepal in 38 out 77 districts [275]. Some supportive environment for this scale-up includes the inclusion of IMAM into the national policy framework (within MSNP), a well-established nutrition governance and financing commitment, an established community health system, and commitment and ownership from different tiers of government. However, there is still more work to be done, including increased funding allocation by the GON for procurement of ready to use therapeutic food (RUTF) and therapeutic milk, reducing coverage gaps since on average only 15% of children with wasting in the treatment center's area are treated through IMAM.

5.2. Direct interventions | Other sectors

5.2.1. Fortification

Food fortification is one of the most cost-effective strategies to improve micronutrient status through a variety of food vehicles, including staples, condiments, and processed foods [276]. Food fortification is efficacious in reducing anemia and iron deficiency anemia and improving vitamin A, folate, niacin, thiamin, vitamin B-6, vitamin B-12, zinc, and iodine status of women of reproductive age and adolescents [276–281]. However, many fortification programs in low- and middle-income countries, including Nepal, are regional or voluntary and, thus, might have a limited nutritional impact at the national level [282]. Moreover, scaling up fortification has been found to be affected by suboptimal programming, low-bioavailability fortificants (e.g., reduced iron powder), poor consumption rates, weak enforcement mechanisms, and inadequate monitoring [283]. There was mixed evidence that consumption of fortified foods reached all socioeconomic groups. Some studies showed differences in consumption between nonpoor and extremely poor, and between urban and rural stakeholders [284]. Women with the most needs usually have restricted access to markets or have limited purchasing power and therefore depend largely on locally grown, non-fortified foods [241,284].

The Government of Nepal, in partnership with the UN World Food Program (WFP), recently intends to introduce fortified rice via Nepal Food Corporation (NFC) social safety nets in remote and food-insecure districts by establishing blending units in NFC rice mills. A modeling study found that this program would resolve dietary deficiencies in rice purchasing households amongst all population subgroups analyzed for all fortified micronutrients [285]. They also found that rice fortification is predicted to improve adequacy in pregnant women's diets more than adult males for most nutrients and in more remote hilly and mountainous populations than in the plains due to their high reliance on cereal in their diet.

5.2.2. Nutrition interventions in schools

Limited effects on increasing nutrition, school attendance, and protein-energy malnutrition have been found through school-based meal programs for primary school children [286]. However, school-based programs that target IFA supplementation along with integrative health and nutrition

methods demonstrated effectiveness in reducing rates of anemia for adolescent girls when compared with community-based interventions. Recent integrated, school-based adolescent intervention programs focus on younger adolescents, whose current beliefs are less engrained, and target dietary practices through engaging adolescents and providing them the knowledge and tools to take responsibility for nutrition within their community and to share with their fellow peers. Such programs are to be scaled up in collaboration with local governments [287].

5.2.3. Women's groups

Bringing women together in groups where they can share their experiences, gain access to resources and build knowledge, skills, and social networks are increasingly recognized as a potential strategy to empower women [288] and may also be a way to improve maternal and child health and nutrition. Collective action is vital to the effectiveness of women's groups to enact impact. Simply forming group without effectively enabling basic tenets of group-based engagement, such as building social capital, promoting women's empowerment, and advocating for community leaders, would prove unhelpful [289]. A review of 36 studies showed that women's groups focused on behavior change are beneficial for improving child feeding practices in South Asia [290]. Another found mixed results on effectiveness [291]. Inclusion of explicit nutrition goals and actions in programs made them more successful in delivering on improved nutrition outcomes, with the strongest evidence for IYCF practices. Another insight relates to targeting: one study found greater impacts on those with higher initial poverty, suggesting that there are gains to targeting nutrition interventions delivered through women's groups to the poorer groups in the population [292].

5.3. Indirect interventions | Health sector

5.3.1. Family planning & reproductive health services

In July 2017, the Government of Nepal reiterated that it will continue to increase the government budget in family planning by 7% each year up to 2020 [293]. Nepal is committed to 'leaving no one behind' and 'reaching the unreached' to accelerate the progress of increasing the number of additional users of family planning by an estimated 1 million and the proportion of demand satisfied to 71% by 2020. A 2016 review of 102 interventions that integrated family planning activities with food security and/or nutrition interventions highlighted the importance of co-locating projects in the same geographical areas that deliver nutrition, food security, and family planning and ensure that they are reaching the same populations; integrating voluntary family planning within nutrition and food security projects from the start of a new program design; using program platforms across sectors to deliver consistent family planning and nutrition education and referral recommendations; working at both the community and facility levels, including home visits; incorporating referral systems for family planning services (especially for long-acting and permanent methods into integrated programs and strengthening with improved monitoring); ensuring regular supply of commodities; and engaging youth, engaging men, and empowering women.

5.3.2. Integrated health care services

National- and district-level efforts address nutrition policies, stakeholder coordination, and service quality. Training and knowledge are provided to female community health volunteers in order to

disseminate information [141]. A strong health system is essential for the delivery of nutrition-specific interventions [294], but globally nutrition policymakers fail to anticipate health system bottlenecks, resulting in poor implementation strength and low population coverage [283,295]. While there is much evidence for the efficacy of nutrition interventions, evidence on the implementation of nutrition programs at scale to achieve meaningful impact is lacking [44,296–298]. Understanding health system components, especially how it works in Nepal, can help to explain program successes and failures and help to identify levers for improvement [296,299,300]. Continued attention is needed in all countries to gather, analyze, and use data to assess progress and inform decisions. This includes the use of routine information systems and periodic surveys to gather data on anthropometric indicators, feeding practices, and the coverage of essential nutrition, health, and social protection services for children and women [44,301].

Community–based primary health care (CBPHC) is an approach used by health programs to extend preventive and curative health services beyond health facilities into communities and even down to households [302]. In a series of comprehensive review, an expert panel analyzed the effectiveness of CBPHC in improving maternal health [303], in improving neonatal health [304], in improving child health [305], and in promoting equitable improvements in child health [306]. They also analyzed the strategies employed by effective CBPHC programs for achieving improvements in MNCH [307] and common characteristics of integrated projects with long–term evidence of effectiveness in improving MNCH [308]. In their summary, the panel concluded that CBPHC is an undervalued resource and should be a priority for strengthening health systems [309]. Nepal is mentioned in this review as an example country that has successfully established strong CBPHC programs that have made a major contribution to these achievements.

5.3.2.1. Peer facilitation

A recent systematic review highlighted the effectiveness of peer support models for improving health outcomes [310]. Global evidence also shows the effectiveness of peer support in nutrition programming, particularly for the promotion of optimal breast-feeding [311] and complementary feeding practices [312]. Suaahara piloted a peer facilitator (PF) approach in some intervention areas: PF was to work in close collaboration with the government health infrastructure, including FCHV, to reinforce important MIYCN messages [313]. The analysis found that the PF approach had a significant positive impact on several indicators of mothers' knowledge and practices relating to maternal and child nutrition. Additionally, exposure to a PF three or more times in the past 6 months was positively associated with a small improvement in maternal and dietary diversity scores. However, improvements were not observed in maternal health-seeking behaviors, such as the number of antenatal care visits. Peer mobilization is a potential approach for improving health- and nutrition-related knowledge and behaviors among women in hard-to-reach communities of Nepal [313].

5.4. Indirect interventions | Other sectors

5.4.1. Nutrition-sensitive agriculture

Nutrition-sensitive agriculture (NSA) interventions, i.e., agricultural interventions with the goal of improving human nutrition [125], are hypothesized to improve nutrition through three pathways: food production, agricultural income, and women's empowerment [314]. Improvement in food production and agricultural income is hypothesized to improve child nutrition by increasing household

resources (e.g., food, money) and the availability of and price of healthy foods in the local market [315]. Improvements in women's empowerment, i.e., power and control over different dimensions of their lives [316], are expected to increase the allocation of food and income from these interventions towards children's nutrition [317]. A recent systematic review of NSA interventions suggests that they can improve the dietary practices of children and women [126]. They have also been shown to have the potential to address other relevant causes of malnutrition, such as household food insecurity and (lack of) women's empowerment, even though there are limited trials measuring these indicators. However, the same systematic review also found little evidence of impacts on children's nutritional status. Findings from Nepal [318–320] and South Asia [321,322] agree with these global findings.

NSA interventions have been criticized for their focus on the promotion of a specific biofortified crop, small-scale homestead vegetable production, or small farm animals, which leaves the primary food production system 'in place,' ignoring emergent and salient issues of biodiversity, soil and water conservation, and energy use [323]. Moreover, in Nepal, there has been criticism that NSA interventions did not promote technology use in agriculture fast enough, and on a scale that would make a difference. Moreover, participation in NSA interventions is dependent upon access to adequate land and water and, therefore, can be unequal according to age, caste, gender, household wealth, access to resources, training, and education [324]. This suggests that successful interventions must address context-specific structural barriers [325].

A thorough review of Nepal's agricultural sector identified the need to accelerate growth in agriculture [124] through investment in agricultural research and extension system for the rapid spread of modern technology and agricultural infrastructure (irrigation, rural roads, electrification, etc.). The authors emphasized the importance of the focus on demand-driven agricultural research and extension services and highlighted the opportunity of engaging with private extension service providers through capacity building and incentives. The utilization of the participatory approach in demand-driven agricultural research and extension has been found to improve the adoption of technology and practices since they are both practical and harmonious with local and indigenous social and ecological contexts [146,326].

The authors also emphasized the importance of promoting agricultural diversification through the production of high-value commodities, such as horticultural products and dairy and livestock products, with the dual objectives of nutritional security and increasing farmers' incomes. In order to accelerate the pace of agricultural diversification, the authors recommended policy support for improving infrastructure (markets, agro-processing facilities, etc.), improving access to longer-term credit, and encouraging migrant returnees in commercial farming with appropriate support. The article also recommended promoting institutional development for contract farming within the framework of property rights, even though such an approach has been criticized for the potential to worsen inequities [327].

To specifically provide support for smallholder farmers, the authors recommended increased attention towards agroforestry products and currently underutilized crops [124,328,329] and the provision of climate-smart agriculture technologies and practices. Some currently underutilized indigenous crops have been identified as 'future smart crops' for their high potential for food and nutritional security, and high adaptability to marginal soils and harsh climatic conditions [330]. In addition to improving resilience to climate change, the adoption of climate-smart agriculture increases farm productivity and yield stability while lowering the need for external agricultural

inputs [331,332] and are therefore more affordable to scale up [333]. These products and approaches have been found to be an important source of income and employment for many smallholders and other rural poor in remote areas. Moreover, smallholder farmers' adoption of improved technologies and practices were associated with access to market and capital [334]. In an evaluation of the USAID-led Knowledge-Based Integrated Sustainable Agriculture in Nepal (KISAN), investment in infrastructure and access to credit, provision of subsidies for seeds, private sector involvement in selling improved seeds and disseminating information, membership in progressive farmers groups and cooperative societies, and participation in agricultural training and farm visits have been found as effective ways to improve technology adoption [328,334].

Promoting Agriculture, Health and Alternative Livelihoods (PAHAL) promoted kitchen gardens and permagardens (uses principles of agroecology, conservation agriculture, and permaculture) in remote areas in the Mid- and Far-Western regions of Nepal [335]. An evaluation of the program found an impact on household food security and increased consumption of fresh vegetables. These impacts, combined with skills transfer, improved ability to cope with production shocks and constraints, and enhancements in income and savings, show that these gardens can contribute meaningfully towards smallholder farmers' resilience. Permagardens appear to produce greater yields per acre and possibly accomplish this with less time investment. However, participants reported that they were more difficult to manage. Overall, the results for both approaches were fairly similar. Another intervention, Sabal (Sustainable Action for Resilience and Food Security), [336] lessons learned documents recommended engagement with youth ages 15-24, better engagement with migration patterns, and improved monitoring and evaluation of non-farm livelihood outcomes.

5.4.1.1. Biofortification

Biofortification is the process of increasing the density of vitamins and minerals in a crop through plant breeding or agronomic practices so that when consumed regularly, its intake will generate measurable improvement in vitamin and mineral nutritional status. Examples include Vitamin A-Biofortified Maize, High-Iron Pearl Millet, and zinc-biofortified rice. Biofortified staple crops are a practical, cost-effective strategy for the delivery of essential micronutrients to vulnerable rural communities in low- and middle-income countries—especially smallholder farming families who cannot afford or readily access nutritionally diverse diets [337]. Zinc and iron biofortified crops, including pearl millet, rice, and beans, have been contributing to improvements in iron status in women of reproductive age, with the greatest efficacy in those who were iron deficient at baseline [240]. Information on the health benefits of the crops were the most important determinants of acceptance and adoption, and therefore behavior change communication strategies are integral [338]. Concerted scientific investments are required to expand these biofortification strategies so that they could play an important role in ensuring the nutritional security of an expanding population contending with agricultural and environmental constraints [339]. A high-zinc variety of wheat was recently released in Nepal, the impacts of which are yet to be determined [340].

5.4.2. Social protection programs

Social protection interventions are intended to support vulnerable households by providing them with in-kind (e.g., food) or cash transfers. Globally, the average social protection program increases the value of food consumed/expenditure by 13% and caloric acquisition by 8% [341]. Food expenditure rises faster than caloric acquisition because households use transfers to improve the quality of their

diet, most notably increasing their consumption of calories from animal source foods. Since the consumption of animal-sourced foods in these populations is low, and because there are significant nutritional benefits to increasing the consumption of these, this is a positive outcome. One review found that cash transfers program has been found to positively impact household food security, health care access, and empowerment [342]. Another review found that cash transfer is effective in improving dietary diversity, while findings are mixed on their impact on stunting and wasting [343]. Key gaps should be addressed in future research, including examination of CT impacts on proximate outcomes, such as caregiver behaviors, IPV, and caregiver stress/mental health, all of which have implications for child health and well-being [342].

The Government of Nepal introduced The Child Grant in 2009, an unconditional cash transfer program. Recently, this was expanded to all households with children under five years of age in the geographically and economically isolated and chronically food-insecure Karnali zone, and other districts that had low human-development index scores, or with children from the Dalit caste across the country. The transfer covers up to two children per household, with a transfer level of NRS 200 400 ($1.95) per child per month, paid three times a year. Birth registration is a registration requirement. There was an evaluation of the impact of this program in five districts that found trends of improved child anthropometry, WASH outcomes, food availability, and care and health-seeking behaviors [344,345]. However, the study's limitations in methodology, namely reliance on repeated cross-sectional data and lack of control group and unclear evidence of pathway (e.g., the analysis found no impact on food security and child's dietary diversity), indicate that more rigorous evaluation is needed. In a focus group discussion, Dalit women from recipient households reported that they had a say on how the cash from the grant is spent and that the program improved their self-esteem and social networking [346]. However, the analysis found that these improvements were not to an adequate degree to impact nutrition.

A recent briefing paper identified four implementation bottlenecks on the Child Grant [347]. First, the wealth targeting criterion adds another layer of complexity that overburdened local officials and recipients and therefore increased barriers for those who are most in need of the grant. Second, there are big variations in implementation, which introduced a gap between the way the policy is laid out on paper at a central level and the way it is operationalized. This and weak monitoring prevent positive learning and adaptation. Third, there is inadequate outreach and information dissemination, with many beneficiaries unsure how the Grant should work, particularly in terms of the registration process, but also in terms of when and how much they should be getting. Finally, weak formal accountability mechanisms prevent beneficiaries from speaking out. Addressing the bottlenecks above, the inclusion of a complementary behavior change communication strategy, and a stronger monitoring and evaluation component is needed to maximize returns on the GoN's investment.

5.4.3. Women's empowerment

While the importance of women's empowerment in child nutrition and health is widely acknowledged, little is known on how to best promote it. Women's empowerment interventions are often integrated into income-generating activities and agricultural extension, and therefore, there are many challenges in disentangling empowerment interventions from other interventions with which they are delivered [348]. In addition, many studies are limited in scope and their evaluation of nutrition outcomes [349], and it is difficult to evaluate which dimensions of women's empowerment matter most for nutrition [171,350]. Notably, indicators to quantify women's empowerment are also not

used consistently and vary widely between individual studies [171,351]. Moreover, most women's empowerment interventions are targeted towards adult women while adolescent girls were under-served [241].

Some women's empowerment interventions were focused only on one domain (financial) but failed to be truly gender-transformative [352]. These types of interventions usually only enroll women and provide them with income-generating activities, such as agriculture. However, doing this runs the risk of putting an additional burden on women's already limited time. Feminization of labor does not ensure the strengthening of women's position in the household; rather. If women get more work and no influence in decision-making processes, the "feminization of agriculture" is just a form of exploitation [353]. This is because the reproductive activities, which are in the form of unpaid labor in their own homes, tend to not be accounted for, even by women themselves [186]. One study did find a positive effect of mothers' work on weight/height indicators for slightly older children, between 12 and 18 months of age, which then attributed to the increase in available income for nutrition-related consumption. Moreover, increasing women's decision making power without addressing underlying gender bias seems to favor boys in adolescence [354]. Engaging only women in NSA also ignores the crucial decision-making role that husbands, grandmothers, and other household members play in affecting childcare and nutrition decisions [355,356].

5.4.3.1. Engaging family members

Despite the extensive discussion on the importance of engaging men in maternal and child nutrition [171,357], interventions that attempt to do this is still rare. Alive and Thrive targeted both wives and husbands through an existing Maternal, Neonatal, and Child Health (MNCH) platform in Bangladesh [358]. Not only did they see an increase in husbands' support for their wives, but husbands' behavioral determinants and support also explained nearly half of the program's impact on maternal supplement intake and one-quarter for dietary diversity. Globally, a review summarized 35 peer-reviewed articles on 25 studies (16 with quantitative and 13 with qualitative data). They found most evidence on engaging husbands or, less often, mothers-in-law [359]. Most found positive impacts on exclusive breastfeeding rates and family members' knowledge and support. They also found the benefits of engaging family members on complementary feeding and maternal nutrition; however, there were fewer studies that examine these outcomes. Qualitative themes included improved nutrition behaviors, enhanced relationships, and challenges due to social norms. Another scoping review that analyzed 54 studies describing social and behavioral interventions to engage family members to support MIYCN in low- and middle-income countries found that few interventions explicitly addressed gender norms, decision-making, and family dynamics or described formative research or theories informing intervention design [under review]. Technical guidance by USAID's Advancing Nutrition recommended programs to go beyond simply providing information, but to engage family members in discussing and reconsidering traditional roles and practices related to care for women and children [360].

5.4.4. WASH interventions

Water and Sanitation Hygiene (WASH) interventions, including access to improved and safe water supply, upgraded sanitation facilities, promotion of handwashing with soap, has been found to reduce diarrhea, intestinal worm infections, and environmental enteropathy, and in turn, improve nutrition and health of entire communities [2,361–364]. One review found that interventions that

include multiple components were more effective in improving child nutritional status than single interventions [361]. Results from Nepal reaffirm the primacy of addressing WASH to address child malnutrition. In analyses of stunting reduction in Nepal, improvements in WASH were repeatedly identified as important [13,32–35,41]. Analysis of Suahaara II findings found WASH behaviors to be crucial mediators of nutrition impacts [365]. Moreover, an integrated intervention consisting of the school garden, WASH, nutrition, and health components (SG+) increased children's fruit and vegetable consumption, decreased parasitic intestinal infections, and improved hygiene behaviors [158]. A market-based sanitation project called was recently launched in Nepal; results from this project are pending [366].

It is important, however, to recognize that the existing global literature on the impact of WASH interventions is mixed. Despite previous findings of WASH interventions' found significant impact on stunting and height-for-age z-scores [361], three large randomized control trials of unprecedented scale and cost: WASH Benefits trials in Kenya and Bangladesh and the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trials in Zimbabwe found no effect of their WASH interventions on stunting in low-income country settings [367–370]. Reviews and reflection from leaders in the WASH community found that these trials to have high internal validity, constituting good evidence that these specific interventions had no effect on childhood linear growth and mixed effects on childhood diarrhea. These results suggest that in settings such as these, more comprehensive or ambitious WASH interventions may be needed to achieve a major impact on child health [371]. One example of such an exploration is the creation of an infant and young child play space: a clean, safe environment in which babies and infants can freely play that avoids key fecal transmission routes [372]. This approach might be especially important in households with livestock ownership to minimize negative impacts through increased risk of infections and/or EED [373].

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