



**SAHLGRENKA ACADEMY**

## **Degree Project**

### **Towards No Hunger**

Micronutrient Deficiencies and Nutritional Status among Children and Women in Nepal

Amanda Carlsson

University of Gothenburg

Gothenburg, Sweden

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Supervisor:	Prof. Göran Kurlberg

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## Abstract

### Towards No Hunger

#### Micronutrient Deficiencies and Nutritional Status among Children and Women in Nepal

Author: Amanda Carlsson  
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Supervisor: Prof. Göran Kurlberg  
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**Background:** For decades, nutritional deficiencies have been major public health concerns in Nepal, where children and women are most vulnerable. Deficiencies in the micronutrients vitamin A, iodine and iron are among the most common. The Sustainable Development Goal no 2 “Zero Hunger”, declared by the United Nations, aims to defeat hunger by 2030.

**Aim:** To elucidate the development regarding anemia, iodine deficiency, vitamin A deficiency and the nutritional status among children and women of reproductive age in Nepal.

**Methods:** A retrospective analyzing study using the Nepal National Micronutrient Status Survey from 1998 and 2016 among children mainly aged 6-59 months and women aged 15-49 years. Since the datasets consist of aggregated data of Hemoglobin, S-Retinol and Urinary Iodine Concentration and anthropometric measures for nutritional status, “individual confidence interval for the difference between proportions” was mainly used for the statistical analysis.

**Results:** The prevalence of anemia, vitamin A deficiency and iodine deficiency were statistically decreased for both children and women during this period. Iodine deficiency was eliminated as a public health concern, while anemia and vitamin A deficiency still were considered as mild to moderate public health concerns. Similarly, the prevalence of stunted children, as well as underweight among both children and women, were significantly decreased, but the high prevalence remained. In contrast, the prevalence of wasted children significantly increased.

**Conclusions:** Altogether, the nutritional health among children and women has remarkably improved during the last decades in Nepal. Despite this, Nepal is far from achieving the nutritional targets of “Zero Hunger” since, except iodine deficiency, major nutritional deficiencies persist, where children and women in rural areas are more exposed. Alarmingly and unexplainable, an increased prevalence of wasted children was found throughout Nepal, but most prominent in rural areas and in the Terai.

## Acronyms and Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
CVD	Cardiovascular Disease
FCHV	Female Community Health Volunteer
HAZ	Height-For-Age Z-score
ID	Iodine Deficiency
IDA	Iron Deficiency Anemia
IDD	Iodine Deficiency Disorder
LBW	Low Birthweight
LMIC	Low-Middle Income Country
MAM	Moderate Acute Malnutrition
MN	Micronutrient
MND	Micronutrient Deficiency
MRDR	Modified Relative Dose Response
NCD	Non-Communicable Disease
NMSS	Nepal Micronutrient Status Survey
NNMSS	Nepal National Micronutrient Status Survey
NPW	Non-pregnant Women
NVAP	National Vitamin A Program
PW	Pregnant Women
SAM	Severe Acute Malnutrition
SD	Standard Deviation
SDG	Sustainable Developing Goal
UIC	Urinary Iodine Concentration
USI	Universal Salt Iodization Program
VAD	Vitamin A Deficiency
WAZ	Weight-For-Age Z-score
WHZ	Weight-For-Height Z-score
WHO	World Health Organization
WRA	Women of Reproductive Age
XN	Night Blindness

### Glossary

Anthropometry	Human body measurements
Obesity	High weight for height or high BMI for age
Overweight	High weight for height or high BMI for age
Stunting (HAZ)	Low height-for-age
Underweight (WAZ)	Low weight-for-age or low BMI for age
Wasting (WHZ)	Low weight-for-height

## Background

Hunger is a global threat to human health. For more than a decade world hunger has been following a falling trend. In 2016, this falling trend shifted, and the burden of undernutrition increased. (1) Most children under 5 years of age die from treatable or preventable reasons. Leading causes are e.g., complications from premature birth and infectious diseases such as malaria, diarrhea, and pneumonia. (2) Globally, undernutrition among children is a pronounced public health concern, especially in developing countries (3) such as Nepal (4), and contributes to both morbidity and mortality (3). In Nepal, approximately half of the under-five mortality is related to malnutrition (4).

## About Nepal

### History of Nepal

In the mid to late 18<sup>th</sup> century the first Shah king, A.D., King Prithvi Narayan Shah, unified the former independent kingdoms to one united nation. In 1769 the Shah dynasty was established and ruled the country until 2008. In the mid-19<sup>th</sup> century, the first Rana Prime Minister came to governance and the first government with a system of cabinets was established. The minister post was inherited by Ranas for the next hundred years. Due to a democratic movement during the 1950s King Tribhuvan regained the power from the Ranas and a new, democratic system was implemented. (5) Shortly, the first democratic government including the first prime minister was elected, (5) but only a few years later, after King Mahendra became king of the country, the parliament was dissolved and the Panchayat System was implemented. A political system, with only one party and the power stayed by the King. (6)

During early 1990's a multiparty democracy with the monarchy as Head of State, replaced the Panchayat System, after political unrest. However, the turbulence persisted and as the disparity and poverty grew, the Communist Party of Nepal, the Maoists, started a Civil war in 1996. (6) The war that lasted for ten years resulted in a considerable internal migration in Nepal, but also to neighboring countries. When the war ended, the King resigned, and the Parliament was reestablished. After being a monarchy for nearly two and a half centuries, the country underwent a political transition and in 2015, Nepal was declared as a Federal Democratic Republic. (5)

Nepal, amongst the most disaster-inclined countries worldwide, is affected by various natural disasters annually due to heavy rainfall and the country's dramatic landscape. Weather-related

disasters, such as fires, landslides, floods, and earthquakes are the most common. (7) In the year of 2015, several crises affected Nepal. On the 25<sup>th</sup> of April 2015 a devastating earthquake, the worst in more than 80 years (8), hit Nepal and injured over 22,000 people and caused the death of nearly 9,000 people. The earthquake lasted for over two weeks, until the 12<sup>th</sup> of May (9), consisting of many aftershocks (5). The disaster left major damage to the constructions in the county. Approximately 500 health care facilities and nearly 500 000 homes were left destroyed, hitting harder and more severely to the poor population in rural areas. (9) Shortly thereafter, severe drought hit Nepal due to sharply reduced rainfall during the monsoon period. The drought negatively affected the agriculture and caused food prices to increase. (10) In late September, directly after the political transition, a blockade of the border between Nepal and India was initiated (11). The blockade stopped the import of medicines, fuel, and food for four months, affecting both health care services and the daily life which resulted in a humanitarian crisis in Nepal (11), since the country depends on trade of both rice (12) and medicines (13).

Geography and Topography

Nepal is a South Asian country with an area of approximately 147 square kilometers. This Himalayan country is landlocked, surrounded by China to the north and India to the remaining latitudes (14, 15). The topography is dramatic, and the altitude varies between the highest point on Earth, Mount Everest with an altitude of 8,848 meters, to 60 meters above sea level (14, 15), where above four-fifths of the land area consists of a mountainous and hilly landscape (7). Further, the country is divided into three ecological zones, the Mountain, the Hill and the Terai from north to south (Figure 1). (14, 15)



Fig. 1: Ecological and Developing regions in Nepal - A map of the three ecological regions in Nepal, Mountain, Hill and Terai and the five developing regions which divided the country until 2015. Source: Nepal Demographic and Health Survey of 2011(16)

### *The Mountain*

The Mountain is the northernmost of the three ecological zones with the lowest altitude of 4,800 meters above sea level. Living conditions are tough in this part of the country due to the rough arctic climate and rough terrain. (14, 15) This extreme topography also entails limitations of both communication and transportation facilities. Although covering about 35% of the land area, merely 7% of the Nepalese population lives here. (17)

### *The Hill*

The Hill is the largest of the three ecological zones and covers about 42% of the land area. In this ecozone the capital of Nepal, Kathmandu is located. The topography in this ecozone is, likewise to the Mountain area, harsh but the climate condition is gentler ranging between sub-arctic to temperate. (14) This is a more populated part of the country where approximately 43% of the population lives. The infrastructure here is more developed in comparison with the Mountains. Furthermore, this is the most urbanized part of Nepal. (17)

### *The Terai*

The Terai, also called the Plains, is the southernmost of the three ecological zones and covers around 23% of the land area. Though it is the smallest ecozone, this is the most populated area where approximately 50% of the total Nepalese population lives. The Terai is the most fertile area of Nepal, and the infrastructure is more developed because of its plain terrain. The climate in this ecozone is subtropic to tropic, in comparison, warmer than the two other ecological zones. (17)

### *Population and urbanization*

The Nepalese population is growing. According to the World Bank, life expectancy has increased by nearly 9 years between 1998 and 2016, from approximately 60.9 to 69.8 expected life years (18). The total population was in 1998 approximately 23 million and had increased to approximately 27 million in 2016 (19). The urban population in Nepal has increased from approximately one-tenth of the Nepalis living in urban areas in 1998 to one-fifth in 2016 (20). The urbanization has mainly taken place in the Kathmandu Valley, nearby highways and throughout the southern border to India (21). Despite the fact that urbanization has grown rapidly during the last decades, Nepal is still considered as one of the countries in South Asia with least urbanization (22). However, urbanization is not only beneficial (23). Migration from rural to urban areas leads to a growing urban population that might exceed the

capacity of both primary health care services (23) and other institutions important to manage the growing urbanization (21).

#### Infrastructure

The infrastructure in Nepal is poorly developed. The harsh terrain makes the construction of roads difficult and might contribute to why Nepal has the least developed road network in South Asia. Due to the mountainous environment in the two most northern ecological zones, the Mountain and the Hill, approximately half of all roads are placed in the Terai. In urban areas the quality of the roads is more improved. The deficiency of roads between different parts of Nepal has a negative effect on the development of both urban and rural areas due to limited exchange possibilities and elevated costs for transport. (24)

#### Economy and poverty

Recently Nepal reached an economic level of a lower middle-income country's (LMIC), which is defined as a gross national income (GNI) of at least \$1,036 per capita. Formerly, Nepal was considered as a low-income country. In 1998 the GNI was \$210 per capita and elevated to \$880 per capita in 2016. The gross domestic product (GNP) has also increased during the last decades from 4,8 Billion in 1998 to 24,5 Billion in 2016. (19)

Still, Nepal has one of the highest amounts of people living in absolute poverty in South Asia, where above 20% of the Nepalese live in absolute poverty (25). Absolute poverty is defined as when an individual has an income that is not enough to fulfill essential needs (26). The poverty in Nepal has large disparities between geographical areas and by gender where women are more exposed (27).

#### Health Care System

To provide basic health care for all citizens of Nepal a General Health Plan was established in 1956. Since then, Nepal has continued their work to develop and improve the health care system and the health of the Nepalese people by implanting several interventional actions, e.g., Eradication programs for Tuberculosis, Leprosy and Malaria, Family planning programs, as well as the National Vitamin A Program (NVAP) (28) and the Universal Salt Iodization Program (USI) (15). The health care system in Nepal could be divided into three levels; *primary health care* to provide basic health care, *secondary health care* to provide inpatient care at a district level including specialized care, and *tertiary health care* including Regional and Central hospitals to provide referral and specialized care. (28)

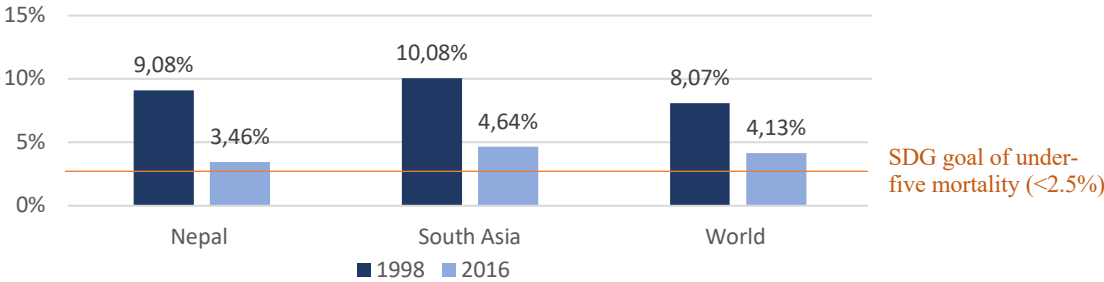
The availability of health care remains unequal in both economical and geographical aspects. The overall aim for the Government of Nepal is to provide basic health care, including essential medicines and emergency care, free of cost. Insurance is required to obtain non-basic health care. In 2017 an optional Health Insurance Act was established, including certain premiums for elderly, orphans, poor and disabled. Historically health care in Nepal has been financed by external donations, the national budget, and the person himself. (29) The majority of health care personnel are working in the urban parts of the country. Challenging is also the unequal access to supplies, the rapid urbanization, the rough environment, especially in rural areas, and nonetheless the growing Nepalese population. (28)

*The Female Community Health Volunteers*

The Female Community Health Volunteers (FCHVs) consist of local volunteers throughout all ecological zones. The FCHV program was established in 1988 to improve primary healthcare in rural areas. Their work is crucial to the health of the country and includes e.g., supplementation of Vitamin A capsules, child health care, maternal health care and primary health care. An important part of their work is also to inform and educate the population about health. (30)

*Under-five Mortality in Nepal*

The under-five mortality in Nepal is decreasing, concordant with the rest of the world. In 1998, almost one-tenth of children (9.08 %) died before reaching the age of five. In 2016, this number was reduced by almost two thirds to 3.46 % (see Figure 2) (31).



*Fig. 2: Under-five Morality - Under-five mortality in Nepal, South Asia and Globally in 1998 and 2016 with data from the Child mortality rate from Our World in Data. Compared to the sustainable developing goal (SDG) goal to decrease under-five mortality to below 25 per 1,000 live births, i.e., below 2.5%. Source: Our World in Data – Child mortality rate (31)*

In Nepal, more than half of the deaths among children under the age of five occur during the first 28 days of life (32). Though, the decrease of the under-five mortality in Nepal is significant (32), it has still not reached beyond the Sustainable Development Goals (SDGs) of

2030 which goal is to reduce the under-five mortality to below 25 per 1,000 live births, i.e., below 2.5% and the neonatal mortality to less than 12 per 1,000 live births, i.e., 1.2% (2). The mortality risk before an age of five in Nepal is unequal by several factors. For instance, is the under-five mortality greater in rural areas compared with urban areas and the risk is also increased for children in poor households compared with children in more wealthier households (32).

### Global Developing Goals

In 1990, the first World Summit for Children (WSC) took place, organized by the United Nations (UN) as an action to improve children's health all over the world. The WSC consist of several major goals including e.g., *“Reduction in severe, as well as moderate malnutrition among under-5 children by half”*, *“Reduction of iron deficiency anaemia in women by one third”*, *“Virtual elimination of iodine deficiency disorders and “Virtual elimination of vitamin A deficiency and its consequences including blindness”*. (33) The Government of Nepal has committed to several nutritional targets during the last decades, to improve the nutritional health of the Nepalis population (3). Current targets are the Global Nutrition Targets and the Sustainable Development Goals (SDGs), to be achieved by 2025 and 2030 respectively (34).

### Global Nutrition Targets

The World Health Assembly developed in 2012, six global nutritional goals to improve the nutritional status among newborns, children, and women including e.g., *“40% reduction in the number of children under-5 who are stunted”*, *“50% reduction of anemia in women of reproductive age”* and *“reduce and maintain childhood wasting to less than 5%”* (35).

### Sustainable Development Goals

In the year of 2016, following the previous Millennium Development Goals (36), seventeen SDGs were established by the UN, with the nutritional target to *“End hunger, achieve food security and improved nutrition and promote sustainable agriculture”* to be achieved by 2030, which includes the global nutrition targets regarding stunting, anemia and wasting for 2025 (37).

## Malnutrition

Malnutrition, which includes both undernutrition and overnutrition, refers to an imbalance in the supply of nutrients and dietary insufficiencies, or increased losses of nutrients (38).

Malnutrition affects people worldwide at all ages, but vulnerable groups are newborns,

children at young age and pregnant women (PW). The condition is mostly caused by an inadequate diet or infectious diseases (39). Yet, the cause of severe malnutrition is generally multifactorial, e.g., due to lack of education, poverty, infectious diseases, and unavailability of health care (40). Malnutrition can both directly and indirectly lead to morbidity and mortality, but it is seldom the primary cause of death (39). Usually, infectious diseases are the main cause of both severe morbidity and mortality among severely malnourished children (40). Undernutrition is a term including underweight, wasting, stunting and insufficiencies of micronutrients (MNs) (41). Overnutrition, i.e., an excessive dietary intake of MNs and macronutrients, includes overweight and obesity and can cause non-communicable diseases (NCDs), e.g., diabetes mellitus and cardiovascular diseases (CVDs) (42). According to the Global Nutrition Report from 2020, more than every third adult suffer from overweight or obesity (41). The number of countries that are facing the *double burden of malnutrition*, both undernutrition and overnutrition (41), are increasing, especially in LMICs (43). Food with high amounts of salt, sugar, fat, calories, and low consistency of MNs is more often low-priced and combined with physical inactivity the number of children with obesity are increasing, but the nutritional deficiency remains. (43)

Environmental factors are affecting the prevalence of malnutrition. Different seasons in Nepal also have varied effects on malnutrition, where the monsoon (mid-June to mid-September) and the pre-harvest (mid-September to mid-December) periods are associated with a decreased food availability and are periods where diarrhea are more common, which in turn increases the risk of malnutrition (15). The availability and production of food are affected by e.g., a growing population, infectious diseases spread through vectors and climate changes, which all are contributors to the prevalence of malnutrition (39).

In developing nations, there are major inequalities in child nutrition between urban and rural areas, where children living in rural areas are more vulnerable compared to children living in urban areas. However, due to a growing urbanization, urban areas are facing disparities in nutritional health and an increasing amount of malnutrition among children. (44)

### Forms of malnutrition

There are several manifestations of malnutrition: wasting, stunting and nutritional oedema or *kwashiorkor* (40). Acute malnutrition in children is divided into moderate acute malnutrition and severe acute malnutrition (SAM) (45). The latter includes severe wasting, or marasmus, and kwashiorkor. Edema is the one clinical symptom that differentiate between marasmus and

kwashiorkor. If these two conditions are present at the same time, the condition is called *marasmic kwashiorkor* (45). The prevalence of undernutrition in Nepal has remarkably improved during the last decades. Since 2001, the prevalence of both stunting and underweight have gradually reduced, in contrast to wasting where the prevalence has remained more static (3), and fluctuant overtime (46).

SAM can lead to complications such as sepsis, pneumonia, severe diarrhea, hypothermia, and hypoglycemia among others. In case of SAM with complications, the child needs hospital care. Otherwise, the child can be treated with specific therapeutic food recommended by the World Health Organization (WHO), consisting of e.g., vitamins, peanuts past and milk powder, which often are available in the society. In contrast, children with moderate acute malnutrition can mainly be treated at home with nutritious food and/or breastfeeding. During the initiation of treatment of SAM, the intake of glucose should not be too rapid. A rapid increase of glucose might cause *refeeding syndrome*, a severe and deadly condition causing an imbalance of electrolytes such as low concentrations of magnesium, potassium, and phosphate, which negatively affects the heart muscle's ability to contract. (45)

#### Stunting

Stunting, *low height-for-age*, is defined as a height-for-age Z-score (HAZ) < (below) -2 standard deviations (SD) from the *WHO growth reference* for children (41). The condition is caused by deficiencies under the child's two first years of life and results in a reduced growth (47), and is a result of chronic malnutrition (48). Stunting is associated with several factors such as infectious diseases, poverty, maternal malnutrition during pregnancy, inappropriate feeding practices including breastfeeding and complementary feeding causing micronutrient deficiencies (MNDs), lack of safe drinking water and sanitation (49). Important is that stunting indicates a failure of growth in the past. Interventions for stunted children under the age of two years are more likely to have a desired response, in comparison to children older than two, where the condition is more likely to be irreversible. (47)

#### Wasting

Wasting, *low weight-for-height*, is in comparison to stunting an indicator of an acute or present nutritional deficiency (47) and is defined as a weight-for-height Z-score (WHZ) < -2 SD from the *WHO growth reference for children* (41), where the reference consists of the weight of a child with the same sex and length (50). The condition is, like stunting, caused by infectious diseases, deficiency in feeding practice or lack in food consumption (49). Severe

wasting, or *marasmus*, is strongly related to mortality (40) and hurried actions are in need (51). Marasmus, the most common condition of SAM, occurs when the insufficient energy consumption lasts for a longer period, months to years. Characteristic of the condition is wasting of subcutaneous fat and muscles. Most vulnerable are children under five years of age, which will be affected with fatigue and weakness, their skin will be loose, dry, and wrinkled. The condition is also related with hypotension, hypothermia, and bradycardia. (45)

#### Underweight

Underweight, *low weight-for-age* is defined by WHO as a body mass index (BMI)  $<18.5$   $\text{kg/m}^2$  for adults. A BMI  $<17.0$   $\text{kg/m}^2$  is equal to moderate or severe thinness and a BMI  $<16.0$   $\text{kg/m}^2$  leads to a significantly increased risk for harmful effects on health and could be deadly. (52) For children aged 6 to 59 months, underweight is instead defined by SD in relation to *WHO growth reference*, where underweight is defined as a weight-for-age Z-score (WAZ)  $< -2$  SD from the *WHO growth reference* (40). Underweight can indicate current or past malnutrition, in other words, both wasting and/or stunting, in combination with low body mass (47). The risk of mortality is increased for underweighted children, proportionally to the severity of the condition (52).

#### Overweight and obesity

Overweight is defined by WHO as a BMI  $\geq$  (equal to or above)  $25$   $\text{kg/m}^2$  for adults. For children overweight is, like underweight, defined by SD above the *WHO growth reference*, where overweight for children under five are defined as a weight  $>$  (above)  $+2$  SD. Obesity is defined by WHO as a BMI  $\geq 30$   $\text{kg/m}^2$  for adults. For children until an age of five is defined as a weight  $> +3$  SD. (43)

#### Micronutrients and Micronutrient Deficiency

MNs are vitamins and minerals essential for several functions in the body. MNDs indicated a lack of these MNs of importance e.g., to produce hormones and enzymes required for adequate development and growth. (53) Fruits, vegetables, and animal products are highly consistent of MNs. A lack of intake of these products are commonly due to local or economic unavailability. In contrast to deficiencies in macronutrients; proteins, carbohydrates, and lipids, MNDs are associated with fewer clinical symptoms that first are noticed when the deficiency is severe. Therefore, MNDs is also called “hidden hunger”. (54) The needed daily amount of MNs are small, which also indicates that MNDs rather easily could be treatable and preventable (53).

Three MNDs, with severe consequences, are deficiencies in iodine, vitamin A and iron. The latter is the most common nutritional deficiency worldwide. (55) Another example of a MND, that might have harmful effects on health, is deficiency in folic acid (54). Folate deficiency has negative effects on the fetus as well as the newborn child, and can e.g., cause neural tube defects including *anencephaly* (a serious and mostly deadly condition in infants) and *spina bifida*, a serious but more various condition (56).

## Anemia

*Anemia* is a condition that occurs when the concentration of hemoglobin (Hb), an oxygen-carrying protein, falls below normal levels and is thereby unable to meet the physiological need. The WHO has defined different cut-off points which differ according to gender and age (see Table 1). Children aged 6 to 59 months are anemic when the Hb-concentration falls <11.0 grams/deciliter (g/dL). For non-pregnant women (NPW) the cut-off point is <12.0 g/dL and for PW <11.0 g/dL. (57)

Table 1: The WHO's definition of anemia

	Non-anemia <sup>a</sup>	Mild anemia <sup>a</sup>	Moderate anemia <sup>a</sup>	Severe anemia <sup>a</sup>
Children 6-59 months	≥ 11.0	10.0-10.9	7.0-9.9	< 7.0
NPW (>15 years)	≥12.0	11.0-11.9	8.0-10.9	< 8.0
PW (>15 years)	≥ 11.0	10.0-10.9	7.0-9.9	< 7.0

<sup>a</sup> Hemoglobin (Hb) in g/dL, NPW = non-pregnant women, PW = pregnant women

Source: World Health Organization, *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity*. 2011 (58)

Anemia affects people of all ages throughout the world and is caused by blood loss, hemolysis, and insufficient erythropoiesis and the condition might have a negative effect on child development, premature birth, or low birthweight (LBW). Anemia is also associated with an increased risk for both perinatal and maternal mortality. The latter could be caused by nutritional insufficiencies, most commonly a lack of iron, alongside with deficiencies in vitamin A, vitamin B12 and folate which all are involved in the erythropoiesis or the synthesis of hemoglobin. Anemia caused by nutritional deficiencies are called *nutritional anemias*. (49)

## Iron Deficiency Anemia

*Iron* is a MN essential for both the erythropoiesis and hemoglobin, and lack of iron causes eventually a *microcytic* and *hypochromic* anemia called iron deficiency anemia (IDA). IDA is the most common MND in Nepal and occurs when the dietary intake of iron is insufficient to fulfill the required need. Women of reproductive age (WRA), adolescents, children of young age and newborns are especially vulnerable due to the increased need of iron because of the

rapid development and growth during this period. (49) The condition does not only impact physical and cognitive development, it is also associated with an elevated risk for LBW and premature birth, especially during the first two trimesters, as well as an increased risk of maternal, early child mortality during pregnancy and labor. (59) Iron deficiency can also be caused by e.g., menstruation or by blood loss secondary to parasite infection. Hookworms, which is an intestinal helminths transmitted through soil, are examples of parasites that can cause both IDA and blood loss (49). In LMICs, including Nepal, parasitic infections are common. Therefore, deworming tablets have been nationally implanted in the NVAP in Nepal nationwide for children aged 12 to 59 months as well as for children aged 6 to 11 years and for PW (14). Adolescent girls and WRA also are at risk to develop IDA due to regular blood loss, and thereby iron losses, during menstruation. Teenage pregnancy is crucial due to the increased need of iron to meet the own, as well as the developing infants, need for growth. (49)

Annually, it is estimated approximately 20% of all maternal mortality is related to IDA during pregnancy (54). As a part to prevent anemia among women, supplementation of iron and folic acid (IFA) was implanted in Nepal 2002. The program includes supplementations of IFA, from the second trimester of pregnancy till 45 days post-delivery, to all PW. (14) Iron supplementation decreases the LBW risk but has not an significant effect on preventing premature birth. (49)

#### Iodine Deficiency

*Iodine*, a MN mostly contained from water and vegetables grown in soil rich in iodine (60). Iodine is essential for people of all ages (60), and is needed for the thyroid hormone synthesis crucial for an adequate metabolism, development, and growth (15). A lack of iodine causes conditions such as hypothyroidism, enlargement of the thyroid gland and cretinism among others. Since iodine to nearly 90% is excreted in the urine the iodine status could be measured by a urine sample. (15) The WHO has defined cut-off values for iodine deficiency (ID) varying by age (see Table 2) where a urinary iodine concentration (UIC)  $<100 \mu\text{g/L}$  is insufficient and  $\text{mUIC} \geq 300 \mu\text{g/L}$  is excessive. For PW an UIC  $<150 \mu\text{g/L}$  is insufficient and  $\text{UIC} \geq 500 \mu\text{g/L}$  is excessive. (61) Mostly, an iodine intake above the excessive level is well tolerated but can increase the risk for thyroid dysfunction including both hypothyroidism and hyperthyroidism, thyroid enlargement, and autoimmune thyroid disorders which often are

temporary and gentle. However, in some cases, iodine-induced hyperthyroidism could be deadly. (62)

Table 2: The WHO's cut-off points for iodine deficiency

Median UIC <sup>a</sup>	Adequate iodine nutrition	Mild iodine deficiency	Moderate iodine deficiency	Severe iodine deficiency	Above requirements	Excessive
Children ≥ 6 years old	100-199	50-99	20-49	<20	200-299	≥ 300
Pregnant women	150-249	<150 = insufficiency			250-499	≥ 500

<sup>a</sup>Urine iodine concentration (UIC) in micrograms per liter (µg/L)

Source: World Health Organization. *Urinary iodine concentrations for determining iodine status deficiency in populations*. 2013 (63)

ID could cause harmful consequences for human health, conditions called iodine deficiency disorder (IDD) (64). Globally, IDD is the endocrine disorder that is the most common (60) and since a small amount of iodine is required, IDDs are avoidable conditions. Lack of iodine could cause mental impairment and deficiencies during pregnancy and infancy, especially when occurring from the second trimester until an age of three. The condition increases the risk of child mortality, miscarriage, and cretinism. (64) The latter, a condition caused by ID during pregnancy (15), could cause severe neurological dysfunctions such as deaf mutism, spastic diplegia and mental impairment (60).

Enlargement of the thyroid gland, *Goitre*, is a condition mostly caused by inadequate amounts of dietary iodine and can affect people worldwide. This condition is mostly asymptomatic because the function of the thyroid gland is sufficient, but a severe enlargement can lead to obstruction of the airways. Of certain concern are thyroid enlargement among WRA due to the severe consequences occurring from ID during the fetal period. (65)

The *universal salt iodization program* (USI) was implanted during the 1970s (15) in Nepal to defeat this threat to the health of the Nepalese people by making sure that all salts imported contained an adequate amount of iodine. The USI program has the universal goal of a coverage where more than nine out of ten households use iodized salt. (64) An adequate level is >15 parts per million (ppm) and <40 ppm (66). Different types of salt differ on the iodine concentration. Finer salts, *crushed* and *refined* varieties, are more consistent of iodine in comparison to salt containing larger crystals, like *phoda* salt. (15)

#### Vitamin A Deficiency

*Vitamin A* is a MN essential for epithelial tissue and the immune system (67). Vitamin A deficiency (VAD) could cause harmful consequences including blindness and increases the

risk of severe infections, urinary tract infections and prolongs the duration of the infection (68). It is stated, from an article from 2000, that VAD causes irreversible blindness to 2,500 children and the death of approximately 9,000 children annually in Nepal (69). VAD is caused by an insufficient intake during a longer time that will obliterate the liver stores. Vitamin A is also transferred from the mother to the infant by breast milk and during the first time of life, lactating is the only source of vitamin A for many newborns. After 4 to 6 months of age the infants need supplementary food to achieve the acquired amount. (68) The WHO defines VAD based on the level of retinol (the primary form of vitamin A in the blood), as when the serum retinol level falls  $<0.70 \mu\text{mol/L}$  (see Table 3) (70).

Table 3. The WHO's cut-off points for Serum-Retinol and Modified Relative Dose Response (MRDR)

	Deficiency	Subclinical deficiency	Severe deficiency
S-Retinol – all ages	$<0.70^a$	$0.35-0.69^a$	$<0.35^a$
MRDR – all ages	$\geq 0.060$ – indicates insufficient vitamin A liver reserves <sup>b</sup>		

<sup>a</sup> Serum Retinol in micromole per liter ( $\mu\text{mol/L}$ )

<sup>b</sup>MRDR (Modified Relative Dose Response) – measures the vitamin A liver store (14)

Source: World Health Organization. *Serum retinol concentrations for determining the prevalence of vitamin A deficiency in populations*. 2011. (70) and the Nepal National Micronutrient Status Survey 2016 (14).

A deficiency of vitamin A may cause *xerophthalmia*, dry eyes, due to a dysfunction of tear production, and is considered the most common complication of VAD. Xerophthalmia can progress to more severe ocular manifestations including e.g., *night blindness (XN)* and *keratomalacia*. Excluding the scars occurring from the ulcerations of the deep corneal tissue, these eye conditions are all treatable and reversible. But xerophthalmia could also cause harmful outcomes including blindness and are associated with an increased risk of sepsis and fatality. The condition often appears when the vitamin A level falls  $<0.7 \mu\text{mol/L}$  but can occur earlier. S-Retinol levels  $<0.35 \mu\text{mol/L}$  are more severe and harmful. It is believed that the mortality risk of VAD is present before the clinical manifestations appear. (68)

*Night blindness*, the first manifestation of VAD, occurs due to the fact that vitamin A is essential for the retina, more specifically to produce the light receptor rhodopsin in the rods (71). In children, the condition can be detected by the fact that they have difficulties finding their toys or food and are more sedentary after dark. Positive is that the condition responds to the therapy of vitamin A within 48 hours without sequelae. (68)

A deficiency in vitamin A could also cause anemia, not only by its immune function but also because of its modulating effects on the erythropoiesis and due to its function to mobilize the stored iron. In opposite to IDA, anemia caused by VAD leads to an elevated amount of serum ferritin. (49)

Similarly, to other MNDs, VAD is a condition that can be prevented. Nepal is a country where VAD has been widespread with a high mortality rate in children. (72) Therefore, the NVAP was initiated in Nepal in 1997 to defeat this deficiency and its consequences for the Nepalese people. Five years later, in 2002, the program was nationally implanted by the help of the FCHVs where children aged 6 to 59 months receive supplementation of vitamin A capsules twice a year. (14)

### Food security and food practice in Nepal

In Nepal, a major part of the diet consists of rice and bread, which do not contain MNs (54). The Nepalese diet is mainly vegetarian, including pulses and grains. Generally, meat is consumed on specific occasions but dairy products are more usual (15). Food security is measured by the Food Insecurity Experience Scale and is defined as the equal accessibility of adequate food to all people to maintain health and activity (73). Food insecurity is divided by severity; *mild, moderate, and severe insecurity*. In the Nepal National Micronutrient Status Survey (NNMSS) 2016 nearly 16% of the households maintained a mild food insecurity (14), which means that they worry about the accessibility of food often or sometimes (73). Nearly one-fifth of the household stated a moderate food insecurity (14) i.e., where they had to reduce the food consumption by either quantity or quality. By severe food insecurity means that people do not have access to food, suffering from hunger and in the worst case, not being able to eat for several days (73), which 7% of the households experienced in 2016 (14).

### Breastfeeding Practice

In the first months of life the newborn child needs breastfeeding to obtain the most sufficient diet, that includes antibodies and is highly concentrated with nutrients. An inadequate breastfeeding practice is related to malnutrition and mortality. The WHO recommends that breastfeeding is exclusively used until the child reaches an age of six months. Of value is that the newborn is firstly breastfed within the first hour of life since the colostrum consists of high concentrations of antibodies and nutrients. (74) A National Nutritional Policy and Strategy was implemented in Nepal in 2004 where they recommend that complementary food is initiated first after an age of six months in addition to breastfeeding under the first two years of life (75), since an adequate feeding practice is essential to normal growth and development (74). Breastfeeding practices are widespread in Nepal and important because of the low concentration of MNs and energy in the food assumed for children. (14, 15)

## Nepal National Micronutrient Status Survey

The first NMSS report was implemented in 1998 and the second and following survey in 2016. These two surveys reflect the general nutritional status on a subnational and national level among children and women throughout Nepal and clarifies needs where further work are necessary to accomplish the SDGs for 2030 and to evaluate the interventions already implanted. (14, 15)

The work to realize the NMSS 1998 and the NNMSS 2016 were completed by multiple organizations in cooperation with the Ministry of Health (MoH) in Nepal. The surveys were founded by the United Nations Children’s Fund (UNICEF), the United States Agency for International Development (USAID), United States Centers for Disease Control and Prevention (CDC), World Health Organization (WHO) and the European Union (EU) and the logistics and the collection of data was fulfilled by New ERA. (14, 15)

### Aims of the surveys

The aim of the 1998 NMSS was to provide and clarify vulnerable areas of women and children’s nutritional status where Nepal can increase their efforts in order achieve the 1990 WSC: *“the virtual elimination of vitamin A deficiency, iodine deficiency disorders and the reduction in the prevalence of iron deficiency anemia by one third.”* The country also aimed to improve the situation for children by *“reduce the level of stunting by half and the prevalence of babies born with low birth weight by one-third”*. The 2016 NNMSS were completed to continue monitoring the nutritional status in Nepal and clarify how far the country is from realizing the second SDG, *“Zero Hunger”* and the global goals by the World Health Assembly. (14, 15)

### Methodology of the surveys

The sample design, in both the 1998 NMSS and 2016 NNMSS, were based on clusters from the three ecological regions and the five development regions by multistage cluster sampling. One cluster was formed from a ward, and if one ward alone did not fulfill the minimum cluster size several wards were united to form a cluster. In the 1998 survey a population of 400 individuals was the minimum size of a cluster, compared with the 2016 survey where 100 households were stated as the minimum size and 300 households as the maximum size of a cluster. In case the cluster was too large it was instead split in two or more segments. In the 1998 survey 40 households were randomly selected from each cluster and 24 households from

each cluster in the 2016 survey were invited which resulted in a total of 390 clusters and 15,600 households in the 1998 survey and a total of 180 clusters and 4,329 households in the 2016 survey. In the 1998 survey the inclusion criteria were that the household should contain a woman and at minimum one child with an age of 6 to 59 months. Totally, 48,621 persons participated in the NMSS from 1998 and 8088 persons in the NNMSS 2016. Because the cluster sampling design selected the same number of individuals and households for each cluster or region, sample weight was used provide a proper evaluation of each population group. (14, 15)

In the NMSS 1998 the data collection process stretched from the 22<sup>nd</sup> of December until the 14<sup>th</sup> of July. In the NNMSS 2016 survey the data collection period stretched over a shorter time, from the 1<sup>st</sup> of April until the 25<sup>th</sup> of June 2016. The fieldwork included questionnaires, measure of weight and length and collection of samples from the blood, urine, and feces. Since the concentration of hemoglobin is increased among people living on higher altitudes, an adjustment for hemoglobin was carried out of samples from the participants living on or above 1000 meters above sea level in both surveys (see Table 4). In the NNMSS 2016 an adjustment for smoking was also carried out. (14, 15)

**Table 4: The WHO’s recommended adjustment for hemoglobin due to high altitudes.**  
*The table describes how much of the Hb-concentration that needs to be reduced since the concentration of hemoglobin rise with high altitudes.*

Adjustment of Hb <sup>a</sup>	Meters (m) above sea level								
	<1000	1000	1500	2000	2500	3000	3500	4000	4500
	0	-0.2	-0.5	-0.8	-1.3	-1.9	-2.7	-3.5	-4.5

<sup>a</sup> Hemoglobin (Hb) in grams/liter (g/dL)  
 Source: World Health Organization, *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity*. 2011 (58)

The fieldwork was completed by recruited staff, who completed training before the fieldwork was initiated. The training included e.g., education of the methodology of the surveys, testing of the questionnaires, sample collection, anthropometric measurements and ethical considerations. The data were analyzed using Chi-square test and confidence intervals (CI) where a significant result was defined as a p-value below 0.05. (14, 15)

*Survey populations groups*

The population groups of the surveys differ between 1998 and 2016. In the 1998 survey the population groups were divided into children aged 6 to 59 months (preschool children), children aged 6 to 11 years (school-aged children), and women aged 15-49 years (women of reproductive age). In the 2016 survey the population groups were instead divided into children aged 6 to 59 months, children aged 6 to 9 years, adolescent boys, and adolescent girls

aged 10 to 19 years, PW aged 15 to 49 years and NPW aged 15 to 49 years. The survey defined that in case of a girl would be selected into both the group of NPW and the group of adolescent girls the data were analyzed in both groups. (14, 15)

### *Questionnaires*

Questionnaires were used in the surveys under an interview to gather information regarding a household level, for example household facilities and on an individual level including socio-demographic, socio-economic and nutritional and dietary factors. The 1998 survey consisted of six questionnaires regarding: “*Household socio-economic questionnaire*”, “*Individual level questionnaire for mother and preschool children*”, “*Lab questionnaire*”, “*Clinical questionnaire*”, “*Individual questionnaire for the school-aged children*” and “*24 Hour Dietary recall Vitamin A intake and summary*”. The 2016 survey consisted of six questionnaires, one for the household and one formed for each specific population group. (14, 15)

### Aim of this survey

The purpose of this study was to elucidate the burden of micronutrient deficiencies and the nutritional status among children aged 6 to 59 months and women of reproductive age by comparing the results from the National Micronutrient Status Survey 1998 and Nepal National Micronutrient Status Survey 2016.

#### Primary research questions

Has there been an improvement of the nutritional health in Nepal between 1998 and 2016 among children and women of reproductive age regarding micronutrient deficiencies; anemia, iodine, and vitamin A and nutritional status: stunting, underweight and wasting?

What are the variations in prevalence of micronutrient deficiencies and nutritional status in the different ecozones and in urban and rural locations between 1998 and 2016?

#### Secondary research question

Have the National Vitamin A program and the Universal Salt Iodization Program, interventions against micronutrient deficiencies, been effective?

## Material and Methods

### Study design

The NMSS 1998 and the NNMSS 2016 were analyzed retrospectively to compare the prevalence of micronutrient deficiencies and the nutritional status among children and women in Nepal between 1998 and 2016.

### Study population

The primary study population was children aged 6 to 59 months and women of reproductive age (15 to 49 years), pregnant, and non-pregnant. Children of older age and adolescents were excluded from the study due to different divisions of age between the NMSS 1998 and NNMSS 2016, with one exception. The concentration of urinary iodine was detected among children aged 6 to 11 years in the NMSS 1998 and children aged 6 to 9 years in the NNMSS 2016, therefore this exception from the primary study population.

### Studied variables

The prevalence of anemia and VAD among children aged 6 to 59 months and WRA and the prevalence of ID among children aged 6 to 9 (-11) years and WRA, studied on a national level, by ecological region and between urban and rural location.

The coverage of the NVAP was studied through the number of children aged 6 to 59 months who received a vitamin A capsule in the last distribution and the prevalence of XN was studied during the last pregnancy. The effect of the USI program was evaluated through the iodization level in salt and through which salt that was mainly used in each household.

Nutritional statuses are evaluated through the anthropometric measures for children aged 6 to 59 months and for WRA. For children the nutritional status was measured by height-for-age Z-score (HAZ), weight-for-age Z-score (WAZ) and weight-for-height Z-score (WHZ) in comparison to the WHO growth reference. For WRA nutritional status was instead measured by BMI.

### Data collection procedure

The Nepal Micronutrient Status Survey 1998, the starting point of this study, was analyzed and compared to the Nepal National Micronutrient Status Survey 2016. An initial selection of chapters relevant for the research question was performed, where chapter 1-4, 8 and 9 in the NMSS 1998 were considered non-prevalence for the research question and therefore

excluded. Included chapters were systematically reviewed and tables meeting the research question were separated into an excel-file. Tables in the included chapters that were non-relevant for the research question, not presenting data or tables with non-comparable data to the NNMSS 2016 were excluded. A selection of data presented in the included chapters were performed with an inclusion of data regarding ecological regions, national level and by urban or rural location. Presented data, of which were considered non-relevant for the research question were excluded, e.g., other age groups and stratum. In cases where the data were presented in the NMSS 1998 and the NNMSS 2016 were presented differently but an analysis could be possible, a modification was performed to include the data. All modifications are presented in the concerned tables (see Figure 3).

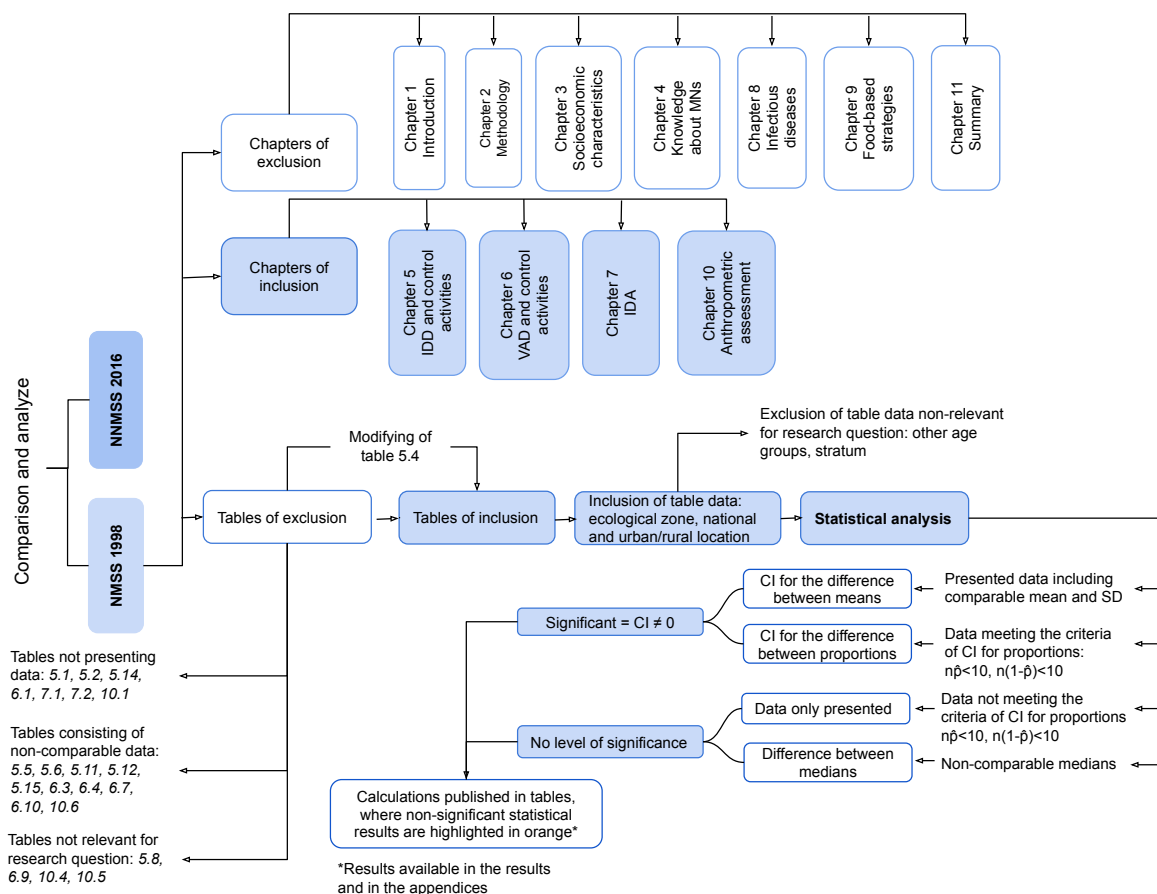


Fig 3: A flowchart over the study design from start to end - starting to the left with the NMSS 1998 and NNMSS 2016. Boxes consisting of included chapters and tables are blue and the boxes consisting of excluded chapters and tables are white. (Self-designed). Abbreviations: NMSS, National Micronutrient Status Survey 1998; NNMSS, Nepal National Micronutrient Status Survey 2016; IDD, Iodine Deficiency Disorder; VAD, Vitamin A Deficiency; IDA, Iron Deficiency Anemia; CI, Confidence Interval; n, sample size;  $\hat{p}$ , sample proportion

## Statistical and data analysis

Since the data from the NMSS 1998 and NNMSS 2016 mainly consisted of aggregated data on a national and subnational level “*Confidence Interval (CI) for the Difference between proportions*” were used as the main statistical analysis method. The level of significance used was CI 99% in all analyses, and the results were considered statistically significant if the calculated CI between proportions did not include 0. For data not meeting the criteria for CI for proportions, i.e., if the data did not fulfill the criteria for normalization with at least 10 successes and 10 failures ( $n\hat{p} < 10$ ,  $n(1-\hat{p}) < 10$ ), CI could not be calculated. For data consisting of comparable means and standard deviations (SD) “*CI for the difference between means*” was performed with a CI of 99%. For data consisting of non-comparable medians, due to lack of SD, the difference between medians was calculated separately, without statistical significance (see Figure 3). Since the study consists of 131 tests, it is estimated that two type 1 errors are present, i.e., falsely significant.

The webpage Mathcracker, an online calculator, was used to perform the calculations of “CI for the difference between proportion” (76) and “CI for the difference between means” (77). Additionally, analysis of Post-hoc Power (P) was fulfilled to determine if a non-significant result might be due to small population size. The P-calculations were performed online on the Clinical Calculator (78).

### Formulas used for statistical analyses

Confidence Interval for the Difference between Proportions

$$CI = \left( \hat{p}_1 - \hat{p}_2 - z_c \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{N_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{N_2}}, \hat{p}_1 - \hat{p}_2 + z_c \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{N_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{N_2}} \right)$$

Confidence Interval for the Difference Between Means

$$CI = \left( \bar{X}_1 - \bar{X}_2 - z_c \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}, \bar{X}_1 - \bar{X}_2 + z_c \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \right)$$

Formula for power calculations

$$Power = \Phi \left\{ \frac{\Delta}{\sqrt{p_1q_1/n_1 + p_2q_2/n_2}} - z_{1-\alpha/2} * \frac{\sqrt{\bar{p}\bar{q}(1/n_1 + 1/n_2)}}{\sqrt{p_1q_1/n_1 + p_2q_2/n_2}} \right\}$$

## Student's contribution

Since the dataset in the NMSS 1998 and the NNMSS 2016 consists of aggregated published data, my contribution has been to select and compare relevant data from these surveys.

Thereafter, by using statistical analysis, calculate the level of significance and interpret the results.

## Ethics

The NMSS 1998 and the NNMSS 2016, which form the basis for this study, are available for public use and the participants of the NNMSS 2016 participated in the study under informed consent. The former entails that a second ethical approval is not mandatory.

## Results

### Anemia

The prevalence of anemia among children aged 6 to 59 months has decreased on a residential, subnational, and national levels between 1998 and 2016, statistically significant. Nationally, there has been a decrease of nearly 60 pp (-58.9 pp, CI 99%, -61.9, -55.9) to 19.1% regarding the total prevalence of anemia (see Table 5.1) and a nearly 70 pp decrease in the prevalence of moderate anemia (-69.6 pp, CI 99%, -71.9, -67.3) to 5.3% (see Table A1).

*Table 5.1. The total prevalence of anemia among children aged 6-59 months between 1998 and 2016*

A table of the results regarding the total number of anemias among children 6 to 59 months. The complete table is presented in the **appendix table A1**.

	Prevalence of anemia (%)				Difference in pp [CI 99%]	P%
	1998		2016			
	n	Hb <11.0 g/dL	n	Hb < 11.0 g/dL		
Terai	1820	79.7	696	23.0	-56.7 [-61.5, -51.9]	100
Hill	1778	76.2	687	14.8	-61.4 [-65.8, -57.0]	100
Mountain	302	78.9	268	16.5	-62.4 [-70.8, -54.0]	100
<b>National</b>	<b>3900</b>	<b>78.0</b>	<b>1651</b>	<b>19.1</b>	<b>-58.9 [-61.9, -55.9]</b>	<b>100</b>
Urban	428	72.0	211	22.6	-49.4 [-58.7, -40.1]	100
Rural	3471	78.8	1440	18.8	-60.0 [-63.2, -56.8]	100

Abbreviations: n, sample size; Hb, hemoglobin; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

For NPW the prevalence of anemia has decreased significantly on all levels. Nationally there has been a decrease of -58.2 pp (CI 99%, -60.7, -55.7) to 6.8% of moderate anemia (see Table A2) and -46.3 pp (CI 99%, -49.4, -43.2) to 20.4% of the total prevalence of anemia (see Table

5.2). Likewise, the total prevalence of anemia among PW had a significant decrease of -47.8 pp (CI 99%, -57.5, -38.1) to 26.8% nationally (see Table 5.3).

**Table 5.2. The total prevalence of anemia among non-pregnant women 15-49 years of age between 1998 and 2016**

A table of the results regarding the total number of anemias among non-pregnant women 15-49 years of age. The complete table is presented in the **appendix table A2**.

	Prevalence of anemia (g/dL) (%)				Difference in pp [CI 99%]	P%
	1998		2016			
	n	Hb < 12.0 g/dL	n	Hb < 12.0 g/dL		
Terai	1612	72.6	885	29.1	-43.5 [-48.4, -38.6]	100
Hill	1562	61.1	895	11.6	-49.5 [-53.7, -45.3]	100
Mountain	263	65.0	356	11.1	-53.9 [-62.6, -45.2]	100
<b>National</b>	<b>3437</b>	<b>66.7</b>	<b>2136</b>	<b>20.4</b>	<b>-46.3 [-49.4, -43.2]</b>	<b>100</b>
Urban	393	62.3	294	18.0	-44.3 [-52.8, -35.8]	100
Rural	3042	67.3	1842	20.8	-46.5 [-49.8, -43.2]	100

Abbreviations: n, sample size; Hb, hemoglobin; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

**Table 5.3. The total prevalence of anemia among pregnant women 15-49 years of age between 1998 and 2016**

A table of the results regarding the total number of anemias among pregnant women 15-49 years of age. The complete table is presented in the **appendix table A3**.

	Prevalence of anemia (%)				Difference in pp [CI 99%]	P%
	1998		2016			
	n	Hb < 11.0 g/dL	n	Hb < 11.0 g/dL		
Terai	193	80.3	94	36.4	-43.9 [-58.8, -29.2]	100
Hill	190	68.4	88	15.6	-52.8 [-66.0, -30.6]	100
Mountain	35	77.1	22	*	**	**
<b>National</b>	<b>418</b>	<b>74.6</b>	<b>204</b>	<b>26.8</b>	<b>-47.8 [-57.5-38.1]</b>	<b>100</b>
Urban	33	51.5	24	*	**	**
Rural	385	76.6	180	27.7	-48.9 [-59.1, -38.7]	100

Abbreviations: n, sample size; Hb, hemoglobin; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

\*Data not presented in the NNMSS 2016

\*\* Due to lack of data, these results could not be presented

## Iodine Deficiency

In 1998 the mUIC among children aged 6 to 11 years was 143.8 µg/L. By 2016 the mUIC among children aged 6 to 9 years had increased to 314.1 µg/L. Due to lack of information on SDs the level of significance could not be presented. The difference in mUIC indicates a national increase of approximately 120%. In 1998, the Terai was the ecological region with the lowest mUIC 108.9 µg/L. In 2016 the mUIC in the Terai had increased to 368.9 µg/L, i.e., the ecological region with the highest mUIC and the Mountain had the lowest mUIC on 238.5 µg/L (see Table 6.1).

**Table 6.1. Urinary iodine status among children aged 6-11 years in 1998 and children aged 6-9 years in 2016 between 1998 and 2016**

A table of the results regarding mUIC among children aged 6-11 years in 1998 and 6-9 years in 2016. The complete table is presented in the **appendix table B1**.

	Median Urinary Iodine Concentration				Ratio between medians [mUIC 2016/mUIC 1998]
	1998		2016		
	n	mUIC (µg/L)	n	mUIC (µg/L)	
Terai	667 <sup>a</sup>	108.9	481 <sup>c</sup>	368.9	368.9/108.9 = 3.388
Hill	660 <sup>a</sup>	183.0	476 <sup>c</sup>	294.7	294.7/183.0 = 1.610
Mountain	113 <sup>a</sup>	196.6	177 <sup>c</sup>	238.5	238.5/196.6 = 1.213
<b>National</b>	<b>1450<sup>a</sup></b>	<b>143.8</b>	<b>1134<sup>c</sup></b>	<b>314.1</b>	<b>314.1/143.8 = 2.184</b>
Children 6-9 years	1125	141.55 <sup>b</sup>	1134 <sup>c</sup>	314.1	314.1/141.55 = 2.219
Urban	220 <sup>a</sup>	259.0	143 <sup>c</sup>	341.8	341.8/259.0 = 1.320
Rural	1230 <sup>a</sup>	133.7	991 <sup>c</sup>	313.7	313.7/133.7 = 2.346

Abbreviations: n, sample size; mUIC, median urinary iodine concentration (µg/L)

<sup>a</sup> Children aged 6-11 years in the NNMSS 1998

<sup>b</sup> Mean of the medians from children aged 6,7,8 and 9 years in the NNMSS 1998

<sup>c</sup> Children aged 6-9 years in the NNMSS 2016

For WRA, PW and NPW, the national level of mUIC has increased from 114.1 µg/L in 1998 to 263.75 µg/L in 2016, i.e., an increase by 130%. The Terai was the ecological zone which had the lowest median in 1998 at 85.0 µg/L which had increased to 278.4 µg/L in 2016. Due to lack of information of SDs could the level of significance not be presented. For NPW the mUIC had increased from 112.0 µg/L in 1998 to 286.2 µg/L in 2016 and for PW the mUIC has increased from 134.0 µg/L to 241.3 µg/L (see Table 6.2).

**Table 6.2. Urinary iodine status among non-pregnant and pregnant women aged 15-49 years between 1998 and 2016**  
A table of the results regarding mUIC among non-pregnant and pregnant women. The complete table is presented in the appendix table B2.

	Median Urinary Iodine Concentration (µg/L)				Ratio between medians [mUIC 2016/mUIC 1998]
	1998		2016		
	n	mUIC (µg/L)	n	mUIC (µg/L)	
Terai	613	85.0	973	278.4 <sup>a</sup>	278.4/85.0 = 3.275
Hill	598	142.7	981	241.6 <sup>a</sup>	241.6/142.7 = 1.693
Mountain	102	168.6	378	280.3 <sup>a</sup>	280.3/168.6 = 1.663
<b>National</b>	<b>1313</b>	<b>114.1</b>	<b>2332</b>	<b>263.75<sup>a</sup></b>	<b>263.75/114.1 = 2.312</b>
NPW	1169	112.0	2129	286.2	286.2/112 = 2.555
PW	132	134.0	203	241.3	241.3/134.0 = 1.801
Urban	193	205.0	320	290.45 <sup>a</sup>	290.45/205 = 1.417
Rural	1120	105.0	2012	259.55 <sup>a</sup>	259.55/105 = 2.472

Abbreviations: n, sample size; mUIC, median urinary iodine concentration; NPW, non-pregnant women; PW, pregnant women

<sup>a</sup> The calculated mean of the medians of non-pregnant women and pregnant women in the NMSS 2016 regarding iodine status.

### Salt iodization

Nationally, the *phoda* salt was the most used salt by the households in 1998, with a prevalence of nearly 63%. In comparison to the *crushed* salt and *refined* salt, which had a prevalence of 4.8% and 9.8% respectively. In 2016, the use of *phoda* salt had decreased to nearly 12% nationally (-50.8 pp, CI 99%, -52.4, -49.2). The highest prevalence was found in the Mountain region at 24.1%. Instead, the use of *refined* salt had increased to 87.6% on a national level in 2016, and in Terai the prevalence was 95.7% (+87.8 pp, CI 99%, 86.3, 89.3). The use of *refined* salt was 53.9% in the Mountain, which also had an increased use of *crushed* salt of nearly 32%. In 2016, urban areas used the *refined* salt by 97.9% and the *phoda* salt by 2.4%. In contrast to rural areas where 86 % of the households are using *refined* salt and 13.4% of the households are using *phoda* salt (see Table B3).

Additionally, the *phoda* salt had the lowest concentration of iodine in 1998 and 2016 (see Appendix table B4). In the Terai nearly 31% of the *phoda* salt had no iodine, and 15.4% in the Hill and 14.7% in the Mountain had no iodine in 1998. In 2016, this number had increased to 20.6% in the Hill and decreased to 11.4% in the Mountain. Among all the collected salt samples in 1998, 17.2% of the salt was not iodinated. In 2016, this number had decreased significantly to 3.5% (-13.7 pp, CI 99%, -15.0, -12.4). The largest decrease was found in the Terai by almost 19 pp (-18.8 pp, CI 99%, -20.7, -16.9). Additionally, in 2016 67.5% of the collected salt had an iodine level >40 ppm (see Appendix table B4). In urban areas over 80% of the salt had an iodine level >40 ppm (see Table B5).

## Vitamin A Deficiency

The total prevalence of subclinical VAD among children aged 6 to 59 had significantly decreased in all studied parameters. In 1998 the national prevalence was approximately one-third, in comparison to 2016 where the prevalence had decreased to 12.5% (-19.8 pp, CI 99%, -25.1, -14.5). The two ecological zones with the highest prevalence of subclinical VAD in 1998 were the Terai and the Mountain at 40.0% and 35.5% respectively. In contrast to 2016, the two ecological zones with the highest prevalence instead were the Terai at 16.3% and the Hill at 9.2%. On residential level, the decrease was more pronounced in rural areas with a decrease of approximately -21 pp (-20.7 pp, CI 99%, -26.4, -15.0) compared to urban areas with a decrease of -14.2 pp (CI 99%, -28.2, -0.2) (see Table 7.1).

**Table 7.1. Prevalence of subclinical Vitamin A Deficiency among children 6-59 months between 1998 and 2016**

A table of the results regarding VAD among children 6 to 59 months. The complete table is presented in the **appendix table C1**.

	Prevalence of subclinical VAD (%)				Difference in pp [CI 99%]	P%
	1998		2016			
	n	S-retinol <0.70 <sup>a</sup>	n	S-retinol <0.70 <sup>a</sup>		
Terai	375	40.0	277	16.3	-23.7 [-32.4, -15.0]	100
Hill	363	23.4	276	9.2	-14.2 [-21.5, -6.9]	99.5
Mountain	105	35.5	106	6.0	*	*
<b>National</b>	<b>843</b>	<b>32.3</b>	<b>659<sup>b</sup></b>	<b>12.5</b>	<b>-19.8 [-25.1, -14.5]</b>	<b>100</b>
Urban	111	26.1	86	11.9	-14.2 [-28.2, -0.2]	45.8
Rural	733	33.3	573	12.6	-20.7 [-26.4, -15.0]	100

Abbreviations: n, sample size; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

<sup>a</sup> Serum-Retinol in micromol/liter (μmol/L)

<sup>b</sup> Suspected printing error were in the annex 11.21 has a total of 658 individuals.

\*Due to the fact that the presented data did not meet the criteria for using confidence interval the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

The coverage of the NVAP for children aged 6 to 59 months has significantly improved since 1998. The percentage of children receiving a vitamin A capsule has increased from 87.4% in 1998 to 92.1% in 2016 on a national level (+4.7 pp, CI 99%, +2.8, +6.6). Most noticeable is the improvement in urban areas where the number of children who received the vitamin A capsule has increased by 23 pp (CI 99%, +16.3, +29.9), from 67.1% in 1998 to 90.1% in 2016. On a subnational level the coverage had increased by approximately 5 pp each (see Table C2).

The prevalence of subclinical VAD was measured among all women in 1998, both PW and NPW. In the NNMSS 2016 VAD was only measured among NPW. For NPW the prevalence of VAD has decreased by nearly -10 pp (-9.8 pp, CI 99%, -14.0, -5.6). In the total comparison

between all women in 1998 and 2016 the prevalence of VAD was significantly decreased by all studied parameters. Nationally, there has been a decrease from 16.6% in 1998 to 5.2% in 2016 (-11.4 pp, CI 99%, -15.5, -7.3). The ecological region with the lowest prevalence of subclinical VAD in 1998 was the Hill at 10.5%, in contrast to 2016 where the Mountain had the lowest prevalence at 0.1%, which was the ecological region with the highest prevalence of approximately 23% in 1998 (see Table 7.2).

**Table 7.2. Prevalence of subclinical Vitamin A Deficiency among women 15-49 years between 1998 and 2016**

A table of the results regarding VAD among all women aged 15 to 49 years in 1998 and non-pregnant women aged 15-49 years in 2016. The complete table is presented in the **appendix table C2**.

	Prevalence of subclinical VAD (%)				Difference in pp [CI 99%]	P%
	1998		2016			
	n	S-retinol <0.70 <sup>a</sup>	n	S-retinol <0.70 <sup>a</sup>		
<b>NPW</b>	<b>740</b>	<b>15.0</b>	<b>529</b>	<b>5.2</b>	<b>-9.8 [-14.0, -5.6]</b>	<b>100</b>
Terai	375	20.8 <sup>a</sup>	223	8.1	-12.7 [-19.8, -5.6]	100
Hill	362	10.5 <sup>a</sup>	217	2.5	*	99
Mountain	105	22.9 <sup>a</sup>	89	0.1	*	100
<b>National</b>	<b>842</b>	<b>16.6<sup>a</sup></b>	<b>529</b>	<b>5.2</b>	<b>-11.4 [-15.5, -7.3]</b>	<b>100</b>
Urban	112	10.7 <sup>a</sup>	73	8.4	*	16.4
Rural	732	16.0 <sup>a</sup>	456	4.7	-11.3 [-15.6, -7.0]	100

Abbreviations: NPW, non-pregnant women; n, sample size; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

<sup>a</sup> Serum-Retinol in micromol/liter (μmol/L)

\*Due to that the presented data did not meet the criteria for using confidence interval for proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Furthermore, the prevalence of night blindness (XN) during the last pregnancy has significantly decreased in all ecological zones, on a national level, as well as in urban and rural locations. Nationally, the number of women suffering from XN during the last pregnancy has decreased from 16.7% in 1998 to 3.2% in 2016 (-13.5 pp, CI 99%, -15.2, -11.8). The prevalence remains highest in the Terai and the Mountain region, each with a prevalence in 2016 of 6.5% each. In rural areas, the prevalence has decreased by nearly 15 pp, from 18.0% to 3.3% (-14.7 pp, CI 99%, -16.5, -12.9) (see Table C4).

### Nutritional status by anthropometric measures

Between 1998 and 2016, the number of children aged 6 to 59 months who were suffering from *severe stunting* (HAZ <-3 SD) decreased significantly in all the three ecological zones, on a national and rural level. In contrast to urban areas where the amount had increased, but not significantly (+1.7 pp, CI 99%, -4.0, +7.4). Significant decreases were found regarding the total amount of *stunting* (HAZ <-2 SD), including both moderate and severe stunting, by all

studied groups, despite in urban locations where the decrease was not significant (-8.0 pp, CI 99%, -16.2, +0.2). This result was concordant with the mean HAZ, where the mean HAZ where significantly improved in all studied groups, except in urban areas where the mean HAZ had improved by +0.26 units, however non-significant (CI 99%, -0.001, +0.52) (see Table D2). Nationally (see Table 8.1), the prevalence of severe stunting had decreased to 14.8% (-7.3 pp, CI 99%, -9.7, -4.9) and to 35.0% (-19.1 pp, CI 99%, -22.2, -16.0) regarding total amount of stunting. In both 1998 and 2016 the Mountain was the ecological region with the highest prevalence of both stunting and severe stunting.

**Table 8.1. Prevalence of stunting among children 6-59 months of age between 1998 and 2016**

A table of the results regarding stunting among children aged 6 to 59 months between 1998 and 2016. The complete table is presented in the **appendix table D1**. Non-significant results are highlighted in orange.

	Prevalence of stunting (%) <sup>a</sup>						Difference in pp [CI 99%]		P%
	1998			2016					
	n	-3 SD	-2 SD	n	-3 SD	-2 SD	-3 SD	-2 SD	
Terai	8856	20.4	50.7	722	16.2	35.4	-3 SD	-4.2 [-7.9, -0.5]	55.7
							-2 SD	-15.3 [-20.1, -10.5]	100
Hill	7962	22.3	55.5	706	12.3	32.7	-3 SD	-10.0 [-13.4, -6.6]	100
							-2 SD	-22.8 [-27.6, -18.0]	100
Mountain	1354	31.2	66.1	273	18.7	45.3	-3 SD	-12.5 [-19.4, -5.6]	96.2
							-2 SD	-20.8 [-29.2, -12.4]	100
<b>National</b>	<b>17472</b>	<b>22.1</b>	<b>54.1</b>	<b>1701</b>	<b>14.8</b>	<b>35.0</b>	-3 SD	<b>-7.3 [-9.7, -4.9]</b>	<b>100</b>
							-2 SD	<b>-19.1 [-22.2, -16.0]</b>	<b>100</b>
Urban	1913	9.4	36.1	226	11.1	28.1	-3 SD	+1.7 [-4.0, +7.4]	60.8
							-2 SD	-8.0 [-16.2, +0.2]	41.8
Rural	15584	23.6	56.3	1475	15.3	36.0	-3 SD	-8.3 [-10.9, -5.7]	100
							-2 SD	-20.3 [-23.7, -16.9]	100

Abbreviations: n, sample size; pp, percentage points; p, post-hoc power (retrospective power); CI = confidence interval

<sup>a</sup> The prevalence presented below -2SD includes both moderate (-2 SD) and severe (-3 SD) stunting.

The total prevalence of *underweight* (WAZ <-2 SD), including both moderate and severe underweight, among children aged 6 to 59 months had a significant decrease in all the three ecological zones, as well as on a national and by urban and rural location. Nationally, the decrease was -18.1 pp (CI 99%, -21.2, -15.1). For *severe underweight* (WAZ <-3 SD) the decrease was significant on a national level, in rural areas as well as in the Hill and the Mountains. However, a non-significant decrease was found in urban areas (-0.6 pp, CI 99%, -4.5, +3.3) and in the Terai (-2.7 pp, CI 99%, -5.7, +0.3) (see Table 8.2). The mean WAZ (see Table D2) was significantly improved in all groups. Nationally, the mean was improved by +0.5 units (CI 99%, +0.423, +0.577).

**Table 8.2. Prevalence of underweight among children 6-59 months of age between 1998 and 2016**

A table of the results regarding underweight among children aged 6 to 59 months between 1998 and 2016. The complete table is presented in the **appendix table D1**. Non-significant results are highlighted in orange.

	Prevalence of underweight (%) <sup>a</sup>						Difference in pp [CI 99%]		P%
	1998			2016					
	n	-3 SD	-2 SD	n	-3 SD	-2 SD	-3 SD	-2 SD	
Terai	8856	12.3	45.7	722	9.6	32.5	-3 SD	-2.7 [-5.7, +0.3]	31.6
							-2 SD	-13.2 [-17.9, -8.5]	100
Hill	7962	10.3	46.4	706	6.7	23.6	-3 SD	-3.6 [-6.2, -1.0]	71.4
							-2 SD	-22.8 [-27.2, -18.4]	100
Mountain	1354	20.4	59.9	273	9.0	35.0	-3 SD	-11.4 [-16.7, -6.1]	99
							-2 SD	-24.9 [-33.1, -16.7]	100
<b>National</b>	<b>17472</b>	<b>12.0</b>	<b>47.1</b>	<b>1701</b>	<b>8.4</b>	<b>29.0</b>	-3 SD	-3.6 [-5.4, -1.8]	<b>98.2</b>
							-2 SD	-18.1 [-21.2, -15.1]	<b>100</b>
Urban	1913	5.5	30.8	226	4.9	18.9	-3 SD	-0.6 [-4.5, +3.3]	1.1
							-2 SD	-11.9 [-19.1, -4.7]	90.2
Rural	15584	12.8	49.1	1475	8.9	30.5	-3 SD	-3.9 [-5.9, -1.9]	97.8
							-2 SD	-18.6 [-21.9, -15.3]	100

Abbreviations: n, sample size; pp, percentage points; p, post-hoc power (retrospective power); CI, confidence interval

<sup>a</sup>The prevalence presented below -2SD includes both moderate (-2 SD) and severe (-3 SD) underweight.

Nationally, the prevalence of wasted children aged 6 to 59 months (WHZ <-2 SD), including both *moderate* and *severe wasting*, significantly increased from 6.7% in 1998 to 11.3% in 2016 (+4.6 pp, CI 99%, +2.6, +6.6). The prevalence of severely wasted children (WHZ <-3 SD) had increased from 0.5% in 1998 to 2.4% in 2016 (+1.9 pp, CI 99%, +0.9, +2.9). Only one ecological region, the Mountain, had a lower prevalence in 2016 compared to 1998. However, non-significant (-1.0 pp, CI 99%, -5.8, +3.8). Non-significant results were also found regarding severe wasting in the Mountain region (+1.3 pp, CI 99%, -1.1, +3.7) as well as in urban areas by both severe wasting (0.0 pp, CI 99%, -1.4, +1.4) and total wasting (0.0 pp, CI 99%, -4.0, +4.0) (see Table 8.3). Additionally, the mean WHZ was non-significantly improved on a national level (+0.5 units, CI 99%, -0.001, +0.121), as well as by residential level and in the Terai. Only in the Hill ecozone was the mean WHZ significantly improved (+0.14 units, CI 99%, +0.028, +0.252). In contrast to the Mountains where the mean WHZ instead was significantly worse by -0.04 units (CI 99%, -0.146, +0.066) (see Table D2).

**Table 8.3. Prevalence of wasting among children 6-59 months of age between 1998 and 2016**

A table of the results regarding underweight among children aged 6 to 59 months between 1998 and 2016. The complete table is presented in the **appendix table D1**. Non-significant results are highlighted in orange.

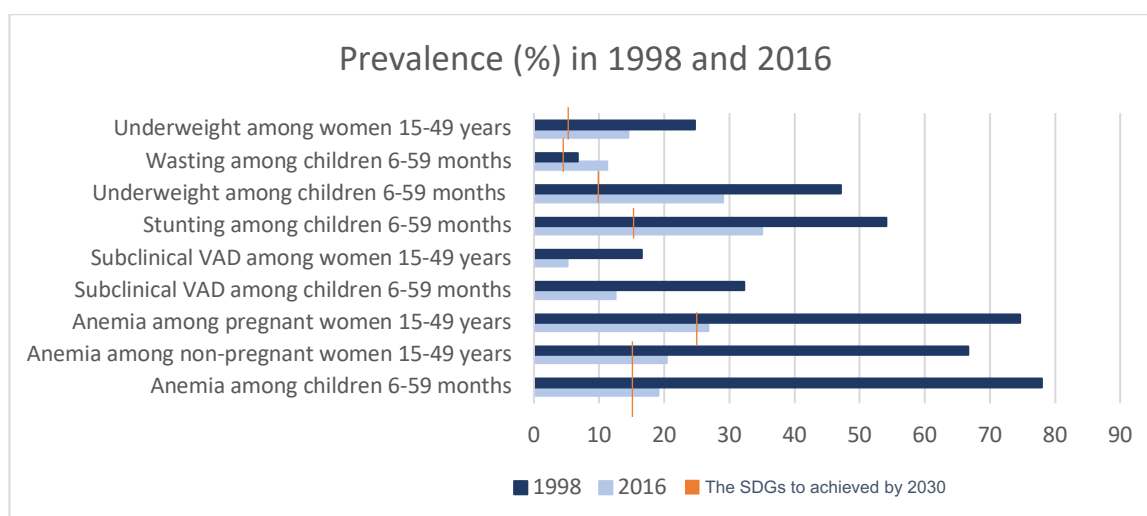
	Prevalence of wasting (%) <sup>a</sup>						Difference in pp [CI 99%]		P%
	1998			2016					
	n	-3 SD	-2 SD	n	-3 SD	-2 SD	-3 SD	-2 SD	
Terai	8856	0.6	6.9	722	2.6	13.2	-3 SD	+2.0 [+0.5, +3.5]	97.2
							-2 SD	+6.3 [+3.0, +9.6]	99.8
Hill	7962	0.3	6.0	706	2.1	9.4	-3 SD	+1.8 [+0.4, +3.2]	98.1
							-2 SD	+3.4 [+0.5, +6.3]	79.9
Mountain	1354	0.9	9.6	273	2.2	8.6	-3 SD	+1.3 [-1.1, +3.7]	29.5
							-2 SD	-1.0 [-5.8, +3.8]	1.7
<b>National</b>	<b>17472</b>	<b>0.5</b>	<b>6.7</b>	<b>1701</b>	<b>2.4</b>	<b>11.3</b>	-3 SD	+1.9 [+0.9, +2.9]	<b>100</b>
							-2 SD	+4.6 [+2.6, +6.6]	<b>100</b>
Urban	1913	0.6	5.1	226	0.6	5.1	-3 SD	0.0 [-1.4, +1.4]	*
							-2 SD	0.0 [-4.0, +4.0]	*
Rural	15584	0.5	6.9	1475	2.6	13.2	-3 SD	+2.1 [+1.0, +3.2]	100
							-2 SD	+6.3 [+4.0, +8.6]	100

Abbreviations: n, sample size; pp, percentage points; p, post-hoc power (retrospective power), CI, confidence interval

<sup>a</sup> The prevalence presented below -2SD includes both moderate (-2 SD) and severe (-3 SD) wasting.

\*Post-hoc power is not able to be performed due to the same rate of incidence.

For WRA the prevalence of underweight (BMI <18.5 kg/m<sup>2</sup>) was significantly improved on a national level, by residential level and in the Terai. Nationally, the results showed a decrease of -10.2 pp (CI 99%, -12.4, -8.0) to a prevalence of 14.5% in 2016. In 1998, Terai was the ecological region with the highest prevalence of underweight among WRA at nearly 37%. In 2016 the prevalence had decreased by -20.5 pp (CI 99%, -24.0, -17.0) to 16.4%. Non-significant results were found in the Hill (-1.6 pp, CI 99%, -4.6, +1.4) and in the Mountain (+1.6 pp, CI 99%, -4.0, +7.2) (see Table D3). Figure 4 below presents a summary consistent of all results.



**Figure 4:** Summarizing figure of the study result regarding the prevalence of anemia, subclinical VAD, stunting, underweight and wasting between 1998 and 2016 compared to specific Sustainable Development Goal to be achieved by the year of 2030 (34). Abbreviations: VAD = Vitamin A Deficiency

## Discussion

Two National Micronutrient Status Surveys initiated by the Ministry of Health, Government of Nepal, financed by the USAID were compared in this trial. The results indicate a remarkable improvement of the nutritional health among children aged 6 to 59 months and WRA in Nepal. Most notable finding was the elimination of iodine deficiency as a public health concern, but also an increased prevalence of wasting among children. Despite this remarkable improvement of MNDs and the nutritional status, nutritional deficiencies are still major public health concerns in Nepal.

*“Confidence interval for the difference between proportions”* was used for statistical analysis since the NMSS 1998 and NNMSS 2016 consisted of aggregated data and for the overall lack of comparable means and SD. A limitation using this analyzing method is the required need of at least 10 successes and 10 failures, wherefore data with small sample sizes, in a few cases, could not be analyzed. To note, is the estimation of two false positive results, due to the multiple analyzing and the confidence interval of 99%.

## Anemia

Despite a remarkable decrease of anemia since 1998, still one-fifth of children, one-fifth of NPW and above one-quarter of PW still were still anemic in 2016, with the highest prevalence in the Terai. Surprisingly, the prevalence of anemia among children was higher in urban areas, compared to rural areas. Contributing to this result might be the increased rural-to-urban migration, which had been observed to affect the nutritional health among urban inhabitants being more like rural inhabitants (79). In contrast, the prevalence of anemia among NPW was higher in rural areas, consistent with a study from 2020 regarding anemia among WRA in South and Southeast Asia (80). Less access to facilities such as basic sanitation and clean water might contribute to the increased prevalence of anemia in rural areas (49). Unfortunately, this result indicates that anemia is still a pronounced public health problem in Nepal. Noteworthy, according to the Nepal Demographic and Health Survey from 2016, presents an even higher prevalence of anemia in the country, where over half of children aged 6 to 59 months and over 40% of WRA were anemic (81) which certainly indicates that both childhood and female anemia remain as major concern in Nepal (49). However, this result indicates that Nepal is well on track to achieve the SDG, especially regarding PW, to reduce the prevalence to below 25%, until 2030. But further actions are in

need to achieve the SDG regarding childhood and female anemia by 2030, of below 15 respectively (34), especially among children and women living in rural areas and in the Terai.

Important for this success might be the introduction of deworming tablets and IFA-supplementation. Fortunately, in 2016, approximately six out of ten took deworming tablets and over nine out of ten of PW consumed IFA-supplementation during their last pregnancy (14). A study from 2019 found that the prevalence of anemia was over 20 times higher among PW not taking supplementation of IFA compared to those who did (82). Crucial for this success might be the FCHVs, who had educated, encouraged, and made a more nearby accessibility of IFA supplementation for pregnant women. Another contributing factor might be the increased visits to the antenatal care during pregnancy (83).

### Iodine Deficiency

Surprisingly and remarkably, the results indicated that iodine deficiency no longer is a public health problem in Nepal, neither among children aged 6 to 9(-11) years nor WRA. The USI program is argued to be one of the underlying measures for this incredible improvement (61). Of interest, the mUIC is above requirement ( $\geq 200 \mu\text{g/L}$ ) in all three ecological zones, and even on an excessive level ( $\geq 300 \mu\text{g/L}$ ) in the Terai, as well as nationally and by urban or rural location, which cause leads to an increased risk for iodine-induced thyroid-dysfunction. To highlight is that almost seven-tenths of the analyzed salt in 2016 had an iodization level above 40 ppm, the WHO's recommendation (66). Additionally, a study from 2018 presents a mean salt intake of 13.3 gram per capita in Nepal, an excessive consumption compared to the WHO's recommendation of less than 5 gram per day (84). Beneficial would be to adjust the iodization level (62) and the salt consumption (85), which might not only reduce the risk of iodine-induced thyroid dysfunction, but also the risk of hypertension and CVDs. Although, with carefulness to remain a good IDD control.

### Vitamin A Deficiency

Overall, the prevalence of subclinical VAD was significantly improved for both children and WRA. For children in urban areas the prevalence was significantly improved, but with a relatively wide CI, ranging from a decrease of -28.2 pp to -0.2 pp, i.e., the decrease might be as high as 30 pp or almost unimproved. Since the post-hoc power is low, this result might be due to small sample size. In comparison to the nearby country Bangladesh, the national prevalence of VAD among children aged 6 to 59 months is lower (12.5%) in Nepal, compared to 20.5% in 2011-2012 in Bangladesh (86). One explanation for this difference might be a

more nationwide supplementation of vitamin A capsules in Nepal with a coverage of over 90%, compared to 77% in Bangladesh (86). Remarkably, in 1998, only a year after the initiation, the NVAP in Nepal had a coverage of 87.4%. However, subclinical VAD remains a moderate public health concern among children in Nepal (70).

For WRA, the burden of VAD is not as severe as for children. In 2016, the prevalence had significantly decreased a mild public health problem (70). A source of error is the difference in the study population, where all women were included in the NMSS 1998 in contrast to NNMSS 2016 which included just NPW. However, the prevalence of VAD where significantly improved while comparing NPW in both surveys. In addition, the prevalence of maternal XN had decreased below 5%, i.e., the level of being considered a public health issue (87). Because vitamin A supplementation or a high food consumption of vitamin A during pregnancy might be teratogenic (88), the WHO only recommend supplementation if the prevalence of XN during pregnancy is equal or above 5% (89), otherwise there is a strong advisement against food highly consistent of vitamin A as well as supplementation of vitamin A during pregnancy (88).

To highlight, the presented S-retinol in this study is not adjusted for inflammation, which causes S-retinol to decrease (14). Therefore, the NNMSS 2016 presents S-retinol adjusted for inflammation (11.1% for children and 5.2% for NPW (14)) and modified relative dose response (MRDR). Based on MRDR, (4.2% for children and 3.0% for NPW (14)), VAD would be defined as a mild where the prevalence of VAD based on MRDR (4.2% for children and 3.0% for NPW) instead is considered as a mild public health concern, since the prevalence is below one-fifth (90).

Despite that the Nepal NVAP is considered the most effective action to improve the health of the Nepalese population (72), VAD is still a public health concern for both children and women which indicates a need for further actions. Since, the NVAP already has a nationwide reach, and general supplementation during pregnancy is unrecommended (88), other additional interventions such as, adequate food fortification and reduction of poverty might be sufficient to maintain an adequate vitamin A intake on a regular basis (91) and thereby might be able to fully eliminated VAD in the country.

### Nutritional status by anthropometric measures

Overall, the nutritional status among children and women has improved between 1998 and 2016. However, still 35.0% of all children aged 6 to 59 months are stunted and nearly three in ten children are underweight. Surprisingly, the prevalence of wasted children were nearly doubled in 2016, compared to 1998. A study from 2021 argues that Nepal is on track to, but relatively far from, achieving the SDGs regarding stunting and underweight of below 15% and 10% respectively (34), and more far from reducing wasting among children to 4% (34).

To note is that different growth reference populations are used in the NMSS 1998 and the NNMSS 2016. The latter uses the WHO growth standard references from 2006 (14) which are settled based on multi-country data, in contrast to the former standard growth references which were formed only by data from the United States (92). Since the nutritional status is measured through the anthropometric measures HFA, WFA and WHZ, all based on SDs from these standard growth references, the study result might be influenced by the fact that these references are based on different populations.

By all parameters, the prevalence of stunting, underweight and wasting among children were more pronounced among children living in rural areas, compared to children living in urban communities. In rural areas, 36.0% of children were stunted, three out of ten were underweighted and the prevalence of wasting was almost doubled to 13.2%. In comparison to urban areas, were below 30% were stunted, approximately one-fifth were underweighted, and 5.1% were wasted. In Bangladesh, a nearby country in South Asia, the prevalence of stunting was 32.1%, underweight 30.0% and wasting 19.3% in 2011-2012 (86). In contrast, the prevalence of stunting and wasting was only slightly higher in rural areas, compared to urban areas. But aligned with Nepal, the prevalence of wasting was higher in rural areas at 21.1%, compared to 12.0% in urban areas (86). Which all designate a continuing inequality between children living in rural and urban areas, that has been the case for the last decades (44). A study from 2021, with the purpose to estimates Nepal's chances to achieve the nutritional SDGs, estimates that the targets regarding stunting are possibly achieved by 2030, in contrast to wasting (3).

The significant increased prevalence of both wasting among children aged 6 to 59 months is alarming, and since the prevalence exceeds 10% it is considered as a serious public health concern in Nepal (52). Especially in rural areas, as well as in Terai, is the development critical. Noteworthy, is that the fieldwork in both surveys mainly did not take place neither

during the monsoon nor the pre-harvest season, which are periods where the risk of wasting increases (15), i.e., the prevalence presented in both surveys might be lower than if the fieldwork was performed during another time of the year. The CI for the difference between wasting and severe wasting in rural areas and in the Terai are both narrow. Regarding severe wasting the increase could vary between 0.9 pp to 2.9 pp on a national level, between 0.5 pp to 3.5 pp in the Terai and between 1.0 pp to 2.3 pp in rural areas. For total wasting ( $<-2$  SD) the increase could vary between 2.6 to 6.6 pp on a national level, between 3.0 pp to 9.6 pp in the Terai and between 4.0 pp to 8.6 pp in rural areas. Whichever, these results indicates a static status or a development in the wrong direction. Non-significant results were found regarding the development of both severe wasting and total amount of wasting in the Mountain, but since the post-hoc power is low the result could be from a small sample size.

A high prevalence of wasting is also seen in Sri Lanka, with a national prevalence of 21.9% (93), which might indicate a high prevalence burden of acute malnutrition, not only in Nepal, both also in several parts of South Asia. The Sustainable Development Goal Report 2018, from the UN, reports an increased prevalence of malnourished people, and thereby an increased hunger worldwide, in the year 2016 (1). Which might explain the founding of increased wasting. The UN lists disasters, conflicts, climate change, and drought as factors that might contribute to these increases, causing for instance food insecurity and increased slum formations (1).

Food insecurity in Nepal, is still a manifest problem in many parts of the country, where four out of ten households are affected by some form of food insecurity in 2016, most prominent in the Mountain region. (14) Which might contribute to why the prevalence of both child stunting and underweight was worse in the Mountain region, compared to the other ecological regions, the Terai and the Hill. Another contributing factor might be the lack of connection between the Mountain region to other parts of Nepal, which makes them more exposed to shocks (94). Contributing to the increased prevalence of wasting in Nepal might also be the 2015 earthquake. Incongruous, is a study from 2018 that presents different results, i.e., that the nutritional status remained constant or improved from the year before to the year after the earthquake (95). The 2015 drought might additionally affect the food security in the country. A study from 2021 examined the effect of the earthquake as well as the drought, separately and compound, on food insecurity. Unexpected, significant association on food insecurity was only found on the compound effect of the earthquake and the drought, but not separately (10). Few studies aiming at the impact of the India-Nepal-blockade have been made. However, a

study from 2017 declares a major impact on the medicine cost due to the blockade (13). These environmental shocks and the blockade might negatively impact on the nutritional health in the country.

The explanation for the increased prevalence of wasted children in Nepal remains unknown. Since the WAZ is a quotient (92), based on the weight and the height of both the individual and the reference group (50), the result is affected by the length and weight of the reference group that the individual value is compared with. The fact that the NMSS 1998 and the NNMSS 2016 uses different growth standard populations might be a possible explanation for the unexpected finding of an increased prevalence of wasting. Nevertheless, with current standards, the burden of undernutrition in Nepal, including wasting, remains high.

Contributing to this might be the natural disasters recurrently affecting the country and this could possibly be an aggravating factor against achieving the second SDG, “Zero Hunger” (37), by the year of 2030.

For WRA the prevalence of underweight was significantly improved, but it is still a public health concern in Nepal (52). Though, the country seems to be on track towards the SGDs to a prevalence below 5% by 2030 (34). In the NNMSS 2016, the prevalence of overweight and obesity exceeded the prevalence of underweight, of 18.5% and 4.6% respectively (14). Since the NMSS 1998 does not contain data on overweight or obesity, neither for children nor women, an evaluating comparison between 1998 and 2016 could not be fulfilled. But the lack of data in 1998, in contrast to 2016, might speak for an increasing concern in the country. Which is consistent with data from the World Bank Data, that presents a small but threefold increase of overweight among children between 1998 and 2016, from 0.40% to 1.20% (96). The still pronounced burden of undernutrition together with an escalating prevalence of NCDs, including CVDs, in Nepal during the last decades (8), designates that Nepal is facing the double burden of malnutrition (41), where the burden of NCDs now has exceeded the burden of communicable diseases (8). Contributing to this shift is the worldwide globalization and an increasing urbanization, which has led to an affected lifestyle such as changes in dietary pattern and food consumption (8).

#### [The datasets of the Nepal National Micronutrient Status Surveys](#)

One limitation in the study is that the content of the NNMSS 2016 is more expanded regarding MNs compared to the NMSS 1998. Interesting would have been to compare the

difference regarding folate deficiency, infectious anemia as well as the prevalence of IDA, but due lack of comparable data the etiology of anemia could not be evaluated further.

Overall, both the NMSS 1998 and the NNMSS 2016, consist of large, nationwide sample sizes, which increases the statistical power. Low post-hoc powers occur in the study, mostly in the Mountain region and by urban location, which might be explained by the lower number of Nepalis living in these areas. Noteworthy, in the comparison between the two surveys is that the sample size is remarkably larger in the first survey of 1998, than the following survey of 2016. The comparability of the data sets increase since both surveys are based on the former administrative structure with five developing regions, which were operative until 2015. However, the new structure was not yet fully developed whereas the NNMSS 2016 were based on the former structure (14). A limiting factor is that the study population, in a few cases, differs, for instance regarding the median urinary iodine concentration among children. Another difference is that for women there is a difference between the datasets regarding pregnancy status, where some measures are on both PW and NPW and sometimes only on one of these. In these cases, modifications had to be made to be able to compare the data due differences between the data presented in the NMSS 1998 and the NNMSS 2016. Each modification is presented in the headnote of the table in the appendix and should be considered as a source of error due to a lack of complete comparable data. Through the analyzing process of the NMSS 1998 and the NNMSS 2016 data sets, two suspected printing errors were found. These are non-confirmed and marked in the specific table of concern. Nevertheless, I hope that this comparative study can point out the advancement of nutritional health among children and women in Nepal, and I hope that it will highlight the need for further actions.

## Conclusion and implications

In 2016, just a decade from the deadline of SDGs, the nutritional health among both children and women, including both micronutrient deficiencies and nutritional status, appears to be remarkably improved throughout Nepal. Despite Nepal's remarkable effort to bring change to nutritional deficiencies, including stunting, underweight, wasting, anemia and vitamin A, remain as pronounced public health concerns in the country. Further, this study indicates a geographical disparity between the ecological regions, where children and women living in the Terai, and the Mountain region are more vulnerable compared to people living in the Hill region. Present is also an urban-rural disparity where rural children and women are more

affected compared to children and women in urban areas. Altogether, despite the remarkable improvement of nutritional health in the country, Nepal is far from reaching the second SDG, “Zero Hunger” and “End all forms of malnutrition” (37), by 2030 and additional interventions are in need to improve the health of the Nepalese population.

Presented conclusions should be interpreted with carefulness since the data used in this study consists of aggregated data and with possible inconsistencies regarding the sample distribution. Further follow-up studies are of importance to continue to evaluate the micronutrient and nutritional status among children and women in Nepal. Hopefully, further research will continue to improve the knowledge and pave the way for further and improved interventions which in turn would improve the nutritional health for children and women in Nepal as well as throughout the world.

## Appendices

### Complete tables

**Table A1. Prevalence of anemia among children 6-59 months of age between 1998 and 2016**

Cut-off points of anemia: Mild anemia = 10.0-10.9 g/dL. Moderate anemia = 7.0-9.9 g/dL. Severe anemia = <7.0 g/dL

Note: Altitude adjustments are carried out in NMSS 1998 and NNMSS 2016.

	Prevalence of anemia (%)									Difference in pp for total anemia [CI 99%]	P%	Difference in pp for moderate anemia [CI 99%]	P%
	1998				2016								
	n	Total	Moderate	Severe	n	Total	Mild	Moderate	Severe				
Terai	1820	79.7	76.0	3.7	696	23.0	16.7	6.2	2 <sup>a</sup>	-56.7 [-61.5, -51.9]	100	-69.8 [-73.3, -66.3]	100
Hill	1778	76.2	74.0	2.2	687	14.8	10.7	4.1		-61.4 [-65.8, -57.0]	100	-69.9 [-73.2, -66.6]	100
Mountain	302	78.9	74.3	4.6	268	16.5	11.0	5.2		-62.4 [-70.8, -54.0]	100	-69.1 [-76.5, -61.7]	100
<b>National</b>	<b>3900</b>	<b>78.0</b>	<b>74.9</b>	<b>3.1</b>	<b>1651</b>	<b>19.1</b>	<b>13.7</b>	<b>5.3</b>		<b>-58.9 [-61.9, -55.9]</b>	<b>100</b>	<b>-69.6 [-71.9, -67.3]</b>	<b>100</b>
Urban	428	72.0	70.1	1.9	211	22.6	16.6	6.0		-49.4 [-58.7, -40.1]	100	-64.1 [-71.2, -57.0]	100
Rural	3471	78.8	75.6	3.2	1440	18.8	13.3	5.1		-60.0 [-63.2, -56.8]	100	-70.5 [-72.9, -68.1]	100

Abbreviations: n, sample size; P, post-hoc power; pp, percentage points (retrospective power); CI, confidence interval

<sup>a</sup> Two children aged 6-59 months had severe anemia

Sources: NMSS 1998 table 7.4, NNMSS 2016 table 11.1

**Table A2. Prevalence of anemia among non-pregnant women 15-49 years of age between 1998 and 2016**

Cut-off points for anemia: Mild anemia = 11.0-11.9 g/dL. Moderate anemia = 8.0-10.9 g/dL. Severe anemia = <8.0 g/dL

Note: Altitude adjustments are carried out in NMSS 1998 and NNMSS 2016.

	Prevalence of anemia (%)									Difference in pp for total anemia [CI 99%]	P%	Difference in pp for moderate anemia [CI 99%]	P%
	1998				2016								
	n	Total	Moderate	Severe	n	Total	Mild	Moderate	Severe				
Terai	1612	72.6	71.2	1.4	885	29.1	18.4	10.2	7 <sup>a</sup>	-43.5 [-48.4, -38.6]	100	-61.0 [-64.9, -57.1]	100
Hill	1562	61.1	59.0	2.1	895	11.6	7.9	3.4		-49.5 [-53.7, -45.3]	100	-55.6 [-59.2, -52.0]	100
Mountain	263	65.0	63.5	1.5	356	11.1	8.2	2.9		-53.9 [-62.6, -45.2]	100	-60.6 [-68.6, -52.6]	100
<b>National</b>	<b>3437</b>	<b>66.7</b>	<b>65.0</b>	<b>1.7</b>	<b>2136</b>	<b>20.4</b>	<b>13.2</b>	<b>6.8</b>		<b>-46.3 [-49.4, -43.2]</b>	<b>100</b>	<b>-58.2 [-60.7, -55.7]</b>	<b>100</b>
Urban	393	62.3	61.3	1.0	294	18.0	8.8	9.2		-44.3 [-52.8, -35.8]	100	-52.1 [-59.8, -44.4]	100
Rural	3042	67.3	65.5	1.8	1842	20.8	14.0	6.4		-46.5 [-49.8, -43.2]	100	-59.1 [-56.4, -61.8]	100

Abbreviations: n, sample size; P, post-hoc power; pp, percentage points (retrospective power); CI, confidence interval

<sup>a</sup> Seven non-pregnant women aged 15-49 years had severe anemia

Sources: NMSS 1998 table 7.3 and NNMSS 2016 table 11.7.

**Table A3. Prevalence of anemia among pregnant women 15-49 years of age between 1998 and 2016**

Cut-off points for anemia: Mild anemia = 10.0-10.9 g/dL. Moderate anemia = 7.0-9.9 g/dL. Severe anemia = <7.0 g/dL

Note: Altitude adjustments are carried out in NMSS 1998 and NNMSS 2016.

	Prevalence of anemia (%)									Difference in pp for total anemia [CI 99%]	P%	Difference in pp for moderate anemia [CI 99%]	P%
	1998				2016								
	n	Total	Moderate	Severe	n	Total	Mild	Moderate	Severe				
Terai	193	80.3	76.7	3.6	94	36.4	23.3	13.1	0 <sup>a</sup>	-43.9 [-58.8, -29.2]	100	-63.6 [-75.4, -51.8]	100
Hill	190	68.4	60.5	7.9	88	15.6	10.1	5.5		-52.8 [-66.0, -30.6]	100	***	100
Mountain	35	77.1	71.4	5.7	22	*	*	*		**	**	**	**
<b>National</b>	<b>418</b>	<b>74.6</b>	<b>68.9</b>	<b>5.7</b>	<b>204</b>	<b>26.8</b>	<b>17.1</b>	<b>9.7</b>		<b>-47.8 [-57.5-38.1]</b>	<b>100</b>	<b>-59.2 [-67.1, -51.3]</b>	<b>100</b>
Urban	33	51.5	48.5	3.0	24	*	*	*		**	**	**	**
Rural	385	76.6	70.6	6.0	180	27.7	17.3	10.4		-48.9 [-59.1, -38.7]	100	-60.2 [-68.6, -51.8]	100

Abbreviations: n, sample size; P, post-hoc power; pp, percentage points (retrospective power); CI, confidence interval

<sup>a</sup> Zero pregnant women 15-49 years had severe anemia

\* Data not shown in the NNMSS 2016

\*\* Due to lack of data, these results could not be presented

\*\*\*Due to that the presented data did not meet the criteria for using confidence interval for proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled

Sources: NMSS 1998 table 7.3 and NNMSS 2016 table 11.9.

**Table B1. Urinary iodine concentration among children aged 6-11 in 1998 and children aged 6-9 years in 2016**

Cut-off points for children  $\geq 6$  years: Adequate levels 100-199  $\mu\text{g/L}$ . Mild iodine deficiency: 50-99  $\mu\text{g/L}$ , moderate iodine deficiency 20-49  $\mu\text{g/L}$  and severe deficiency  $<20$ . Above requirements 200-299  $\mu\text{g/L}$  and excessive levels  $\geq 300$   $\mu\text{g/L}$ .

Note: mUIC was in the NMSS 1998 measured in children aged 6-11 years. In the NNMSS 2016 the mUIC was measured in children aged 6-9 years.

Notes: Due to lack of information in the NMSS 1998 and the NNMSS 2016 the level of significance was not able to be calculated. Because of its relevance regarding iodine status the difference in mUIC is presented below.

	Iodine Deficiency						Ratio between medians [mUIC 2016/mUIC 1998] e	
	1998			2016		n		mUIC <sup>a</sup>
	n	mUIC <sup>a</sup>	1998 (%)					
			<20	20-49	50-99			
Terai	667 <sup>d</sup>	108.9	1.8	19.2	25.7	481 <sup>c</sup>	368.9	368.9/108.9 = 3.388
Hill	660 <sup>d</sup>	183.0	1.6	5.4	18.3	476 <sup>c</sup>	294.7	294.7/183.0 = 1.610
Mountain	113 <sup>d</sup>	196.6	1.8	4.6	14.7	177 <sup>c</sup>	238.5	238.5/196.6 = 1.213
<b>National</b>	<b>1450<sup>d</sup></b>	<b>143.8</b>	<b>1.7</b>	<b>11.9</b>	<b>21.5</b>	<b>1134<sup>c</sup></b>	<b>314.1</b>	<b>314.1/143.8 = 2.184</b>
Children aged 6-9 years	1125	141.55 <sup>b</sup>	1.64	12.2	22.8	1134 <sup>c</sup>	314.1	314.1/141.55 = 2.219
Urban	220 <sup>d</sup>	259.0	0.0	7.3	10.0	143 <sup>c</sup>	341.8	341.8/259.0 = 1.320
Rural	1230 <sup>d</sup>	133.7	2.0	12.7	23.6	991 <sup>c</sup>	313.7	313.7/133.7 = 2.346

Abbreviations: n, sample size; mUIC = Median Urinary Iodine Concentration.

<sup>a</sup> Median Urinary Iodine Concentration in microgram per liter ( $\mu\text{g/L}$ )

<sup>b</sup> Mean of the medians from children aged 6,7,8 and 9 years in the NNMSS 1998

<sup>c</sup> Children aged 6-9 years in the NNMSS 2016

<sup>d</sup> Children aged 6-11 years in the NNMSS 1998

<sup>e</sup> Due to lack of data statistical relevance was not able to be calculated.

Source: NMSS 1998 table 5.4 and NNMSS 2016 table 15.1.

**Table B2. Urinary iodine concentration among non-pregnant women and pregnant women aged 15-49 years between 1998 and 2016**

Cut-off points for non-pregnant women: Adequate levels 100-199  $\mu\text{g/L}$ . Mild iodine deficiency: 50-99  $\mu\text{g/L}$ , moderate iodine deficiency 20-49  $\mu\text{g/L}$  and severe deficiency  $<20$ . Above requirements 200-299  $\mu\text{g/L}$  and excessive levels  $\geq 300$   $\mu\text{g/L}$ .

Cut-off points for pregnant women: Adequate levels 150-249  $\mu\text{g/L}$ . Levels  $<150$  are insufficient. Above requirements 250-499  $\mu\text{g/L}$  and excessive levels  $\geq 500$   $\mu\text{g/L}$ .

Modifications: In table 15.1 in the 2016 NNMSS data regarding iodine status was presented in non-pregnant women and pregnant women separately. To be able to compare with table 5.3 in the NMSS 1998 the data regarding non-pregnant and pregnant women in 2016 was aggregated and the mean of the medians is presented below.

Notes: Due to lack of information in the NMSS 1998 and the NNMSS 2016 the level of significance was not able to be calculated. Because of its relevance regarding iodine status the difference in mUIC is presented below.

	Iodine Deficiency						Ratio between medians [mUIC 2016/mUIC1998] <sup>b</sup>	
	1998			2016		n		mUIC <sup>a</sup>
	n	mUIC <sup>a</sup>	%					
			<20	20-49	50-99			
Terai	613	85.0	4.6	17.8	35.5	973	278.4 <sup>c</sup>	278.4/85.0 = 3.275
Hill	598	142.7	1.7	9.6	20.7	981	241.6 <sup>c</sup>	241.6/142.7 = 1.693
Mountain	102	168.6	2.0	8.2	19.4	378	280.3 <sup>c</sup>	280.3/168.6 = 1.663
<b>National</b>	<b>1313</b>	<b>114.1</b>	<b>3.1</b>	<b>13.3</b>	<b>27.5</b>	<b>2332</b>	<b>263.75<sup>c</sup></b>	<b>263.75/114.1 = 2.312</b>
Non-pregnant	1169	112.0	0.8	14.0	27.1	2129	286.2	286.2/112 = 2.555
Pregnant	132	134.0	3.1	13.4	27.9	203	241.3	241.3/134.0 = 1.801
Urban	193	205.0	2.1	7.8	12.4	320	290.45 <sup>c</sup>	290.45/205 = 1.417
Rural	1120	105.0	3.2	14.3	30.2	2012	259.55 <sup>c</sup>	259.55/105 = 2.472

Abbreviations: n, sample size; mUIC, Median Urinary Iodine Concentration.

<sup>a</sup> Median Urinary Iodine Concentration in microgram per liter ( $\mu\text{g/L}$ )

<sup>b</sup> Due to lack of data statistical relevance was not able to be calculated.

<sup>c</sup> The calculated mean of the medians of non-pregnant women and pregnant women in the NNMSS 2016 regarding iodine status.

Source: NMSS1998 table 5.3, NNMSS 2016 table 15.1

Table B3. Type of salt used in households between 1998 and 2016

Notes: Kurkurtch salt was excluded due to non-comparable data in the NNMSS 2016. Non-significant results are highlighted in orange.

	Different types of salt used in 1998 (%)				Different types of salt used in 2016 (%)				Difference in pp for the different types of salt [CI 99%]	P%	
	n	Refined (R)	Crushed (C)	Phoda <sup>a</sup> (P)	n	Refined (R)	Crushed (C)	Phoda <sup>a</sup> (P)			
Terai	7138	7.9	7.3	44.6	1796	95.7	0.7	5.4	R	+87.8 [+86.3, +89.3]	100
									C	-6.6 [-7.5, -5.7]	100
									P	-39.2 [-41.2, -37.2]	100
Hill	7049	13.2	1.5	78.5	1794	84.4	3.4	16.8	R	+71.2 [+68.8, +73.6]	100
									C	+1.9 [+0.7, +3.1]	98.4
									P	-61.7 [-64.3, 59.1]	100
Mountain	1204	1.4	8.6	78.0	719	53.9	31.9	24.1	R	+ 52.5 [+46.7, +57.4]	100
									C	+ 23.3 [+18.4, +28.2]	100
									P	-53.9 [-59.0, -48.8]	100
National	15391	9.8	4.8	62.7	4309	87.6	4.1	11.9	R	+77.8 [+76.4, +79.2]	100
									C	-0.7 [-1.6, +0.2]	25
									P	-50.8 [-52.4, -49.2]	100
Urban	1637	58.7	2.0	28.8	598	97.9	0.0	2.4	R	+39.2 [+35.7, +42.7]	100
									C	*	93.4
									P	-26.4 [-29.7, -23.1]	100
Rural	13754	4.0	5.1	66.8	3711	86.0	4.8	13.4	R	+82.0 [+80.5, +83.5]	100
									C	-0.3[-1.3, +0.7]	3.1
									P	-53.4 [-55.2, -51.6]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval

<sup>a</sup> Phoda is a crystal salt.

\* Since the presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Source: NMSS 1998 table 5.7 and NNMSS 2016 table 16.1.

**Table B4. The concentrations of iodine among the different types of salt in the three ecological regions between 1998 and 2016**

Cut-off points: The adequate level of iodization is ppm  $\geq 15$ -<40

Exclusions: Kurkurtch salt were excluded due to non-comparable data in the NNMSS 2016: Cut-off points: The adequate level of iodization is ppm  $\geq 15$ -<40.

	Type of salt	Iodization level in 1998 in ppm <sup>a</sup> (%)					Iodization level in 2016 in ppm <sup>a</sup> (%)						Difference in pp for no iodization [CI 99%]	P%
		n	0	7	15	30	n	<5	5-<15	$\geq 15$	$\geq 15-40$	>40		
Terai	Refined	521	0.9	2.8	6.5	89.7	805	0.7	3.2	96.0	27.2	68.8	***	1.7
	Crushed	552	23.3	24.1	26.0	26.2	5	*	*	*	*	*	**	**
	Phoda	3151	30.8	35.2	23.8	10.3	74	*	*	*	*	*	**	**
Hill	Refined	928	0.2	0.9	1.7	97.2	626	0.8	0.5	98.7	13.9	84.8	***	23.1
	Crushed	105	2.8	6.6	29.1	61.4	55	*	*	96.4	72.7	23.6	**	**
	Phoda	5519	15.4	31.6	37.5	15.4	194	20.6	30.9	62.9	38.7	9.8	***	29.1
Mountain	Refined	16	3.6	4.9	6.5	85.1	132	*	*	100.0	28.0	72.0	**	**
	Crushed	103	1.1	5.6	23.7	69.7	148	*	*	99.3	35.1	64.2	**	**
	Phoda	938	14.7	26.8	34.6	23.9	70	11.4	25.7	62.9	55.7	7.1	***	2.3

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval

<sup>a</sup> Level of iodization measured in parts per million (ppm)

\*Data not presented in the NNMSS 2016

\*\*Confidence intervals could not be calculated due to the existence of not presented data in the NNMSS 2016.

\*\*\*Since presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Source: NMSS 1998 table 5.10 and NNMSS 2016 table 16.10, 16.11 and 16.12.

**Table B5. Iodization level among all samples of the collected salt between 1998 and 2016**

Cut-off points: The adequate level of iodization is ppm  $\geq 15$ -<40.

Notes: Since the data regarding the level of iodization in the Mountain and urban regions did not meet the criteria for CI using for the difference between proportions, results could therefore not be presented.

	Iodization level in 1998 in ppm <sup>a</sup> (%)					Iodization level in 2016 in ppm <sup>a</sup> (%)						Difference in pp for no iodization [CI 99%]	P%
	n	0	7	15	30	n	<5	5-<15	$\geq 15$	$\geq 15-40$	>40		
Terai	7206	21.5	28.3	23.8	26.4	884	2.7	5.3	92.0	27.7	64.3	-18.8 [-20.7, -16.9]	100
Hill	7070	13.2	27.7	32.5	26.6	875	4.6	6.2	89.3	16.9	72.4	-8.6 [-10.7, -6.5]	100
Mountain	1204	14.5	24.2	32.5	28.8	350	1.8	6.6	91.6	34.3	57.3	*	100
<b>National</b>	<b>15480</b>	<b>17.2</b>	<b>27.7</b>	<b>28.5</b>	<b>26.7</b>	<b>2109</b>	<b>3.5</b>	<b>5.8</b>	<b>90.7</b>	<b>23.2</b>	<b>67.5</b>	<b>-13.7 [-15.0, -12.4]</b>	<b>100</b>
Urban	1688	4.6	13.5	17.5	64.3	294	0.8	2.0	97.1	16.7	80.5	*	79.4
Rural	13792	18.7	29.4	29.8	22.1	1815	3.9	6.4	89.7	24.3	65.4	-14.8 [-16.2, -13.4]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval

<sup>a</sup> Level of iodization measured in parts per million (ppm)

\*Since the presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled. Source: NMSS 1998 table 5.9 and NNMSS 2016 table 16.9.

**Table C1. Prevalence of VAD among children 6-59 months of age between 1998 and 2016**

Cut-off points for serum retinol: Subclinical VAD is level between 0.35-0.69 µmol/L and severe deficiency <0.35 µmol/L.

Cut-off points for MRDR: ≥ 0.060 – which indicates insufficiency in vitamin A liver reserves

Note: Since the data regarding VAD in the Mountain region did not meet the criteria for CI using for the difference between proportions, CI for proportions was instead calculated for this group. A suspected printing error in the annex 11.21 regarding the total population where there in table 12.1 has a total of 659 and in the annex 11.21 a total of 658 individuals.

	Prevalence of subclinical VAD (%)						Difference in pp of VAD based on S-Retinol [CI 99%]	P%
	1998			2016				
	n	<0.35 <sup>a,c</sup>	<0.70 <sup>d</sup>	n	≤0.70	MRDR ≥ 0.060		
Terai	375	3.7	40.0	277	16.3	7.3	-23.7 [-32.4, -15.0]	100
Hill	363	1.1	23.4	276	9.2	1.2	-14.2 [-21.5, -6.9]	99.5
Mountain	105	3.8	35.5	106	6.0	1.0	*	100
<b>National</b>	<b>843</b>	<b>2.6</b>	<b>32.3</b>	<b>659<sup>b</sup></b>	<b>12.5</b>	<b>4.2</b>	<b>-19.8 [-25.1, -14.5]</b>	<b>100</b>
Urban	111	0.0	26.1	86	11.9	1.9	-14.2 [-28.2, -0.2]	45.8
Rural	733	3.1	33.3	573	12.6	4.6	-20.7 [-26.4, -15.0]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval, VAD, vitamin A deficiency

<sup>a</sup> Serum-Retinol in micromol/liter (µmol/L)

<sup>b</sup> Suspected printing error (The annex 11.21 has a total of 658 individuals)

<sup>c</sup> Serum-Retinol is not adjusted for inflammation

<sup>d</sup> The prevalence presented in below 0.70 includes both subclinical (<0.70) and severe (<0.35) vitamin A deficiency

\*Since the presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Source: NMSS 1998 table 6.6 and NNMSS 2016 table 12.1, annex 11.21

**Table C2. Prevalence of children 6-59 months of age receiving vitamin A capsule in the last NVAP between 1998 and 2016**

	n	Coverage of vitamin A capsules (%)	n	Coverage of vitamin A capsules (%)	Difference in pp for children receiving vitamin A capsule [CI 99%]	P%
Terai	7299	87.3	723	91.9	+4.6 [+1.8, +7.4]	88.5
Hill	1744	87.3	707	91.8	+4.5 [+1.1, +7.9]	74.3
Mountain	533	89.1	275	94.5	+5.4 [+0.4, +10.4]	100
<b>National</b>	<b>9576</b>	<b>87.4</b>	<b>1705</b>	<b>92.1</b>	<b>+4.7 [+2.8, +6.6]</b>	<b>100</b>
Urban	687	67.1	227	90.1	+23.0 [+16.3, +29.9]	99.6
Rural	8890	89.0	1478	92.4	+3.4 [+1.4, +5.4]	93.9

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval

Source: NMSS 1998 table 6.8 and NNMSS 2016 table 6.2.

**Table C3. Prevalence of VAD among all women in 1998 and non-pregnant women aged 15-49 years in 2016**

Cut-off points for serum retinol: Subclinical VAD is level between 0.35-0.69  $\mu\text{mol/L}$  and severe deficiency is levels  $<0.35 \mu\text{mol/L}$ .

Cut-off points for MRDR:  $\geq 0.060$  – which indicates insufficiency in vitamin A liver reserves

Note: The S-retinol was in 1998 measured among all women, pregnant and non-pregnant. In 2016 the measurement of S-retinol was only carried out on non-pregnant women. Since the data regarding VAD in the Hill, Mountain and urban regions did not meet the criteria for CI using for the difference between proportions, CI for proportions was instead calculated for these groups.

	Prevalence of subclinical VAD (%)						Difference in pp of VAD based on S-retinol [CI 99%]	P%
	1998			2016				
	S-Retinol <sup>c</sup>			S-Retinol <sup>c</sup>		MRDR		
	n	$<0.35$	$<0.70^c$	n	$\leq 0.70$	$\geq 0.060$		
<b>NPW</b>	<b>740</b>	<b>1.6</b>	<b>15.0</b>	<b>529</b>	<b>5.2</b>	<b>3.0<sup>b</sup></b>	<b>9.8 [-14.0, -5.6]</b>	<b>100</b>
Terai	375	2.4 <sup>a</sup>	20.8 <sup>a</sup>	223	8.1	5.2 <sup>b</sup>	-12.7 [-19.8, -5.6]	100
Hill	362	0.3 <sup>a</sup>	10.5 <sup>a</sup>	217	2.5	0.8 <sup>b</sup>	*	99
Mountain	105	1.9 <sup>a</sup>	22.9 <sup>a</sup>	89	0.1	0.0 <sup>b</sup>	*	100
<b>National</b>	<b>842</b>	<b>1.4<sup>a</sup></b>	<b>16.6<sup>a</sup></b>	<b>529</b>	<b>5.2</b>	<b>3.0<sup>b</sup></b>	<b>-11.4 [-15.5, -7.3]</b>	<b>100</b>
Urban	112	0.9 <sup>a</sup>	10.7 <sup>a</sup>	73	8.4	4.2 <sup>b</sup>	*	16.4
Rural	732	1.5 <sup>a</sup>	16.0 <sup>a</sup>	456	4.7	2.8 <sup>b</sup>	-11.3 [-15.6, -7.0]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; NPW, non-pregnant women; CI, confidence interval

<sup>a</sup> Prevalence of subclinical VAD among all women, pregnant and non-pregnant in the NMSS 1998

<sup>b</sup> Prevalence of VAD among non-pregnant women 15-49 years in the NNMSS 2016

<sup>c</sup> Serum-Retinol in micromol/liter ( $\mu\text{mol/L}$ )

<sup>d</sup> Serum-Retinol is not adjusted for inflammation

<sup>e</sup> The prevalence presented in below 0.70 includes both moderate ( $<0.70$ ) and severe ( $<0.35$ ) vitamin A deficiency

\*Since the presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Source: NMSS 1998 table 6.5 and NNMSS 2016 table 12.2, annex 11.23.

**Table C4. Prevalence of night blindness (XN) during the last pregnancy among women 15-49 years of age between 1998 and 2016**

Note: Since the data regarding XN among women in Mountain and urban regions did not meet the criteria for CI using for the difference between proportions, CI for proportions was instead calculated for these groups.

	n	XN during last pregnancy in 1998 (%)	n	XN during last pregnancy in 2016 (%)	Difference in pp for XN during pregnancy [CI 99%]	P%
Terai	7256	19.3	355	6.5	-12.8 [-16.4, -9.2]	100
Hill	7076	13.3	421	2.8	-10.5 [-12.8, -8.2]	100
Mountain	1204	20.4	167	6.5	*	99.4
<b>National</b>	<b>15536</b>	<b>16.7</b>	<b>943</b>	<b>3.2</b>	<b>-13.5 [-15.2, -11.8]</b>	<b>100</b>
Urban	1708	5.7	111	1.8	*	9.2
Rural	13828	18.0	832	3.3	-14.7 [-16.5, -12.9]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval; XN, night blindness

\*Since the presented data did not meet the criteria for using confidence interval for the difference between proportions, with a minimum of at least 10 successes and 10 failures, statistical analysis is not fulfilled.

Source: NMSS 1998 table 6.2 and NNMSS 2016 table 12.3.

**Table D1. Prevalence of stunting, underweight and wasting among children 6-59 months of age between 1998 and 2016**

Definition of stunting (height-for-age Z-score): moderate stunting <-2 SD, and severe stunting <-3 SD from the WHO growth reference for children.

Definition of underweight (weight-for-age Z-score): moderate underweight <- 2 SD and severe underweight as <-3 SD from the WHO growth reference for children.

Definition of wasting (weight-for-height Z-score): moderate wasting <-2 SD, and severe wasting <-3 SD from the WHO growth reference for children.

Notes: Non-significant results are presented in orange.

	Prevalence (%) <sup>a</sup>												n (1998)	n (2016)	Difference in pp -3 SD [CI 99%]		P%	Difference in pp -2 SD [CI 99%]		P%		
	Stunting (HAZ)				Underweight (WAZ)				Wasting (WHZ)													
	1998		2016		1998		2016		1998		2016											
	-3 SD	-2 SD	-3 SD	-2 SD	-3 SD	-2 SD	-3 SD	-2 SD	-3 SD	-2 SD	-3 SD	-2 SD										
Terai	20.4	50.7	16.2	35.4	12.3	45.7	9.6	32.5	0.6	6.9	2.6	13.2	8856	722	HAZ	-4.2 [-7.9, -0.5]	55.7	HAZ	-15.3 [-20.1, -10.5]	100		
																	WAZ	-2.7 [-5.7, +0.3]	31.6	WAZ	-13.2 [-17.9, -8.5]	100
																	WHZ	+2.0 [+0.5, +3.5]	97.2	WHZ	+6.3 [+3.0, +9.6]	99.8
Hill	22.3	55.5	12.3	32.7	10.3	46.4	6.7	23.6	0.3	6.0	2.1	9.4	7962	706	HAZ	-10.0 [-13.4, -6.6]	100	HAZ	-22.8 [-27.6, -18.0]	100		
																	WAZ	-3.6 [-6.2, -1.0]	71.4	WAZ	-22.8 [-27.2, -18.4]	100
																	WHZ	+1.8 [+0.4, +3.2]	98.1	WHZ	+3.4 [+0.5, +6.3]	79.9
Mountain	31.2	66.1	18.7	45.3	20.4	59.9	9.0	35.0	0.9	9.6	2.2	8.6	1354	273	HAZ	-12.5 [-19.4, -5.6]	96.2	HAZ	-20.8 [-29.2, -12.4]	100		
																	WAZ	-11.4 [-16.7, -6.1]	99	WAZ	-24.9 [-33.1, -16.7]	100
																	WHZ	+1.3 [-1.1, +3.7]	29.5	WHZ	-1.0 [-5.8, +3.8]	1.7
National	22.1	54.1	14.8	35.0	12.0	47.1	8.4	29.0	0.5	6.7	2.4	11.3	17472	1701	HAZ	-7.3 [-9.7, -4.9]	100	HAZ	-19.1 [-22.2, -16.0]	100		
																	WAZ	-3.6 [-5.4, -1.8]	98.2	WAZ	-18.1 [-21.2, -15.1]	100
																	WHZ	+1.9 [+0.9, +2.9]	100	WHZ	+4.6 [+2.6, +6.6]	100
Urban	9.4	36.1	11.1	28.1	5.5	30.8	4.9	18.9	0.6	5.1	0.6	5.1	1913	226	HAZ	+1.7 [-4.0, +7.4]	60.8	HAZ	-8.0 [-16.2, +0.2]	41.8		
																	WAZ	-0.6 [-4.5, +3.3]	1.1	WAZ	-11.9 [-19.1, -4.7]	90.2
																	WHZ	0.0 [-1.4, +1.4]	*	WHZ	0.0 [-4.0, +4.0]	*
Rural	23.6	56.3	15.3	36.0	12.8	49.1	8.9	30.5	0.5	6.9	2.6	13.2	15584	1475	HAZ	-8.3 [-10.9, -5.7]	100	HAZ	-20.3 [-23.7, -16.9]	100		
																	WAZ	-3.9 [-5.9, -1.9]	97.8	WAZ	-18.6 [-21.9, -15.3]	100
																	WHZ	+2.1 [+1.0, +3.2]	100	WHZ	+6.3 [+4.0, +8.6]	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; CI, confidence interval

<sup>a</sup>The prevalence presented below -2SD includes both moderate (<-2 SD) and severe (<-3 SD) undernutrition.

\*Post-hoc power not able to be performed due to the same prevalence rate.

Source: NMSS 1998 table 10.2 and NNMSS 2016 table 10.1, 10.2, 10.3.

**Table D2. Mean Z-score of anthropometric status among children 6-59 months of age between 1998 and 2016**

Definition of stunting: moderate stunting <-2 SD, and severe stunting <-3 SD from the WHO growth reference  
 Definition of underweight: moderate underweight<- 2 SD and severe underweight as<-3 SD from the WHO growth median.  
 Definition of wasting: moderate wasting <-2 SD, and severe wasting <-3 SD from the WHO growth reference  
 Notes: Non-significant results are presented in orange

	Means and Standard Deviation (SD)												n (1998)	n (2016)	Mean difference [CI 99%]		P%		
	Stunting (HAZ)				Underweight (WAZ)				Wasting (WHZ)										
	1998		2016		1998		2016		1998		2016								
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD							
Terai	-2.01	1.28	-1.57	1.46	-1.88	1.02	-1.50	1.23	-0.83	0.85	-0.87	1.08	8156	722	HAZ	+0.44 [+0.295, +0.585]	100		
																	WAZ	+0.38 [+0.259, +0.501]	100
																	WHZ	-0.04 [-0.146, +0.066]	5.4
Hill	-2.16	1.16	-1.53	1.32	-1.88	0.94	-1.26	1.15	-0.73	0.84	-0.59	1.13	7962	706	HAZ	+0.63 [+0.498, +0.762]	100		
																	WAZ	+0.62 [+0.505, +0.735]	100
																	WHZ	+0.14 [+0.028, +0.252]	73.8
Mountain	-2.48	1.21	-1.91	1.38	-2.22	0.99	-1.58	1.08	-0.21	0.87	-0.66	1.06	1354	273	HAZ	+0.57 [+0.339, +0.801]	100		
																	WAZ	+0.64 [+0.458, +0.822]	100
																	WHZ	-0.45 [-0.626, -0.274]	100
National	-2.11	1.23	-1.58	1.40	-1.91	0.99	-1.41	1.19	-0.79	0.85	-0.74	1.11	17472	1701	HAZ	+0.53 [+0.439, +0.621]	100		
																	WAZ	+0.5 [+0.423, 0.577]	100
																	WHZ	+0.5 [-0.021, +0.121]	22.1
Urban	-1.60	1.17	-1.34	1.47	-1.50	0.98	-0.98	1.26	-0.64	0.86	-0.49	1.01	1913	226	HAZ	+0.26 [-0.001, +0.521]	49.6		
																	WAZ	+0.52 [+0.297, +0.743]	100
																	WHZ	+0.15 [-0.03, +0.33]	33.2
Rural	-2.17	1.22	-1.62	1.39	-1.96	0.98	-1.47	1.17	-0.81	0.85	-0.77	1.12	15584	1475	HAZ	+0.55 [+0.453, +0.647]	100		
																	WAZ	+0.49 [+0.409, +0.571]	100
																	WHZ	+0.04 [-0.037, +0.117]	10.7

Abbreviations: n, sample size; SD, standard deviation, CI, confidence interval; P, post-hoc power (retrospective power)  
 Source: NMSS 1998 table 10.3 and NNMSS 2016 table 10.1, 10.2, 10.3.

**Table D3. Prevalence of underweight among women 15-49 years of age between 1998 and 2016**

Definition of underweight: BMI <18.5 kg/m<sup>2</sup>. Moderate underweight BMI <17.0 kg/m<sup>2</sup> and severe underweight BMI <16.0 kg/m<sup>2</sup>.

Modifications: Due to suspected printing errors in the NNMSS 1998 these numbers were corrected, where the total percentage of BMI <18.5 and >18.5 swished places. Either way, with the correction or not, the results is significant with CI-interval ≠ 0

Non-significant results are presented in orange.

	BMI (kg/m <sup>2</sup> ) among women								n (1998)	n (2016)	Difference in pp for the total amount of underweight (BMI <18.5) [CI 99%]	P%
	1998 <sup>a</sup> (%)					2016 <sup>b</sup> (%)						
	< 16.0	16.0- <17.0	17.0- <18.5	Total <18.5	Total >18.5	<18.5	25.0- <30	>30.0				
Terai	4.1	8.2	16.4	36.9	63.1	16.4	18.6	2.8	7260	887	-20.5 [-24.0, -17.0]	100
Hill	0.5	2.1	12.0	13.6	86.4	12.0	19.1	6.7	7078	893	-1.6 [-4.6, +1.4]	39
Mountain	0.7	2.1	15.6	14.0	84.0	15.6	12.9	4.5	1205	359	+1.6 [-4.0, +7.2]	3.8
<b>National</b>	<b>2.2</b>	<b>4.9</b>	<b>14.5</b>	<b>24.7</b>	<b>75.3</b>	<b>14.5</b>	<b>18.5</b>	<b>4.6</b>	<b>15541</b>	<b>2139</b>	<b>-10.2 [-12.4, -8.0]</b>	<b>100</b>
Urban	1.6	4.8	14.3	21.1 <sup>c</sup>	78.9 <sup>c</sup>	14.3	25.0	5.9	1704	295	-6.8 [-12.6, -1.0] <sup>c</sup>	55.1
Rural	2.3	5.0	14.5	25.1 <sup>c</sup>	74.9 <sup>c</sup>	14.5	17.4	4.4	13838	1844	-10.6 [-12.9, -8.3] <sup>c</sup>	100

Abbreviations: n, sample size; P, post-hoc power (retrospective power); pp, percentage points; BMI, Body Mass Index; CI, confidence interval

<sup>a</sup> Prevalence of underweight were measured among all women, pregnant and non-pregnant 15-49 years in the NNMSS 1998

<sup>b</sup> Prevalence of underweight were measured among non-pregnant women 15-49 years in the NNMSS 2016

<sup>c</sup> Suspected printing error in the NNMSS 1998 why these numbers were corrected.

Source: NMSS 1998 table 10.7 and NNMSS 2016 table 10.9.

## Populärvetenskaplig sammanfattning

### Avsevärd utveckling mot ett hungerfritt Nepal

Författare:	Amanda Carlsson
Examensarbete:	30 hp
Program:	Läkarprogrammet
År:	2022
Handledare:	Prof. Göran Kurlberg
Nyckelord:	Mikronäringsämnen, Nepal, Näringsstatus, Undernäring

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I årtionden har undernäring varit ett allvarligt hälsoproblem världen över. Idag lider en av nio människor av hunger, där kvinnor och barn är särskilt hårt drabbade. Undernäring och hunger medför allvarliga och livshotande konsekvenser för de drabbade, så som påverkad tillväxt och avmagring, men även brist på väsentliga näringsämnen vilka i sin tur kan orsaka bland annat blodbrist, permanent blindhet samt påverkad mental utveckling. Varje år dör över 3 miljoner barn av näringsbrist innan fem års ålder – något som måste förändras, därav FN:s globala mål ”Ingen hunger” till år 2030.

Hunger är ett omfattande problem i Nepal. Näringsbrist orsakas ofta av en kombination av flera saker som tex brist på näringsrik mat och infektioner. Denna studie baseras på de nationella studierna, ”Nepal National Micronutrient Status Surveys”, om näringsstatus hos kvinnor och barn genomförda under 1998 och 2016. Förekomsten av blod-, jod- och vitamin A-brist har varit fokus i denna studie, samt förekomsten av undervikt, hämmad tillväxt (stunting) och borttynande (wasting).

Studiens resultat visade en minskning av näringsbrister samt förbättrad hälsa hos både kvinnor och barn. Jodbrist, som varit ett allvarligt hälsoproblem i landet har avsevärt förbättrats och klassas inte längre som ett folkhälsoproblem. Trots att förekomsten av blodbrist, vitamin A-brist, undervikt och hämmad tillväxt har minskat, är dessa tillstånd fortsatt uttalade hälsoproblem. Alarmerande var att förekomsten av borttynande ökat 2016 jämfört med 1998, vilket kan indikera en ökad förekomst av akut näringsbrist hos barn. Studien påvisar även en ojämlikhet där kvinnor och barn som bor på landsbygden är mer utsatta än de kvinnor och barn som bor i städerna.

Till sist, trots en anmärkningsvärd förbättring är Nepal långt ifrån att uppfylla det globala målet ”Ingen hunger” till år 2030.

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