ASSESSING THE HEALTH AND NUTRITIONAL STATUS OF CHILDREN IN WESTERN NEPAL PRIOR TO HYGIENE AND WATER QUALITY INTERVENTION

A

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PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

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By

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DECLARATION

I, Dikshya Dahal, hereby declare that the work contained herein is entirely my own, except where stated otherwise by reference or acknowledgement, and has not been published or submitted elsewhere, in whole or in part, for the requirement for any other degree or professional qualification. Any literature, data or works done by others and cited within this thesis has been given due acknowledgement and listed in the reference section.

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CERTIFICATION

This thesis entitled **"Assessing the health and nutritional status of children in Western Nepal prior to hygiene and water quality intervention"** is carried out under our supervision for the specified period satisfactorily and hereby certified as original work done by **Dikshya Dahal** in partial fulfilment of the requirements for the Master's degree in **Environment and Natural Resources**, Kathmandu University, Dhulikhel, Nepal.

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ABSTRACT

This study examines the status and risk factors associated with undernutrition and nutritional deficiencies among children within age groups between 6 months to 10 years in Surkhet, Dailekh and Achham of Western Nepal. A set of structured questionnaire was used to collect general information on socio-demographics, knowledge, attitude and practice of water management, hygiene and sanitation, food security, child health, child illness, nutrition, type and frequency of food consumed. Anthropometric data were collected to assess the nutritional status of children. Clinical examinations were done to assess the nutritional deficiencies among children. Microbial quality of drinking water was analyzed using field based membrane filtration method. Information was collected from total 1427 households and were analyzed using SPSS. Two mixed models were retained from multilevel binary logistic regression for risk factors associated with undernutrition and nutritional deficiencies controlling random effect for area. The variables included in the multivariate models were selected based on their significance level ($p<0.05$) in bivariate analysis. Since the four study areas were significantly different from each other, the random effect of areas was controlled in the model. The overall prevalence of children undernutrition was 53.9% (n=769) among which 43.6% (n=622) were stunted, 29% (n=414) were underweight and 10% (n=152) were wasted. On the other hand, a majority of the children (78%; n= 1113) were found to have nutritional deficiencies. Risk factors associated with undernutrition were E.coli contamination in drinking water at point of use, wealth index score of households, cleanliness of hands of caregivers, pale conjunctiva that is also one of the symptoms of anemia. Undernutrition was nearly significant with the practice of seeking medical advice during sickness. The cases of nutritional deficiencies were found mostly associated with the hygiene condition of their caregivers. Caregivers whose hands were clean and who washed their hands with soap and water were significantly associated with reduced nutritional deficiencies of their children. On the other hand, children whose hands were clean had less chances to be nutrient deficient than those who had dirty hands. Environmental hygiene like keeping animals outside their house and cleanliness of drinking water storage containers were significantly associated with nutritional deficiencies of children in respective houses. At the same time, children who were ill in past 7 days with mucus in stool were more likely to have nutritional deficiencies. The main finding from our study was that hygiene conditions of caregivers and surrounding environment has an important impact in the undernutrition and nutritional deficiencies of the children.

ABBREVIATIONS

C.I	: Confidence Interval
DDS	: Dietary Diversification Score
E.coli	: Escherichia coli
FAO	: Food and Agriculture Organization
GoN	: Government of Nepal
NMIP	: National Management Information Project
NSI	: Non-Standardized Index
OR	: Odds Ratio
PCA	: Principal Component Analysis
S.D	: Standard Deviation
S.E	: Standard Error
UNICEF	: United Nations Children's Fund
WASH	: Water Sanitation and Hygiene
WHO	: World Health Organization

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1. INTRODUCTION

1.1. Background

Water quality, sanitation facilities and hygiene practices are one of the major public health issues in the global context, which is more severe in the developing countries like Nepal. Access to safe drinking water, sanitation and hygiene services is a fundamental element of healthy communities and has an important positive impact on nutritional status (WHO & UNICEF, 2015). Water, sanitation and hygiene practices present challenges to population health in Nepal, an estimated 70% of communicable disease-related deaths and 9% of all deaths are attributable to WASH (McMichael et al., 2015).

On the other hand, undernutrition continues to affect millions globally, particularly in low- and middle-income countries (Cunningham et al., 2017). Poor nutrition and exposure to faecal contamination are associated with diarrhoea and growth faltering, both of which have long-term consequences on child health sometimes leading to undernutrition (Null et al., 2018). In addition to the detrimental effect on growth and development, undernutrition was estimated to cause 45% of all child deaths in 2011, and has been recognized as an important determinant of susceptibility to infectious diseases (Black et al., 2013). In Nepal, 36% of children under 5 years of age are stunted which is obviously caused by variety of factors including poor diet and child-care practices, lack of clean water, and limited access to sanitation and hygiene facilities (Cunningham et al., 2017).

According to (Rayamajhi et al., 2014), lack of proper facilities of good water source, adequate sanitation and basic hand-washing practices lead to adverse effects on health like diarrhoeal diseases, respiratory infections and worm infestations. Children bear the greatest health problem associated with poor water and sanitation (Howard et al., 2003). Almost one-tenth of global disease burden could be prevented by improving water supply, sanitation, hygiene and proper management of water resources (Sherwin et al., 2012).

The low quality of drinking water is well recognised as an important transmission route for infectious diarrhoeal and other water-borne diseases which affect both developed and developing countries but higher risk is carried by children in developing countries (Prüss et al., 2002). In developing countries, a majority of households are still deprived of running water, which leads them to collect drinking water at source often located many hundreds of meters away from home and transported to the household where it is stored until consumption. This increases the risk of contamination (Rufener et al., 2010). Contamination

by hands and domestic animals have proven to be the predominant causes of declining the quality of water (Schmidt & Cairncross, 2009). 88% of cases of diarrhoea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene resulting 1.5 million deaths each year, mostly being the death of children (Prüss-Üstün et al., 2008). Improving global access to clean drinking water and safe sanitation is one of the least expensive and most effective means to improve public health and save lives (Montgomery & Elimelech, 2007). Water quality and health being associated to each other improving the water quality in the households and safe storage can be effective to reduce the water-borne diseases.

Moreover, adequate nutrition is essential to ensure children's healthy growth (De Onis et al., 2012). Nutritional status of children is influenced by different direct and indirect factors. The two immediate causes are inadequate dietary intake and diseases, where there is a multitude of indirect factors such as WASH conditions, child-care practices embedded in larger economic and social environment (Dangour et al., 2013) and (Unicef, 1990). The total number of deaths caused directly and indirectly by nutritional deficiencies induced by unsafe water, inadequate sanitation and insufficient hygiene is 860, 000 deaths per year in children under five years of age (Prüss-Üstün et al., 2008). According to the latest findings from Nepal National Micronutrient Status 2016, nationally 35% of children 6-59 months suffer from stunting, 29% suffer from underweight and 11% suffer from wasting where maximum cases are from Western Nepal (GoN, 2018). In such scenario, collection of baseline information of nutritional status of children prior to intervention can be helpful not only to get idea about the overall condition of the area but also to identify risk factors which can be focussed in future for proper implementation and effective outcomes from the intervention.

1.2. Objectives

The general objective of the research is to assess and establish the linkage of nutritional status of children to water quality, sanitation and hygiene infrastructure with following specific objectives:

- To determine the current nutritional status of children in the study area
- To investigate the role of different direct and indirect risk factors affecting nutritional status of children
- To determine how relevant WASH conditions are to nutritional status

1.3. Research Questions

The research questions for the study are as follows:

- What is the current nutritional status of children in the study area?
- What is the role of direct and indirect risk factors affecting the nutritional status of children?
- How relevant are WASH conditions to nutritional status?

1.4. Rationale

Western region bears the highest prevalence of undernutrition cases (GoN, 2018) with the lowest sanitation coverage among other regions in Nepal (NMIP, 2014). With the introduction of nation-wide water, sanitation and hygiene programs, there has been a reduction in disease cases like that of diarrhoea, typhoid, cholera, skin diseases and others. However, data related to the effectiveness of interventions are not well assessed, usually due to lack of baseline data. In addition, news of different cases of diarrhoea and viral fever in Western Nepal is very common especially during summer. No any recent data has been collected regarding health and nutritional deficiencies of children in those areas. This study therefore gives the background information and generates comparable data after interventions. Findings from this study can be used as a reference material if circulated among the concerned stakeholders who are involved in the implementation of WASH interventions in similar setting within the country.

1.5. Scope

The findings of the study will serve as the baseline information for water quality and hygiene interventions, which will be implemented in the study area. It will provide information on the present nutritional status of children along with role of different factors influencing it. At the same time, it will guide students and researchers for conducting similar type of research in future. Additionally, it will also be helpful for different national and international organizations and concerned authorities to implement WASH programs in similar rural setting focussing the vulnerable groups. Furthermore, information about the current feeding practices, WASH structures and behavioural aspect associated with WASH will help to plan the most needed intervention in the area. One important strength of our study would be to add knowledge to reduce the scarcity of literatures that focus on linkage between nutritional status and diseases caused due to lack of nutrient like Vitamin A, protein and iron. This study can therefore be helpful to obtain latest information of such cases in Nepal.

1.6. Limitations of the study

Some of the limitations of the study could be as follows:

- The selection of implementation areas was done purposely. Areas where households have access to a piped water system were selected for interview. Households without connection to a piped water system were excluded. Therefore, the study lacks information of children belonging to households who consume water from open sources and might be at higher risk
- Anthropometric measurements were sometimes not accurate for children below 1 year of age since improper handling alignments influenced measurements of those children
- There is always potential of reporting and recall bias among respondents which may influence the answers for questions like total number of hand washing times using soap and water, frequency of food items consumed, child history of illness, breast-feeding period

2. LITERATURE REVIEW

The term ‘undernutrition’ is generally used to refer to a poor nutritional status, but also implies underfeeding (Shetty, 2006). UNICEF defines undernutrition as the outcome of insufficient food intake and repeated infectious diseases (Unicef, 1990). Undernutrition encompasses stunting, wasting, and deficiencies of essential vitamins and minerals (collectively referred to as micronutrients) (Black et al., 2008).

Undernutrition among children is a major public health problem (Black et al., 2008). Child undernutrition remains alarmingly high in poor countries (Ali et al., 2013). Undernutrition is a critical problem because its effects are long lasting and go beyond childhood with short and long-term consequences (Abuya et al., 2012). Stunting, underweight and wasting are three categories of undernutrition. High chronic undernutrition also signifies children’s failure to grow with impact on both physical and mental capacity (Asfaw et al., 2015). Nutritional deficiencies can cause a variety of symptoms, in addition to weakening the body´s defence against serious illness (Derrick et al., 1997).

2.1. Factors affecting nutritional status of children

Child undernutrition results from series of immediate (individual level), underlying (household or family level), and basic (societal level) causes which work in synergy, with determinants at one level influencing the other level (Unicef, 2014). Undernutrition among children depends on complex interactions of various factors like: socio-demographic, environmental, reproductive, institutional, cultural, political and regional factors (R. E. Black et al., 2008).

There are both direct and indirect causes of undernutrition in children. The two immediate causes are inadequate dietary intake and diseases, which interact in complex manner and manifest stunting or wasting. Underlying these immediate causes are a multitude of indirect factors such as WASH conditions, child-care practices embedded in larger economic and social environment (Dangour et al., 2013) and (Unicef, 1990) . (Dodos et al., 2017) have mentioned the three main underlying causes of undernutrition as unsuitable or insufficient food intake, poor care practices, and infectious diseases, which are directly or indirectly related to inadequate access to water, sanitation facilities, and hygiene practices (WASH).

2.2. Direct factors affecting nutritional status

2.2.1. Diet

In poor populations in low-income countries, diets are often unbalanced and composed primarily of starchy staples, consumption of animal products and fruits and vegetables in dependence of the season (Arimond & Ruel, 2004). Healthy and productive population in future is assured by adequate diet. To maintain an adequate dietary intake, it is crucial that growing children obtain their daily energy from a varied, healthy and balanced diet (Akombi et al., 2017). Adequate nutrition also comes with the advantage of a reduction in public health expenditure on health care and improved health which may lead to economic growth (Frempong & Annim, 2017). Breast-feeding also plays an important role in the nutritional status of children. There is a higher risk of under-nourishment if the children are not breast-fed appropriately (Asfaw et al., 2015).

2.2.2. Diseases

Infectious diseases like diarrhoea caused by a lack of hygienic conditions and clean water are important determinants of child undernutrition (WHO, 2014). Globally, diarrhoea is the third largest cause of morbidity and sixth largest cause of mortality (Montgomery & Elimelech, 2007). Diarrhoeal disease is one of the leading causes of morbidity and mortality in least developed countries, especially among under children aged under 5 years (Fewtrell et al., 2005). Repeated diarrhoea incidence in the first two years of life significantly increases the risk of being stunted by the age of two years (Checkley et al., 2008). In addition, the long-term consequences of diarrheal diseases have been linked to secondary health impacts such as nutritional deficiencies and reduced cognitive function in children (Keusch et al., 2006).

Clinical examination has always been an important practical method for assessing the nutritional status of a community. Clinical assessment can give a valuable information of public health especially in region where nutritional stigma are widespread (Derrick B Jelliffe & Jelliffe, 1997). The method is based on examination of changes, believed to be related to inadequate nutrition that can be seen or felt through several clinical signs like presence of bitot´s spot, hair pigmentation or loss, dry infected cornea, oedema, pale conjunctiva, bowled legs, spongy bleeding gums, dermatitis, red inflamed tongue, sub dermal haemorrhage, goitre and observed wasting. Bitot´s spot is considered as a symptom of Vitamin A deficiency. The spot is slightly refractive with oval, triangular or irregular in shape, build-up of keratin located superficially in the conjunctiva (Derrick B Jelliffe & Jelliffe, 1997). The Vitamin A deficiency is an important public health problem worldwide that contributes significantly to

the global burden of diseases (Sherwin et al., 2012). Vitamin A deficiency is one of the most profuse deficiencies worldwide associated with increased susceptibility to diseases (Reifen, 2002) including disorders like dry or infection in cornea and increased risk of infectious diseases (Sherwin et al., 2012). Children who are Vitamin A deficient will not have eye signs known as xeropthalmia or dry eye (Gilbert, 2013). Deficiencies of vitamins and proteins may cause diseases or problems like dry or infected cornea and pale conjunctiva and lead to undernutrition. Dry or infected cornea is the reflection of vitamin deficiency (Jelliffe, 1966) and protein deficiency (Kuming & Politzer, 1967). Pale conjunctiva is the situation with very little or no red evidence of red colour on the anterior rim of eyes, which matches with the fleshy colour of posterior aspect marking anaemia. Anaemia is a prevalent health problem in many parts of the world especially where dietary iron deficiency, malaria and hook worm infections are common (Stoltzfus et al., 1999). Xeropthalmia is a public health problem in Nepal reported that cases of xeropthalmia had the lowest intake of Vitamin A in Eastern and Far-western Region (Upadhya et al., 1985). Hair pigmentation or loss can be seen due to caloric deprivation in deficiency of several components such as protein, mineral, fatty acids, vitamins caused by reduced intake of proper diet (Finner, 2013). Protein deficiencies in children lead to oedema, which is swelling conditions characterised by excess of watery fluid collection in cavities or tissues (Golden, 1982). Bowled legs is an underlying disease mainly due to lack of Vitamin D deficiency which presents changes in bone (Wharton & Bishop, 2003). As deficiency develops, weakened bones are unable to support body weight and lower extremities become bowled (Jen & Yan, 2010). Spongy bleeding gums is the clinical sign indicating the deficiency of Vitamin C where red inflamed tongue includes iron and Vitamin B deficiency (Popovich et al., 2009). Children with deficiencies of Vitamin D are prone to respiratory problems and skin allergies or dermatitis (Litonjua, 2012). It is also sometimes due to unhygienic conditions. Goitre is mainly due to lack of iodine in the body. When iodine is deficient, hypothyroidism occurs, resulting in increased production of thyroid stimulating hormones and goitre (M. M. Black, 2003). Examination of such clinical signs can give proper indication of nutritional deficiencies in children.

2.3. Indirect factors affecting nutritional status

2.3.1. WASH Conditions

2.3.1.1 Water

Safe water and adequate sanitation are basic to health of every person on the planet, yet many people throughout the world do not have access to these fundamental needs (WHO & UNICEF, 2006). Safe drinking water is defined as water with microbial, chemical and

physical characteristics that meet WHO Guidelines of national standards on drinking water quality (Salud & Suiza, 1997). The presence of indicator organism (Escherichia coli or thermos tolerant coliform bacteria) in water indicates recent contamination of water by faecal matter and have possible presence of intestinal pathogens (Kimani-Murage & Ngindu, 2007). Table 2.3-1 shows the risk categorization and colour code scheme for E.coli in water according to WHO Guidelines (WHO, 1997). According to (UNICEF, 2018), total 71% of households are at risk from E.coli contamination of source water and 82% are at risk of from re-contamination by E.coli at point of use.

Table 2.3-1 : Risk classification and colour code scheme for E.coli in water

Count per 100 ml	**Category and Colour code**	**Remarks**
0	A (blue)	In confirmity with WHO guidelines
0-10	B (green)	Low risk
10-100	C (yellow)	Intermediate risk
100-1000	D (orange)	High risk
>1000	E (red)	Very high risk

In 2015, 6.5 billion people used improved sources of drinking water walking no more than 30 minutes per trip to collect water whereas 263 million people (4 per cent of the population) used improved sources that required more than 30 minutes collection time. Improved sources are those that have the potential to deliver safe water by nature of their design and construction such as households with tap water in their dwelling, yard or plot; or public stand posts and non-piped supplies such as boreholes, protected wells and springs, rainwater and packaged or delivered water (WHO & UNICEF, 2017).

2.3.1.2. Sanitation

Sanitation is far beyond the issue of toilet, although safe disposal of human excreta and other domestic wastewater is major and necessary requirement for safe sanitation. Sanitation is generally activities, which improve and sustain hygiene in order to raise quality of life of an individual (Patel et al, 2011). Worldwide, one in five persons does not have access to safe and affordable drinking water and every second person doesn´t have access to safe and sufficient sanitation (Langergraber & Muellegger, 2005). In 2015, 5 billion people had access to an

improved sanitation facility that was not shared with other households whereas 600 million people (8 per cent of the population) used improved sanitation but shared with other households. Improved sanitation facilities are those designed to hygienically separate excreta from human contact which includes flush and pour flush toilets connecting to sewers, septic tanks or pit latrines and dry sanitation technologies (ventilated improved pit latrines; pit latrines with slabs; or composting toilets) (WHO & UNICEF, 2017).

2.3.1.3. Hygiene

Hygiene refers to conditions or practices by which people maintain or promote health by keeping themselves and their surrounding clean (Kagan et al., 2002). Hygiene deserves first priority because attitude and practices are much more important than physical infrastructure. Hygiene is multi-faceted and can comprise much behaviour, including hand washing, menstrual hygiene and food hygiene. International consultations among WASH sector professionals identified hand washing with soap and the availability of sufficient and clean water as a top priority for prevention of diseases in all settings, and as a suitable indicator for national and global monitoring of hygienic condition (WHO & UNICEF, 2017).

2.3.1.4. WASH and health

WASH practices are linked to diarrhoea and nutrition through multiple pathways. Faecal exposure through contaminated water, unimproved sanitation and poor hygiene can lead to diarrhoea and subclinical infections including environmental enteropathy both of which are negatively associated with child growth (Sinharoy et al., 2016). Improvement in water, sanitation and hygiene practices plays an important role in the better health status of a community. In developing countries, water and sanitation services are still severely lacking. As a result, millions suffer from preventable illness and die every year (Montgomery & Elimelech, 2007). Water quality and hygiene interventions are intended to protect health by reducing exposure to pathogens (Brown et al., 2012). Increasing evidence suggests that water, sanitation and hygiene (WASH) practices affect linear growth in early childhood (Rah et al., 2015). Unhealthy sanitary practices like disposal of child faeces in open area increases exposure to faecal pathogens among susceptible children by allowing direct contact with faeces and contaminated soil during play behaviour and through vectors such as flies, spreading faecal pathogens to food (George et al., 2016). Children living in poor sanitary conditions ingest high concentrations of faecal bacteria, which trigger the metabolic changes in the body retarding growth (Humphrey, 2009).

2.3.2. Socio-economic status

Poverty is associated with poor housing, crowding and lack of access to sufficient and clean water and inadequate sanitary disposal. Poverty restricts the ability to provide age appropriate, nutritionally balanced diet or to modify diets. As a result, children are unable to mitigate or repair nutrient loss when they suffer from diarrhoea (Keusch et al., 2006). A low family income and poor living conditions increase the risk of child stunting, due to high food insecurity, low access to health care, unhealthy environments and a high risk of infections (WHO, 2014). Nearly all Nepalese rural women engage in subsistence agricultural production activities, including more than 70% of labour related livestock production (Miller, 2011). This is beneficial sometimes leading to higher production of food but also risky since children are not provided with timely care and are involved in labour intensive works in the field.

2.3.3. Child care practices

In low- and middle-income countries, children living rural areas are prone to undernutrition due to the lack of better-equipped health-care systems and limited access to health-care facilities (WHO, 2014). The impacts on undernutrition are exacerbated by the lack of adequate, available and affordable medical care. Thus, the young ones suffer from an apparently never-ending sequence of infections, rarely receive appropriate preventive care and receive treatment through the health care system only when they are severely ill (Keusch et al., 2006).

2.3.4. Food security

Food security is commonly conceptualized as the availability, access, and utilization of food (Barrett, 2010). Food security is defined as the availability of food at all the times, every individual have means to access it and food is nutritionally adequate in terms of quality, quantity and variety and is acceptable within given culture (Bashir & Schilizzi, 2013). Children living in households without food security experience poorer nutritional, health, and psychosocial outcomes by being compromised by the lower quality and quantity of dietary intake (Ali et al., 2013). At the same time, the inability to consume enough food affects ability of under nourished children to properly develop physically and mentally which in long-term will lower the ability to generate an adequate income and strengthen the poverty trap (Ki-Moon, 2013).

3. MATERIALS AND METHODS

3.1. Study Area

The study was carried out in Surkhet, Dailekh and Achham of Mid-Western and Far- Western Development Region. Surkhet was divided into two areas as A and B for carrying out the study where Dailekh and Achham were area C and D. Lekhbesi, Dullu and Kamalbazar were respective municipalities for Surkhet, Dailekh and Achham. The areas were divided based on the implementation strategy of different interventions.

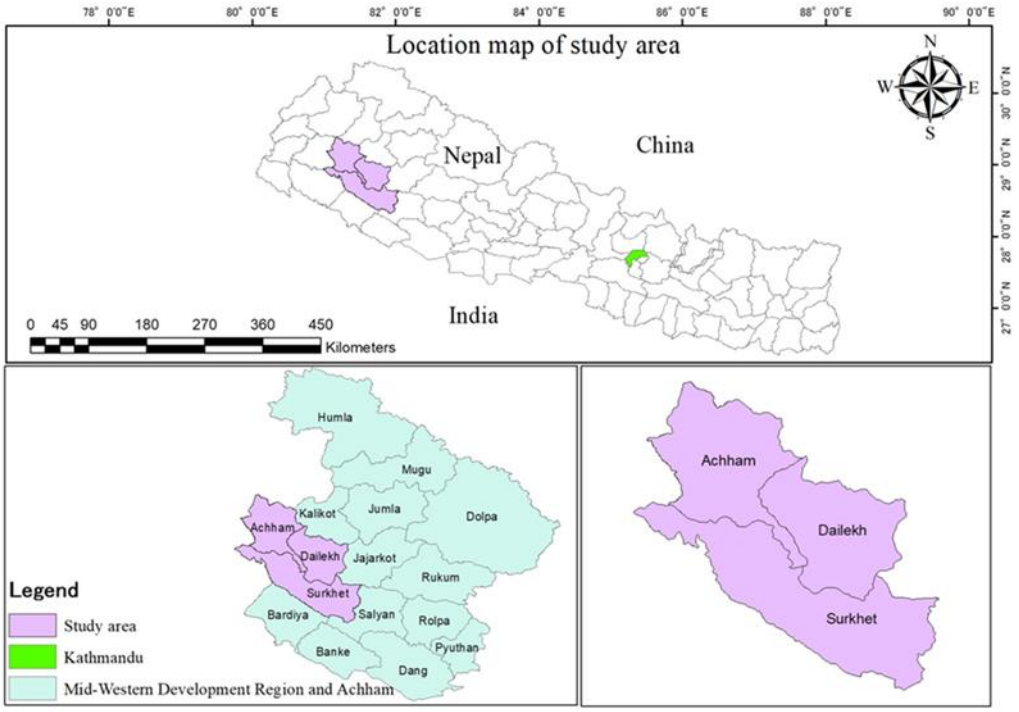

Figure 3.1-1 : Location map of study area

Surkhet and Dailekh belongs to districts of Province 6 whereas Achham is one of the nine districts of Province 7. According to the census of 2011, population of Surkhet, Dailekh and Achham was 343,318, 261,770 and 257,477 respectively (GoN, 2012). Surkhet in one of the inner Terai valleys whereas Dailekh and Achham lies in the hilly region of Nepal. More than half of Surkhet has upper tropical climatic zone comparative to Dailkeh and Acham, which have sub-tropical climatic zone. With limited infrastructures, Surkhet still remains a rural area, however, development of some cities like Birendranagar have influenced the lifestyle of those living here. On the other hand, Dailekh and Achham are considered as the most remote areas of Nepal with little or no access to proper infrastructures. Thus, these districts provide a suitable setting of Western Nepal to represent and compare the changes in nutrition and WASH practices before and after interventions.

3.2. Research Design

The research design adopted in the course of study is illustrated in Fig 3.2-1. At first, a desk study was carried out followed by reviewing of related documents, reports, journals, articles, books etc. to accomplish the part of literature review. A pre-test of study was done before conducting the study. The entire study was carried out following regular consultation with supervisors.

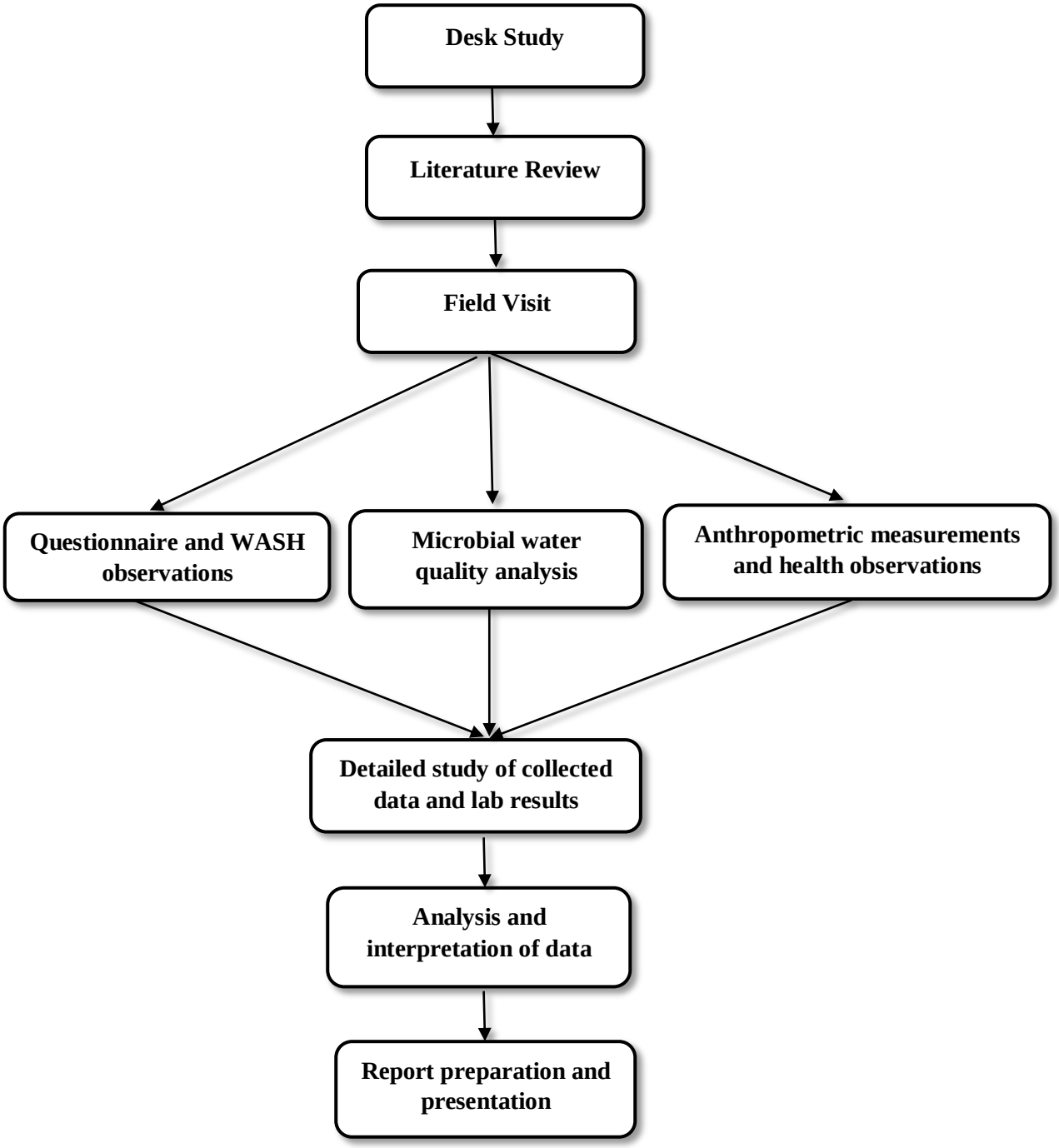

Figure 3.2-1 : Research Design

3.3. Research Methodology

Data were collected using structured questionnaire via face-to-face interviews and anthropometric measurements. The number of households required for the survey was calculated using G*Power Software 3.1 which revealed a sample size of 350 households in each group to detect a small effect between 4 groups with a correlation of 0.1 among repeated measures with 80% power and a one-tailed alpha of 0.05 (Erdfelder et al., 1996). A sample size of 300 households was required to detect a small to medium effect in Cohen's f2 at one-tailed alpha of 0.05 and a statistical power of 95% with multiple linear regression and 15 predictor variables (Faul et al., 2009). In our study, 375 households per study area, was surveyed to have the better advantage of balancing potential design effects. The number of households retained after cleaning entire data set and merging all variables was 1427, among which 348, 365, 356 and 358 were from area A, B, C and D respectively.

3.3.1. Standard questionnaire including WASH observations, anthropometric measurements and clinical examinations

The interview using structured questionnaire with pre coded answer categories was conducted in the households that had access to piped water supply scheme but had not received any WASH intervention yet. Another important criterion was that the households should have children between 6 months to 10 years. Female representatives of households were given priority for interview since they could provide more information on children's care.

A set of structured questionnaire was used to collect general information on socio-demographics, knowledge, attitude and practice of water management, hygiene and sanitation, food security, child health, child illness, nutrition, type and frequency of food consumed. Answers were digitally recorded on tablets via ODK. The recorded information was electronically transferred to excel for data analysis.

Information was collected by direct observation on household to examine the condition and availability of proper water, sanitation and hygiene infrastructure. Information about condition of transport and storage containers, condition of toilet, personal hygiene, hand washing stations and surrounding environment were gathered. Interviewee observation was also done for the types of wall, roof and floor the houses had.

Information on health status of children was collected from children below the age of 10. Health and indicators on the nutritional status were measured on the youngest child in each of the participating households (aged between 6 months to 10 years). A child of each kitchen was examined if a single house was shared among 2-3 families with separate kitchens. The

health and nutritional status were determined by measuring height, weight, mid upper arm circumference, head circumference, wrist and waist measurement. Clinical signs for nutritional deficiencies were examined by assessing bitot´s spot, hair pigment loss, dry infected cornea, oedema, pale conjunctiva, bowed legs, spongy bleeding gums, dermatitis, red inflamed tongue, sub dermal haemorrhage and goitre. After omission of outliers or flagged values, the total number of cases for stunting, underweight and wasting was 1389, 1360 and 1344 respectively.

3.3.2. Drinking water quality test

3.3.2.1. Water sample collection and lab analysis

100 ml of water samples for every households were collected at both point of collection and point of use. Representatives from each households were requested to fetch fresh water from point of collection where water sample for point of collection was collected and sample for point of consumption was collected from the fetched container in drinking cup after they arrived their kitchen. 100 ml of water samples were sampled into sterile whirl packs after letting water run for three seconds for point of collection sample and pouring water from drinking cup directly into container for point of use water sample. The water samples were kept inside cooler bags for transport between sample collection location and the field lab. Water quality analysis was conducted within one hour after collection of the samples. The contamination levels of total coliform and E.coli were analysed at the field site using standardized membrane filtration techniques. 100 ml were passed through 0.45 μm Millipore cellulose membrane filters, plated on Nissui Compact Dry Plates (EC) and incubated for 24 hours at 35+/- 2°C. Colonies were counted visually for assessing the total and E.coli colonies.

3.4. Data Analysis

The collected data were analysed using appropriate statistical methods in SPSS Statistics 24 and WHO Anthro Plus. After cleaning and merging the various data files, data from 1427 households remained for the analysis. Data of drinking water quality were log-transformed to meet the assumption of normality. To be able to do a logarithmic transportation, values with 0 CFU coliforms/100ml were replaced by 0.5.

3.4.1. Calculation of z-scores to determine nutritional status

Stunting, wasting and underweight were calculated using WHO AnthroPlus software. z-scores were calculated for height-to-age (HAZ, stunting), height-to-weight (HWZ, wasting) and weight-to-age (WAZ, underweight). Child Growth Standard, z-scores for HAZ, HWZ and WAZ were used as an evaluation standard of stunting, underweight and wasting as recommended by WHO, 2006. A low height-for-age, z scores below -2SD of population

indicates stunting while below -3SD indicates severe stunting. A low weight-for-age, z-scores below –2SD of population indicates underweight while below -3SD indicates severe underweight. A child with weight-for-height z-score below -2SD indicates wasting while below -3SD indicates severe wasting (WHO, 2006). The results from AnthroPlus were used to retain binary outcome variable for undernutrition.

3.4.2. Calculation of nutritional deficiencies

The results from clinical examination were used to assess the nutritional deficiencies among children. Those children who had any one of the twelve problems were considered positive for the case of nutritional deficiencies. Value 1 was assigned to those children who had nutritional deficiencies and 0 for those who didn´t have any. Furthermore, the obtained result was used as outcome variable to undergo multilevel binary logistic regression controlling area as random effect.

3.4.3. Calculation of Dietary Diversification Score

The frequency of consumption of nine food groups in last one week was assessed for nine food groups: (1) starchy staple food, (2) beans, peas or lentils, (3) nuts or seed, (4) dairy products, (5) meat or fish, (6) eggs, (7) leafy green vegetables, (8) other vegetables, (9) fruits. Dietary Diversification score for daily food items was calculated using Principal Component Analysis. The average of the first three factors for Eigenvalues obtained through PCA was used for further analysis.

Information on any food provided to children in addition to regular meals was also assessed through the questionnaire. The obtained answers from respondents were classified into twelve food groups: (1) cereals, (2) green vegetable, (3) vegetables, (4) fruits containing vitamins, (5) other fruits, (6) meat, (7) legumes, (8) eggs, (9) milk, (10) sweets, (11) fish, (12) beverages. The Dietary Diversity Score for additional food items was calculated following the Guidelines for measuring household and individual dietary diversity prepared by (Kennedy et al., 2011), FAO. If a child consumed at least one food item from food group, the group was assigned a value of one for that child. The group scores were further added to obtain dietary diversification score, which ranged from zero to twelve. The overall score for daily food items and additional items was categorized into low (at least three items), medium (4-5 items) and high (>6 items) based on the same guidelines provided by FAO. The calculated scores were used in the regression model for stunting, underweight and wasting.

3.4.4. Calculation of wealth and hygiene index

Indices for hygiene and wealth were calculated using Principal Component Analysis. The obtained scores were further broken down into quintiles for further analysis. In case of the hygiene index, the first quintile was rated as very poor hygiene and the fifth as best hygiene. Similarly, the first quintile was rated as poorest and the fifth as richest in case of the wealth index.

The following indicators were used to calculate the wealth index:

-Education level of the interviewee (none, informal education, primary, secondary, college/high school)

- Monthly expenditure (in Rs)

- Land owned by the households (in Ropanis)

- Durable assets (T.V, solar panels, mobile phone, motorbike, fridge, watch)

- Electricity present or absent in the house (binary variable)

- Type of fuels used (wood, charcoal, gas, electricity)

- Own/rented house

-Crowding (number of people/number of rooms)

- Kind of wall in the house (stone with mud, stone with cement, wood planks, brick with cement, corrugated iron, cement)

- Kind of roof in the house (mud, straw, roof tiles, Corrugated Galvanised Iron sheet, Reinforced Cement Concrete)

- Kind of floor in the house (earth, cement, floor tiles)

-Kind of hand washing facilities used (none, pour out water, drum with tap)

The following indicators were used to calculate the hygiene index:

-Conditions of water transport container (cleanliness, lid, broken or not)

- Condition of hand washing condition (cleanliness, contains soap and water or not)

- Condition of kitchen (dish high, dry rack, food covered, flies)

- Environmental observations (animals inside/outside, trash inside/ outside the house, untidy pile of clothes in the house)

- Personal hygiene of parents (cleanliness of hands, wearing shoes or not)

Non-standardized index (NSI) was calculated in accordance with (Krishnan, 2010) using the following formula:

NSI = (variance explained by factor 1/total variance) (Factor 1 score) + (variance explained by factor 2/total variance) (Factor 2 score) + (variance explained by factor 3/total variance) (Factor 3 score) + (variance explained by factor 4/total variance) (Factor 4 score) + (variance explained by factor n/total variance) (Factor n score)

The calculated NSI was normalized for obtaining an index within 0-1 using the formula:
SEI (0-1) = value of factor score (NSI)/(max - min). The final values were used to assess the association of wealth, hygiene and the nutritional status in bivariate and multivariate analysis.

3.4.5. Statistical analysis

Descriptive statistics was calculated to describe the characteristics of the population and the status of WASH indicators. Frequencies and percentage were computed for categorical variables. Multilevel methods were used to obtain the significant variables based on areas to further input indicators as risk factors in the multivariate logistic regression model. The variables with significance level $p<0.05$ were considered as significant risk factors. Multilevel binary logistic regression was used to retain models for undernutrition and nutritional deficiencies controlling area as random effects. Area was assigned as random effect whereas risk factors were assigned as fixed effect. The factors that were significant in bivariate analysis at significance level less than 0.05 were retained in the model. Our study was conducted on a random sample of the population in four areas which were significant different; therefore, area is assigned as random effect keeping other risk factors as fixed effect. The overall percentage explained by the model was used to test the model referring to Andy Field (Field, 2013).

4. RESULTS AND DISCUSSION

4.1. Socio-demographic description of sample population

Among surveyed respondents, majority 94.4% (n=1347) were female and more than half 57.9% (n=826) belonged to age group 25 to 40. Out of total sampled population, 81.9% (n=1168) could both read and write where 33.9% (n=484) completed primary level of education whereas 28.9% (n=412) had informal education. 16.5% (n=235) could neither read nor write. Agriculture was main occupation for both head of family and spouse with 60.6% (n=865) and 89.7% (n=1280) respectively followed by laborer which was found to be 36.2% (n=512).

4.2. Nutritional status of children

Table 4.2-1 shows the frequencies of different categories of undernutrition among children in Western Nepal. Majority of cases were found for undernutrition (53.9%; n= 769) and nutritional deficiencies (78%; n=1113).

The overall prevalence of stunting among 1389 children was assessed where 26.8% (n=372) were stunted and 17.9% (n= 250) were severely stunted.

By assessing the weight-for-age of 1360 children, 20 % (n=272) of underweight was revealed among which 10.4 % (n=142) were severely underweight.

According to the result of z-score of height-for-age of 1344 children, 7.2 % (n =97) were found to be wasted, among which 4.1% (n=55) were severely wasted. The prevalence of nutrition deficiencies was higher in children below 5-years of age.

Table 4.2-1: Nutritional status of children in study area

	Percentage	**Frequency**
Stunted[a]	26.8 %	372
Severely stunted[b]	17.9 %	250
Underweight[c]	20 %	272
Severely underweight[d]	10.4 %	142
Wasted[e]	7.2 %	97
Severely wasted[f]	4.1 %	55

[a] : HAZ <-2Z and ≥-3Z, [b] : HAZ <-3Z, [c] : WAZ <-2Z and ≥-3Z, [d] : WAZ <-3Z, [e] : HWZ <-2Z and ≥-3Z, [f] : HWZ <-3Z

4.3. Direct factors affecting nutritional status

4.3.1. Diet

The frequency of consumption of seven food groups in last one week was assessed for nine food groups: (1) starchy staple food, (2) beans, peas or lentils, (3) nuts or seed, (4) dairy products, (5) meat or fish, (6) eggs, (7) leafy green vegetables, (8) other vegetables, (9) fruits.

The maximum consumption frequency of starch was 57.5% (n= 821) whereas beans was once per day by 50.9% (n=726). 79.1% (n= 1129) mentioned that they consume nuts sometimes and maximum of the households (42.5%, 606) had dairy items once per week. Maximum of the households mentioned that they sometimes consume eggs (73.9%, n= 1054) and fruits (90.7%, n=1295). 35.8% (n=511) consume leafy vegetables once a day whereas 51.7% (n=738) consume other vegetables once per day. Table 4.3-1 shows the frequency of different food items consumed by members in houses within one week. This information was obtained through questionnaire survey.

Table 4.3-1: Frequency of consumption of daily food items

	Daily food_items								
	starch	**beans**	**nuts**	**dairy**	**meat**	**egg**	**leafveg**	**veg**	**fruits**
	f (%)	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**
thrice/day	215 (15.1)	42 (2.9)				1 (0.1)		8 (0.6)	
twice/day	821 (57.5)	583 (40.9)	3 (0.2)	140 (9.8)	8 (0.6)	4 (0.3)	266 (18.6)	314 (22.0)	6 (0.4)
once/day	389 (27.3)	726 (50.9)	11 (0.8)	277 (19.4)	50 (3.5)	58 (4.1)	511 (35.8)	738 (51.7)	18 (1.3)
every second day		28 (2.0)	1 (0.1)	27 (1.9)	120 (8.4)	46 (3.2)	129 (9.0)	56 (3.9)	8 (0.6)
twice/week	1 (0.1)	12 (0.8)	1 (0.1)	48 (3.4)	230 (16.1)	68 (4.8)	109 (7.6)	32 (2.2)	21 (1.5)
once/week		3 (0.2)	12 (0.8)	132 (9.3)	606 (42.5)	75 (5.3)	69 (4.8)	19 (1.3)	25 (1.8)
<once/week		3 (0.2)	3 (0.2)	65 (4.6)	131 (9.2)	11 (0.8)	25 (1.8)	12 (0.8)	15 (1.1)
sometimes	1 (0.1)	29 (2.0)	1129 (79.1)	708 (49.6)	275 (19.3)	1054 (73.9)	316 (22.1)	244 (17.1)	1295 (90.7)
not at all		1 (0.1)	267 (18.7)	30 (2.1)	7 (0.5)	110 (7.7)	2 (0.1)	4 (0.3)	39 (2.7)
total	1427 (100)	1427 (100)	1427 (100)	1427 (100)	1427 (100)	1427 (100)	1427 (100)	1427 (100)	1427 (100)

DDS for the above-mentioned food items based on the frequency showed that majority (94%, n=1341) had a low dietary diversification score meaning that they consume less than 3 food items weekly. Only 0.6% (n=8) had higher scores meaning that they consume more than 6

food items. On the other hand, 5.5% (n=78) had medium scores explaining that they consume 4 to 5 food items. The overall score ranged between 0 to 9.

Information on any additional food if provided to children was also assessed through questionnaire. The obtained answer from respondents were classified into twelve food groups: (1) cereals, (2) green vegetable, (3) vegetables, (4) vitamins containing fruits, (5) other fruits, (6) flesh, (7) legumes, (8) eggs, (9) milk, (10) sweets, (11) fish, (12) beverages. The result showed that maximum food items consumed in the study area was 4. Among the total surveyed households, 34.9% (n=498) had 0 diversity since they did not provide any of the categorized food items to their child as additional food where 64.9% (n=926) provided at least three of the items and 0.2% (n=3) provided four to five items to their children. Table 4.3-2 shows the frequency of households that provided listed additional food items to their children.

Table 4.3-2: Frequency of households providing additional food items

	Frequency	**Percentage (%)**	**N**
cereals	907	63.5	1427
sweets	82	5.7	1427
otherfruits	31	2.2	1427
eggs	25	1.8	1427
milk	21	1.5	1427
legumes	17	1.2	1427
beverages	8	0.6	1427
flesh	4	0.3	1427
fish	1	0.1	1427
greenveg	1	0.1	1427
veg	1	0.1	1427
vitfruits	0	0.0	1427

Poor feeding practices, such as inadequate breastfeeding, offering the wrong foods and not ensuring that child gets enough nutritious food contributes to poor nutritional status (Chataut and Khanal, 2016). Among the surveyed children, maximum (99.6%, n=1422) were breast-fed where 44.1% (n=630) were breast-fed at least for a year occupying the highest percentage. Figure 4.3-1 shows the categorical breastfeeding time among examined children.

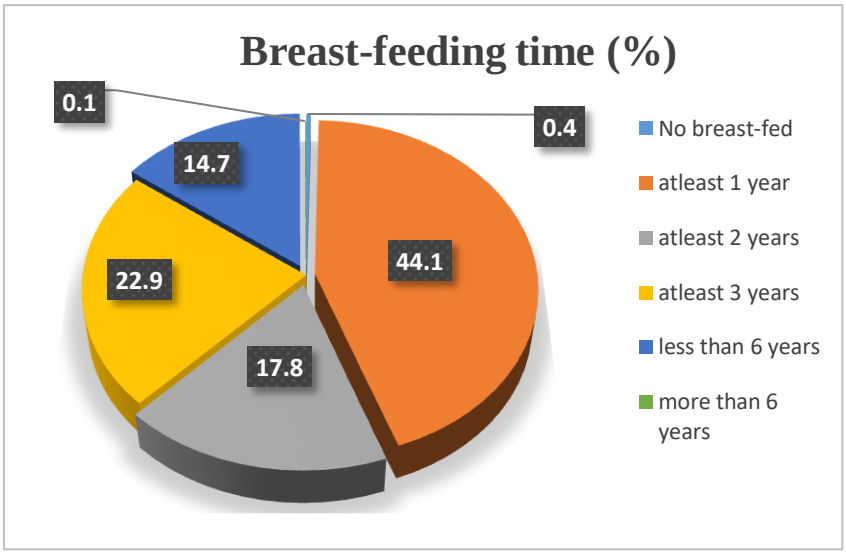

Figure 4.3-1 : Pie-chart showing breastfeeding time of examined children

4.3.2. Diseases

Among the surveyed children, 49.9% (n=712) of children were had some kind of sickness in last 7 days where 16.5% (n=235) of children had diarrhea. From the physical observation, maximum number of children were found to have problem of dermatitis holding the percentage of 57.3% (n=818). The second problem among children was found to be pale conjunctiva with 35.9% (n=513) followed by bitot´s spot with 19.8% (n=283) of surveyed children. Table 4.3-3 shows the disease prevalent among examined children. Table shows the mixed result from questionnaire and physical examination.

Table 4.3-3: Table showing prevalence of diseases among examined children

	Frequency	Percentage (%)	N
dermatitis	818	57.3	1427
other sickness	712	49.9	1427
fever	565	39.6	1427
cough	555	38.9	1427
paleconjunctiva	513	35.9	1427
bitotspot	283	19.8	1427
redinflammed tongue	261	18.3	1427
diarrhoea	235	16.5	1427
spongy bleeding gums	232	16.3	1427
respiration	217	15.2	1427

obs_wasting	197	13.8	1427
dryinfected cornea	189	13.2	1427
hairpigmentloss	153	10.7	1427
subdermalhaemorrhage	66	4.6	1427
mucusstool	53	3.7	1427
bloodystool	46	3.2	1427
oedema	38	2.7	1427
bowedlegs	37	2.6	1427
bloodyurine	9	0.6	1427
goiter	9	0.6	1427

4.4. Indirect factors affecting nutritional status

4.4.1. WASH Conditions

4.4.1.1 Water

4.4.1.1.1 Source and accessibility of drinking water

Piped water in village was found to be the main source of drinking water in the study area. About 75% (n=1077) of households consumed water from such pipes whereas 20.7% (n=296) had piped system within their household. 87.5% (n=1249) mentioned that water from their main source was sufficient for their daily activities where 33.7% (n=481) consume water from other sources apart from their main source. Maximum households, 35.2% (503) had to walk 5 minutes to fetch water followed by 29.2% (n=417) who had to walk 10 minutes to fetch water. 8.8% (n=125) had to walk more than 25 minutes to fetch water where 3.6% (n=51) had to walk even more than 30 minutes back and forth to fetch water. Figure 4.4-1 shows the range of one round time taken for households to fetch water from source.

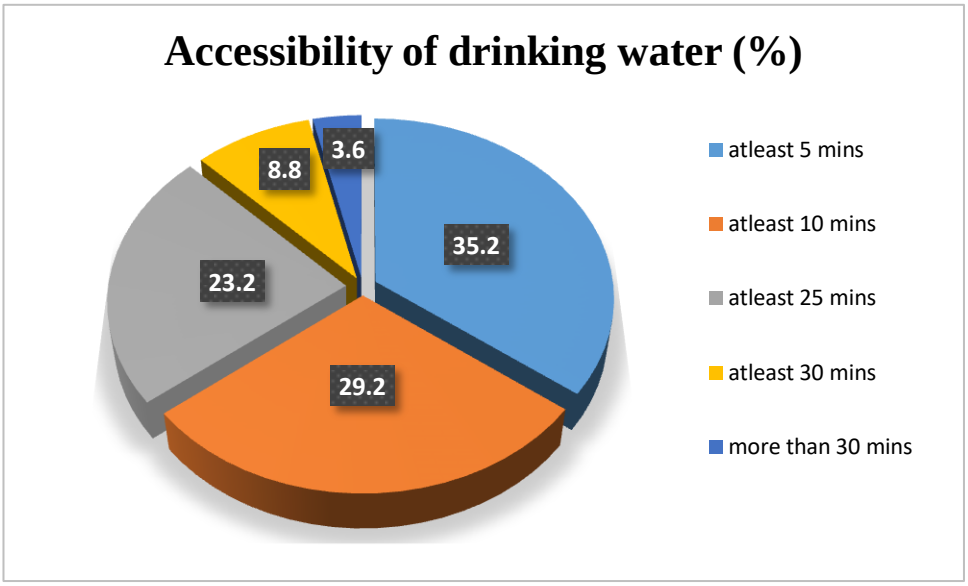

Figure 4.4-1 : Pie chart showing the time taken to fetch water by surveyed households

4.4.1.1.2. Storage and treatment of drinking water

Maximum number of households used aluminum gagri (n=852; 59.7%) followed by plastic jerry can (n=778; 54.5%) for transport of water. 94.5% (n=1348) of the surveyed households used same container for transport and storage which also corresponds to one of the studies in Bolivia (Rufener et al., 2010). Among those who used different container, 3% (n=43) used gagri, 0.4% (n=6) used jerry can and 0.1% (n=2) used plastic containers for the storage of drinking water.

Among the total surveyed households, respondents from 32.2% (n=460) did not know any method for treating water before drinking. Among those who knew some methods, 4.5% (n=64) could not explain well whereas maximum, 22.3% (n=318) could explain three methods of treatment properly. Out of 13.5% (n=193) households that used water purification method, wife were responsible for water purification in 12.8% (n=183) households where 9.6% (n=137) used filter and 4.1% (n=58) boiled their water before drinking. Fig 4.4-2 shows water purification practices present in the study area.

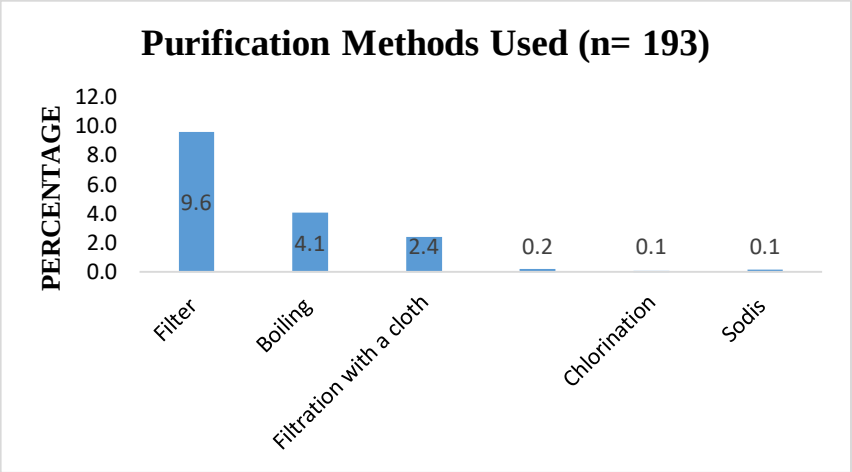

Figure 4.4-2 : Bar chart elaborating different types of water purification method used

Improper handling of water drawing and drinking utensils by children may further contaminate the stored water (Sharma et al., 2013). In such cases, if caregivers are not aware about the water purification method or do not use any treatment method children are more likely to be victim of diseases or illness leading them to undernutrition which is supported by our study.

4.4.1.1.3. Quality of drinking water

Microbial water quality results from 84.9% (1211) of households are included in the result whereas results from 15.1% (n=216) households were discarded due to processing problems and weird results. The grading score for risk of E.coli contamination in drinking water quality showed that 44.6% (n=637) of households in study area had intermediate risk followed by 20.3% (n=289) which had high risk and 4.1% (n=59) of the households had very high risk. Only 0.1% (n=2) had no contamination of E.coli whereas 15.7% (n=224) had low risk. Risk categorization of sampled water based on WHO Guidelines has been shown in Figure 4.4-3.

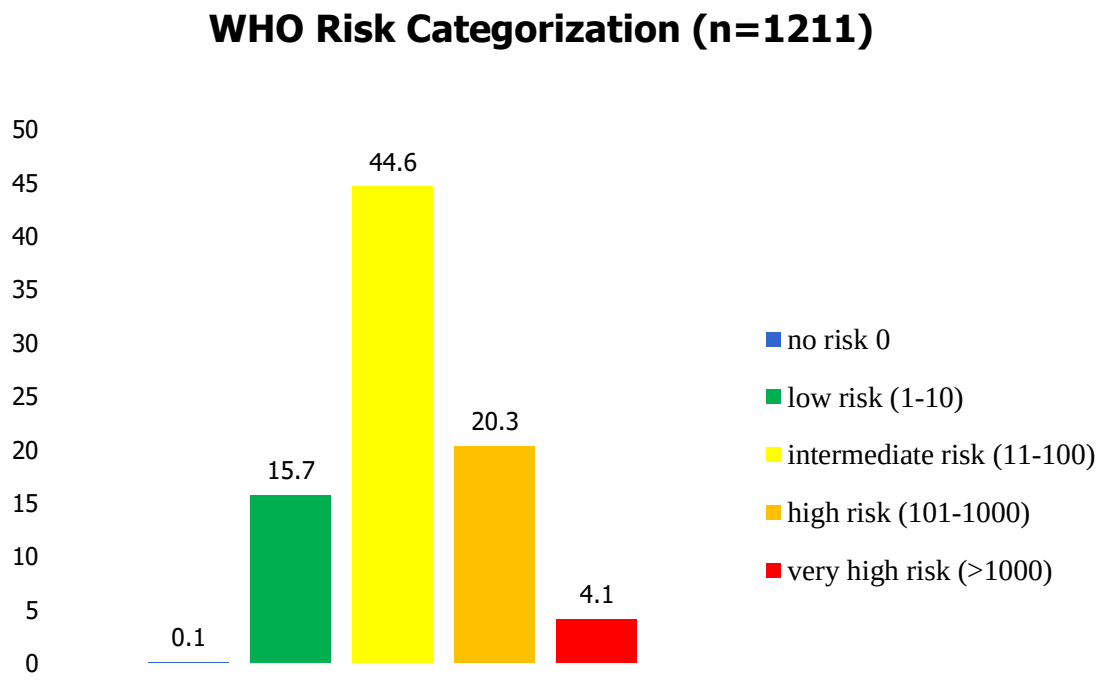

Figure 4.4-3 : Bar graph showing the risk categorization of microbial quality of water

4.4.1.2. Sanitation

Among the total households surveyed, 93.7% (n=1337) mentioned that they defecate in toilet whereas toilet was absent in 6.3% (n=90) of households. The most common type of toilet found was water pit latrine in 84.1% (n=1200) and pit latrine in 9.6% (n=137) of households. The condition of toilet was clean only in 46.7% (n=666) of households whereas toilet was found dirty in 46.9% (669) of households. Materials like water drum, brush and sandals were found in 80.6% (n=1150), 26.3% (n=375) and 3.7% (n=53) of households respectively.

4.4.1.3. Hygiene

In our study, majority of the surveyed population were found to fall within the lowest category of the hygiene index. There was absence of hand washing stations in 59.9% (n=855) of the households whereas using water from drum with tap was mostly prevalent among those households who had hand washing stations. Table 4.4-1 shows the descriptive statistics of different hygiene indicators in the study area.

Table 4.4-1 : Table showing descriptive results of different hygiene parameters (N=1427)

hygiene status	**Frequency**	**%**	**hand_washing_type**	**Frequency**	**%**
first quintile (very poor hygiene)	752	52.7	No hand-washing station	855	59.9
second quintile	162	11.4	pour_from_bucket	255	17.9
third quintile	101	7.1	drum_with_tap	317	22.2
fourth quintile	92	6.4			
fifth quintile (better hygiene)	318	22.3			
total_hand_washing_number			hand-washing_soap		
<= 5 times	408	28.6	<= 5 times	1084	76.0
5-10 times	935	65.5	5-10 times	337	23.6
10-15 times	61	4.3	10-15 times	5	0.4
>=15 times	23	1.6	>=15 times	1	0.1
hand_washing_times					
when hands look dirty			after going to toilet		
Yes	862	60.4	Yes	1402	98.2
No	565	39.6	No	25	1.8
when clean baby bottom			before eating food		
Yes	834	58.4	Yes	1039	72.8
No	593	41.6	No	388	27.2
before cooking			don´t know		
Yes	572	40.1	Yes	3	0.2
No	855	59.9	No	1424	99.8
no special occasion					
Yes	2	0.1			
No	1425	99.9			
condition_storage_container			condition_transport_container		
lid	934	65.5	lid	934	65.5
no lid	491	34.4	no lid	487	34.1
clean	1089	76.3	clean	1098	76.9
dirty	335	23.5	dirty	328	23.0
not broken	1387	97.2	not broken	1389	97.3
broken	37	2.6	broken	36	2.5
condition_kitchen					
Is the entirety of food covered?			Are clean dishes kept high?		
yes	989	69.3	yes	750	52.6
no	438	30.7	no	677	47.4
Is there dry rack to dry			Is there significant number of		

utensils?			flies?		
yes	609	42.7	few flies	331	23.2
no	818	57.3	many flies	1096	76.8
surrounding_environment					
Does household have garbage pit?			Can you see any dirty cloth piles lying?		
present	84	5.9	no pile	509	35.7
absent	1343	94.1	pile	918	64.3
Can you see trash spread inside the house?			Can you see trash spread outside the house?		
no trash	646	45.3	no trash	473	33.1
trash	781	54.7	trash	954	66.9
Are animals kept inside house?					
inside	851	59.6			
outside	575	40.3			
hygiene observation					
Are mother/father´s hand clean?			Are hands of child clean?		
Yes	1131	79.3	Yes	726	50.9
No	296	20.7	No	701	49.1
Is mother/father wearing shoes?					
Yes	1061	74.4			
No	366	25.6			

4.4.2. Socio-economic status

Agriculture was the main occupation of people in the study area where maximum households were found to have family member between 5-10. The poorest and richest households ranged from 5.7% (n=81) to 3.4% (n=48). Table 4.4.2-1 shows the descriptive statistics of different socio-economic parameters of study area.

Table 4.4.2-1 : Table showing descriptive results of different socio-economic parameters (N=1427)

	frequency	**%**		**frequency**	**%**
wealth index			**household_member**		
first quintile (poorest)	81	5.7	1-5	421	29.5
second quintile	560	39.2	5-10	921	64.5
third quintile	466	32.7	10-15	78	5.5
fourth quintile	266	18.6	15-20	6	0.4
fifth quintile (richest)	48	3.4	>=20	1	0.1

occupation_head			**occupation_spouse**		
agriculture	865	60.6	agriculture	1280	89.7
laborer	517	36.2	business	106	7.4
employed	175	12.3	laborer	58	4.1
business	145	10.2	service	45	3.2
govt_service	56	3.9	no_spouse	10	0.7
ethincity			**fuel_used**		
Brahmin, Chhetri, Thakuri	704	49.3	wood	1394	97.7
Dalit	451	31.6	gas	313	21.9
Janajati	266	18.6	electricity	17	1.2
Other	6	0.4	charcoal	1	0.1
walls			**expenditure per month (NRS)**		
stone with mud	1116	78.2	<=15000	982	68.8
stone with cement	219	15.3	15000-30000	410	28.7
brick with cement	71	5.0	30000-45000	29	2.0
wood planks	21	1.5	>=45000	6	0.4
floor			**land ownership (Ropanis)**		
earth	1200	84.1	<=15	1339	93.8
cement	227	15.9	15-30	72	5.0
			>=45	11	0.8
roof					
roof tiles	671	47.0			
CGI sheet	483	33.8			
straw	137	9.6			
RCC	113	7.9			
Mud	23	1.6			

4.4.3. Child Care Practices

Among the total surveyed children, 49.9% (n=712) were sick in last 7 days. Parents of 42.8% (n=599) of sick children sought for medical advice where majority of them, 20% (n=285) went to community health workers, 17.9% (n=256) went to pharmacy and 5.3% (n=76) went to hospital for medical advice. On the other hand, 8% (n=114) did not seek any advice. Maximum of non-seeker parents, 92.1% (n=1413) mentioned that lack of good health facility was main reason for them not to seek advice, 4.9% (n=70) think that it is not necessary to go to health facility for such sickness and 1.7% (n=24) did not seek medical advice due to poor economic condition to go to health facility. Figure 4.4.3-1 shows treatment seeking places by caregivers when children are sick.

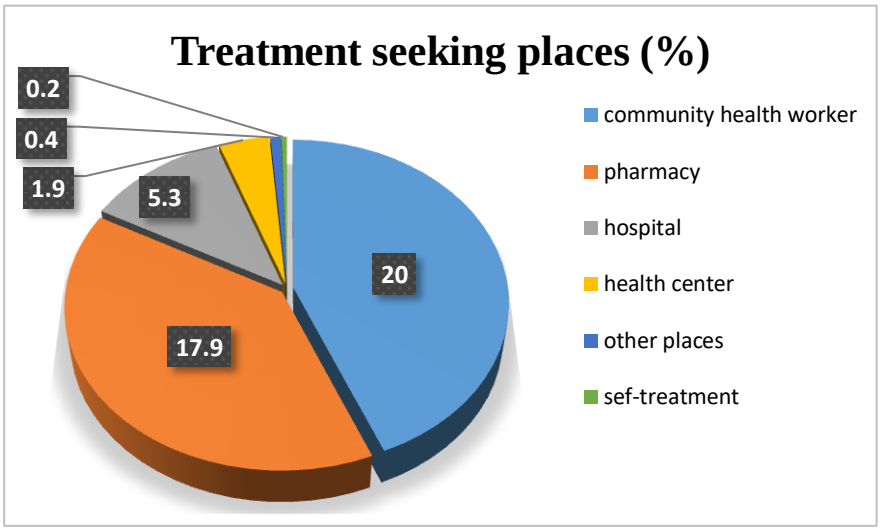

Figure 4.4.3-1 : Pie-chart showing treatment seeking places by caregivers when children are sick

4.4.4. Food security

Among the total surveyed households, 61% (n=871) produced their own food among which 24.3% (n=347) harvest sufficient. Out of 36.7% (n=524) who didn't have sufficient production from own agricultural activities, 22.2% (n=317) bought food for more than 6 months; 14.9% (n=213) buy food for 3 to 6 months and 11.2% (n=160) bought food up to 3 months.

4.5. Risk factors associated with undernutrition

Multilevel binary logistic regression was used to retain a mixed model by controlling random effect for area to identify the risk factors associated with undernutrition. The outcome variable for undernutrition was obtained from the result of stunting, underweight and wasting. Child was undernourished if there was positive result for any one of the categories. Area was assigned as random effect whereas risk factors were assigned as fixed effect. Since our study areas were significantly different from each other, they were controlled at random intercept during the multivariate model. The factors that were significant in bivariate analysis at significance level less than 0.05 were retained the multivariate model. The intercept of variance of the model was 0.254. The factors that were significant in the bivariate analysis are as follows:

- E.coli contamination in drinking water
- Wealth index
- Cleanliness of hands of caregivers
- Children with pale conjunctiva

- Caregivers involved in agriculture
- Children taken to seek medical advice during illness
- Households that use water purification method
- Children who consume eggs as additional meals
- Storage containers are clean

Table 4.5-1 shows different risk factors associated with undernutrition among children between 6 months to 10 years in the study area. The factors that were significant in the mixed model have been highlighted.

Table 4.5-1: Risk factors associated with undernutrition

	Univariate		**Multivariate**	
Model Term	**O.R**	**Sig (C.I)**	**O.R**	**Sig (C.I)**
Intercept			0.432	0.110 (0.155-1.210)
E.coli contamination in drinking water	1.238	0.004 (1.072-1.428)	**1.438**	**0.001 (1.162-1.780)**
wealth index	0.188	0.00 0 (0.100-0.371)	**0.137**	**0.000 (0.049-0.381)**
cleanliness of hands of caregivers	1.404	0.014 (1.079-1.853)	**1.928**	**0.002 (1.267-2.934)**
children with pale conjunctiva	1.116	0.346 (0.884-1.397)	**1.432**	**0.046 (1.006-2.038)**
caregivers involved in agriculture	1.713	0.003 (1.200-2.438)	1.409	0.239 (0.796-2.494)
children taken to seek medical advice during illness	1.601	0.028 (1.054- 2.432)	1.553	0.061 (0.979-2.463)
households that use water purification methods	0.724	0.048 (0.526-0.997)		
children who consume eggs as additional meal	2.38	0.042 (1.031-5.494)		
storage containers are clean	1.332	0.027 (1.041-1.727)		

E.coli contamination in drinking water at point of use, wealth index, cleanliness of hands of caregivers and children showing symptom of anaemia through pale conjunctiva were found to be significantly associated with undernutrition in the model. On the hand, children from those houses that used water purification method and had clean storage containers; also those children who consumed eggs in their additional meal were significantly associated with undernutrition in univariate model but not included in the multivariate model due to collinearity with other variables.

E-coli in drinking water was found to be positively associated at 0.01 level of significance with undernutrition (OR= 1.438; 95% C.I 1.162 to 1.780). Contamination by hands and domestic animals has been shown to be a predominant cause of declining the quality of water (Schmidt & Cairncross, 2009). In our study, maximum (59.6%, n=851) of the households mentioned that they kept animals inside house. On the other hand, through the hygiene observation, hands of 79.3% (n=1131) of caregiver looked clean. Drinking water quality was significantly associated with the observed cleanliness of hand of caregiver (p=0.00; OR= 0.649 at 95% C.I 0.538 to 0.784) and domestic animals within households (p= 0.00; OR= 0.754 at 95% C.I 0.650 to 0.875). Even if water is treated, there are chances of contamination. According to one of the studies in Uganda, recontamination risk of water is reduces in the households that had soap in hand washing station (Meierhofer et. al., 2017). The households that keep animals outside the house have less chances of E.coli contamination in their drinking water. This prevents the chances of fecal contamination by animals like chicken. It explains that the hygiene practices of caregivers and surrounding environment has a remarkable impact on the drinking water quality and further on child health.

Wealth index was negatively associated with undernutrition. Children from households with higher wealth index were 87% less likely to be undernourished compared to those with higher wealth index (p=0.00; OR= 0.137 at 95% C.I 0.049 to 0.381). The major occupations of households in our study area were agriculture and daily labour. Agriculture is not productive in Dailekh and Achham due to hailstorm, lack of sufficient water for irrigation, unavailability of necessary fertilizers or manure and sometimes due to barren land. On the other hand, wages for daily labourer is not sufficient to fulfil all the basic needs including food. In such cases, wealth could certainly be an important risk factor for undernutrition.

In one of the studies in Ghana, children from wealthier households were found to have better nutritional status than poorer households where one-third of children born to poor parents were stunted (Frempong & Annim, 2017). In one the studies done in Western China, poor family with low income were significantly found to be associated with child's stunting (Wang et al., 2017). Wealth index (poor household) was found to be associated with all categories of undernutrition in one of the studies done in Kenya (Gewa & Yandell, 2012).

Observed cleanliness of hands of caregivers was found to be associated with children's undernutrition. Cases of undernutrition was 92% more likely among those children whose parents hands looked clean (O.R=1.928 at 95% C.I 1.267 to 2.934). This indicates observed cleanliness of hands is not an adequate indicator to assess risk factors for the nutritional status of children. An observation yields only a momentary impression and does not provide a clue on regular behavior, in addition, it might be that not have cleaned their hands were not cleaned properly or used only water to clean. It could also be that the caregivers were not aware about proper hand washing practices or didn´t wash their hands properly with soap and water.

In our study, there was no significant association between hand washing number of caregivers with water or soap with undernutrition which corresponds to one of the studies in Malaysia done among indigenous community named Orang Asli, where no any significant association was observed between hand washing with soap and stunting (Murtaza et al., 2018). According to (Huttly at al., 1997), promotion of hand washing reduces diarrhea incidence by an average of 33% . Hence, proper hand washing practices by caregivers in the area itself could be one of the preventive measures for improvement of health of children.

In our study, undernutrition was 43% more likely among children who had clinical sign of pale conjunctiva (p= 0.046; O.R= 1.432 at 95% C.I 1.006 to 2.038) in comparison to those who didn´t have such problems. This can be assumed due to lack of proper nutrients in diet of children. They are only provided with rice almost every time feeding only carbohydrate. Consumption of fruits is not common in our study area where maximum mentioned that they buy fruits sometimes in a week depriving their children from other necessary nutrients leading to nutritional deficiencies and risk of undernutrition. Not many recent and related researches for clinical observations were conducted in Nepal.

In our study, trend of almost significant association (p= 0.061; OR= 1.553 at 95% C.I 0.979 to 2.463) was observed in multivariate analysis between children who were taken to seek

medical advice and undernutrition. It was significantly associated with undernutrition in biivariate analysis (p= 0.028; OR= 1.601 at 95% C.I 1.054 to 2.432). Children who were taken to seek medical advice were 60% more likely to be undernourished than those who were not taken for any treatment or advice. Lack of proper health care facilities, infrastructures and skilled health workers may be one of the causes of no improvement in health or nutritional status of children even after seeking advice. This association can be further associated with our findings. Maximum of caregivers who didn´t seek any medical advice mentioned that the main reason for not seeking advice was due to lack of proper infrastructure. Hence, there might be chances that those taken for treatment or advice still had poor health conditions. At the same time, spiritual taboos or beliefs of taking child to "dhami" (who is supposed to have spirits within themselves), could also be one of the reasons that caregivers are not serious about medical doses provided in health post. On the other hand, lack of proper diet could be one of the confounding factors to influence the obtained result.

In our study, no association between the undernutrition and stated food security was observed at 0.01 and 0.05 level of significance which corresponds to one of the studies done in Lalitpur (Sarki et al., 2016). In another study conducted in Kailali, Nepal, no association was found between household food insecurity and the nutritional status of children under 3 years of age (Osei et al., 2010). Several other indirect factors apart from food security may play an important role in children undernutrition such as dietary diversity, care giving practices, employment of parents and WASH practices. In addition, even if a household states food sufficiency, child-feeding practices still may be inappropriate.

In the bivariate analysis, children of caregivers involved in agriculture were 71% more likely to be undernourished (p= 0.003; OR= 1.713 at 95% C.I 1.200 to 2.438) than those who caregivers don't have this occupation. This variable has been included in the model but is not found to be significant. The households engaged in agriculture give birth to higher number of with traditional practice of employing them in field. Due to this reason, they lack proper care from their parents and could be victim of undernutrition. In one of the studies in Ghana, number of children in households were directly associated with undernutrition (Frempong & Annim, 2017).

In our study, children who consumed eggs as additional meals were also found to be undernourished according to the result of bivariate analysis (p= 0.042; OR= 2.38 at 95% C.I 1.031 to 5.494). One of the reasons could be that those who produce eggs in their own house

consume eggs lacking other source of proper diet. To maintain adequate dietary intake, it is crucial that growing children obtain their daily energy from a varied, healthy and balanced diet (Akombi et al., 2017).

4.6. Risk factors associated with nutrition deficiencies

Multilevel binary logistic regression was used to retain a mixed model by controlling random effect for area to identify the risk factors associated with nutrition deficiencies. The outcome variable for nutrition deficiencies was obtained from the result of clinical examination. Child was considered to have nutritional deficiencies if there was positive result for any one of the examination. Area was assigned as random effect whereas risk factors were assigned as fixed effect. Our study areas being significantly different from each other, they were controlled for area while retaining the model. The factors that were significant in bivariate analysis at significance level less than 0.05 were used for retaining the model. The variance of intercept of the model was 0.425. The factors significant in bivariate analysis are as follows:

- Cleanliness of hands of caregivers
- Cleanliness of hands of child
- Storage containers are clean
- Hand washing number with soap
- Children with mucus in stool in past 7 days
- Animals are kept outside the house
- Households produce their own food
- Water is sufficient for daily need
- Households that use water purification methods
- DDS for regular food items
- Households with brush in toilet
- Households with no any materials (brush, sandals and water drums) in toilet
- Parents wearing shoes

Table 4.6-1 shows different risk factors associated with nutritional deficiencies among children between 6 months to 10 years in the study area. The factors that were significant in the mixed model have been highlighted.

Table 4.6-1 : Risk factors associated with nutrition deficiencies

	Univariate		**Multivariate**	
Model Term	**O.R**	**Sig (C.I)**	**O.R**	**Sig (C.I)**
Intercept			10.629	0.000 (4.402-25.663)
cleanliness of hands of caregivers	1.084	0.631 (0.780-1.507)	**1.724**	**0.015 (1.109-2.679)**
cleanliness of hands of child	0.521	0.000 (0.401-0.693)	**0.375**	**0.000 (0.263-0.536)**
storage containers are clean	1.53	0.005 (1.133-2.064)	**2.414**	**0.000 (1.648-3.536)**
handwashing number with soap	0.764	0.000 (0.692-0.844)	**0.817**	**0.000 (0.371-0.913)**
children with mucus in stool in past 7 days	3.224	0.028 (1.137-9.145)	**2.946**	**0.052 (0.990-8.765)**
animals are kept outside the house	0.431	0.000 (0.326-0.569)	**0.516**	**0.000 (0.377-0.705)**
households produce their own food	0.408	0.000 (0.305-0.546)	**0.597**	**0.002 (0.430-0.829)**
water is sufficient for daily need	0.579	0.016 (0.371-0.904)	0.833	0.454 (0.517-1.344)
households that use water purification methods	0.686	0.033 (0.485-0.970)		
Dietary Diversification Score for regular food items	0.799	0.000 (0.721-0.886)		
households with brush in toilet	0.681	0.007 (0.514-0.901)		
no any materials (brush, sandals and waterdrums) in toilet	1.793	0.026 (1.074-2.995)		
parents wearing shoes	0.286	0.000 (0.197-0.414)		

The major factors associated with nutritional deficiencies are cleanliness of hands of caregivers and child, condition of storage containers, hand washing with soap and water, presence of mucus in stool in past 7 days, animals kept outside the house and households producing their own food. Other factors like households with availability of sufficient water for daily use, households using any method of water purification, DDS for regular food items, households having either cleaning brush in their toilet, households without any materials (brush, sandals and water drums) and child of parents wearing shoes were significantly associated in bivariate but altered the significance level of other variables in the multivariate analysis. Hence, those variables were excluded while retaining the model.

Unlike undernutrition, cleanliness of hands of caregivers were significantly associated with nutritional deficiencies (p= 0.015; OR= 1.724 at 95% C.I 1.109 to 2.679). Children whose parents had clean hands were still 72% more likely to have nutrition deficiencies. Carelessness of caregivers regarding use of soap for hand washing could be one of the reasons for this association. (Nizame et al., 2013) in their study in Bangladesh mentioned that even after knowing the importance of washing hands with soap, community had not developed habit of washing hands. In one of the studies in Bangladesh, children experienced less diarrhea when caregivers washed their hands with soap before preparing food (Luby et al., 2011). Fewer diarrheas help in proper functioning of metabolic system of body. As a result, children gain body weight and height accordingly based on the diet they take. At the same time, food contamination with dirty hands could be a source of diarrhoea and other water related pathogens. On the other hand, cleanliness of hands of child was significantly associated with nutritional deficiencies. Children with clean hands were 63% less likely to have nutritional deficiencies (p= 0.00; OR= 0.375 at 95% C.I 0.263 to 0.536). Children move to different places and put different objects in their mouth. When their hands are dirty, there are greater chances for children to inject infectious pathogens into their body through their dirty hands. In contrast to our study area, where most of the households had mud floor and kept animals inside house, children are highly susceptible to external infectious agent. In such cases, dirty hands of children could lead to higher faecal contamination and are prone to diarrhoeal diseases leading them to be unhealthy showing any of the clinical signs for nutritional deficiencies. . In one of the studies in India, children with better personal hygiene were found to be healthy in comparison to those who didn´t have better personal hygiene (Deb et al., 2010).

In our study, positive association was found between cleanliness of storage container and nutritional deficiencies. Even if the storage container was observed clean, there were chances for children from those houses to have nutritional deficiencies. Children were 64% more likely to have nutritional deficiencies even if storage containers were clean (p=0.00; OR= 1.648 at 95% C.I 1.648 to 3.536). This could be either there are other factors contributing to nutritional deficiencies or diseases caused due to consumption of unsafe water.

Another risk factors associated with nutritional deficiencies is number of hand washing times using soap. Children of those caregivers who washed their hands with soap were 19% less likely to have nutritional deficiencies than those whose caregivers didn´t wash their hands (p= 0.052; OR= 0.817 at 95% C.I 0.731 to 0.913). Washing hands properly with soap and water has proven to be one of the best ways to reduce diseases.

Children who faced problem of mucus in stool in past 7 days had higher chances of being nutritional deficient with odds of 2.946 (p= 0.052; OR= 2.946 at 95% C.I 0.990 to 8.765). It can be assumed that with frequent problem of diarrhoea or any of its type, children are at higher risk of losing their weight and decreasing appetite ultimately leading to show any of the clinical signs of nutrition deficiencies.

Environmental hygiene like keeping animals outside the house was found to be significantly associated with nutritional deficiencies. Children from those households who kept their animals outside house were 49% less likely to be nutrient deficient (p= 0.00; OR= 0.516 at 95% C.I 0.377 to 0.705). Free movement of animals in surrounding environment could increase the risk of faecal contamination in both water and food items. Animals carry different infectious disease pathogens, when children are exposed to such animals there might be higher risk of children to have several health problems directly or indirectly. Additionally, in our study area maximum of surveyed households kept their animals inside house where poultry and agriculture were most common occupation. Hence, if children are not exposed to unhygienic environment, they are less likely to have nutrient deficient.

Children from those households who produce their own food were 41% less likely to have nutritional deficiencies (p= 0.002; OR= 0.597 at 95% 0.430 to 0.829). Households producing own food have food security and do not have to buy food for every meals. This increases the chances to nourish children with necessary food items.

From the result of bivariate analysis, children with higher DDS for regular food items were 21% less likely to have nutritional deficiencies (p= 0.00; OR= 0.799 at 95% C.I 0.721 to

0.886). Dietary diversity is a critical determinant of child nutritional status where increasing dietary diversity of children reduced the risk of stunting and improved growth within 20 months interval in one of the studies in rural Nepal (Busert et al., 2016). Lack of diverse diet was a strong predictor of child stunting in one of the studies in Bangladesh (J. Rah et al., 2010). In the study area, children were deprived of proper diet which can be due to poverty, less production due to fragile land and lack of proper knowledge on balanced diet that should be provided to children.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The objective of study to access current nutritional status of children and identify associated risk factors in Western Nepal was accomplished through interviews, anthropometric measurements and microbial analysis of drinking water. Some of the major conclusions have been extracted from the findings of the study.

Majority of the children between 6 months to 10 years were found to be undernourished and have nutritional deficiencies in the study area. There were higher cases of stunting followed by underweight and wasting.

Factors leading to undernutrition are diverse and complex. The key factors associated with undernutrition were E.coli contamination in drinking water, poor economic condition of households, cleanliness of hand of caregivers and clinical sign indicating anaemia through pale conjunctiva. On the other hand, nutritional deficiencies was found to be associated with cleanliness of hand of caregiver and child, hand washing with soap and water, condition of storage container, animals inside the house, mucus in stool in past 7 days and households producing their own food.

Maximum of the households had lower DDS for both regular and additional food items provided to children. On the other hand, maximum of the children were breast-fed at least for a year. Result from wealth index support that overall environmental and socio-economic conditions influence child nutrition through different pathways. Maximum of children were sick during collection of health data and anthropometry measurements. No progress in nutritional status of children was observed even if they were taken to seek medical advice during sickness.

WASH factors hold maximum weightage for influencing nutritional status of children. Inadequate WASH conditions are identified as major contributors to both undernutrition and nutritional deficiencies. E.coli contamination in drinking water, cleanliness of hands of caregivers and child, hand washing with soap and water, keeping animals outside the house were some of the WASH parameters associated with undernutrition and nutritional deficiencies in children.

No significant association was found between nutritional status of children and sanitation facilities present in the house. However, they had negative relationship. There were chances of child being undernourished or have nutritional deficiencies even if caregivers had clean

hands. No significant association was found between cleanliness of hands of caregivers and hand washing numbers.

Recommendations

Risk factors for undernutrition and nutritional deficiency have been identified through statistical analysis. Following are the sets of recommendations that can be taken into consideration:

- Hygiene education with regard to water management and hygiene practices such as hand washing habits could help to reduce cases of undernutrition and health of children with higher percentage.
- Interventions to improve microbial quality of drinking water should target at public level, which can be easily accessed by every individual irrespective of their economic background. Interventions to improve domestic faecal contamination would have better result.
- Safe water handling practices can be promoted with little investment in households.
- WASH intervention should focus on contamination at transmission routes. At the same time, easy and simple knowledge on water purification method should be provided at household level.
- Training on proper hand washing practices and maintenance of hand washing stations alone can be effective to reduce poor nutrition status among children. Interventions should focus on this factor as well.
- Political leaders can mobilize proper framework for improvement of nutritional status by organizing group discussions, meetings or public hearing programs to know about the opinion of people, their perception and type of intervention they expect.
- Failure of many interventions is due to poor management and maintenance, mismatch with local water environment, technology and capacity of users to maintain system. Therefore, before implementation of any interventions, opinion of public, real scenario of water system and practices should be taken into consideration.
- After implementation of intervention, monitoring should be done timely in order to determine the gap between coverage and functionality of programs. Implementation alone doesn´t give expected results. Real scenario can be known only when monitored.

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ANNEX A : Photographs

Interview with respondent

Processing of water sample for microbial analysis

Examination of child health

Children exposed to unhygienic condition in the study area

Improper management of shelter for both animals and humans living in the households

Unhealthy hygienic environment within household

Undernourished child in the study area