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Dissertation Review

Prevalence and Determinants of Undernutrition in Women in Nepal

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Abstract

Undernutrition is defined as insufficient intake of nutrients. Maternal undernutrition increases the risk of child mortality and impaired development perpetuating an intergenerational vicious cycle of malnutrition. Undernutrition in Nepal causes thousands of deaths annually. This study investigated the prevalence of undernutrition (as underweight, stunting, anaemia and iodine, vitamin A and zinc deficiencies) in women to identify causative factors and research gap areas. A literature review was undertaken from studies published in English between 1998 and 2019. 7 databases were consulted. 14 studies were found to be eligible by applying specific inclusion and exclusion criteria. Underweight prevalence declined from 1998 (24.7%) to 2016 (17.3%). Decreases were observed also in stunting rates from 2001 (15.3%) to 2016 (10.6%), anaemia (67.7% in 1998 and 40.8% in 2016), iodine deficiency (43.6% in 1998 and no prevalence in 2016), vitamin A deficiency and zinc deficiency (61.0% in 1998 and 24.0% in 2016). There is a lack of data for pregnant and non-pregnant women, especially for stunting, vitamin A and zinc deficiencies. Results may lack in validity due to different methodologies used. The major determinants of undernutrition appear to be insufficient diet variability, which is linked with poverty, poor nutrition education, inappropriate coverage of health services, social discrimination and unsuitable climate and land topography to agriculture. Health policies should focus on improving agriculture methods to overcome soil and climate-related issues and promote food-based approaches to decrease micronutrient deficiency rates. Health policies should also focus on expanding health services and nutrition education. A major focus should be given to mothers, women belonging to low castes and/or living in remote areas. This will allow to breaking the intergenerational cycle of malnutrition.

Keywords: Undernutrition; Malnutrition; Nutrition; Food Insecurity; Women; Nepal; Micronutrient Deficiency; Underweight; Stunting; Anaemia; Iodine Deficiency; Vitamin A Deficiency; Zinc Deficiency

List of Abbreviations

BMI: Body Mass Index; FI: Food Insecurity; FS: Food Security; GoN: Government of Nepal; Hb: Haemoglobin; ID: Iodine Deficiency; IUG: Intrauterine Growth; LBW: Low Birth Weight; LDC: Least Developed Country; MND: Micronutrient Deficiency; MRDR: Median Relative Dose Response; mUIC: Median Urinary Iodine Concentration; NDHS: Nepal Demographic and Health Survey; NMSS: Nepal Micronutrient Status Survey; NNMSS: Nepal National Micronutrient Status Survey; PW: Pregnant Woman; NPW: Non-Pregnant Woman; SGD: Sustainable Development Goal; UIE: Urinary Iodine Excretion; UN: United Nations; VAD: Vitamin A Deficiency; WRA: Women of Reproductive Age; XN: Night Blindness.

Introduction

Food insecurity and undernutrition

In 1948, the United Nations (UN) recognised the Right to Food in the Declaration of Human Rights, since it is vital for the enjoyment of all other rights [1]. However, after a prolonged period of decline, hunger and undernutrition appears to be on the rise again, despite the fact that the global food system is able to produce sufficient amounts of food to feed the entire population of the world [2]. Undernutrition is defined as the insufficient intake of macronutrients and/or micronutrients, whose causes are mainly linked to states of food insecurity and poverty [3]. Food Security (FS) is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for a healthy and lifestyle; therefore, Food Insecurity (FI) can be chronic, seasonal or transitory and exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development for a healthy and active life [1]. There can be various reasons causing FI such as unavailability of food, inaccessibility to food (e.g. due to inappropriate purchasing power), inadequate biological utilisation of food and/or limited utilisation within the household due to poor conditions [1]. Table 1 depicts the four pillars of FS, which summarise the factors that need to be met in order to achieve FS.

Food Availability	Domestic Production, Import Capacity, Food Stocks, Food Aid
Food Access (Physical and economical access to food)	Purchasing Power, Income of Population, Transport and Market Infrastructure
Food Utilization	Food Safety, Hygiene and Manufacturing Practices (applied in Primary Agricultural Production, Harvesting and Storage, Food Processing, Transportation, Retail, Households) Diet quality and Diversity (meeting needs in terms of energy, macro- and micronutrients)
Food Stability (Stability of supply and access)	Weather Variability, Price Fluctuations, Political Factors, Economic Factors

Table 1. The Food Security Pillars [1].

Africa and Asia, in particular in the sub-Saharan region and South-Eastern Asia, are described as the hub of global poverty and undernutrition since the majority of their populations live in remote rural areas by practising farming activities [2]. The levels of undernutrition across these populations have recently increased by 11%, from an estimated 777 million in 2015 to 815 million in 2016 [2]. It is estimated that at least 120 million of women in developing countries are underweight (BMI <18.5 kg/m^2) of which 60% live in in South Asia [2].

Maternal and child undernutrition

Children and women are the most vulnerable to FI and undernutrition due to the increased needs of nutrients for growth, pregnancy and lactation [4]. Women who are undernourished during pregnancy are unlikely to improve their nutritional status due to the additional demands of the growing foetus [5]. As a consequence, maternal undernutrition is a crucial contributor to restricted foetal development, poor birth outcomes, including low birth weight (LBW), which is among the strongest predictors of child mortality under the age of 5 years [4]. The survivors are likely to suffer from stunted growth (low height-for-age) with subsequent irreversible impairment of physical and cognitive growth and development [2]. Later in life, the consequences of child undernutrition are increased morbidity and mortality risk from infections and non-communicable diseases (NCD), poor educational performance and low productivity [2]. In addition, female offspring of undernourished mothers are at greater risk of becoming stunted themselves and having LBW infants, hence perpetuating an intergenerational vicious cycle of malnutrition which jeopardises the population well-being and prevents a country from improving productivity and development [4,6].

Overview of food insecurity in Nepal

Background information

Nepal is a country located in South Asia, characterised by a non-uniform climate and geography. More specifically, it is divided into three different ecological regions: the Mountain (Himalaya) region in the north, the Hill region in the middle of the country and the lowland plains of the Terai region in the south (see figure 1) [7]. A map of the Development Regions of the country is depicted in figure 2. Nepal is one of the poorest and least developed countries (LDC) in South Asia and in the world, with an estimated population of 29 million of which one-quarter survives below the poverty line (defined as people earning less than $ 1.25 per day) [8,9]. Poverty is strongly reflected in the high prevalence of chronic maternal undernutrition and thousands of deaths every year: in 2016, 17% of woman of reproductive age (WRA) were underweight and as a consequence, 18% of infants were LBW and 36% of children under 5 years of age were stunted [10]. This makes women's malnutrition a major concern in Nepal as it has a direct impact on maternal health and is strictly related to children's physical and mental development [11]. However, there is a lack of research monitoring the changes in nutritional status of women across the years [10].

Figure 1: Ecological regions of Nepal [12].

Figure 2: Development Regions of Nepal [13].

Economic causes of food insecurity and undernutrition in nepal

Nepal's economic growth has been severely affected by various factors such as the Nepalese civil war from 1996 until 2006, corruption and the recent change from being a monarchy to a republic in 2008. Additionally, economic growth appears to occur mainly in urban areas, while the rural economy, especially in the mountainous and hilly regions seems to be stagnant due to geographical isolation which affects the presence of and access to economic services, hence food security stability and accessibility [14]. Nepal's economy has also been challenged by its high susceptibility to natural disaster (e.g. earthquakes) and to the effects of climate change, which is defined as a phenomenon altering weather patterns and deriving from increased gas emissions from urbanisation, fuel combustion, deforestation and solar energy variability [15]. It has been significantly preventing Nepal from achieving long-term FS by promoting geological processes such as landslides, floods and desertification, therefore affecting agriculture, water resources and ecological habitats [16, 17]. The poor population living in rural areas practice subsistence farming (the major staple foods are grains, pulses and potatoes) [18]. Other agricultural, as well as livestock products, are mostly sold for cash. This inability of having a more varied diet often leads the Nepali population to co-exist with several nutrient inadequacies such as anaemia, vitamin A, iodine and zinc deficiencies, low birth weight, stunting and other health issues [18,19].

Social causes of food insecurity and undernutrition in nepal

FS is also highly variable among households also due to the Hindu caste hierarchy system. Caste positions are determined by birth, thereby dependent on the prevailing family caste identity, which unequally divides the population across 4 hierarchies: Bahun on the top, followed by Chhetris, Baishyas/Vaishyas and Dalit as the lowest caste, whose individuals are also defined as "untouchables" [20]. This system unequally distributes access to basic economic and social resources (e.g. land ownership and education) to the lower castes in favour of the higher castes [21]. Despite the country trying to abandon this system, its development continues to be affected by it as it promotes poverty rates and therefore FI among low-caste individuals by preventing them from being upwardly mobile [22]. Subjects belonging to the Dalit caste are among the most discriminated and poorest individuals due to educational and job segregation, meaning that they are not allowed to decide their educational pathway and are exclusively assigned to low-income occupations (e.g. blacksmiths, street cleaners, tailors and shoemakers). As a consequence of this poverty trap, they are also subject to chronic FI due to the lack in dietary variety. Additionally, FI is even higher among Dalit women and children as they are often forced to work poorly paid jobs or unpaid as servants for their landlords [20].

Rationale for this review

In the new Nepal's constitution, the Government of Nepal (GoN) has recognised the Right to Food as a fundamental right for its citizens [18,19]. Additionally, the GoN has joined the 2025 Zero Hunger Challenge and the UN 2030 Agenda for Sustainable Development, which require implementation of several development strategies that aim at improving the productivity and resilience of the current food systems. These plans envisage the Nepali population enjoying their Right to Food and being free from hunger and malnutrition-related issues. However, since the majority of the Nepali population is food insecure and lives in poverty, their Right to Food is not respected. This is due to many challenges preventing them from becoming food secure such as a lack of data available on the population nutritional status. Additionally, the earthquake that occurred in 2015 caused further challenges in achieving FS due to the extensive loss of lives and damage to the agricultural assets and the country's economy [2,23]. Since women play a crucial role in ending the intergenerational vicious cycle of malnutrition across the whole population, it is essential to monitor undernutrition issues in women and strengthen the current published evidence [4,6]. This can help the GoN and humanitarian actors to improve nutrition interventions and end malnutrition-related issues.

Aims of this Review

Due to the important role of women in ending malnutrition and to the lack of data available on nutritional status of women, the aims of this review have been framed into the following research objectives:

- Investigate the prevalence of undernutrition (underweight, stunting, anaemia, iodine deficiency, vitamin A deficiency and zinc deficiency) in WRA between 1998 and 2019;
- Identify the determinants of undernutrition in WRA;
- Identify research gap areas that require further investigation to help to improve health policies and nutritional interventions.

Methods

Development of the Research Question

As explained in the introduction, women play a crucial role in ending the vicious cycle of malnutrition [4] The development of the research question of this review is based on the lack of evidence and temporal monitoring available on the nutritional status of women in Nepal. Due to the lack of data available prior to 1998, this study focused on the studies published between 1998 and 2019.

Data search strategies

The background research undertaken allowed identification of the topics that needed to be searched and enabled the selection of specific search terms. The same keyword search terms were used for all selected databases (see below table 2). The data search occurred between January and February 2019 by using the following databases: Google, Google Scholar, Search Oxford Libraries Online, PubMed, Cochrane, Web of Science and Science Direct. These 7 databases were consulted as they were considered the most suitable for the literature review in order to find, and not omit, any national health surveys and research publications relevant to the purpose of this study between 1998 and 2019. Firstly, any Nepal Health Surveys were selected. Secondly, the studies found from the initial database searches needed to be in a full-text format to ensure that the whole paper could be examined in detail. Finally, the articles were reviewed by their title, abstract and methods to determine the suitability with the inclusion and exclusion criteria of this review:

Search keywords	Databases used and number of results							Date of search
	Google	Google Scholar	PubMed	SOLO	Cochrane	Web of Science	Science Direct	
Malnutrition AND Nepal	3,310,000	42,200	284	7,958	21	158	1,882	18 January 2019
Micronutrient AND Nepal	350,000	18,700	373	2,484	1	201	859	18 January 2019
Women AND Malnutrition AND Nepal	1,630,000	31,900	67	5,816	2	41	1,220	18 January 2019
Women AND Micronutrient AND Nepal	238,000	13,500	104	1,882	1	103	554	18 January 2019
Women AND Vitamin A deficiency AND Nepal	724,000	15,900	21	2,755	1	94	723	23 January 2019
National Micronutrient Survey 1998 Nepal	130,000	8,560	2	1,010	0	1	219	4 February 2019
Women AND Zinc deficiency AND Nepal	345,000	8,780	15	1,154	29	395	396	6 February 2019
Women AND Iodine deficiency AND Nepal	229,000	6,630	9	923	0	8	350	6 February 2019
Women AND Anaemia OR Anemia AND Nepal	208,000	11,000	59	3,511	1	92	1,122	6 February 2019
Women AND BMI AND Nepal	464,000	11,300	38	2,611	4	36	535	6 February 2019
Women AND Nutritional Status AND Nepal	1,440,000	35,700	78	7,483	16	81	2,058	6 February 2019
Women AND Stunting AND Nepal	415,000	13,800	1,594	1,645	2	26	428	6 February 2019
Women AND Underweight AND Nepal	290,000	9,680	715	1,711	1	23	310	6 February 2019

Table 2: Search keywords, databases used, number of results and date of search.

Inclusion criteria

- Studies published between 1998 and 2019;
- Quantitative result-based studies;
- Primary research studies in English language;
- Population characteristics: WRA (pregnant and/or non-pregnant), (15-50 years old);
- Studies about the prevalence of anaemia, vitamin A deficiency, iodine deficiency, zinc deficiency, underweight and stunting in WRA;
- Studies conducted in Nepal at the national and District levels, across the ecological regions (Terai, Hill and Mountain) and Development regions (Western, Central, Eastern, Mid-Western and Far-Western regions).

Underweight, stunting, anaemia, vitamin A deficiency, iodine deficiency and zinc deficiency were included in this review as all the background research revealed them to be the most common nutritional issues present in WRA in Nepal [24,25]. Studies conducted across Districts and Ecological regions were included due to the lack of research available at the national level and because they allowed comparison of the results with the other studies selected. This was possible because the results from the other selected studies were also reported by ecological and/or development regions.

Exclusion criteria

- Studies published prior to 1998;
- Qualitative result-based studies;
- Secondary research studies;
- Studies not written/translated in English language;
- Presentations;
- Studies conducted at the community, village and municipality level;

- Studies conducted on less common nutritional issues (e.g. niacin deficiency);
- Studies on specific types of anaemia (iron, folate or vitamin B12 deficiency anaemia) - excluded due to lack of studies available;
- Studies conducted on sub-populations (e.g. social caste, medical conditions, women with disabilities, educational level, etc.);
- Studies with limited access (e.g. abstract).

In addition to this, where access to full-texts was restricted, the authors were contacted. Other sources were used to support the discussion. In order to improve the reporting quality of this review and clarify the selection process of the scientific literature, the PRISMA Flow Diagram and Checklist [26] were used (see below figure 3 for PRISMA Flow Diagram and Appendix A for PRISMA checklist). The selected literature had been critically reviewed by using the Critical Appraisal Skills Programme (CASP), (see Appendix B), in order to enhance the critical appraisal process and therefore improve the quality of this review [27]. Using this appraisal tool, of the original 63 publications found from the initial database searches, 26 had been screened from which 12 had been excluded due to the exclusion criteria, hence 14 studies were found to be eligible for this study.

Figure 3: Methods PRISMA Flow Diagram [26]: records identified, duplicate records removed, records screened and excluded, full-text articles assessed for eligibility and excluded and studies included for qualitative and quantitative synthesis.

Results

From the background research, the following themes emerged in order to determine the prevalence of undernutrition in WRA: prevalences of underweight, stunting, anaemia, iodine deficiency, vitamin A deficiency and zinc deficiency. These nutritional issues are among the most common in WRA and were included in the current review as they reflect states of chronic undernutrition [11,28].

Underweight

Underweight is defined as a body mass index (BMI) below 18.5 kg/m2 [11]. Details on underweight prevalence are reported below in Table 3. There is a lack of data available for pregnant women (PW) [10,25,29,30-32].

dds Data source	Population (%) with a BMI <18.5 kg/m^2								
	National	Pregnant women				Non-pregnant women			
		Terai	Hill	Mountain	Total	Terai	Hill	Mountain	Total
NMSS 1998 [33]	24.7	36.9[c]	13.6[c]	14.0[c]	11.6	36.9[c]	13.6[c]	14.0[c]	26.3
NDHS 2001 [29]	26.7	-	-	-	-	35.6	19.2	16.6	26.7
NDHS 2006 [30]	24.4	-	-	-	-	32.7	15.9	17.1	24.4
NDHS 2011 [31]	18.2	-	-	-	-	22.7	12.4	16.5	18.2
Bhandari *et al*., (2014)[a] [32]		-	-	-	-	26.6[a]	14.8[a]	6.1[a]	-
Karki *et al*., (2016)[b] [34]		15.4[b, c]	-		-	15.4[b, c]	-		-
NNMSS 2016[d] [25]	15.6[d]	-	-	-	-	16.4[d]	12.0[d]	15.6[d]	-
NDHS 2016 [10]	17.3	-	-	-	-	23.0	11.6	12.1	17.3

Table 3: Prevalence (%) of underweight (BMI <18.5 kg/m^2) in women (15-49 years old).

[a] Data collected between 2011-2012.

[b] Data collected in Mid-Western Terai in 2015.

[c] The prevalence of underweight is not shown separately between pregnant and non-pregnant women.

[d] Data collected between 2015-2016.

In 1998, the prevalence of underweight in PW was less common compared to non-pregnant women (NPW) [33]. Overall, a decline in underweight rates from 1998 (24.7%) to 2016 (17.3%) has been observed [10,25,29-34].

The highest rates of underweight from 1998 to 2016 were in the Terai, followed by the Mountain and Hill regions [10,25,29-34].

Stunting

Stunting is defined as low stature below 145 cm [11]. Details on stunting prevalence are reported below in Table 4. There is a lack of data available for PW. A slight decrease in stunting prevalence occurred from 2001 (15.3%) to 2016 (10.6%), indicating a decrease by only 4.7% over a period of 15 years (see Table 4) [7,10,25,29-31].

The most recent data showed that highest prevalence of stunting was observed in the Terai, followed by Hill and Mountain ecological regions [7,10,25,29-31].

Data source	Percentage of women with height below 145 cm			
	Terai	Hill	Mountain	Total (%)
NDHS 2001[a] [29]	14.6[a]	15.7[a]	17.5[a]	15.3[a]
NDHS 2006[a] [30]	12.7[a]	15.8[a]	13.7[a]	14.1[a]
NDHS 2011[a] [31]	10.8[a]	12.4[a]	13.6[a]	11.6[a]
Bhandari *et al*., (2016)[b] [7]	15.0[b]	16.4[b]	17.8[b]	-
NNMSS 2016[a, c] [25]	12.8[a, c]	8.2[a, c]	12.9[a, c]	10.8[a, c]
NDHS 2016[a] [10]	11.3[a]	10.0[a]	9.6[a]	10.6[a]

Table 4: Prevalence (%) of stunting (height < 145 cm) in women (15-49 years old).

[a] Non-pregnant women.

[b] Data collected in 2012. Pregnant and non-pregnant women were included in the study.

[c] Data collected between 2015-2016.

Anaemia

The details on anaemia prevalence are reported below in table 5. Nationally, in 1998 the anaemia rates were very high in WRA and almost halved between 1998 and 2015 [25,33]. All studies showed that the prevalence of anaemia was higher in PW compared to NPW from 1998 to 2016 [10,25,30-37].

Anaemia rates in PW decreased from 1998 to 2006 and slightly increased again in 2011 [31,33,35].

Bhandari et al., (2014) [32] reported contrasting results with the NDHS 2011 (see table 7) [31]. The NDHS 2011 results for the Western region slightly differed from Sing, Khan and Mittal (2013) [36] (34.5% vs 41.0%) [31]. A further worsening in this trend was observed in both groups (PW and NPW) in 2016 [10, 25]. The results obtained from the NNMSS 2016 and NDHS 2016 for PW were in contrast, since the anaemia rates were respectively 26.8% and 46.0% [10,25]. Contrasting results are depicted also by Karki *et al*., (2016) [34], the NNMSS 2016 and NDHS 2016 for the Terai region [10,25]. Other discrepancies in the results can be observed between the NNMSS 2016 and NDHS 2016 across all ecological regions [10,25]. Therefore it is not clear whether anaemia rates improved or remained the same since 2011. Overall, the highest prevalence of anaemia was found in the Terai region, followed by the Mountain and Hill ecological areas [10,25,27,30-37].

Data source	Anaemia status by low haemoglobin levels								
	National (%)	Pregnant women (%) with Hb <11.0 g/dL				Non-pregnant women (%) with Hb <12.0 g/dL			
		Terai	Hill	Mountain	Total	Terai	Hill	Mountain	Total
NMSS 1998 [33]	67.7	80.3	68.3	77.1	74.6	72.6	61.1	65.0	66.7
Jiang *et al*., (2005)[2, C] [35]	-	-	-	-	33.0[C]	-	-	-	-
NDHS 2006 [30]	36.2	51.4[1]	20.7[1]	21.5[1]	42.4	51.4[1]	20.7[1]	21.5[1]	35.9
NDHS 2011 [31]	35.0	42.0[1]	26.9[1]	26.9[1]	47.6 34.5[W]	42.0[1]	26.9[1]	26.9[1]	34.5
Bhandari *et al*., (2014)[3] [32]	-	24.7[1]	26.0[1]	2.2[1]	-	24.7[1]	26.0[1]	2.2[1]	-
Sing, Khan and Mittal, (2013)[4] [36]	-	-	-	-	41.0[W]	-	-	-	-
Singh Karki, Karna and Sinha (2015)[E] [37]	-	-	-	-	-	-	-	-	58.0[E]
Karki *et al*., (2016)[6] [34]	-	28.3	-	-	-	37.6	-	-	-
NNMSS 2016[7] [25]	-	36.4	15.6	-[5]	26.8	29.1	11.6	11.1	20.4 27.4[E]
NDHS 2016 [10]	40.8	51.9[1]	28.9[1]	35.4[1]	46.0 47.7[1, E]	51.9[1]	28.9[1]	35.4[1]	40.6 47.7[1, E]

Table 5: Prevalence (%) of anaemia in WRA (15-50 years old).

[1] The prevalence of anaemia is not shown separately between pregnant and non-pregnant women.

[2] Data collected between 1998 and 2001.

[3] Data collected in 2011-2012.

[4] Data collected in 2012.

[5] Too small sample to perform a significant test.

[6] Data collected in 2015.

[7] Data collected in 2015-2016.

W = Western Development region.

E = Eastern Development region

C = Central Development region

Iodine Deficiency

Details on iodine deficiency (ID) prevalence are reported below in Table 6. There is a lack of data available for ID in NPW and across ecological areas. In 1998 the prevalence of ID was high and slightly more common in PW compared to NPW (44.4% vs 41.9%) [33] A decline in ID prevalence was observed in the following years [25,38-40]. The studies conducted in 2012 showed identical results for PW (respectively 28.8% and 28.6%) [38,39]. The NNMSS 2016 reported no presence of ID among most female population as all participants were above the cut-off point. The only exception was shown in the Far-Western region where the mUIC of PW was 133.6 µg/l, which is below the threshold levels for PW of >150µg/l [25].

	Population (%) with iodine deficiency					
Data source	**Total**	**Pregnant women**	**Non-pregnant women**	**Terai**	**Hill**	**Mountain**
NMSS 1998[1] [33]	43.6	44.4	41.9	57.8	32.0	29.6
Agrawal *et al.*, (2013)[2] [38]	-	28.8[2]	-	-	-	-
Joshi *et al.*, (2016)[2, 3] [39]	-	28.6[2, 3]	-	-	28.6[2, 3]	-
Chaudhary *et al.*, (2017)[4] [40]	-	18.5[4]	-	18.5[4]	18.5[4]	-
NNMSS 2016[5] [25]	-	241.3 µg/l[5] 133.6 µg/l[5, 6]	286.2 µg/l[5]	326.3 (N)[5] 230.5 (P)[5]	241.1 (N)[5] 242.1 (P)[5]	280.3 (N)[5] - (P)

Table 6: Prevalence (%) of iodine deficiency in women (15-49 years old).

[1] Iodine deficiency measured through urinary iodine excretion (UIE) (<150 µg/l and <100 µg/l in pregnant and non- pregnant women).

[2] Data collected in 2012.

[3] Data collected in the Sindhupalchowk District (Hill ecological region).

[4] Data collected in 2013-2014 in Eastern Nepal (Hill and Terai ecological regions).

[5] Prevalence (%) of iodine deficiency not reported since the measurement of median urinary iodine concentration (mUIC) was adopted (iodine deficiency cut-off point: pregnant women <150 µg/l and <100 µg/l non-pregnant women).

[6] mUIC of the Far-Western Development Region.

(N): non-pregnant women

(P): pregnant women

Vitamin a deficiency

The details on vitamin A deficiency (VAD) and XN prevalence are reported below in Table 7. There is a lack of data available to compare the results at a national level. A decrease in VAD prevalence was reported in NPW from 1998 to 2016 [25,29,33,35]. In the NDHS 2001, VAD had not been measured, although 19.7% of women reported as having suffered from XN during pregnancy [29]. Similar findings have been depicted by Jiang *et al.*, (2005) [35] in their study conducted in the Sarlahi District, between 1998 and 2001, where 6.8% of non-lactating PW (aged 15-45 years) had VAD. The NNMSS 2016 outlined a significant decrease in the prevalence of VAD among non-pregnant mothers [25].

Zinc deficiency

Details on zinc deficiency prevalence are reported below in Table 8. There is a lack of data available at the national level for zinc status and deficiency in women. Jiang., *et al*. (2005) [35] showed that between 1998 and 2001, 61% of pregnant non-lactating women (15-45 years old) suffered from zinc deficiency. The NNMSS 2016 showed differences in zinc deficiency rates across these zones (24% in both the Hill and Terai regions each and 29% in the Mountain) [25]. Overall, 24% of NPW (15-49 years old) and 31% of non-currently-lactating women had zinc deficiency in 2016 [25].

	Population (%) with Serum Retinol levels <70 µmol/L			Reported Night Blindness (%)	
Data source	**Total**	**Pregnant women**	**Non pregnant women**	**Current XN**	**XN in previous pregnancy**
NMSS 1998 [33]	16.6 20.8[1]	31.5	15.0	4.7	16.7
Jiang *et al.,* (2005)[2] [35]	-	6.8[2]	-	-	-
NDHS 2001 [29]	-	-	-	-	19.6
NNMSS 2016[3] [25]	-	-	3.0[3]	-	3.2

Table 7: Prevalence (%) of subclinical vitamin A deficiency (serum retinol <70 µmol/L) and/or night blindness (XN) in mothers (15-49 years old).

[1] Terai ecological region.

[2] The data was collected between 1998 and 2001 in non-lactating pregnant women aged 15-45 years old in the Sarlahi District (Central Nepal).

[3] VAD assessment through Median Relative Dose Response (MRDR value ≥ 0.060)

	Population (%) with zinc deficiency				
Data source	Pregnant women	Non-pregnant women	Terai	Hill	Mountain
Jiang *et al.* (2005)[1] [35]	61.0[1]	-	-	-	-
NNMSS 2016[2] [25]	-	24.0	24.0	24.0	29.0

Table 8: Prevalence (%) of zinc deficiency in women (15-49 years old).

[1] Data collected between 1998-2001 in Southeastern Nepal.

[2] Data collected between 2015-2016.

Discussion

The aims of this review were:

- To investigate the prevalence of undernutrition as underweight, stunting, anaemia, ID, VAD and zinc deficiency in WRA between 1998 and 2019;
- To identify the determinants of undernutrition (underweight, stunting, anaemia, ID, VAD and zinc deficiency) in WRA;
- To identify research gap areas that require further investigation to help to improve health policies and nutritional interventions.

Underweight

Discussion of results

Underweight occurs in case of inadequate nutrient intakes and is associated with increased risk of morbidity and mortality [3]. Overall, the results showed a decline in underweight rates from 1998 to 2016 [10,25,29-34].

The reasons of high underweight prevalence are unlikely to be associated with insufficient energy intakes as in 2010-2011 the national average daily caloric intake was 300 kcal/day per person above the 2,200 kcal daily requirement set by the GoN [41]. However, the results show that underweight rates decreased only by 1% between 2011 (18.2%) and 2016 (17.3%) [10,31]. This suggests that energy intake alone is not a good indicator of nutritional status and that a cause of high underweight prevalence in females could be the lack of a diversified diet rich in different nutrients, therefore causing multiple micronutrient deficiencies (MNDs) that lead to underweight, rather than the caloric intake.

The increase in underweight rates observed in 2001 could be associated with the Nepalese Civil War occurred between 1996 and 2006, which exacerbated FI especially among the most vulnerable groups, including WRA [42]. In support of this, the results show that the highest increase in underweight prevalence occurred in the Hill and Mountain regions, where the conflict was at its peak in the early 2000s [43]. The results discrepancies between the NNMSS 2016 and NDHS 2016 may derive from the different methodologies adopted: the sample sizes were different, as the number of participants were respectively 6,069 and 2,139 (further details are depicted in Appendix C). This may suggest that the results of the NNMSS 2016 could be more accurate than the NDHS 2016 as the sample size was bigger, therefore could better represent the targeted population [10,25].

Strengths and limitations of the results

The lack of data available for BMI of PW could derive from the absence of a consensus on which BMI cut-off values should be used (especially in Asian and adolescent individuals) for this population group due to the changes in body composition during pregnancy [44,45]. For this reason, the anthropometric data obtained from the NDHS 1998 [33] and Karki., *et al.* (2016) [34] study needs to be considered with caution: the same BMI cut-off values were used for both PW and NPW; furthermore, adolescent participants were included in the studies (see Appendix C). This may need to be further investigated for validation. Therefore, the results could not properly reflect the underweight prevalence of PW. Overall, it was possible to investigate the prevalence of underweight in NPW, whereas there is not sufficient data available to assess PW.

Research areas identified for women in Nepal

There is a need to increase anthropometric/body weight assessment and find an anthropometric method suitable to assess underweight in PW and adolescents, in order to not exclude them from future studies. This will allow to improve the monitoring of nutritional status and underweight prevalence.

Stunting

Discussion of results

Stunting (stature <145 cm) is caused by chronic undernutrition and linked to increased risk of obstetric delivery complications (e.g. due to smaller pelvic size), poor birth outcomes and LBW infants, increasing the risk of mortality, becoming stunted and developing disease throughout life [11]. The results showed a decrease by 4.7% in stunting rates over 15 years (15.3% in 2001 and 10.6% in 2016), with the highest rates observed in the Terai [7,10,25,29-31]. This is a minor decrease in prevalence compared to reductions observed in other nutritional issues (underweight, anaemia, ID and VAD) during the same period of time. The underlying reasons of these findings are not clear and would need to be further investigated.

Only one study [7] assessed the prevalence of stunting in PW. It was not possible to understand why most studies did not assess stunting prevalence in this population group as the same anthropometric method (stature measurement) can be used for both PW and NPW [6]. This may be due to the methodology used (see Appendix D), which also assessed underweight and overweight via BMI in the same participants, therefore causing limitations in using this anthropometric method with PW and leading to exclude them from the data collection [44,45].

Strengths and limitations of the studies selected

No data about stunting rates was found prior to 2001. There is a lack of data available for PW across all years investigated. Therefore, it was possible to clearly investigate on stunting prevalence from 2001 to 2016 only in NPW.

Research areas identified for women in Nepal

Due to the detrimental consequences of stunted growth on health, physical and cognitive development, further monitoring of stunting rates is required to help policy makers to understand the burden of this issue and actions to be taken in order to reduce stunting incidence [4,6].

Anaemia

Discussion of results

Globally, iron deficiency is among the most common causes of anaemia, although other health-related issues including different nutritional deficiencies (vitamin B12, folate and vitamin A), parasitic infections, inflammatory states and disorders affecting haemoglobin levels and red blood cell count, can all induce anaemia [46].

The results showed an anaemia prevalence of 67.7% in 1998 and 40.8% in 2016 [25,33]. The high rates of anaemia observed in 1998 made anaemia being among the most severe Public Health issue in Nepal [33], which causes may be associated with restricted dietary variety [47]. In support of this, a study [7] showed that 99% of mothers were used to having cereals and 75% pulses; iron and folate-rich foods such as dark green leafy vegetables and animal-food products were respectively consumed only by 51% and 37% of mothers, thereby facilitating the development of anaemia [47]. Cereals and pulses are largely consumed as they can be easily stored for a prolonged period of time, hence favouring their consumption, whereas the low consumption of iron-rich foods could be linked with a difficulty to store them in conditions of underdevelopment and poverty [7]. However, the portion size of the foods consumed by the participants was not investigated [7], despite their important role in ensuring the adequate intake of micronutrients in food-based strategies [48].

The highest rates of anaemia were found to be among PW and women living in Terai [25]. Anaemia rates are likely to be higher among PW compared to NPW, due to the increased demands of iron and other micronutrients that are required for pregnancy, foetal development and lactation [49]. The consequences of anaemia during pregnancy are associated with increased risk of maternal mortality and infant's impaired cognitive and physical development [50]. The high anaemia prevalence in Terai could be associated with the Caste system, since most Dalit individuals live in this region and are among the most food insecure social groups [34]. As anaemia used to be a major Public Health problem in 1998 and that anaemia can severely affect maternal and infant health, the GoN has put in place various interventions to address this issue since 2002 [32]. This included supplementation of iron and folic acid, deworming for PW and promotion of the use of mosquito nets in malaria-endemic areas [25]. The results of this study reflect the benefits of these interventions, as the prevalence of anaemia almost halved between 1998 and 2006 (respectively 67.7% and 36.2%) [30,33]. The increase in anaemia prevalence observed between 2011 (35%) and 2016 (40.8%) could be associated with the earthquake that occurred in 2015 which severely affected health services in most regions, hence the distribution of supplements [10,31]. The susceptibility of the country to earthquakes and natural disasters indicates a strong need to reinforce preparedness policies to mitigate future potential worsening of FI and losses in human assets [3]. Furthermore, the NNMSS 2016 reported a decrease in the intake of iron and folic acid supplementation [25]. However, healthcare education is associated with better compliance to nutritional supplementation [51]. Therefore, failed adherence to iron and folic acid supplementation in WRA may also depend on a lack of education, especially among Dalit women since many reported being unable to access health services due to discrimination and are unaware of anaemia consequences due to poor education [7].

Strengths and limitations of the results

A strength of this review is due to the similar methods used by the national surveys (from 1998 to 2016) as they used the same anaemia assessment method (Hb levels), cut-off values and type of population (PW and NPW aged 15-49 years old), hence improving the reliability of the results (see Appendix E). However, the NDHS 2016 did not show results separately between PW and NPW [10].

As PW are more vulnerable to anaemia due to the increased demands of iron and other micronutrients during pregnancy, results may not be accurate [34]. Furthermore, all studies including the national surveys had different sample sizes (number of participants ranged between 1,232-13,369), hence affecting the validity of the results (see methodology differences of the studies included in this review in Appendix E). This could explain the result discrepancies between the NDHS 2016 and NNMSS 2016 as their sample sizes were different (respectively 2,139 and 6,069 participants) [10,25]. In addition, the remaining studies did adopt different methods to assess anaemia as hematocrit value (cut-off point of <35%) [32] instead of Hb levels; another study [7] adopted different Hb cut-off values in PW (Hb <12.0 g/dL) whereas other studies and the WHO use an Hb threshold of <11.0 g/dL for PW, hence affecting the validity of the results (see Appendix E) [31, 32, 46].

Some of the studies also differed in geographical location as Bhandari., *et al.* (2014) [32] study was conducted across 9 Districts, whereas the national surveys were conducted across the whole nation (75 districts) and Jiang., *et al.* (2005) [35] assessed only participants from Sarlahi [10,25,31-33].

Another study [34] occurred across 3 Districts in Mid-Western Nepal, whereas an ulterior research [37] was based in Eastern Nepal (see Appendix E). This made the comparison of results difficult and unreliable as anaemia rates were different across geographical locations.

The Tharu population is an ethnic group living in the Terai region, whose 95% is affected by sickle cell anaemia, a genetic hemoglobinopathy that is not caused by dietary inadequacies [52]. This suggests that the anaemia data for the Terai region could result higher compared to other regions also due to this condition. Therefore the validity of the results may be compromised and further investigation may be required.

Despite the important role of folate, iron and vitamin A in the prevention of anaemia in WRA, the prevalence of these specific types of anaemia could not be investigated due to the lack of research available [46]. Overall, it was possible to investigate the prevalence of anaemia, which appears to still be a main Public Health issue in Nepal. However, due to the discrepancies in the results obtained from Karki., *et al.* (2016) [34] study, the NNMSS 2016 and NDHS 2016, it is not clear whether anaemia rates in 2016 improved or remained the same since 2011 [10, 25].

Research areas identified for women in Nepal

There is a lack of data available on different types of anaemia caused by folate, iron and/or vitamin A deficiency. Therefore, further research is required to better understand which micronutrients play a major role in causing anaemia in order to improve health policies and decrease anaemia rates.

Portion sizes of meals consumed by women are not clear [7,25], despite their important role in ensuring the adequate intake of micronutrients in food-based strategies [48]. Therefore, understanding this could help to improve nutrition-sensitive programmes that educate women about healthy eating practices in order to reduce anaemia and other MNDs prevalence.

Iodine deficiency

Discussion of results

Pregnant and lactating women are often affected by ID, which is associated with adverse pregnancy outcomes such as abortion, perinatal death, stillbirth and impaired child's brain development such as cretinism [53]. Results show that ID was present in more than 40% of Nepali women in 1998 [33]. For this reason, the Nepali Ministry of Health (MoH) managed to address this problem through universal salt iodisation since 2010 [25,54]. The benefits of this intervention are reflected in the results as ID prevalence almost disappeared (43% in 1998 and no presence of ID in 2016) [25,33]. The only exception was observed in the Far-Western Development region, where the mUIC for PW was 133.6 μg/l [25]. This could be caused by geographical isolation of the Far-Western Development region, which leads to inaccessibility and unavailability of iodized salt.

Strengths and limitations of the results

In this study, it was not possible to report the prevalence of ID in WRA between 1999 and 2011 as no data was found for that period. The NNMSS 2016 used the mUIC instead of the UIE as the other studies did to assess iodine status (see methodology differences in Appendix F). Therefore, the prevalence as percentage of ID in the Far-Western region is unknown [25]. The number of participants enrolled ranged between 45 and 2,332, suggesting that the sample sizes were small compared to the number of participants enrolled to assess other MNDs (e.g. the NMSS 1998 had 2,332 participants to assess ID and 5,757 participants to assess anaemia - see Appendix F). Furthermore, the studies were conducted across different geographical areas, making it difficult to understand whether there were differences in ID prevalence across the ecological areas (see Appendix F) [38-40]. Due to the lack of data available, the small sample sizes and different geographical locations of the studies included in this review, the results for ID prevalence of this review may lack in validity. Therefore, it was not possible to effectively investigate the prevalence of ID in WRA between 1998 and 2016 and understand the causative factors of ID in the Far-Western development region. On the other side, it is clear that universal salt iodisation is an efficient method to improve iodine status for WRA in Nepal [25].

Research areas identified for women in Nepal

There is a lack of data available on ID, especially in NPW. Therefore, further research is required to better monitor iodine status. Additionally, further research is required to investigate the factors preventing women from being iodine sufficient in the Far-Western development region and find potential solutions to this issue.

Vitamin a deficiency

Discussion of results

VAD is the main cause of night blindness (XN) in women, especially during pregnancy due to the increased metabolic demands. VAD can also increase morbidity and mortality in children due to infections [55]. A decrease in VAD prevalence was reported in NPW from 1998 (15%) to 2016 (3%) [25,33]. The causes of VAD could be linked with the lack in dietary variety as in the NDHS 2016, only 37%of women reported to consume vitamin A-rich fruits and vegetables; 34% were used to consume animal foods (meat, poultry and fish). Only 30% of PW used to eat milk and dairy products whereas the consumption of eggs was very low (14%) [10]. This reinforces the need to increase dietary variety of WRA and strength food-based approaches to prevent and treat MNDs, including VAD.

Strengths and limitations of the results

A limitation of this review depends on the limited data available about VAD in PW as no studies were found from 2002 onwards. Furthermore, the data included in this study was extracted from research that enrolled different types of populations as the NMSS 1998 assessed PW and NPW of both VAD and XN prevalences [25], whereas Jiang., *et al*. (2005) [35] assessed VAD only in PW and no XN; the NDHS 2001 assessed only XN in mothers and the NNMSS 2016 assessed VAD and XN only in NPW [25,29]. Also the sample sizes of these studies were different, ranging between 842-4,745 participants (see methodology differences of the studies in Appendix G). These differences between methodologies influenced the validity of the results of this study. Therefore, it was not possible to clearly investigate the prevalence of VAD between 1998 and 2016, as no data was found between 2002 and 2015.

Research areas identified for women in Nepal

An increase in the assessment of vitamin A status for WRA is required due to the lack of data available. Further research is required to investigate the factors preventing women from not suffering from VAD and find potential solutions to this issue (e.g. vitamin A supplementation and/or promotion of food-based approaches to improve Vitamin A status) [56].

Zinc deficiency

Discussion of results

Women of reproductive age can be affected by zinc deficiency, which often co-exists with iron deficiency. Zincaemia can compromise the child's brain and immunity development and gastrointestinal health, increasing the risk of mental retardation and mortality due to pneumonia and frequent enteric infections causing severe diarrhoea (Jiang., *et al*. 2005) [35]. There is a lack of data available for zinc status in women. The results show that a decline in zinc deficiency in women occurred between 1998 and 2016 (respectively 61% and 24%) [25,35]. Zinc is mainly found in foods deriving from animal sources and cereals [57]. The Nepali diet is cereal-based, however, cereals are high in phytate, which inhibits zinc absorption [57]. Therefore, health policies should focus on zinc supplementation, especially for PW, and promote the consumption of zinc-rich foods and/or fortified foods with zinc [57].

Strengths and limitations of the results

As only two studies were found about zinc status for WRA, there is a lack of data available between 2002 and 2015 [25,35]. Furthermore, the populations enrolled by the studies were different as Jiang., *et al*. (2005) [35] tested PW and the NMSS 1998 assessed NPW [33]. As Jiang., *et al*. (2005) [35] study was conducted in the Sarlahi District this indicates that there is no national data available for zinc status of PW between 2002 and 2016. Additionally, the NNMSS 2016 enrolled only 529 NPW, therefore due to the small sample size their data may not be accurate in reflecting the zinc status of women on a national level (see Appendix H) [25]. For these reasons, it was not possible to clearly investigate the prevalence of zinc deficiency between 1998 and 2016.

Research areas identified for women in Nepal

Despite the decline observed in the prevalence of zinc deficiency (61% in 1998-2001 in PW and 24% in 2016 in NPW), there is not enough data available to understand the severity of this issue

[25,35]. Due to the severe consequences of zinc deficiency on foetal development and immune function [24], it is crucial to increase the assessment and monitoring of zinc status for WRA.

Interaction of undernutrition determinants in women

Discussion

As previously mentioned, the energy intakes of Nepali women appear to be sufficient [41]. This suggests that undernutrition in WRA is characterised by the coexistence of multiple micronutrient deficiencies (MNDs) deriving from the Nepali diet which is cereal-based and monotonous; hence leading to the insufficient consumption of micronutrient-rich foods [24]. According to the WHO (2001) [47], a diversified diet represents the cornerstone of MND prevention, especially during pregnancy and lactation. Varied diets should be composed by 5 different food groups, including grains and potatoes, fruits and vegetables, milk and dairy products, animal products and legumes, and finally, fats, oils, sweets and salt group [47]. As previously mentioned, the typical Nepali diet is mainly composed by staple foods (cereals and pulses), representing only 2 food groups out of 5 [41]. In support of this, the NDHS 2016 showed that vegetables, fruits and animal foods were respectively consumed by 63%, 48% and 34% of mothers; only 30% of PW used to consume milk and dairy products whereas the consumption of eggs was low (14%) [10]. However, the NDHS 2016 did not specify food portion sizes. These findings clarify the underlying triggers of MNDs in Nepal, hence the need for increasing the consumption of different food groups to decrease the prevalence of undernutrition in WRA [56]. Most of the Nepali population relies on subsistence agriculture [24]. Home growing of fruits and vegetables showed to be an efficient approach to increase their consumption, hence reduce the rates of MNDs [58]. However, the majority of the low caste population lives in the Terai region and most of them do not possess cultivating land [24]. This could be the reason why the results show the highest rates of undernutrition being in the Terai region, compared to the other regions. In support of this, a study [7] reported that 20% of women in Terai did not own a home garden and most of the ones having land, cultivated mainly cereals as they can be easily stored compared to fruits and vegetables [7]. Therefore, focus on women's empowerment policies should be given in order to provide farming land to prevent undernutrition and finding ways to improve the storing of fruits and vegetables (e.g. solar drying) [58-60]. However, agricultural production in Nepal is highly unpredictable and uncertain in meeting the population food demands as the majority of the cultivated land is rainfed and depends on erratic weather patterns (e.g. insufficient or too heavy monsoon rains leading to crop losses and rain shadow areas causing desertification) [14]. Only 15% of the land in Nepal is irrigated [14]. This is likely to be another reason preventing women from cultivating fruits and vegetables, hence reducing MNDs and undernutrition prevalence. Additionally, the land topography of the mountainous and hilly regions is often unsuitable for agriculture (e.g. high altitude, inarable land - e.g. rocky soil, water scarcity and soil erosion), causing a food deficit in the domestic production which is sufficient only for 4-10 months depending on the size of the land owned and location, leaving their inhabitants highly food insecure and in need of food assistance to meet their daily calorie requirements [14,22]. This suggests that the high prevalence of undernutrition in women reported in the results, is also caused by insufficient caloric intakes and that is likely to be affected by agricultural seasonality. For instance, the Trans-Himalaya has a very limited growing season due to the altitude, snow or drought periods, increasing the vulnerability to FI [22] In the Upper-Mustang (at around 3000 masl), oats, maize, wheat, barley, potato and beans are the major crops cultivated and can be grown only between April and November, whereas in villages above 3600 masl, oat is the only single crop able to grow due to the very short growing season (September-October) [22]. Therefore, it is necessary to find ways to improve agriculture techniques and cropping systems (e.g. promotion of use of biofertilizers to improve soil fertility, use of sloping agricultural techniques and distribution of improved seeds to increase micronutrient concentrations in staple food crops) [24,61]. Although, this does not address the low consumption of other micronutrient-rich food groups such as milk, dairy and other animal products [25]. This could be either due to the restricted accessibility to these food groups at the household level, deriving from limited purchase power and/or unavailability of such foods in other regions, especially in the Mountains, due to geographical constraints.

Another issue related to MNDs and malnutrition could be the widespread presence of convenience stores selling junk food and other confectionery products poor in micronutrients instead of selling fresh fruits and vegetables [24]. This problem is also likely to be linked to remoteness and unavailability of fruits and vegetables and/or inability to cultivate them due to adverse climate.

Another reason associated with the high prevalence of poor nutritional status and MNDs, could be a lack of education about healthy eating practices as underweight was more common among uneducated women (22.6%) than the women with a higher level of education (15.2%) [31]. This could also be linked with the consumption of junk foods and low cultivation of different varieties of fruits and vegetables due to the lack of education. In contrast with this finding, Bhandari., *et al*. (2014) [32] reported that educated women were 1.4 times more likely to be malnourished than uneducated women. However, part of the participants who were educated (48.5%) was unemployed, therefore their food purchase power was likely to be reduced when the study was conducted. Additionally, women who had been educated could not necessarily mean that they received education also about nutrition since nutrition education has been introduced in schools only in 2006, letting out adults and older generations [62]. Outside schools, most nutrition education programmes are delivered by local health services, yet in 2016 about 50% of women in the Mountain region did not have access to any health service providing nutrition education, thereby suggesting that lack of nutrition knowledge could be associated with limited health assistance coverage, especially in remote areas [25]. Another study [18], supports the need of expanding health services and nutrition education to the far corner of the country to help to improve undernutrition in women. Educating the whole community about the importance of sustainable and healthy eating practices is considered to be among the best approaches to manage and prevent MNDs [63].

Strengths and limitations of the results

In this study it was possible to identify several determinants of undernutrition in WRA and their interconnection. However, there are many other causes of undernutrition in WRA in Nepal which were not possible to investigate due to their complexity, including food fortification methods, social injustice and discrimination, climate change, development and political factors.

Research areas identified for women in Nepal

As many studies conducted on food consumption did not focus on the size of the meals [25, 32] future research would need to assess it in order to assess micronutrient intakes. Further research is required to evaluate the impact of nutrition education on nutritional status of WRA. There is a strong need to improve agricultural methods in order to increase agricultural production especially in areas unsuitable to agriculture (e.g. Mountain region).

Strengths and limitations of this study

Potential limitations of this review were reduced by following the methodology described in section “2. Methods”. However, studies published prior 1998 were not included due to the lack of data available, despite they could have contained important findings. This was the same for the literature not published in English.

Conclusion

Overall, the rates of undernutrition appear to have declined between 1998 and 2016 thanks to the various interventions implemented by the GoN and humanitarian actors [2,25]. The major nutritional issues identified appear to be underweight in Terai; nationally, anaemia and zinc deficiency [25]. However, there was not enough data to investigate the prevalence of underweight in pregnant women probably due to the BMI limitations with gestational weight [44,45]. Due to unknown reasons, lack of data was identified also for stunting prevalence in pregnant women, VAD and zinc deficiency. Therefore, an increase in the assessment of these nutritional issues is required to monitor their prevalence.

The determinants of undernutrition are interconnected and seem to derive mainly from a lack in dietary variety, hence micronutrients [11]. The typical Nepali diet is based on staple foods as they are easy to be stored and grown compared to fruits and vegetables [7]. Furthermore, erratic weather conditions and inadequate agriculture methods often prevent women from cultivating fruits and vegetables [22]. As the majority of the Nepali population relies on subsistence farming, health policies should focus on improving agriculture methods to overcome food-deficits in domestic production, soil and climate-related issues [22]. Health policies should also focus on expanding health services and nutrition education to the far corner of the country to help to decrease undernutrition rates in women [7].

Further research would need to be conducted also on other determinants of undernutrition in women in Nepal, including food fortification methods, social injustice and discrimination factors, climate change, development and political factors.

Due to the vulnerability of the country to earthquakes, a strengthening of preparedness policies is needed to mitigate potential worsening of FI and losses in human assets in case of natural disaster [2].

Overall, health policies should prioritise the promotion of sustainable food-based approaches with a special focus on the most vulnerable sub-groups including mothers, women belonging to low castes and/or living in remote areas. This could help to eradicate the problem of undernutrition from women and their offspring and consequently to break the intergenerational cycle of malnutrition nationally [11].

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Conflict of Interest

There are no conflicts of interest to declare.

Appendices

Appendix A: PRISMA 2009 Checklist

Figure a

Appendix B: Critical Appraisal Skills Programme (CASP)

Figure b

Appendix C: Underweight (BMI <18.5 kg/m^2) - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status, geographical location and year of data collection) for women aged 15-49 years old.

Data source	Sample size (N =)	Pregnant women (n =)	Non-pregnant women (n =)	Study details
NMSS 1998 [33]	15,541	1,601	13,756	National surveys on WRA who did not give birth in the past 2 months prior the studies.
NDHS 2001 [29]	7,784	-	7,784	National surveys on WRA who did not give birth in the past 2 months prior the studies.
NDHS 2006 [30]	10,003	-	10,003	National surveys on WRA who did not give birth in the past 2 months prior the studies.
NDHS 2011 [31]	5,800	-	5,800	National surveys on WRA who did not give birth in the past 2 months prior the studies.
Bhandari *et al*., (2014) [32]	13,369	-	13,369	Survey conducted in 2011-2012 in Illam, Dolakha, Kavrepalanchowk, Sarlahi, Kathmandu, Lamjung, Kaski, Nawalparasi and Kailali Districts.
Karki *et al*., (2016) [34]	781	-	781	Descriptive cross-sectional study conducted in 2015 in Banke, Bardiya and Dang Districts (Mid-western Terai).
NNMSS 2016[a] [25]	6,069	-	6,069	National surveys on WRA who did not give birth in the past 2 months prior the studies.
NDHS 2016 [10]	2,139	-	2,139	National surveys on WRA who did not give birth in the past 2 months prior the studies.

Table a

[a] Data collected between 2015-2016

Appendix D: Stunting (height <145 cm) - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status, geographical location and year of data collection) for women aged 15-49 years old

Data source	Women (N =)	Study details
NDHS 2001 [29]	7,784	National surveys conducted on non-pregnant women who did not give birth in the past 2 months prior the study.
NDHS 2006 [30]	10,003	National surveys conducted on non-pregnant women who did not give birth in the past 2 months prior the study.
NDHS 2011 [31]	5,800	National surveys conducted on non-pregnant women who did not give birth in the past 2 months prior the study.
Bhandari *et al*. (2016) [7]	14,366	Survey conducted in 2012 on pregnant and non-pregnant women in Illam, Dolakha, Kavrepalanchowk, Sarlahi, Kathmandu, Lamjung, Kaski, Nawalparasi and Kailali Districts.
NNMSS 2016 [25]	6,069	National surveys conducted on non-pregnant women who did not give birth in the past 2 months prior the study.
NDHS 2016 [10]	2,139	National surveys conducted on non-pregnant women who did not give birth in the past 2 months prior the study.

Table b

Appendix E: Anaemia - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status, geographical location and year of data collection) for women.

Data source	Sample size (N =)	Pregnant women (n =)	Non-pregnant women (n =)	Study details
NMSS 1998 [33]	5,757	560	5,197	National survey conducted on women 15-49 years old. Anemia assessment: Hb levels <11.0 g/dL (pregnant women) and <12.0 g/dL (non-pregnant women).
Jiang *et al*., (2005) [35]	1,232	1,232	-	Double-masked, cluster-randomized, controlled trial conducted on women 15-49 years old (Sarlahi District) in 1998-2001. Anemia assessment: Hb levels <11.0 g/dL.
NDHS 2006 [30]	10,646	604	10,042	National surveys conducted on women 15-49 years old. Anemia assessment: Hb levels <11.0 g/dL (pregnant women) and <12.0 g/dL (non-pregnant).
NDHS 2011 [31]	6,088	293	5,795	
Bhandari *et al*., (2014) [32]	13,369	-	13,369	Survey conducted conducted on women 15-49 years old in 2011-2012 in Illam, Dolakha, Kavrepalanchowk, Sarlahi, Kathmandu, Lamjung, Kaski, Nawalparasi and Kailali Districts. Anaemia assessment: hematocrit value <35%.
Sing, Khan and Mittal, (2013) [36]	512	512	-	Hospital-based study (Nepalgunj Medical College - Western Nepal) conducted on 15-45 years old subjects. Anemia assessment based on Hb levels <12.0 g/dL).
Singh Karki, Karna and Sinha (2015) [37]	735	-	735	Cross sectional study conducted in Tankisinwari District (Eastern Nepal) in 21-50 year old subjects. Anemia assessment: Hb levels <12.0 g/dL.
Karki *et al*., (2016) [34]	781	-	781	Descriptive cross-sectional study conducted in 2015 in Banke, Bardiya and Dang Districts (Mid-western Terai). Mentally challenged and severely ill subjects were excluded. Anemia assessment: Hb levels <12.0 g/dL.
NNMSS 2016 [25]	6,069	-	6,069	National surveys conducted in 2015-2016 in 15-49 years old subjects. Anemia assessment based on Hb levels <12.0 g/dL.
NDHS 2016 [10]	2,139	-	2,139	

Table c

Appendix F: Iodine deficiency - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status and age, geographical location and year of data collection) for women.

Data source	Sample size (N =)	Pregnant women (n =)	Non-pregnant women (n =)	Study details
NMSS 1998 [33]	1,313	132	1,169	National survey conducted in 15-49 year old WRA. ID assessment: UIE - sufficiency threshold levels: >150 µg/l (pregnant women) and >100 µg/l (non-pregnant women).
Agrawal *et al*., (2013) [38]	45	45	-	Hospital-based cross-sectional pilot study conducted in 2012 in subjects from all ecological regions, 18-35 years old. ID assessment: UIE - sufficiency threshold levels: >150 µg/l.
Joshi *et al*., (2016) [39]	98	98	-	Cross-sectional study conducted in 2012 (Chautara Hospital - Sindhupalchowk District - Hill ecological region of Central Nepal) in 21-35 year old women. ID assessment: UIE - sufficiency threshold levels: >150 µg/l.
Chaudhary *et al*., (2017) [40]	92	92	-	Cross-sectional study conducted in 2012-2013 in Eastern Nepal (Sunsari, Morang and Jhapa Districts - Department of Biochemistry of BP Koirala - Dharan) in 19-29 year old women. ID assessment: UIE - sufficiency threshold levels: >150 µg/l.
NNMSS 2016 [25]	2,332	203	2,129	National survey conducted in 2015-2016 in 15-49 year old WRA. Assessment of ID: median urinary iodine concentration (mUIC) - sufficiency threshold levels: >150 µg/l (pregnant women) and >100 µg/l (non-pregnant women).

Table d

Appendix G: Vitamin A Deficiency (VAD) and **Night Blindness** (XN) - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status, geographical location and year of data collection) for women aged 15-49 years old.

Data source	Sample size (N =)	Pregnant women (n =)	Non-pregnant women (n =)	Study details
NMSS 1998 [33]	842	89	740	National survey. VAD assessment: Serum Retinol levels: <70 μmol/L and self-reported XN.
Jiang *et al.,* (2005) [35]	1,165	1,165	-	Double-masked, cluster-randomized, controlled trial (Sarlahi District) between 1998-2001. VAD assessment: Serum Retinol levels: <70 μmol/L.
NDHS 2001 [29]	4,745	-	-	National survey on mothers who gave birth in the past 5 years prior the study. VAD assessment: self-reported XN.
NNMSS 2016 [25]	529	-	529	National survey conducted in 2015-2016 on mothers who gave birth in the past 5 years prior the study. VAD assessment: Median Relative Dose Response (MRDR value ≥ 0.060) and self-reported XN during previous pregnancy.

Table e

Appendix H: Zinc Deficiency - Methodology differences of the studies included in this review (study reference, sample size, study design, participant pregnancy status, geographical location and year of data collection) for women aged 15-49 years old.

Data source	Pregnant women (N =)	Non-pregnant women (N =)	Study details
Jiang *et al.,* (2005) [35]	1,165	-	Double-masked, cluster-randomized, controlled trial conducted (Sarlahi District) between 1998-2001. Zinc deficiency defined as zinc levels <8.6 μmol/L.
NNMSS 2016 [25]	-	529	National survey conducted in 2015-2016 on mothers who gave birth in the past 5 years prior the study. Zinc deficiency defined as zinc levels <66 μg/dL.

Table f

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