THE UNIVERSITY OF NEWCASTLE AUSTRALIA

# Household Water, Sanitation and Hygiene and Their Effects on Child Health in Nepal


**By**

**Shalik Ram Dhital**

**Master of Science in Public Health (MScPH)**

**Centre for Women's Health Research (previously Research Centre for Generational Health and Ageing)**

School of Medicine and Public Health, Faculty of Health and Medicine

The University of Newcastle, Australia


A thesis submitted in fulfilment of the requirements for the degree of

**Doctor of Philosophy (Public Health and Behavioural Sciences)**

**January 2021**

## Statement of originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

Shalik Ram Dhital

January 2021

## Acknowledgements

***"Life does not drive as we think it will; likewise, the success of a PhD is possible, with hard work and a fluctuating learning curve."***

Firstly, I would like to acknowledge and express my gratitude to my principal supervisor, Professor Deborah Loxton, and my co-supervisor, Dr Catherine Chojenta, from the Research Centre for Generational Health and Ageing (RCGHA), Faculty of Health and Medicine, University of Newcastle, Australia, for their constructive feedback, supportive supervision and assistance at each step of my PhD studies.

Secondly, I would like to thank the people of Australia and the Australian Government for all the direct and indirect support they have provided during my study period. I am indebted to the University of Newcastle's Graduate Research Office for providing the Non-commonwealth University of Newcastle Scholarship (UNIPRS and UNRSC 50:50) to support me through this period of study. I also acknowledge the University's Human Research Ethics Committee for the ethical approval for the project. The cooperation and timely support for any Information Technology matters provided by RCGHA database developer, Ryan Tuckerman, has been greatly appreciated. I would also like to thank Tiffany Evans from the Hunter Medical Research Institute (HMRI) for her technical coaching in the statistical analysis of my research data. My thanks go to Peta Forder, senior statistician from RCGHA, who has edited the spatial analysis part of the analysis. Special thanks go to Katherine Tuckerman from RCGHA for editing my thesis and also thanks to Gloria Webb from Wordfix, an Institute of Professional Editors for academic editing this thesis. My thanks also go to Ryan O'Neill and Natalia Soeters, who have provided valuable academic language support. I would like to express my sincere gratitude to the School of Medicine and Public Health's Higher Degree Research (HDR) team members, the HDR Co-ordinator, head of the school, and RCGHA and HMRI staff who have supported me during this PhD journey.

Thirdly, I am grateful for the Nepal Demographic and Health Survey (NDHS) data access forum, Inner City Club, which provided the NDHS 2016 data for this study. Sincere thanks go to the Director, Section Officer and all staff at the National Health Education, Information and Communication Centre in Kathmandu, Nepal, for their recommendation for this PhD project. I am indebted to Nepal's Ministry of Health and Population, which has allowed me to take the necessary leave to undertake this study.

I am always obligated to my mother and father, Kala Kumari and Kabi Raj Dhital, for their continued blessing of my academic career and success, and I also acknowledge my siblings, Tirtha, Debaki, Govind, Nagendra, and Prakash Dhital, who have always shown respect for my chosen career path. I am thankful for my lovely spouse, Madhu Koirala Dhital, and her love, inspiration, support and cooperation throughout our life together. My children, Samip and Garima Dhital, are my pride and joy, and their intelligence, good character and humility are encouraging and inspiring.

Finally, thanks to my friend, Vickie Owens, who has helped with the presentation of my writing and has provided supportive comments. I also would like to express my thanks to Professor Chandra Prasad Rijal from the Midwestern University in Surkhet, Nepal, for his academic and research advice, and to my school teacher, Bal Bahadur Budhathoki, who has always encouraged me to work for the betterment of society. Sincere thanks go to my all family members, relatives, friends and well-wishers for their motivation, encouragement and support.

# Table of Contents

# List of Tables

# List of Figures

## Courses completed

Biostatistics A (BIOS6910): The University of Newcastle, 2017

Biostatistics B (BIOS6920): The University of Newcastle, 2017

## Abbreviations

| | |
|---|---|
| AOR | Adjusted Odds Ratio |
| ArcGIS | Aeronautical Reconnaissance Coverage Geographic Information System |
| BR | Births recode |
| CBS | Central Bureau of Statistics |
| CHUs | Community Health Units |
| CI | Confidence Interval |
| CINAHL | Cumulative Index to Nursing & Allied Health Literature |
| DAG | Directed Acyclic Graphs |
| DHO | District Health Office |
| DHS | Demographic and Health Survey |
| DIVA-GIS | Data-Interpolating Variational Analysis-Geographical Information System |
| DoHS | Department of Health Services |
| FCHV | Female Community Health Volunteer |
| HFOMC | Health Facility Operational Management Committee |
| GIS | Geographical Information System |
| GOF | Goodness of Fit |
| GPS | Geographic Positioning System |
| HDR | Higher Degree Research |
| HMG | Health Mothers' Group |
| HMIS | Health Management Information System |
| HP | Health Post |
| HR | Household recode file |
| ICF | Inner City Fund |
| IR | Individual women recode |

| | |
|---|---|
| KR | Children's recode file |
| MDG | Millennium Development Goals |
| MICS | Multiple Indicators Cluster Survey |
| MoHP | Ministry of Health and Population |
| MR | Male recode |
| NDHS | Nepal Demographic and Health Survey |
| NGO | Non-government Organisation |
| NHSP | Nepal Health Sector Programme |
| NHSS | Nepal Health Sector Support |
| NHSS–IP | Nepal Health Sector Strategy– Implementation Plan |
| NPHC | National Population and Housing Census |
| ODF | Open-defaecation-free |
| PHCC | Primary Health Care Centres |
| PHD | Provincial Health Directorates |
| PR | Household members recode |
| SAR | South Asian Region |
| SBA | Skilled Birth Attendant |
| SDG | Sustainable Development Goal |
| SEAR | South East Asia Region |
| SLC | School Leaving Certificate |
| SSA | Sub-Saharan Africa |
| TV | Television |
| UNICEF | United Nations Children's Funds |
| USAID | United States Agency for International Development |
| VIF | Variance Inflation Factor |

| | |
|---|---|
| VIP | Ventilated Improved Pit |
| WASH | Water, Sanitation and Hygiene |
| WHO | World Health Organization |

# Abstract

Water, sanitation and hygiene (WASH) are public health concerns associated with communicable diseases. Despite some progress toward the increase of WASH over the past decade, the population of Nepal still has poor access to WASH facilities, and diarrhoea is ranked the second highest disease-related cause of child mortality. This thesis identifies the availability of household-level WASH facilities and examines individual-,family/household-, and community-level factors associated with WASH, assesses the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal.

Firstly, a systematic review on maternal handwashing with soap was conducted. Next, Nepal Demographic and Health Survey 2016 data from 11,040 households were used to map current WASH facilities. To do this, bivariate and spatial analyses were conducted. Then, data from 5,038 mothers with children under five years were analysed to examine individual-, family/household-, and community-level factors associated with WASH and to assess the effects of WASH on diarrhea and malnutrition among children under five in Nepal.

This thesis showed approximately 95% of households had access to improved water sources, 84% had access to sanitary toilets, 81% had access to fixed places for handwashing, and 47% had access to soap and water for handwashing.

Education level, place of residence and Province were significantly associated with sanitary toilets and handwashing facilities. The household wealth index, ecology and distance to a water source were significantly associated with WASH facilities.

Lack of combined WASH facilities was associated with a 50% higher chance of contracting diarrhoea among children under five years. Lack of sanitary toilets increased the likelihood of children suffering from stunting and underweight, while the absence of a fixed place for

handwashing increased the risk of wasting.

This is the first study of WASH in Nepal that has included a comprehensive measure of the combined WASH factors. This thesis highlights the need to create enabling environments for sustainable WASH facilities. The Government of Nepal should launch a comprehensive WASH package for all households. This is possible by mobilising teachers, traditional healers, priests, politicians, and other organisations and resources to meet this aim.

# Chapter 1: Introduction

## 1.1 Background to water, sanitation and hygiene

Water, Sanitation and Hygiene (WASH) has been recognised as being of great importance to public health, particularly for the health of children under five years [1-4]. Adequate and improved WASH are key components of health promotion and disease prevention interventions which are practical [5], cost-effective [6], and possible at the household level [7]. For the purposes of this thesis, the definition of adequate water, sanitation and hygiene is access to “an improved water source, a sanitary toilet, and to facilities for handwashing with soap” [8]. The purpose of this thesis is to identify the availability of household-level WASH facilities and to examine individual-, family/household,- and community-level factors associated with WASH, and to assess the effects of households’ WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal. This chapter describes the global, regional and Nepal-specific WASH status, child health, communicable diseases, and the role of WASH, and includes the context of the health care system of Nepal.

Over the past three decades, there have been significant improvements in WASH throughout the world [9]. The rates of improved water sources worldwide have increased from 78% in 1990 [10] to 81% in 2000 and to 90% in 2017 [11]. The rates of improved sanitation (i.e. sanitary toilets) across the world were 55% in 1990 [12] and 56% in 2000, increasing to 68% in 2015 [13] and 74% in 2017 [11]. The regions with the scarcest water sources and highest rates of open defaecation include sub-Saharan Africa (SSA), and the South Asian Region (SAR), which includes Nepal. In SSA countries in 2017, only 30% of the population had access to improved and safely managed sanitation services. However, this had increased from a rate of 23% in 2000, when 20% of people in SSA practiced open defaecation[11].

In SAR in 1990, 71% of the population had access to improved water sources. This rate increased to 88% in 2020, as reported by Water Aid [14]. These figures indicate that approximately 10% of the global population and 12% of South Asian people did not have access to improved water sources between 2017 and 2020. According to the WHO/UNICEF joint monitoring program (JMP) 2019 report, approximately 71% of the world population has safely managed water, 90% have basic sanitation practices and 60% have handwashing facilities with soap and water. Approximately 35% of populations from the least developed countries have safely managed water, 80% have basic sanitation and 60% have access to handwashing facilities with soap and water. In Nepal, only 20% of the population has safely managed water, 84% has basic sanitation and 81% has handwashing facilities with soap and water [11].

The Millennium Development Goals (MDG) targets for improved sanitation were 78% for the world and 60% for SAR [15]. Rates of improved sanitation worldwide and in SAR did not meet the MDG targets by 2015, with shortfalls of 10% and 15%, respectively. Approximately 32% of the world's population do not have access to sanitary toilet facilities. Disturbingly, 12% of the total global population still practice open defaecation, and of this group, 34% are in SAR. As a result, Nepal, India, Pakistan and Bangladesh achieved to reduce the practice of open defaecation by 30% in 2016 [16, 17]. A randomised controlled trial in India, conducted between May 2010 and December 2013, claimed that increasing the numbers of sanitary toilets reduces exposure to micro-bacteria, thus further helping to prevent diarrhoeal disease [18].

Handwashing with soap is one of the key components of WASH. The global prevalence of handwashing with soap after handling human excreta in 2014 was 19%, while rates were as low as 17% in SAR and 14% in SSA [19]. As of 2017, 40% of the global population was without access to basic handwashing facilities with soap and water [11].

Handwashing with soap practices differ between developed and developing countries, rural and urban, and poor and rich [9]. The country with the highest rates of adherence to recommendations for handwashing with soap was New Zealand at 72% [19]. In general, between 3% and 34% of the population in developing countries routinely wash their hands with soap at the five critical moments: after defaecation or using toilets; after cleaning a child's bottom or handling nappies; before eating food or feeding a child; before preparing or handling food; and before breastfeeding [20].

## 1.2 Child health, communicable diseases and the role of WASH

Child health is one of the key components of public health. Child health is a state of complete physical, mental, intellectual, emotional and social wellbeing, and not merely the absence of disease or infirmity [21]. Children are unable to achieve good health alone; rather, they are largely dependent upon their parents, families and other caregivers. For example, children under five need help with personal hygiene and toileting, and the provision of soap and water for handwashing.

Communicable diseases are still a significant public health challenge and can create endemic problems in developing countries, where about 34% of deaths occurred as a result of such diseases in 2014 [22]. Globally, this rate was 19% in 2016 [23]. Bacteria, viruses, and protozoa are the main causes of communicable diseases associated with WASH practices. Contaminated drinking water, poor sanitation, and not handwashing with soap are associated with communicable diseases among children under five years, and are responsible for almost 10% of the global disease burden [24]. Approximately 827,000 people died due to inadequate WASH in low- and middle-income countries in 2020, with 60% of these deaths due to diarrhoea alone [25]. Approximately 297,000 child deaths can be prevented through increased access to adequate and improved WASH in low- and middle-income countries [26]. However, the number of deaths attributable to unsafe water and not handwashing with soap fell by more than 12% at the global level between 2005 and 2015. The population's Disability Adjusted Life Years decreased by more than 20% in the same time frame [27].

Diarrhoea has persisted as a global burden over the past few decades and is a major public health concern [28], particularly for developing countries, including Nepal. It is attributed to unimproved sources of drinking water, lack of sanitary toilets, and inadequate practices of handwashing with soap [29]. Globally, diarrhoea is one of the major causes of childhood morbidity and mortality. Approximately 525,000 children die from diarrhoea each year, and of these, 90% are in SAR and SSA [28, 30]. Approximately 50% of children who died due to diarrhoea in Nepal also experienced malnutrition [31]. Malnutrition consists of stunting (height for age), wasting (weight for height), and underweight (weight for age). Previous evidence regarding WASH and nutritional status among children has been inconsistent. A few studies reported an association between WASH and stunting, wasting and underweight [32-36]. However, other studies have reported no direct linked between WASH and stunting, wasting and underweight [18, 37-39].

The World Health Organization (WHO) identified communicable diseases, reproductive health, and maternal, newborn and child health as areas of focus in 2016 [40]. Approximately 50% of malnutrition cases among children who also have diarrhoea occur as a result of unimproved water sources, inadequate sanitation, and insufficient hygiene [41, 42]. Therefore, these issues have been included in the research agenda of the United Nations' Sustainable Development Goals (SDGs) for 2016–2030 [43], with SDG–6 focusing on achieving adequate and equitable universal access to sanitation and hygiene by 2030 [44].

Adequate WASH in the home can reduce the spread of communicable diseases by 50% [37]. Approximately 10% of the total global burden of disease can be prevented with improved WASH [42]. Handwashing with soap is fundamental to stopping the spread of communicable diseases, preventing illness [19, 45] and promoting health, improved standards of living, and positive health outcomes.

Constructing a water supply, as well as sanitation and hygiene facilities, may not be sufficient to improve child health outcomes, as sustained human behaviour change must also be considered [46]. Specifically, handwashing with soap is highly recommended during the five critical moments [5]. The six steps of handwashing recommended by the WHO are: wet hands with clean water; apply soap to cover all surfaces of hands and fingers; rub hands for at least 20 seconds; rinse hands with water; and dry hands with a clean single use towel; with this whole process to take 40-60 seconds [47]. Contaminated hands can act as a vector for transmission of faecal pathogens, either via direct person-to-person contact or by contaminating food that is later eaten [48].

## 1.3 Statement of the problem

Children under five years, who comprise 10% of the total population of Nepal, are the focus of these studies [49]. Preventable WASH related diseases are a major cause of child illness. Children under five years, compared to older children, are more prone to exposure to communicable diseases such as diarrhoea and malnutrition, which are ranked in the top 10 morbidity list[50]. In developing nations, children under five are 11 times more likely to die compared to children of the same age in developed nations [51] with diarrhoea being the second leading cause of mortality in Nepal [52].

Inadequate improved water source, lack access to sanitary toilet and handwashing facilities at households' level are likely to account for a substantial proportion of communicable diseases particularly children under five year. Improved WASH helps to protect against faecal contamination in order to prevent diarrhoea but indirect association to malnutrition among children [2]. Previous evidence about the association between WASH and malnutrition indicators had mixed results. Studies based in Nepal showed that household water purification practices were significantly associated with lower rates of wasting but not with stunting and underweight [36, 53]. These studies further indicated that there were association between sanitary toilet and handwashing with soap facilities with stunting and underweight among children but not with wasting. In contrast, another study showed that there was no association between handwashing with soap practice and stunting [54]. The SDG-6 has given priority to improved WASH especially for children and mothers. The GoN's five year plan targeted to reducing child mortality to 24 per 1,000 live births, reduce underweight by 15% and stunting by 20% in 2023-24 [55]. Therefore, it is important to conduct research on WASH and related consequences with a focus on children under five to support programs and policies in Nepal.

### 1.3.1 Water, Sanitation and Hygiene in Nepal

The proportion of households in Nepal with access to improved water sources was 46% in 1990 [56], increasing to 95% in 2016 [57]. The Ministry of Water Supply Nepal reported in 2019 that an estimated 11% of the population did not have access to improved water facilities [58]. While Nepal is one of the richest countries in the world in regards to availability of water resources [59], its water sources are often polluted by the practice of open defaecation, and contamination by household and industrial waste which puts Nepal among one of the most water-insecure countries in the SAR [60].

The household Family Health Survey in 1991 estimated that 21% of the population in Nepal had access to sanitary toilets [56], increasing to 68% in 2011 [61]. The rates of adequate sanitation in Nepal range from 20% to 99%, with the overall rates of adequate sanitation increasing from 30% in 2000, to 62% in 2011 and to 87% in 2016, as reported by Water Aid Nepal [62]. The success of sanitation status of Nepal was due to a national open-defecation-free campaign.

A study on hygiene conducted in 2015 found that of children aged 12–15, 43% adhered to recommended safe food hygiene practices, 12% practiced handwashing with soap, and 10% maintained adequate oral hygiene. This study found that most hygiene practices were not regularly performed [63, 64]. Nepal's overall rates of adequate handwashing at the household level were 17% in 2004. In 2017, the rates of available handwashing facilities with soap were 48% overall, 43% in rural areas and 67% in urban areas [65]. In Nepal, handwashing with soap is particularly challenging before breastfeeding, after discarding children's stool, and before preparing food. An observational study conducted among mothers in Kirtipur, Kathmandu in 2019 showed that only 10% of participating mothers practiced handwashing with soap at critical times [66]. The handwashing facilities with a fixed place, soap and water by provinces in Nepal were province 1(47%), Province 2 (33%), Bagmati Province (63%), Gandaki Province(53%),Lumbini Province(42%), Karnali Province(25%) and Sudurpashchim Province (46%) in 2016 [57, 67].

In Nepal, most WASH campaigns are implemented by private organisations or Non-Governmental Organisations (NGOs) on a pilot project basis, rather than through sustainable Government of Nepal (GoN) programs. This lack of sustainability may affect communities' ability and inclination to adopt lasting WASH practices [68]. Sanitation and hygiene issues in Nepal are often overlooked during health planning [69]. Approximately 22% of the Nepali population did not have access to clean water, 54% lacked adequate sanitation in 2015 [70], and 28% of households did not have soap and water available in handwashing places [71]. Previous studies have analysed WASH components separately, but the composite outcome variable, combined WASH, has not been previously examined. Combined WASH has been analysed in this thesis; the availability of clean water, sanitary toilet facilities, and adequate handwashing with soap are all required, and the absence of any single item results in incomplete WASH.

### 1.3.2 Child health in Nepal

While Nepal has made some progress toward reducing child mortality, the burden is still high. Child age can be divided into three categories: less than four weeks (neonates); under one year (infants); and under five years. Table 1.1 shows mortality rates in Nepal for these age categories between 1996 and 2016.

**Table 1.1: Status of child mortality of Nepal**

| **Indicators** | **Mortality rates by years (per 1,000 live births)** | | | | |
|---|---|---|---|---|---|
| | **1996** | **2001** | **2006** | **2011** | **2016** |
| Neonatal mortality rate | 50 | 43 | 33 | 33 | 21 |
| Infant mortality rate | 78 | 64 | 48 | 46 | 32 |
| Under-five mortality rate | 118 | 91 | 61 | 54 | 39 |

**Source:** Demographic and Health Survey, Further Analysis Reports [72, 73]

The neonatal mortality rate was 50 in 1,000 live births in 1996, 43 in 1,000 live births in 2001, 33 in 1,000 live births in 2006 and 2011 and 21 in 1,000 live births in 2016. The constant rates between 2006 and 2011 indicate the challenges to improving neonatal health in Nepal. However, reductions were seen in the infant mortality rate from 78 in 1,000 live births in 1996, 64 in 1,000 live births in 2001, 48 in 1,000 live births in 2006, 46 in 1,000 live births in 2011 and 32 in 1,000 live births by 2016. Similarly, the under-five mortality rate in 1996 was 118 in 1,000 live births, 91 in 1,000 live births in 2001, 61 in 1,000 live births in 2006, 54 in 1,000 live births in 2006 and decreased to 39 in 1,000 live births by 2016 [57]. These trends indicate there was a satisfactory reduced of under-five deaths compared to neonatal deaths.

In Nepal, diarrhoea is still a significant public health challenge and has been ranked as the second leading cause of child mortality, according to the Nepalese Health Management Information System (HMIS) report [52]. It was thereby listed by the GoN as the Nepal Health Research Council's 'Priority Area 2' in 2013 [74]. The prevalence rate of diarrhoea among children under five years in Nepal persists at 8.8% [75]. The frequent occurrence of diarrhoea causes poor absorption of nutrients and loss of sodium and chloride, dehydrating the body, causing malabsorption of food, and leading to acute malnutrition among children under five years. In Nepal, approximately 50% of child mortality is associated with malnutrition [31]. The rates of stunting, wasting and underweight among children under five years in Nepal in 1996 were 57%, 15% and 42%, respectively, whereas in 2016 the rates decreased to 36%, 10% and 27%, respectively[57].

### 1.3.3 Child health and WASH in Nepal

Nepal's Constitution of 2015 declared 'health, hygiene and clean environment' as a fundamental human right for all citizens [76]. At the same time, the Nepal Health Sector Strategy – Implementation Plan (NHSS–IP) 2016–21, targeting healthy behaviour and practices as key outputs aimed at improving the population's health status [77]. However, disadvantaged groups, those who are economically underprivileged, the indigenous population, ethnic minorities, and people living with disability have more limited access to WASH facilities and practices at the household level than other population groups [78]. Parents' and caregivers' lack of knowledge on hygiene and sanitation, particularly the consequences of open defaecation, and financial crises of households are further barriers to the uptake of good sanitation and hygiene [79].

Geographical difficulties and lack of political willpower and action in Nepal also contribute to the population's challenges in accessing WASH [60]. Other barriers to WASH access for households include lack of high-quality WASH interventions; missed opportunities for delivering WASH messages to students, and local leaders; a lack of targeted WASH messages and services; inadequate WASH messages in mother languages; and poor coordination between service providers and family members [80]. The GoN has allocated 35.6 Billion Nepalese Rupees (BNR) toward WASH programs. However, the SDG estimated the actual cost of effective WASH programs to be 59.7 BNR in 2018–2019, leaving a gap of 24.1 BNR [81]. Therefore, research on this issue is crucial to emphasise to the GoN and stakeholders the importance of achieving SDG–6 (i.e. universal access to clean water and sanitation).

The existing global evidence has shown that unimproved WASH components contribute to increased risk of diarrhoea by 50% [82]. The under-five mortality rate of Nepal is 39 in 1,000 live births in 2016, with 50% of the children who died having malnutrition [31], and 50% having diarrhoea, which is associated with poor WASH [41, 42].

In 2019, a review of 59 countries, including Nepal, indicated that improved sanitation can reduce the risk of under-five mortality by 10% [1]. Mothers who washed their hands prior to handling their infants had a 60% lower risk of their neonates dying. Likewise, birth attendants who washed their hands prior to assisting with delivery led to a 25% lower risk of neonatal mortality in Nepal [83]. Therefore, providing improved WASH access can prevent child morbidity and mortality.

Mothers are typically the primary carers of their children and family members in patriarchal societies such as Nepal [84, 85]. They are the initial teachers of children in the home, and children generally adopt their mothers' behaviours through imitation [86, 87]. Mothers' WASH practices have a direct impact on the hygiene and health of their children [88]. However, more than half of Nepalese mothers and other carers (54%) clean and discard stool without access to toilets for their children under the age of 24 months [57]. This is because family members, including parents and carers, as well as community members, believe that children's stool is harmless [89]. A study carried out in rural areas of hill regions in Nepal in 2014 showed that more than 43% of households disposed of their children's faeces in open spaces, and 41% threw the faeces on gardens [79]. The lack of knowledge of the risks of unhygienic child stool disposal is a contributing factor to the low uptake of sanitary toilet use for children.

The main causes of under-five mortality in 2017 were preterm birth complications, acute respiratory infections, diarrhoea, intrapartum complications, and congenital abnormalities [90]. The underlying causes of under-five morbidity and mortality are the lack of clean water, sanitation and hygiene, as well as infection, poor nutrition and low-quality health care services [91]. Geography and terrain are also common barriers which prevent the timely provision of good-quality health services, improvements in WASH access, and subsequent improvements in the status of child health in Nepal. Unimproved water sources, unsanitary toilet facilities, and poor handwashing practices are intangible causes of morbidity and mortality for children under five. However, it is crucial for household members to understand the importance of WASH as a factor in the prevention and control of communicable diseases, such as diarrhoea. These deadly diseases are easily preventable but policy development requires a robust evidence base to enable further effective health promotion and public health action.

The principal approaches for WASH promotion at the household level are educating people about WASH and the associated disease risks, providing access to good-quality WASH facilities, and effective development and implementation of WASH policies. The aim of this thesis is to identify the availability of household-level WASH facilities and to examine individual-, family/household,- and community-level factors associated with WASH, and to assess the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal.

## 1.4 Background to Nepal

Nepal is a developing nation and is a Federal Democratic Republic (*Sangiya Loktantrik Gantantra Nepal*). Nepal is ruled according to the Constitution of Nepal, which came into effect on 20 September, 2015 [76]. The country became secular in 2006 [92] and it has a diverse range of castes, religions, traditions, and beliefs [93]. The main religions practiced in Nepal are Hinduism (81% of the population), Buddhism (9%), Islam (4%), Kirat (*Bantawa, Chamling, Sampang and Kulung*) (3%), Christianity (1.4%), other religions (Prakriti (*Nature Worship*), Bon, Jainism, Bahai and Sikhism; 1.6%) [49, 94]. Nepal is located in the central Himalayas in South Asia, and is characterised by slow economic growth, socioeconomic underdevelopment, and a low ranking on the Human Development Index [76]. Nepal is a landlocked country situated between China to the north and east, and India to the west and south. The total geographical area of Nepal is 147,181 square kilometres, and the nation measures 885 kilometres from east to west, and 193 kilometres from north to south. Nepal occupies 0.03% and 0.3% of the total geographical area of the world and Asia, respectively [95].

Nepal has a diverse geography, including fertile plains (17%), subalpine-forested hills (68%) and mountains (15%), with fifteen peaks higher than 7,000 metres. These include the world's highest peak, Mount Everest, at 8,848.86 metres, with Nepal having a higher elevation than most countries in the world [96].

Nepal's mountains, hills and plains (*terai*) regions are shown in Figure 1.1. The mountains region's altitude ranges from 4,877 metres to 8,848.86 metres, and 6.7% of Nepal's population live in this region. The hills districts, where 43.1% of the population live, are 610 metres above sea level; and 50.3% of the population live in the plains region. Many rivers run through Nepal, providing rich sources of fresh water and a potential source of hydropower for energy exploration [59]. The country is divided into seven provinces, 77 districts, and 753 local government bodies. In 2019, there were 6 metropolises, 11 sub-metropolises, 276 urban municipalities, and 460 rural municipalities [97, 98]. A total of 6,743 wards are available under these 753 viable units or bodies in Nepal [99]. Wards are local administrative bodies where ward chairpersons elected from people who have full authority of local level government services such as providing citizenship recommendations, birth, death and marriage registrations, monitoring and supervision for local governance, and many other public issues.

In 2011, Nepal's overall literacy rate (ability to read and write) was 66% (males 75% and females 57%) [49, 94]. Nepal's overall poverty rate (i.e. earning <1 US dollar per day by a person) was 41.8% in 1996 and 30.9% in 2004 [100]. According to a latest Nepal living standard survey 2010/11 report, approximately 25.2% of Nepalese people live under the poverty line [101, 102]. The main sources of income in the country are agriculture, tourism, herbal medicines and foreign remittances.

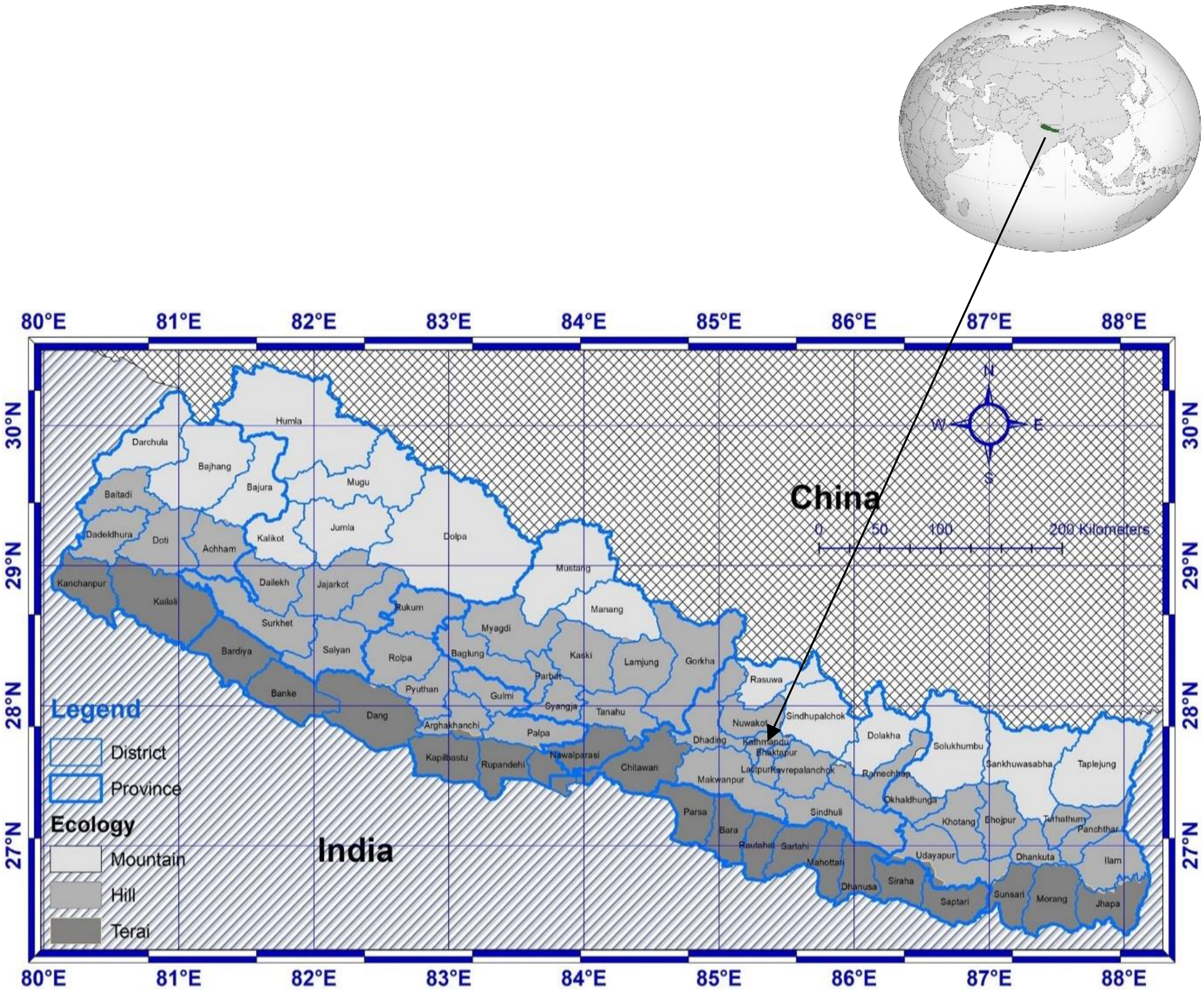



**Figure 1.1: Geographical map of Nepal**

**Source:** Wagle and Acharya, 2020 [103]

## 1.5 Health care system of Nepal

Nepal's health care system has been restructured in alignment with three-tiered government, ranging from the primary to the tertiary level, which is reported in Figure 1.2. Health promotion, disease prevention, disease diagnosis, treatment, and rehabilitation are the main areas of Nepal's health care service provision. There are both public and private health care settings controlled by the Ministry of Health and Population (MoHP) Nepal. The lowest level of health service provision in Nepal is called a Health Post (HP), which provides basic health care services. Female Community Health Volunteers (FCHVs) provide health education, counselling for mothers and children, and referral services [104]. The FCHVs can assist in addressing local challenges, such as understanding local languages and contexts, social mapping, and advocacy for traditional socio-cultural norms [105]. Furthermore, they support government stakeholders in the implementation of national public health programs in the community.

The newly restructured organogram of the Department of Health Services (DoHS) under the MoHP and its units are explained in the annual report of DoHS, 2017–2018 [52]. There are five divisions: the Management Division; the Curative Division; the Epidemiology and Disease Control Division; the Family Welfare Division; and the Nursing and Social Security Division. There are also five centres: the National Health Education, Information and Communication Centre; the National Tuberculosis Centre; the National Centre for AIDS and HIV Control; the National Public Health Laboratory Centre; and the National Health Training Centre. DoHS coordinates all centres and divisions which deliver preventive, promotional, diagnostic and curative health care services.

There are seven different Provincial Health Directorates (PHD) under the Ministry of Social Development at each provincial government level. The PHDs provide technical support for planning and implementation, and are also directly involved with public health program monitoring and supervision. The three levels of hospitals are categorised as primary (district hospitals), secondary (provincial hospitals), and tertiary (central hospitals). According to the 2017–2018 DoHS annual report [52], there are a total of 125 public hospitals, ranging from district to central levels, including four teaching hospitals. Six central-level hospitals, two regional-level hospitals, three sub-regional-level hospitals, and ten zonal hospitals provide tertiary-level health care services. The secondary level of health care services are provided by district hospitals. In 2020, there were 196 Primary Health Care Centres (PHCCs) and 3,806

HPs, which provide primary health care services in Nepal. There are 51,420 FCHVs, 11,974 Primary Health Care Outreach Clinics, and 15,835 Expanded Programme of Immunization clinics in Nepal. The Urban Health Centre in the municipality level and Community Health Units in the community levels are also functional for primary health care services. Monthly progress reports from health facilities are collected by DoHS. These are processed, recorded and presented through the Health Management Information System (HMIS).

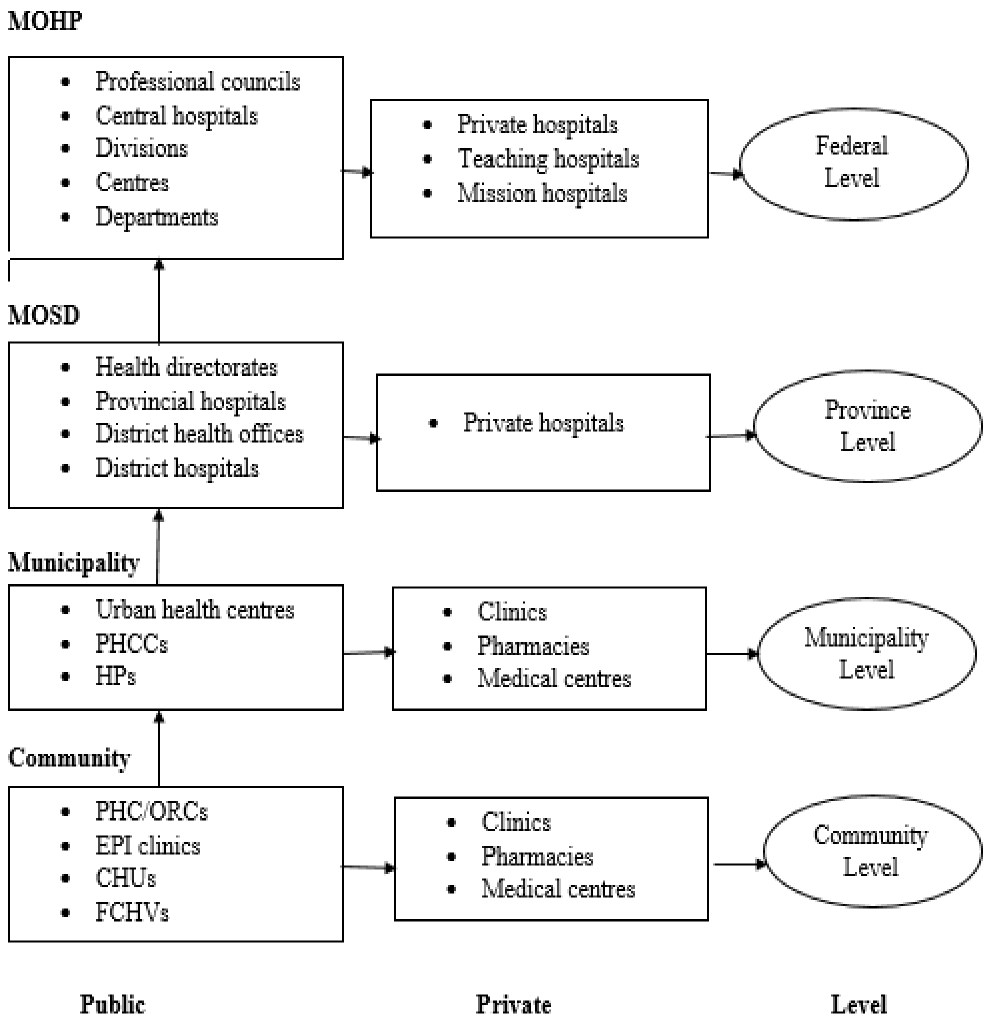



**Figure 1.2: Health care system of Nepal**

**Source:** www.mohp.gov.np

## 1.6 Water, Sanitation and Hygiene Committees

The WASH steering committees have been developed by the GoN, which supports the health care system of Nepal. Three levels of government, the federal, provincial and local levels have different roles for improving WASH. The structure of the WASH committees are shown below (Figure 1.3). The committees help to support the federal, provincial and local government to enable quality WASH programs and outcomes.

The key roles of the National WASH committee are to formulate sectoral WASH policies and plans and coordination between ministries for sanitation and hygiene initiatives. They work on coordination between the WASH stakeholders. The Provincial WASH coordination committee aims to organise seminars, workshops and WASH conferences. This committee also provides support to the District WASH coordination committee. The district WASH coordination committee prepares the district profile and the municipality and rural municipality WASH coordination committee work on situation analyses of WASH, resource mobilization, planning, mapping and implementation of WASH services. Each level of the committee has a task force with four to five members with at least one female representative.

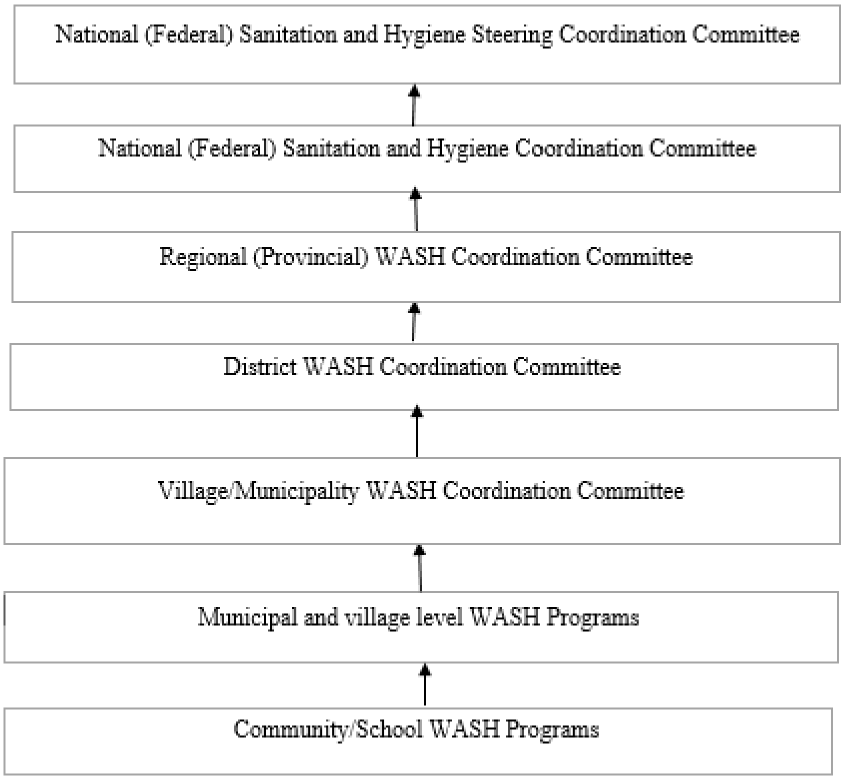



**Figure 1.3: Structural diagram of WASH committee**

**Source:** Sanitation and Hygiene master Plan 2011[106]

## 1.7 Summary

Poor WASH access is an ongoing public health problem and a major contributor to communicable diseases, especially for children under five years worldwide [24]. Diarrhoea is the second leading cause of death among children under five years, and 99% of these deaths occur in low-income and lower-middle-income countries such as Nepal [107]. Approximately 90% of diarrhoea cases worldwide are attributable to poor WASH [42]. Previous studies have shown that poor household WASH facilities are due to lack of family and community knowledge, poverty, lack of political willpower and action, poor management systems, lack of coordination, gender discrimination, sociocultural beliefs, and geographical constraints [60, 68, 85, 108-111]. Approximately 50% of child mortality is due to malnutrition, which is associated with poor WASH and diarrhoeal diseases [31]. Effective WASH promotion activities are the most cost-effective ways to prevent and control communicable diseases, and reduce morbidity and mortality [112-116]. Although a limited number of studies have been conducted on the individual components of WASH, little is known about small-area-based WASH problems. A multi-level study on the association between WASH on diarrhoea and malnutrition in Nepal is therefore required [60].

Thus, the purpose of this thesis is to identify the availability of household-level WASH facilities and to examine individual-, family/household-, and community-level factors associated with WASH, and to assess the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal.

## 1.8 Chapter review and thesis organisation

This thesis has been designed as a hybrid thesis, where some results chapters are presented as manuscripts that will be submitted to a peer reviewed journal (Chapters 4 and 5) and others are presented as traditional thesis chapters (Chapters 6 and 7).

**Chapter 1** of this thesis provides a problem statement of the global, regional and national WASH situation, child health, communicable diseases, and the role of WASH, a description of the country, and summaries of the health care system of Nepal. It also provides a summary of this research project. A literature review related to all studies of this thesis is provided in **Chapter 2**. For the literature review, a systematic approach was taken to identify previous findings from journal articles, reports, and other published and unpublished documents, to determine current knowledge about WASH in Nepal. It also includes a description of the ecological model, which is the theoretical underpinning of this thesis. The research gaps of the study were identified and aim, objectives and research questions of this thesis were determined. **Chapter 3** outlines the research methods used in this thesis. **Chapters 4–7** provide the results of the thesis. **Chapter 4** is presented in the form of a manuscript, which has been drafted and will be submitted to a peer reviewed journal. Chapter 4 describes the rates of household handwashing for mothers of children aged under five, and explores the factors associated with the uptake of handwashing in Nepal, using a systematic review. The results of the systematic review indicated the need to examine WASH at the household level, and so three separate analyses of the 2016 NDHS data were carried out. The first analysis **(Chapter 5**) is also presented as a manuscript, which will be submitted to a peer reviewed journal. This analysis estimated the prevalence and correlates of WASH at the household level in Nepal, including identification of areas where WASH facilities were unimproved. The results of this first study indicated that less than one-third of females undertook adequate WASH. The mothers with children under five years were a particularly vulnerable population for inadequate WASH. Therefore, the second analysis (**Chapter 6,** presented as a thesis chapter) identified the individual- family- and community-level factors associated with household WASH facilities. Finally, the third analysis **(Chapter 7,** presented as a thesis chapter**)** assessed the effects of household WASH facilities on diarrhoea and malnutrition among children under five years in Nepal. **Chapter 8** discusses the overall findings of the thesis. The thesis discussion covers the main results, compares these results with previous research, assesses the strengths and limitations of the thesis, and identifies the contribution of the research to knowledge. This chapter also includes the overall conclusions, and policy and practice recommendations of the findings of this thesis. A policy brief on the "importance of handwashing and opportunities for improvement" was included in **Chapter 9**, and is a recommendation for local, provincial and central government authorities.

# Chapter 2. Literature Review

## 2.1 Introduction and literature search strategy

In Nepal, mortality of children under five years is high. The major cause of mortality is diarrhoea, which causes malnutrition, and is preventable through adequate improved water sources, sanitary toilets and handwashing with soap (WASH) facilities. This chapter provides evidence of the existing literature on WASH in Nepal; factors affecting household WASH; accessibility to and effects of mass media exposure; importance of social and family roles in relation to WASH; diarrhoea and malnutrition among children under five; and a review of WASH-related policies of Nepal. This chapter also includes application of the ecological model to WASH.

A literature search was conducted in 2017 using PubMed/Medline, PsycINFO, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar. The search criteria included keywords such as *water*, *toilet*, *handwashing*, *soap*, *household, mother, children, diarrhoea, malnutrition,* and *Nepal*. Further references were added as the list evolved during the review period (2017-2020). Cross-references were also sought to explore relevant information related to this research. Retrieved references were stored in Endnote [117].

## 2.2 Water, Sanitation and Hygiene in Nepal

Adequate WASH facilities are a basic need for maintaining an individual's health and reducing communicable diseases. Previous evidence has shown that adequate improved WASH facilities can reduce the risks of communicable diseases by 10% of the total burden of all diseases [42].

### 2.2.1 Water

The SAR countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Pakistan, Sri Lanka and Nepal) have bacteriologically and chemically contaminated water sources. Approximately

15% of households in Nepal, India and Bangladesh have access to appropriate water-treatment techniques [16]. In SAR countries, including Nepal, approximately 68% to 84% of water sources are contaminated [118]. The proportion of improved drinking water sources in Nepal is 92% [61]. According to the JMP 2019 report, 89% of the population had basic water access and 7% had unimproved water, 3% has limited water and 2% has surface water access in 2017 [11].

Nepal faces a problem of obtaining and consuming safe water at the household level. Most water sources are polluted due to sewage, agriculture and industry, mostly in urban and city areas [119]. The ground water sources are contaminated in urban and highly populated cities like Kathmandu, Nepalgung, Biratnagar and Bhutwal due to sewerage lines, open pit latrines, septic tanks, and leakage of septic tanks [120]. Hazardous chemicals such as ammonia, nitrate and arsenic [121-123] also cause water pollution. The surface water pollution is caused by direct disposal of sewage and the practice of open defaecation in Nepal [124]. Disposal of waste into the rivers and ponds are a result of human behaviour and cause water pollution in Nepal. Seasonal dryness is one of the highest risk factors for unavailability of adequate water in the hills and mountains regions of Nepal. Nepal is a medium water-stress country, with a water poverty index rank of 54.4 [125]. Inadequate improved water sources are associated with rainfall variability, drought, landslides, and floods [126, 127]. Poor institutional capacities are policy-level factors which also influence decreased access to improved water sources [128].

### 2.2.2 Sanitation

Approximately 610 million people of the SAR, including Bangladesh, India, Pakistan and Nepal, practiced open defecation in 2020 [17]. The proportion of households in Nepal with sanitary toilets in 2001 was 46%; this increased to 68% in 2011 [61]. In 2016, approximately 62% of households in Nepal had access to toilets that were not shared with another household [57]. Nevertheless, households in many regions of Nepal have poor WASH access. The JMP

2019 report has shown approximately 49% of households used septic tanks for human excreta disposal, 22% used latrines and only 5% of households had a sewer connection [11]. There are large variations in the proportion of households with sanitary toilets between rich and poor areas of Nepal (80% and 12%, respectively) [106]. Regular use of toilets by household members remains a major health promotion challenge in Nepal. Another study conducted in 2016 indicated that about 32% of constructed toilets needed maintenance [129]. This evidence shows that toilet use and the safe disposal of human excreta in Nepal are still problematic. The cleanliness and maintenance of toilets in a sustainable way remains a challenge in Nepal. If the situation continues, communicable diseases will remain a major public health problem.

### 2.2.3 Hygiene

The prevalence of adequate handwashing practices at the household level in Nepal in 2004 was 17%, and in 2017 the availability of adequate handwashing facilities was 48% (rural 43% and urban 67%) [65].According to the JMP report 2019, basic hygiene facilities were available in 48% of households, limited facilities without either soap or water were available in 51% of households, and 1% of households had no WASH facilities[11].

Habitual handwashing practices might have changed significantly across the world during 2020, due to the global COVID–19 pandemic [130]. The global hospital health staff compliance with hand washing recommendations was 45% in 2015 which increased to 62% in 2019 and 66% in 2020 [131]. In India the handwashing rate increased up to 86% after COVID-19 [132]. In Lahan Municipality in Nepal handwashing with soap increased compared to before the onset of COVID-19[133]. Nevertheless, sustainable handwashing behaviour still is challenging.

A study conducted by Australian Aid in 2015 in the Rolpa district of Nepal showed that the prevalence of handwashing after defaecation was 44%, after cleaning child faeces it was 25%, and before eating a meal it was 39% [134]. In 2002, a New ERA (a research company) [135] study revealed that only 14% of Nepal's population used soap and water for handwashing before eating meals, and only 26% were aware of the importance of handwashing after defaecation. In developing countries, only 3% to 34% of the population routinely wash their hands with soap at critical moments throughout the day [20]. A telephone survey conducted January 2021 showed that 70% of households have access to handwashing facilities with soap and water in Nepal [136]. The Multiple Indicator Cluster Survey (MICS 2019) report showed that 81% of households had a fixed place for handwashing with soap and water [137]..A study was conducted among women aged 18–59 years (n=12,000) in the Nawalparasi, Bajhang and Sindhuplanchowk districts of Nepal from October 2012 to January 2013, and showed that the prevalence of handwashing with soap before eating was 20.7% at baseline, increasing to 29.5% by the end of the intervention. Handwashing after cleaning a child's defaecation was 46.3% at baseline and 66.7% after the intervention [116].

A 10-year institutional based study conducted in the Dhanusha and Nawalparasi districts of Nepal between 2001 and 2011 indicated that the practice of handwashing with soap before handling the delivery of babies varied by the circumstances of the births. In the Dhanusha and Nawalparasi districts, rates of handwashing with soap prior to births in the home assisted by a person who was not a Skilled Birth Attendant (SBA) were 69% and 51% respectively, while rates for births in the home attended by an SBA were 95% and 74% respectively, and the rate for births in health institutions was 95% [138]. A retrospective cross-sectional study done in Makwanpur, Nepal, in 2002 showed that half of the participating birth attendants washed their hands prior to attending deliveries [139]. The incidence of traditional birth attendants washing their hands prior to deliveries was 74% [140]. Studies conducted in Nepal in Kathmandu, Lalitpur, Illam and Chitwan have shown that using soap for handwashing was significantly associated with the prevention and control of worm infestation [141].

A cross-sectional study conducted in 2012 showed that the rate of 'knowledge about influenza transmission' due to not washing hands was 8.3%, the rate of 'knowledge that handwashing prevents the transmission of influenza' was 19.6%, and the incidence of handwashing after handling poultry and raw meat as a precaution was 7.9% [142]. A recent cross-sectional study conducted in 2018 in Makwanpur district after it become ODF showed that the availability of sanitary toilets at the household level was 92%, access to improved water sources was 90%, and handwashing with soap at critical moments (after defaecation or using toilets, after cleaning a child's bottom or handling nappies, before eating food or feeding a child, before preparing food or handling food, and before breastfeeding) was 43% [143]. A caste-specific study conducted in the plains region of Nepal in 2009 showed that the incidence of using soap during general handwashing practices of two indigenous groups in Nepal, Tharu and Musahar were 46% and 25%, respectively [144].

In summary, although households may have access to WASH facilities, adequate practice continues to be a problem. Additionally, only 23% of households apply domestic water purification techniques, and 54% do not wash their hands with soap [145]. Cleanliness and maintenance of household toilets remain a challenge in Nepal. The management of water, soap and toilets are predominant factors for maintaining hand washing [146].

### 2.2.4 Water, Sanitaion and Hygiene in Health Facilities in Nepal

WASH in health care settings are essential for the quality of health care services. Improved WASH facilities improves the experience of care, strengthens staff skills and their morale and provides opportunities for health staff to act as a role model for the community [147]. Low and middle-income countries like Nepal have a low rate of WASH facilities within health facilities. In 2015, the WHO and UNICEF reported that 38% of health facilities did not have improved water, 19% of health facilities did not have sanitary toilet facilities and 35% of health facilities did not have handwashing facilities with soap and water[148]. A report published by Water Aid

Nepal showed the overall water coverage in all health facilities of Nepal as 84%, sanitation coverage was 71% and hygiene coverage was 19% in 2011. [149]. Approximately 47% of health facilities have access to handwashing facilities with soap and water and only 24% of health staff have handwashing compliance in rural Nepal [150]. Poor WASH conditions at health facilities increases the risk of infection, which causes a resource burden for management, increased use of services and poor health outcomes for staff and patients.

In general, the household WASH coverage of Nepal has been less than 100%. Table 2.1 shows the WASH coverage in Nepal, as reported in the Nepal Demographic and Health Surveys. This table indicates the improved water sources were gradually increased but household level water treatment practice rate was lower. The sanitary toilet was increased by almost 50% between 2011 and 2016. The availability of handwashing with soap was in decreasing way but a fixed place for handwashing rate was increased from 2011 to 2016 which proved that there was a poor management of household level handwashing facilities.

**Table 2.1: Household WASH coverage in Nepal**

| SN | WASH indicator | 1996 | 2001 | 2006 | 2011 | 2016 |
|---|---|---|---|---|---|---|
| 1 | Improved water sources | - | 67% | 82% | 89% | 95% |
| 2 | Pipe water supply in to yard | 9% | 35% | 15% | 22% | 33% |
| 3 | Water source on their premises | - | - | 46% | 58% | 69% |
| 4 | Water treatment practices | - | - | 15% | 18% | 23% |
| 5 | Sanitatary toilet | 23% | 30% | 28% | 38% | 62% |
| 6 | Handwashing with soap | - | - | 64% | 48% | 47% |
| 7 | Fixed place for handwashing | - | - | - | 53% | 81% |

Source: Nepal Demographic and Health Survey (1996-2016)

## 2.3 Factors affecting household WASH in Nepal

A number of factors, including the economic cost of gaining access to adequate facilities, influence WASH at the household level [151]. The factors affecting the consumption of improved WASH are briefly reviewed in this section.

### 2.3.1 Socio-demographic factors

A systematic review conducted by Robert Dreibelbis in 2013 identified that WASH practices are determined by individual socio-demographic factors, such as age, sex, ethnicity, economic status, and parents' education [152]. Similarly, ethnicity, religion, marital status, and total number of members living at home, were identified as determining WASH by Ashish Joshi and Chioma Amadi in 2013 [3]. Household assets, such as ownership of a radio, television, computer or mobile phone, are determined by a household's wealth index; both media access and wealth indices can affect the WASH facilities of household members [153].

### 2.3.2 Cultural factors

Culture is a complex concept, which includes community norms, values and traditions, as well as beliefs. These norms and values can determine a community's sanitation and hygiene practices. Culture can influence handwashing and sanitation. A Nepalese study conducted in 2017 reported on the common cultural practice whereby fathers-in-law and senior citizens often do not use a toilet which has previously been used by a daughter-in-law [154]. Cultural values also dictate that although mothers are the primary carriers of water from the source to the home, they are not allowed to use or carry water when they are menstruating. Such rules may exacerbate water scarcity, which can also be a cause of psychological stress among Nepalese mothers [110]. Additionally, the caste system in Nepali society prohibits some people from touching a water source [110]. Scheduled castes, including Kami, Damai, Badi, Sarki, and Sunar, as well as marginalised groups, such as Muslims, Madhesis, third gender, people with a disability, and women, are more vulnerable to poor access to WASH due to cultural beliefs and value [85, 155-157].

### 2.3.3 Environmental factors

Physical environmental factors related to WASH include water quality, substance and hazard waste (specifically, excreta), home and communities, and infrastructure (handwashing places, soap and water storage). These factors can determine distance to a water source and availability of water, availability of soap, location of toilets, fixed places for handwashing, health care services, and disposal methods for human excreta [7].

Access to an adequate water supply is important because it enables household family members, including mothers and children, to keep healthy. When mothers in Nepal have to travel further than 30 minutes from home to collect water, this can add to household pressure because of over-work and insecurity for mothers and children, and may further increase the risk of family conflict [158]. Households in the rural and remote mountains and hills areas of Nepal tend to be further from a water source than those in urban and plains areas, as the installation of water systems in these difficult terrains is costly [62]. A study conducted in Surkhet district in Karnali province of Nepal showed that a shortage of water at the household level was due to the amount of time required to collect water from the source, which in this study was approximately 2 to 3 hours from the home [159]. The poorest households in Nepal have less access to soap and water than the richest households [160]. Natural disasters, such as earthquakes, landslides and storms, damage water systems and pollute water sources. For example, after an earthquake with a magnitude of 7.8 in 2015, approximately 8,000 water structures and 388,000 sanitation facilities in Nepal were damaged [161]. Rapid population growth, urbanisation, industrialisation, and agricultural growth can cause water sources to become polluted [162]. These environmental factors can affect the population's access to improved WASH facilities.

A systematic review conducted in 2020 on studies on 44 countries, including Nepal, found that physical infrastructure, such as distance from home to water sources, handwashing places and soap, and social factors such as unemployment and lack of community support for infrastructure management, may affect handwashing practices [163]. Also, during winter, the practice of adequate handwashing reduces due to the extremely cold weather in Nepal [164].

The impact of environmental factors can be mitigated, even in challenging areas such as rural Nepal. A study conducted in a hilly region in the Rolpa district of Nepal in 2018 provided evidence that addressing these factors, including by setting sanitation targets and budgets, providing hardware subsidies, establishing WASH committees, and promoting sanitation and regulations, increased the sanitary use of toilets [115].

### 2.3.4 Personal factors

Personal factors such as knowledge, attitudes and behaviour are also important in utilizing available WASH resources and services at household levels. Knowledge consists of theoretical and practical understanding of subjects [165]. Knowledge- and attitude-related factors play significant roles in improving access to clean water. Water literacy is the concept of advocating for water resources and its management [166]. Community knowledge about improved WASH and its management is vital and can lead to a positive impact on family health through active participation in WASH interventions [167]. People living in rural Nepal are unaware of the risks of communicable diseases due to lack of knowledge about WASH services [79]. Attitudinal factors, such as beliefs about the cost of WASH in terms of money, time, effort and benefits associated with a desired WASH behaviour, as well as feelings towards WASH habits, are instrumental in improving WASH access [168]. A cross-sectional study conducted in Nepal's Saptari district in 2017 concluded that knowledge is the main factor that influences access to, and use of good-quality water [169]. Another study conducted in Nepal also claimed that poor knowledge about water sources and its management and purification increases the risk of diarrhoea [170].

Family members' positive attitudes towards WASH services and their ownership are significantly associated with utilising sanitary toilets [171]. The knowledge of household members, including that of the head of the household and the mother, influence the utilisation of sanitary toilets, providing privacy, safety and convenience for mothers, children and people living with disability [172]. Knowledge about other family members' sanitary use of the household toilet can influence children to do the same [173]. A sound knowledge of safe hygiene practice motivates household members to utilise adequate latrines, that is, latrines that function appropriately and provide safe disposal of child faeces. While attitudes toward human excreta have played a significant role in lack of sanitation practices in daily life, individual perceptions and circumstances also contribute to adopting or rejecting the installation and use of flush and ventilated improved pit latrines [174]. A study conducted in East Nepal showed that a health education program implemented by a local community hospital played a significant role in increasing the use of sanitary toilets, as 75% of households had sanitary toilets available to the occupants, and 95% used them properly after the program [175]. This indicates that better education can increase toilet use.

However, knowledge is not the only factor that influences the use of toilets in Nepal; geography, culture, norms and the economy are further determinants [176]. A study conducted in Mahottari district, a sanitary 'dark zone' in the plains region, suggested a reward and penalty system as a way to improve sanitation of households and their surroundings. This could involve a reward, such as 50% of the money charged to information providers for those whose households use sanitary toilets and wash their hands with soap and water after defaecation, and a penalty for those who ignore sanitation and hygiene recommendations. Penalties may include fines of 100 Nepalese Rupees for those who defaecate in an open space in the first instance, with increased fines for subsequent offences [177].

Household members’ lack of knowledge and their existing feelings and beliefs about handwashing, as well as their level of awareness of the implications of poor hand washing, are all contributing factors to communicable diseases [178]. Lack of knowledge about the importance of soap and the critical moments for handwashing at the household level is the primary barrier to effective handwashing practices [109]. There is evidence from Australia that compliance of health care professionals, with assumed sound knowledge of WASH, with washing their hands before coming into contact with patients is as low as 30% [179] and 24% hand washing compliance was seen among health care workers in rural Nepal [150]. Household members do not give importance to the use of soap due to low levels of knowledge about disease transmission and the need for handwashing at critical moments [180].

A 2015 Nepalese study of Mahottari, Sarlahi, Siraha and Saptari districts showed that participants were more likely to wash their hands with soap when their hands looked dirty, and were motivated by wanting to see their hands soft and smelling good, so that they could maintain their dignity in the community [181]. High self-efficacy, commitment, and hygiene planning skills are factors that can support the use of improved WASH facilities to reduce the risk of communicable diseases [182]. WASH services should be established in the home in sustainable ways. These services can be affected by broader factors, such as the absence of a community WASH committee, poor quality of WASH infrastructure, and poor follow-up systems [183]. To prevent a breakdown in household WASH access due to these factors, household members, especially the heads of households, must be aware of these barriers when they arise, and local government authorities must coordinate with community representatives to implement emergency measures to maintain WASH in the affected households.

Inadequate WASH are also determined by behavioural factors [178]. Behavioural factors with potential to affect access to WASH include habits, psychological issues, technology, and context [178]. An individual's behaviour towards drinking water and handwashing, having soap and water in the correct place for handwashing, proper use of sanitary toilets, and the regular habit of handwashing after contact with contaminated sources during critical moments are behaviour-related factors [184].

Habits are formed on the basis of knowledge; repeated behaviour in a specific context forms a habit [185], with the behaviour repeated until it is performed automatically [186]. This concept can be applied to WASH practices. For example, the washing of hands with or without soap commonly occurs before meals and after defaecation, habits often formed during childhood [180], when children are encouraged to wash their hands [151]. In Nepal, children are accustomed to defaecating in open spaces, as their parents may not understand that children's stool can be harmful [89]. Household members may be less motivated to wash their hands when they do not have a fixed place for handwashing, as a lack of a fixed place for handwashing can cause confusion, and it can be difficult to locate soap and water if they are kept elsewhere instead of in the fixed place.

In Nepal, the FCHVs conduct home visits to educate mothers and other family members about the appropriate use of WASH [161]. Therefore, interventions that aim to modify WASH behaviours can be effective, but are dependent on the FCHVs' education level, interest and activity level.

Habits, motivated behaviours and cognitive factors, can affect WASH behaviours [151]. Perceived disease severity, perceived vulnerability, attitudes, and use of and control over good WASH practices are also related to psychological factors [171]. Poor access to WASH facilities can contribute to feelings of perceived vulnerability to risk of communicable diseases, disease severity, and further long-term effects of the diseases [187].

Technological factors can improve uptake of WASH by encouraging WASH behaviours. Technological facilitators include accessible water sources; transport and roads; water storage facilities; water purification devices and chemicals; and affordable cost [188-190]. These factors are interconnected and have significant roles in preventing diarrhoea and many other communicable diseases [178]. A spring and/or tap water source is safe for human consumption and use if the reservoir is clean and protected [191, 192] but the road between the home and the water source must be sufficiently wide and not slippery to encourage use of the facilities. For improved water to be available in the household, filtration and boiling practices have to be established. The rope pump, India Mark II, play pump, bio-sand filters, constructed rain water harvesting jars, life straw and Jerry Lans are popular technological tools used in the African region to make water clean and safe for human use and convenient [174]. However, their management and handling may make these resources unsuitable and too costly for rural areas of Nepal.

### 2.3.5 Communication factors

WASH-related messages, such as appropriate use of toilets, handwashing with soap, and water purification, are provided to individuals and family members in Nepal through FCHVs, local health workers and media [52]. During Health Mothers' Group (HMG) meetings, the FCHVs communicate WASH messages to all the participating mothers. Additionally, WASH-related messages are shared by community health workers through primary health care out-reach clinics and immunisation sessions, and are also broadcast via radio and television. Effective communication of WASH messages leads to an increase in rates of sanitary toilet use and presence of handwashing facilities with soap at the household level in Nepal [193].

Communication is a valuable method for sharing knowledge, but risk communication can have negative effects. Sub-optimal communication between the health and non-health sectors can create confusion about the roles and responsibilities of WASH maintenance in Nepal [161]. For example, WASH-related messages that communicate information about risk of disease may not be effective in remote Nepalese communities, if the people believe that hands only need to be washed if they are visibly dirty, that water can be safe to drink if it looks clean, and that mothers are taught their children's stool is not harmful.

These instances of poor communication of adequate WASH practice were evident in a study conducted in 2017 in Nepal, where FCHVs and health workers lacked appropriate knowledge and communication skills to provide adequate health services and advice [194]. Ineffective communication can prevent family members from adopting the healthy behaviour of utilising improved WASH [7, 71, 195].

#### 2.3.5.1 Accessibility and effects of mass media exposure at the household level

Different methods and media, ranging from individual to mass media, are recommended for providing knowledge and encouraging a change in WASH behaviour, including handwashing with soap in the households [196]. Media for health promotion can be by audio, visual and audio-visual aids. To date, individual, group and mass methods of health education and promotion have been used for promoting the drinking of safe water, use of sanitary toilets, and access to handwashing with soap. These methods include strategies targeted at individuals, such as counselling and individual contact, groups such as, demonstrations, group discussion and group counselling, peer education, symposia, workshops, seminars, and mass methods, such as lectures, drama, exhibitions, campaigns, television shows, radio broadcasting, and newspapers reading [197]. However, the main sources of health information in Nepal are health workers and FCHVs [198].

Mass media are public, private and community in the nature, scope and roles that can inform, motivate and guide people towards effective WASH behaviour [199]. Mass media can play a significant role in informing an individual about issues such as safe water and good sanitation, as well as handwashing with soap to prevent communicable diseases, especially for mothers and their children [100]. Modern media such as radio, television, internet, telephones, and mobile phones are used to share health messages. Likewise, printed visual aids such as booklets, pamphlets, posters, diaries, signage, stickers, flip charts, brochures, flash cards, and bulletin boards are used for the effective dissemination of health messages and information.

In Nepal, the preferred sources of mass media in 2011 were as follows: radio (14% for men, 15% for women); FM station (36% for men, 33% for women), television (45% for men, 43% for women), newspapers (2% for men, 7% for women), posters (1% for both), and hoarding boards (0.1% for both) [145]. The rates at which women and men in Nepal were exposed to different types of mass media in 2011 and 2016 are shown in Table 2.2

Women have less access to mass media than men, and both men and women watch television more frequently than they read newspapers or listen to radio. As media exposure is related to household wealth index, both need to be considered when examining WASH affecting factors.

**Table 2.2: Percentage of mass media exposure by sex in Nepal**

| **Media exposure** | **Women** | | **Men** | |
|---|---|---|---|---|
| | **2011** | **2016** | **2011** | **2016** |
| Newspapers | 13 | 9 | 34 | 22 |
| Television | 47 | 50 | 55 | 51 |
| Radio | 44 | 28 | 59 | 36 |

**Source:** Nepal Demographic and Health Survey 2011and 2016 [57, 145]

## 2.4 Importance of social and family roles in relation to WASH in Nepal

Nepal is a multi-ethnic and socio-culturally diverse country. Men and women have different roles and responsibilities for WASH in Nepali families [200]. Most families have a patriarchal structure where family members' roles determine property ownership and level of authority for decision-making within the home [84]. In Nepal, the main decision-maker of the household is the head, and this is often a man (approximately 70%). In relation to WASH facilities in the household, the father, husband, father-in-law or mother-in-law makes decisions regarding construction of toilets, installation of water sources, and purchase of soap for family use. While mothers, children, people with disability, those of Dalit caste, and ethnically marginalised and disadvantaged people have increased their participation in WASH practices in recent times, their roles in decision-making are still limited [110]. The GoN proposed to reserve 33% of decision making positions for women, to enable participation of women at all levels of decision making  but effective implementation remains a challenge [201]. These groups have low levels of access to WASH facilities at home. Despite lacking such facilities, mothers take care more than other household members for the overall management of WASH in the home [85]. Therefore, mothers' roles are important for improving access to WASH at the household level.

In Nepali communities, men assume that the supply of water in the home is a technical matter, and as such, they believe women have no understanding about or influence on these decisions [202]. Thus, fathers lead water supply projects in the home, and mothers are influenced by decisions made by the head of the household [203]. However, within the household, mothers take the lead in WASH activities and advocate for improvements through HMG meetings and community networks, which strengthens community WASH management committees [204]. In Nepal, in their traditional roles within the household, mothers spend more time and work hard in managing WASH, but this work is seen to be of little value by other household members [200]. This practice still exists in Nepal, particularly in rural areas.

WASH services in the households are influenced by the roles of different family members. Although mothers may have primary responsibility for maintaining sound WASH facilities in the home, other family members, such as the husband, father-in-law, and/or mother-in-law, often overrule the mothers' decisions regarding WASH. In Nepalese households, the household heads, mostly men, are given first priority in accessing WASH facilities, while mothers are often required to wait until after other household members have used the facilities, and thereby, their use of these services is less frequent than for men and other family members [85]. However, in urban and developed areas of Nepal, attitudes towards mothers' autonomy in this domain are evolving, and they are increasingly able to lead in decision-making for WASH-related matters in the home. Family support, community services and policy advice recommend equal access to WASH facilities for all family members. There is a need to better understand the role of mothers and their capacity for driving uptake of WASH in the Nepalese context. With this in mind, Chapter 4 is comprised of a systematic review that focuses on mothers' handwashing in Nepal.

The number of households in Nepal with adequate WASH facilities is continuing to increase, but their sustainability and management remain a challenge, and are subject to influences from socio-demographic, environmental and cultural factors, family knowledge, attitudes and practices, and communication and the media. The current literature concerned with WASH in Nepal has not examined all components of WASH [121], involved small sample sizes [205, 206] has not fully considered potential influences of individual, family/relationship and community level factors [60, 125] that might influence WASH, and analysis techniques have also been less than optimal (discussed further in Section 2.8).

## 2.5 Diarrhoea and malnutrition among children and WASH in Nepal

Diseases directly related to WASH include diarrhoea and cholera, [42, 207] typhoid fever ,[208] acute respiratory infection and impetigo, [113] corona virus (covid-19), [209-211] worm infestation, [141] trachoma, [212] and other infections [48]. Children under five especially are affected by many of the above mentioned communicable diseases which diseases are related to WASH.

Communicable diseases have adverse effects on growth and nutrition, and children with poor nutrition have excess mortality from such diseases.

Diarrhoea is the second highest leading cause of child mortality, with 38.5% of children being infected in 2018 in Nepal [52]; among these deaths approximately half were due to malnutrition [31]. A number of factors are associated with diarrhoea and malnutrition. The most significant contributing factors to diarrhoea rates in Nepal are unsafe water sources and sanitation, and lack of access to handwashing facilities. Subsequently, the frequent occurrence of diarrhoea in children under five years can lead to malnutrition. These two diseases are bidirectional and interrelated [213].

### 2.5.1 Diarrhoea

While Nepal ranked 41st in the world with regard to prevalence of diarrhoea, it is still an issue of concern for child health, with 14% of children in Nepal reported as having diarrhoeal infections in 2011 [145]. The prevalence of diarrhoea for children under five years in Nepal varies by ecology (rates in 2016 were 8.7% in the plains region, 6.4% in the hills region and 5.2% in the mountains region); rural/urban settings (rates in the same year were 7.4% in rural areas and 7.8% in urban areas); and socioeconomic status (with rates of 5.9% in the lowest wealth index bracket, 8.4% in the middle wealth index bracket, and 7.3% in the highest wealth index bracket) [57]. Outbreaks of diarrhoea persist longer in the remote and hard-to-reach areas of Nepal, and when these outbreaks are not investigated or managed, the risks of severity and death increase.

Vibrio cholera is the most common causative agent for cholera during the monsoon season in Nepal, from April to September, and it is also more prevalent when WASH conditions are poor. In 2009, Nepal faced a massive outbreak of diarrhoea which affected Province 7 (previously called far-western region), where a total of 3,080 diarrhoea and 51 cholera cases were confirmed from July to August 2009; of these cases, 17.6% were in children under five years [214]. The Nepal Health Research Council (NHRC) conducted a research project in 2016 using secondary data from all districts and the three ecological zones (mountains, hills and plains) of Nepal. This study found that the incidence of diarrhoea varied by year. For instance, in 2003, the rate was 187 cases per 1,000 people, in 2005 it was 73 cases in 1,000, and in 2012 it was 540 cases in 1,000 [215].

Knowledge about hygiene and sanitation is the main determinant of diarrhoea [216]. A systematic review conducted in 2014 found poor household conditions, such as unimproved water sources, poor sanitation and absence of handwashing facilities in developing countries, including Nepal [41]. A Nepal-specific study conducted in 2015 found that age, sex, children's nutritional status, provision of water, sanitation, handwashing with soap, mother's education, provision of health care services, community culture and values, and economic status of households were risk factors for diarrhoea in Nepal [175].

### 2.5.2 Malnutrition

In 2016, a study on the nutritional status of Nepal's population found that 18% of females were underweight compared with 15% of males. Provinces 2, 6 and 7 had higher prevalence of underweight (28.2%, 22.5% and 19%, respectively) than the other four provinces [217]. People from the plains region of Nepal were more vulnerable to being underweight (21.3%) than those from the hills and mountains regions. A previous study involving interviews of mothers from the eastern part of Nepal with children under five years found higher prevalence of the children being underweight if they were over 24 months of age, had a low birthweight, had poor growth monitoring, and lived in a household where drinking water was not treated [53]. Another study conducted in a plains region of Nepal indicated that the factors affecting undernutrition and stunting were children's ages, mothers' level of education, the discarding of rice scum, not feeding infants colostrum, and frequent diarrhoea [218]. Lack of sanitation education, poor-quality health care services, and poor wealth index of households in Nepal can contribute to malnutrition in children. According to the Asian Development Bank, child malnutrition occurs because of inadequate food consumption, worm infestation due to poor hygiene and sanitation, maternal underweight, and lack of social protection such as cash, food and health insurance [219].

Early marriage, short birth spacing, intrauterine growth retardation due to maternal undernutrition, and poor WASH knowledge of family members also contribute to malnutrition. A study conducted in the Bara district of Nepal showed that mothers who had a child before 20 years of age or after 35, a short birth interval (<2 years), and an illiterate father, and were of low socioeconomic status, and more likely to bottle-feed than breast-feed, have a higher chance of children with severe acute malnutrition ($WHZ < -3$) in Nepal [31]. The NDHS dataset from 2006, 2011 and 2016 identified factors which can cause stunting in children: being from an extended family or a large family, food insecurity, low birthweight, and poverty [220]. Improved sanitation plays a role in lowering the rate of malnutrition among children in Nepal, as water-treatment techniques are significantly associated with a lower rate of wasting, and lack of household-level handwashing with soap and water is significantly associated with underweight [36].

Although the literature on communicable diseases and WASH in the Nepalese context have demonstrated associations, [114, 170, 175, 221] the connections between gastrointestinal disease and malnutrition have not been fully explored in relation to all components of WASH.

## 2.6 Review of WASH-related policies of Nepal

There are limited policy-related governmental documents regarding water, sanitation and handwashing in Nepal. The available WASH-related official documents are briefly explained in this section.

Nepal's 2015 constitution has proposed that all citizens shall have the right to access clean drinking water and sanitation [76]. This commitment realized that the WASH is a fundamental human right [62]. The coverage of water source and construction of sanitary toilets are quite good but handwashing facilities coverage less than half of the households. The GoN formulated a rural water supply policy in 2004 that aimed to provide a safe, accessible and adequate water supply, with sanitation facilities, to reduce water-borne diseases, and to alleviate the burden of carrying water over long distances [222]. This policy focused on health and hygiene, and was promoted by a variety of mass communication and locally suitable methods in simple and socially acceptable ways to increase awareness. It also focused on improvements in hygiene and sanitation for schools. This policy did not have any strategies for handwashing, either in households or institutions.

The urban water supply and sanitation policy of 2008 focused on the quality of water and human excreta disposal. This policy endorsed core principles, such as public health, economic growth, social inclusion, protecting and optimising investment, environmental protection, and urban water supply and sanitation [223], all of which were achieved effectively, efficiently, and with accountability. However, this policy also lacked strategies for handwashing. The GoN's sanitation and hygiene master plan of 2011 emphasised five key hygiene and sanitation issues: toilet use; handwashing with soap at critical moments; safe handling and treatment of water in households; maintaining personal hygiene by regular fingernail and toenail cutting, washing of clothes, daily hair combing, and teeth brushing; and proper solid and liquid waste management within and outside the home [224]. This plan was responsible for organising resources (human and financial) behind coordinated approaches to progress the country's sanitation goals. The Public Health Service Act 2018 also has given importance to water and sanitation but not addressed handwashing in Nepal [225]. Nepal's multi-sectoral nutritional plan 2018-22 targeted to reduce malnutrition among children under five. WASH is one of the key components of improving nutritional status and therefore this plan has given priority to WASH promotion [226]. Nepal Water supply, Sanitation and Hygiene Sector Development plan 2016-30 addressed the importance of handwashing with soap, safe disposal of faeces, safe handling and treatment of drinking water, enhanced nutrition and promoted other personal hygiene activities [227]. The Ministry of Health formulated the national WASH standard for health facilities in 2018, which aims to provide basic standards and guidelines for both health workers and patients, as well as their visitors, to adopt sustainable hygiene behaviour within the health care settings [147]. However, effective implementation of the 'national WASH standard for health facilities' remains challenging. The district, municipal and village strategies are focused on promoting WASH facilities [228].

The 15th five year plan (2019-24) was formulated by the national planning commission and addressed the water and sanitation issue, with the target of achieving access to quality water and sanitation for 99% of the population by 2024 [55]. This plan also includes food hygiene and a sanitation program but has not addressed the issue of handwashing with soap. National health policy 2019 declared to ensure to regulate water pollution [229]. However this policy has not addressed sanitation and hygiene matter. In line with the Constitution of Nepal, the NHSS–IP (2016-21) aimed to increase the rate of fixed places for handwashing with soap and water at the household level for 90% of the population by 2021 [77]. This plan achieved target (95%) of supply improved water source and a fixed places for handwashing (75%) in 2017. The main message of this plan related to WASH was to conduct health behavior change activities, ensure hygiene and sanitation at all health facilities and prepare Behavioral Change Communication plans for handwashing and community hygiene promotion, as well as health facility based sanitation. However, there are absence of sub-national or provincial level WASH policies in Nepal.

Regular reporting of the status of child health and children's disease risks is important for the prevention, control and timely treatment of diarrhoea and malnutrition [230]. Nepal's MoHP has its own monthly reporting system, from FCHVs to the DoHS level [52]. FCHVs prepare a monthly progress report of first aid and basic care services, and report to local health facilities (HP or PHCC). Local health facilities prepare their own monthly progress reports, including FCHVs reports, and send these to the DHO. Each DHO collates all reports from all health facilities, including district hospitals, and sends them to the HMIS section of the DoHS in Kathmandu, Nepal.

The SDG– 6 aimed to ensure availability and sustainable management of water and sanitation for all [231]. However, available policies and strategies, as discussed above, need to be implemented effectively all over the country and handwashing with soap remains an under-developed initiative. The Constitution of Nepal 2015 has given priority to WASH facilities as a fundamental human right. Nepal became the first country of ODF in SAR in September 2019, which achieved an international commitment [232]. Currently the Australian Government has been supporting Nepal in system strengthening for inclusive WASH leaving "No one behind" under Water for Women Fund since 2018 [233]. The above mentioned policies and strategies are implemented through BCC approaches in Nepal.

## 2.7 The Ecological Model and Underpinned Theories

This section describes the ecological model of public health. The ecological model was used throughout this thesis to contextualise the different factors related to WASH in Nepal.

### 2.7.1 Introduction

The ecological model can be referred to as a "social-ecological model" from the perspective of public health [234]. An early ecological model was first introduced by Russian psychologist, Uric Bronfenbrenner (1917–2005) [235]. Later, this model was applied by Dahlgren Göran and

Margaret Whitehead in 1991 to address issues of social health equity, including individual lifestyle factors, social and community factors, and general socioeconomic, cultural and environmental conditions [236]. This model has been applied in many developing countries over recent years in health promotion research [237-239]. The main value of this model is that it emphasises how human health and behaviour are determined by multiple factors through their interaction [240]. Applying an ecological model in this thesis is relevant because it can be used to describe each level of factors associated with WASH. Social, biomedical and behavioural factors are determinants of health, and this supports the use of the ecological model as it takes a holistic approach [241].

### 2.7.2 Application of the ecological model to WASH

The ecological model as a public health approach focuses on individual, family/relationship, community and public policy level determinants of health [234, 242]. These levels of determinants are also called *micro-, meso-* and *macro-level* determinants, respectively [243]. In the context of this research, the micro-level ecological determinants of WASH are defined as the individual and their family, the meso-level ecological determinants are defined as the community or neighbourhood, and the macro-level ecological determinants are defined as public policy and government. A study using the ecological model to determine facilitators of and barriers to uptake of water, sanitation and hygiene practices was conducted in 2020 in Uganda [244]. Knowledge and attitude of community members, cost of the WASH facilities, lack of cooperation between neighbours, poor community participation, and inadequate space for sanitary facilities were barriers to uptake WASH. The ecological model has been applied in this thesis to the determinants of WASH and disease outcomes, as shown in Figure 2.1.

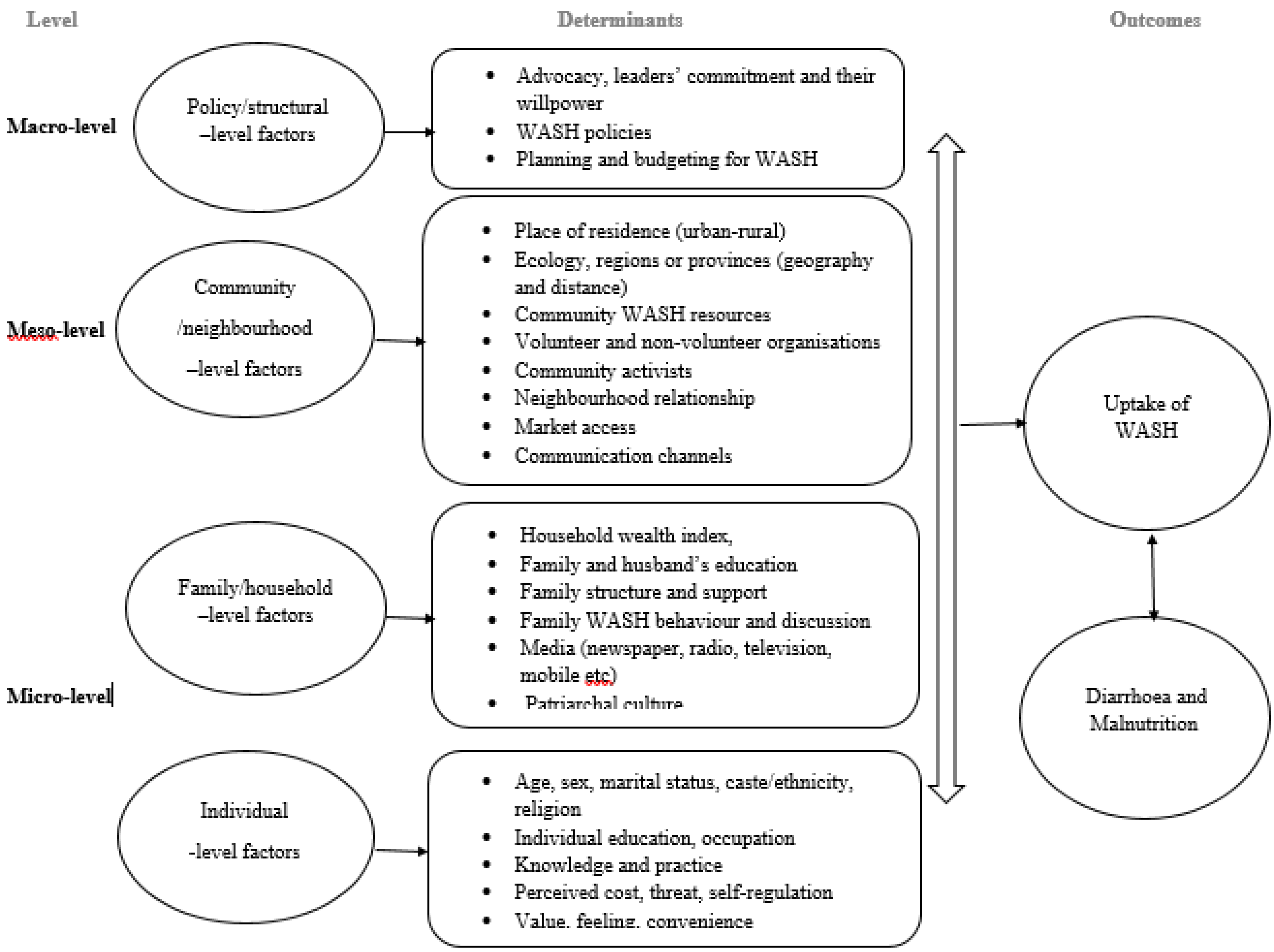



**Figure 2.1: The ecological model of uptake of WASH**

**Source:** Uric Bronfenbrenner **[235]**, Golden and Earp 2012 **[245]**

### 2.7.2.1 Individual-level factors

Household WASH facilities and their utilisation are influenced by individual-level factors [246]. These factors include age, sex, education, marital status, caste, employment, income [247-250], and cost of soap and toilets [152, 251]. Individual feelings about the value of handwashing and usage of water and toilets, perceived threat, and knowledge are further factors related to the individual [152, 252-254]. People who live in extreme poverty may not understand the importance of sanitation and hygiene or have capacity to enact WASH [109].

Age, economic status, and employment are interrelated factors which influence the access to and practice of WASH [110, 255]. Gender, education level, and caste can also affect the utilisation of WASH services. While both men and women are required to be responsible for WASH management, the gender roles in Nepal are distinct, as previously discussed [256].

Hygiene education is a process of alerting individuals to the relationship between WASH and communicable diseases [257]. From a gender and social inclusion perspective, rural, lower caste females have lower levels of hygiene education, which determines how they utilise improved WASH [227]. Knowledge influences individual attitudes and behaviour about WASH facilities [109, 258] which explored by individual determinants in the ecological model [259]. Good knowledge and a positive attitude always encourage individuals to adopt improved WASH [260].

Mothers' and child caregivers' behaviours regarding using the toilet, using safe and clean water, and handwashing practices encourage their children to adopt WASH practices at home [151]. These factors contribute to promoting child health and can help to reduce communicable diseases. In order to improve and maintain WASH practices, there must be improved social connections, education, sound economic status, maturity, and the adoption of scientific methods by the local culture [261]. This evidence will be supported by careful consideration of individual factors, such as age, education, occupation, caste or ethnicity, and religion.

#### 2.7.2.2 Family-and household-level factors

The family structure, relationship to household head, family education, wealth index, media exposure, family discussions about handwashing with soap, availability of water and toilets, handwashing places, convenience of such resources, usage of sanitary toilets, maintenance of a safe and clean water supply, availability of support for the family, the social network society, peers, and religious and cultural networks are all family- or household-level (interpersonal) factors [234].

The family structure is one of the most important factors that influence the use of WASH services by family members, including children. A family's low economic status inversely affects the purchase of soap, improved toilet construction, and access to safe water. People with low economic status have low rates of toilet construction due to financial hardship [262]. Therefore, the low economic status or poverty of a family affects their buying of hygiene and sanitation commodities and may influence their handwashing practice [263].

Access to improved WASH is a significant issue at the household level that can impact on health [264]. Children under five years can have poor hygiene and sanitation practices due to their families' and carers' lack of knowledge, lack of resources and dependency on their parents. Children under five years utilise toilets less, are more likely to practice open defaecation, and have been reported as being unsure about handwashing with soap [265, 266]. Children need the assistance of parents and caregivers to access water, toilets and handwashing [267].

**2.7.2.3 Community- and neighbourhood-level factors**

The ecological model suggests that the uptake of WASH is also influenced by the environment where all individuals are exposed to WASH. The community or neighbourhood level of the model includes places where people obtain support, networks and/or information from neighbours [268]. WASH-related community or neighbourhood factors, such as health organisations, community activists, volunteer organisations, community leaders, and neighbourhood relationships, have the capacity to influence access to improved water and toilet facilities, the distance to the water source, handwashing provisions, availability and usage of soap during handwashing, and facilities for processing waste other than excreta [178]. Community factors include the following: ODF areas; a lack of community taps and access to rivers; having to travel a long distance (>30 minutes) to bring water home; lack of public toilets; no household waste-processing facilities; water contamination by human activities;

geographical difficulties; and poor access to markets, all of which can have adverse impacts on health [257].

If there is a good water source and public toilet in the community, then the risks of contamination are reduced [269]. While a sanitary method of disposal of human excreta (using sanitary toilets) increases the sanitation level of household family members, it may not be sufficient for the elimination of faecal contamination due to other local people's behaviour, if they have poor sanitation facilities and practices [18]. A community where safe water and improved sanitation are present, where mothers have access to education and greater decision-making power, and where people have generally received an appropriate level of education is strongly associated with reduced diarrhoeal diseases among children under five years [264]. A high level of health literacy around WASH and communicable diseases (i.e. diarrhoea) will also ultimately help to reduce malnutrition [270]. These factors are all influenced by policy-level decisions, which are discussed in the next section

The decentralisation process is ongoing in Nepal and the decision-making power is authorized to local government by the federal government. The rural and urban municipality managed a faecal sludge at local level and regulate to promote WASH. The WASH coordination committee coordinate with local stakeholders and project workers in the local level.

#### 2.7.2.4 Public policy-, societal- and structural-level factors

Policy-level factors are also called societal- or structural-level factors. This level has a wider area of influence on WASH status and the related burden of diseases. Local, provincial and central government bodies and civil society (such as NGOs, international non-government organisations, and community groups) are key sectors responsible for operating WASH services through the process of policy formulation [261]. Policy-level authorities, mainly federal governmental, have the strongest effect on achieving universal access to water for drinking and cleanliness. Key strategies will promote safe and adequate sanitation or disposal of human excreta, and the promotion of handwashing [4]. The formulation of context specific hygiene polices, acceptance of policies by different stakeholders, and political determination and leaders' willpower are important as factors affecting WASH improvement at the policy level. Leaders are the key persons involved in planning and formulating such policies in the community [271], which contribute to the degree of WASH that is accessible and used at the household level [272]. The federal government worked for planning, implementation, evaluation and monitoring of WASH program. The MoHP worked to promote health and hygiene through the surveillance of water quality and emergency responses in Nepal [229]. There are not any particular WASH related policies developed yet at sub-national or provincial level. However they have conducted WASH related activities based on the federal/central level available policies in Nepal.

The federal level WASH policies are important guiding tools for all other levels of government, so that they are locally acceptable, accessible and practical [273]. The provincial and local level policies are developed based on the federal policy. However, the local and provincial WASH policies might differ by culture, geography, and context. It is of concern that poor participation and lack of commitment to the principles of WASH by political leaders will negatively influence access to WASH. Policy formulation is incomplete if it has not been effectively implemented. This is a major challenge for establishing federal WASH policies due to political instability, lack of coordination, poor supervision and monitoring systems, non-scientific evaluation of rewards and punishment, low-level community participation in policy formulation, and discriminative policy formulation and processes [274].

This thesis intends to apply the ecological model by considering the individual, family/household and community level factors associated with WASH. This model has a few limitations. The ecological model permits a broad view that permits research design but frequently requires the addition of advanced operational models to test hypotheses and to develop suitable guidelines for public health interventions [275]. This model is based on estimation of model parameters either derived from observations or laboratory investigations, which might be expensive [276]. Application of the ecological model is complex for spatial modelling and can lead to difficulties in defining the levels where variables best fit. [277] Nevertheless, this model was considered the best for the current studies because this thesis addressed a multi-level factors related to WASH in Nepal.

In summary, the ecological model is useful in describing and developing an understanding of the above-mentioned risk factors at individual-, family-, community-, and public policy levels that influence the status of childhood diarrhoea and malnutrition. The importance of viewing each level of the ecological model within the context of WASH is clear at the micro-, meso-, and macro-levels. This multi-level approach is required to better understand the determinants of WASH, with the ultimate aim of preventing diarrhoea and malnutrition in children aged under five years in Nepal.

Along with this ecological model some behavioural theories were used in WASH related previous other studies. For example the Behaviour Change Design (BCD) approach was used in an intervention study for food hygiene behaviour change in 2015 in Nepal [205] and Super Amma handwashing intervention studies in India in 2011-12 [278]. This model was developed by the School of Hygiene and Tropical Medicine UK[279]. The FOAM and SanFOAM model was developed by The World Bank to analyse handwashing and sanitation behaviour [280]. This is a framework design of opportunity, ability and motivation. The Hygiene Improvement Framework, developed by the Environmental Health Project in partnership with USAID, UNICEF, and others, proposes a framework for combating diarrhoeal disease that consists of three main components: improving access to water and sanitation hardware, promoting hygiene, and strengthening the enabling environment[281].Awareness, action and maintenance component are required to manage household WASH facilities[282].

## 2.8 Research gaps

Previous studies have suggested that poor WASH conditions have a positive relationship with communicable diseases such as diarrhoea. It is evident that people in poor resource settings and rural areas have poor access to WASH and a high risk of disease prevalence. Therefore, further research is required in the areas of WASH, diarrhoea and malnutrition. This section will specify current research gaps.

### 2.8.1 Nepal-specific WASH situation

Despite efforts to improve WASH conditions in Nepal, obtaining improvements in WASH practice remains a public health challenge in Nepal. WASH conditions in Nepal vary by ecological zone and type of place of residence. Previous studies on WASH were limited, with low sample sizes, and regional and community settings, and these factors may have affected the results [283]. Therefore, a nationally representative study with a large sample, considering geography and ecology, is required. The 2016 NDHS data used in this study will fill this gap.

This study (Chapter 5) has considered the status of WASH in households in Nepal and has identified further exposure variables. Three ecological zones in Nepal – mountains, hills and plains – were considered when mapping the current status of WASH conditions in Nepal. This study also included Nepal’s seven provinces: Provinces 1 and 2 which have not yet been named; Province 3, Bagmati Pradesh; Province 4, Gandaki Pradesh; Province 5, Lumbini Pradesh; Province 6, Karnali Pradesh; and Province 7, Sudurpashchim Pradesh. This study (Chapter 5) reflected on whether the different geographical areas can influence improved access to WASH. The gap between the previous administrative structure of five development regions and the newly redesigned structure of the current seven provinces, and their relationships to WASH, has not yet been explored.

### 2.8.2 Ecological determinants of WASH

Many public health studies have been conducted into WASH, but there is still a lack of research from the health promotion perspective, such as WASH disease prevention strategies and socioecological mandates. Most studies are cross-sectional without accounting for clustering, and this can result in underestimated results [284]. Previous studies have not examined all aspect of WASH. For example, one previous study was conducted in Nepal on geographical inequalities in accessing improved water and sanitation facilities, but it did not include handwashing with soap, and also did not consider unobserved multi-level factors [60]. A recent study using multi-level analysis of individual, family and community factors influencing child growth in Nepal showed that individual factors, such as age and sex of child, breastfeeding, age at first birth, education, caste, water purification, and access to handwashing, were associated with child growth [285]. However, no studies to date have conducted a multi-level analysis of WASH in Nepal. Therefore, individual, family and community factors that may influence WASH in Nepal have not been adequately explored. To meet this knowledge gap, this thesis will address these factors in relation to WASH in Nepal. This thesis will also explore the relationships between individual WASH components, such as improved water sources, sanitary toilets, fixed places for handwashing, and available soap and water, and combined WASH facilities.

### 2.8.3 WASH and diarrhoea and malnutrition

The reported benefits of improved WASH can be underestimated where studies have focused solely on diarrhoea. While past research [175] has suggested that WASH practices are related to diarrhoea among children under five years, it is still unclear whether improving WASH facilities in Nepal is effective in reducing malnutrition among children under five years [286].

Diarrhoeal disease and malnutrition are interrelated, but there is very little evidence and few rigorous studies concerning the link between WASH and nutritional status [287]. Therefore, further study is required to assess the effects of WASH facilities on malnutrition among children under five years (Chapter 7).

### 2.8.4 Methodological gap

Most previous studies only focused on small samples and conducted statistical analyses, using descriptive statistics, qualitative analyses, and applied a cut-off point (p value 0.25) to determine confounders, and these may not be an accurate assumption of the covariates [288]. Instead of these traditional methods for identifying possible confounders, alternative modern techniques are required, such as Directed Acyclic Graphs (DAGs) in DAGitty software. This thesis applied DAGs to identify possible confounders and avoid confusion, through use of visual representations of existing knowledge, experiences, literature and expert opinion [289]. The DAG technique has not been used in previous studies related to WASH in Nepal. Therefore, this is the first study to apply the DAG approach to the identification of confounders to give accurate results on the effects of WASH on diarrhoea and malnutrition among children under five years in Nepal.

### 2.8.5 Policy and plan gaps

The major WASH related policies, plans, and strategies were discussed in Section 2.6. The majority of these have not prioritised handwashing with soap but have targeted the water and sanitation components of WASH in Nepal. Handwashing policies and strategies have yet to be sustainably developed at the household and institutional levels in Nepal.

## 2.9 Aim, objectives and research questions

The aim of this thesis is to identify the availability of household-level WASH facilities and to examine individual-, family/household-, and community-level factors associated with WASH, and to assess the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal.

**Objective 1 (Chapter 4): To determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing.**

**Objective 2 (Chapter 5): To estimate the prevalence and correlates of household level of WASH in Nepal, including identification of areas where WASH facilities were unimproved.**

Research question 2.1: What is the prevalence of improved water sources, sanitary toilets and handwashing with soap at the household level in Nepal?

Research question 2.2: Which predictors are correlated with improved water sources, sanitary toilets and handwashing with soap at the household level in Nepal?

Research question 2.3: What is the distribution of unimproved water sources, unsanitary toilets and unavailability of soap and water at the cluster level in Nepal?

**Objective 3 (Chapter 6): To identify the individual, family/household and community factors associated with household WASH facilities in Nepal.**

Research question 3.1: What are the individual, family/household and community level factors associated with household WASH facilities in Nepal?

**Objective 4 (Chapter 7): To assess the effects of household WASH facilities on diarrhoea and malnutrition (stunting, wasting, and underweight) among children under five years in Nepal.**

Research question 4.1: What are the effects of household WASH facilities on diarrhea among children under five year in Nepal?

Research question 4.2: What are the effects of household WASH facilities on malnutrition among children under five year in Nepal?

# Chapter 3. Research Methods

## 3.1 Introduction

This chapter details the methods that were used to conduct the research included in this thesis. The research methods used in conducting the systematic review (Chapter 4) are addressed first, followed by a detailed description of the 2016 NDHS data source for the analyses conducted to answer the remaining objectives, covered in Chapters 5, 6 and 7.

## 3.2 Systematic review

A systematic review was conducted to satisfy Objective 1, which was to determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing. Detailed methods for the systematic review are included in Chapter 4, along with the results and conclusions. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) check list (Figure 4.1) [290] was used to guide the review and is included full text articles (Table 4.1). Articles were identified through electronic searches using keywords. The following databases were searched: PubMed/Medline, Embase, PsycINFO, CINAHL, and Google Scholar. Keywords included *handwashing, situation, households, mothers, children, determinants, knowledge, soap, health education,* and *Nepal.* Grey literature (e.g. government reports, project reports, working papers, technical reports, and unpublished theses) was searched by using keywords that were the same as those used to search the peer-reviewed literature. Google Scholar was searched, and a hand search of relevant papers was conducted. Articles were included if i) the study was conducted in Nepal, ii) information was collected from mothers, and iii) the paper was published in English. No limits were placed on the dates of data collection or publication, and articles were included if they were published up to November 2019 when the search was conducted.

All eligible articles and records were extracted and recorded in an Excel spreadsheet. Extracted information included author, year of publication, study design, participants, age group, study place, study periods and outcome measures.

Descriptive analysis was performed for this review paper. The articles were selected if they met at least one inclusion criterion, based on the article title or abstract. Articles and records were excluded if they were animal studies, non-human studies, study protocols, systematic reviews, abstracts only, or editorials. Meta-analysis was impossible due to the low number of studies identified and the heterogeneity of the outcome measures. A quality assessment was done using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for observational studies [291]. All required fields of the guideline were completed, and cross-verification was done by supervisors. Once the extraction of eligible studies was completed, a narrative synthesis was conducted to provide evidence of handwashing with soap by mothers. The characteristics recorded for all eligible articles comprised first author's name, publication year, study design, study population, sample size, study period, and key findings. The statement of main findings, strengths, and limitations was carefully reviewed and reported in the conclusion section. The main results were presented and matched with the study aims.

## 3.3 Nepal Demographic and Health Survey (NDHS)

The statistical analyses conducted in Chapters 5, 6, and 7 satisfied the remaining Objectives: to estimate the prevalence and correlates of household-level of WASH, including identification of areas where WASH facilities were unimproved, to identify the individual, family and community factors associated with households' WASH facilities and to assess the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting, and underweight) among children under five years in Nepal**.**

These studies were conducted using data from the nationally representative NDHS 2016. Demographic and Health Surveys (DHS) provide a systematic means of exploring health and population issues to provide up-to-date estimates of basic demographic and health indicators, such as wealth quintile, fertility, disease prevalence, under-five mortality, and maternal mortality. DHS are conducted in 93 countries, and most participating nations carry out these surveys every five years. The concept of the DHS evolved from the World Fertility survey and the Contraceptive Prevalence Rates survey, implemented between 1974 and 1980 and later established as the DHS in 1984 [292].

The Nepal Demographic and Health Survey commenced in 1976 (under the name: Family Health Survey) and has been conducted every five years since 1996. The most recent NDHS was conducted in 2016, and this was the fifth such survey in Nepal. NDHS 2016 is a nationally representative and comprehensive survey. The lead role was taken by the Ministry of Health and Population (MoHP) Nepal. NDHS receives financial assistance from the United States Agency for International Development (USAID) and technical support from Inner City Fund (ICF), a global consulting and technology services company. The primary implementation partner of this survey was New ERA, a research company in Nepal.

NDHS 2016 is a publicly accessible data source, obtained via an online database. The full dataset was made available after completion of the required registration and application processes. Downloaded datasets were saved on a password-protected laptop. The NDHS 2016 data has some limitations including the self -report nature of the survey, which might involve recall and desirability biases. However, while behaviour was measured by self-report, facilities were observed by data collectors, which improved the overall validity of the data.

### 3.3.1 Research design and setting

The 2016 NDHS used a cross-sectional survey design, covering 383 clusters from three geographical areas, the plains, hills and mountains regions, in Nepal. These geographical areas are further divided into rural municipalities (*Gaounpalika*) and urban municipalities (*Nagarpalika*), more commonly called rural and urban settings, respectively. The sample population by provinces and rural urban distribution is illustrated in Table 3.1. There were 383 study clusters representing the rural and urban setting of each province. A total of 11,040 household heads were interviewed, including 36.8% from rural and 63.2% from urban areas. Data from mothers with children under five (n=4,861) were also included in this thesis from that provided by all eligible interviewed women (n=12,862), with 58.1% of mothers living in rural areas, and 48.9% in urban areas.

**Table 3.1: Household sample by provinces and rural urban wards allocation**

| **Provinces** | **Wards allocated** | | | **Household heads** | | | **Household mothers** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Rural** | **Urban** | **Total** | **Rural** | **Urban** | **Total** | **Rural** | **Urban** | **Total** |
| 1(Not named yet) | 30 | 27 | 57 | 595 | 1080 | 1675 | 399 | 264 | 663 |
| 2(Not named yet) | 30 | 26 | 56 | 674 | 952 | 1626 | 616 | 412 | 1028 |
| 3(*Bagmati*) | 28 | 30 | 58 | 514 | 1125 | 1639 | 274 | 219 | 493 |
| 4(*Gandaki*) | 27 | 25 | 52 | 539 | 959 | 1498 | 275 | 217 | 492 |
| 5(*Lumbini*) | 30 | 26 | 56 | 618 | 1013 | 1631 | 459 | 322 | 781 |
| 6(*Karnali*) | 27 | 25 | 52 | 551 | 937 | 1488 | 429 | 312 | 741 |
| 7(*Sudurpashchim*) | 27 | 25 | 52 | 571 | 912 | 1483 | 373 | 290 | 663 |
| **Total** | **199** | **184** | **383** | **4062** | **6978** | **11040** | **2825** | **2036** | **4861** |

**Source:** Nepal Demographic and Health Survey 2016, Household recode file and children’s recode file

### 3.3.2 Sampling frame

Nepal is divided into seven provinces in accordance with the new Constitution, approved on 20 September 2015. Within these provinces, the rural and urban sub-division and three ecological/geographical zones (plains, hills and mountains) were further examined. There are 77 districts after splitting Rukum district and Nawalparasi district into two in Nepal. Structural changes made as a result of the 2015 Constitution change were not reflected in the sampling frame for NDHS 2016.

The sampling frame includes information about wards, type of residence (rural or urban), and estimated number of residential households. Wards were the primary sampling unit (clusters), and the households were proportionally selected from the wards. In rural areas, wards are generally smaller than those in urban areas, with an average of 104 households per rural ward. A two-stage selection sampling design was applied for rural clusters. In contrast, the urban wards have an average of 799 households per ward.

The Central Bureau of Statistics (CBS) has a frame of enumeration areas for each ward of 58 municipalities. As for the 159 newly declared municipalities, each is comprised of former wards, which were small in size and previously functioned as enumeration areas [57]. In urban areas, a three-stage selection sampling design was used, and wards were selected as primary sampling units. The enumeration areas were selected from each primary sampling unit. Lastly, households were selected from the selected sample of enumeration areas.

The study flow diagram illustrated in Figure 3.1

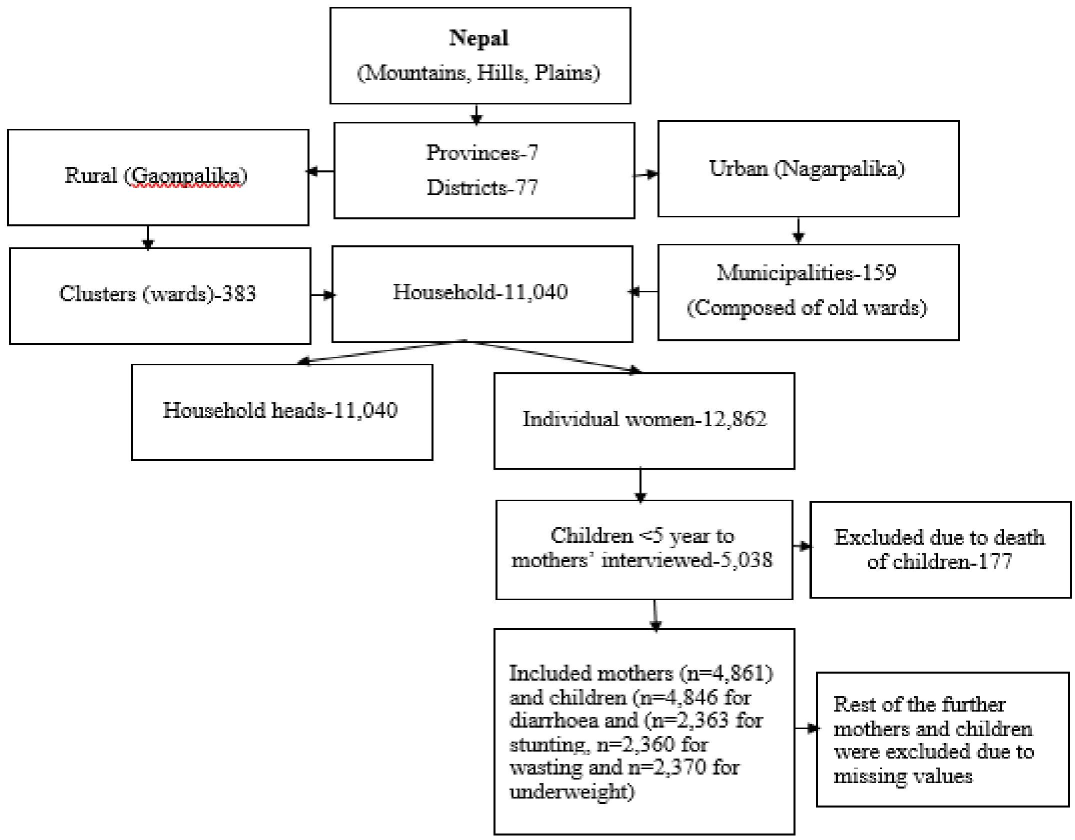



**Figure 3.1: Study flow diagram**

The following process was adopted in selecting respondents. Firstly, each of the seven provinces was stratified in the NDHS survey into rural and urban settings available from 14 sampling strata. Secondly, a total of 383 clusters (wards) were selected proportionally as a primary unit of enumeration, and were drawn from the latest National Population and Housing Census (NPHC) 2011, conducted by the CBS Kathmandu, Nepal. Thirdly, household listing was conducted in the selected enumeration areas, and households from each primary sampling unit (ward) were selected, with an equal probability of systematic sampling. The study respondents were household heads and mothers aged 15–49 years with children under five years. The respondents were interviewed randomly and toilet facilities, handwashing with soap facilities and availability of soap and water were observed by the data collectors. This study sample of household heads (n=11,040) was selected to allow investigation of the household

WASH situation at the national level in Nepal. The number of mothers (n=5,038) were estimated from the actual sample size of 5,060, after adjusting for strata and cluster (using ***svy*** STATA command), which affected the sample size. These mothers were taken from the total number of women interviewed (n=12,862) from the preselected households (n=11,040). The NDHS used a two- and three-stage (multistage) cluster design, which deviates from a simple random sample. Analyses included in this thesis involved adjustment for stratification and clustering in the multivariable logistic regression, using complex samples procedures in STATA. A total of 177 unadjusted samples were excluded from the studies in this thesis. These excluded samples were mothers whose children died between birth and 36 months of age. For the children's studies, data collected from 4,861 mothers aged 15-49 years were analysed (adjusted sample size 4,887) were included. All selected mothers were aged 15–49 years and were permanently living in their homes (De Jure or usual residence). However, mothers who stayed at least one night prior to being interviewed as a guest (De Facto) were excluded in this thesis. Data for diarrhoea were not available for 41 children, so data from these children were excluded from analyses where diarrhoea was the outcome being examined. Data from children where values for height (n=2,524) and value for weight (n=2,517) were missing due to absence of children for height and weight, unknown date of births and excluded from the analysis the data for stunting and underweight outcomes. Data from children with missing height and/or weight (n=2,527) due to absence of children for whether height or weight, unknown date of births and implausible measurement were excluded from the analysis for wasting outcomes.

### 3.3.3 Questionnaires

Six different questionnaires were administered in 2016 NDHS. These questionnaires were the household questionnaire (per household), the woman's questionnaire (per household), the man's questionnaire (per household), the biomarker questionnaire (per household), the field worker questionnaire (to collect background characteristics of interviewers and supervisors), and the verbal autopsy questionnaire was administered in the households where a neonatal deaths occurred with in a five years of NDHS [57]. This thesis used the household questionnaire for household heads and the woman's questionnaire for mothers. The WASH-related survey questionnaires were completed by household heads who have household level decision making power in Nepal [293]. The household and women's questionnaires were based on the DHS Program's standard Demographic and Health Survey (DHS-7) questionnaires and were adapted for the population and health issues of Nepal [294]. The NDHS protocol was reviewed and approved by the NHRC and the ICF Institutional Review Board. The 2016 NDHS required written consent from the respondents prior to conducting the interviews. Once the questionnaires were finalised in English, they were translated into Nepali, Maithili and Bhojpuri.

### 3.3.4 Pre-testing questionnaires

Staff from New ERA pre-tested the questionnaire after receiving three weeks training in February 2016 [57].The questionnaires were pre-tested in the Sarlahi, Bara and Dhading districts of Nepal. Both rural and urban areas of each district were selected for the pre-test. The Maithili, Bhojpuri and Nepali languages were used in Sarlahi, Bara and Dhading districts, respectively. Debriefing sessions were conducted with field staff who performed pre-testing. Questionnaires were modified based on the evaluation of the pre-test prior to the 2016 NDHS [57].

### 3.3.5 Data collection period and response rates

The NDHS 2016 data were collected by trained enumerators between 19 June 2016 and 31 January 2017 [57]. The response rate of household heads was 98.5% (rural=99.1% and urban=98.2%), and for women aged 15–49 years was 95.9% (rural=99% and urban=97.9%). There were 3,456 (31.3%) women who identified as household heads in Nepal.

### 3.3.6 Structure of the Nepal Demographic and Health Survey dataset

The four main 2016 NDHS questionnaires and the datasets were distributed as six files:

**HR file**: Known as the Household recode, where the unit of analysis was a number of households. The HR dataset was used for water, sanitation and hygiene-related variables calculation. It also included basic household characteristics.

**IR file:** Known as the Individual women recode, where the unit of analysis was a woman aged 15–49 years. It contained all data collected in the women's questionnaire for De Jure women and some variables from the household questionnaire.

**KR file:** Known as the Kids recode, where the unit of analysis was children under five years who were the children of mothers interviewed for the survey. Variables available in KR file were derived from the individual women's questionnaire. It included information related to the child's health, and nutrition data. The data on behalf of the mothers' socio-demographic of each of these children was also comprised in this file.

**MR file:** Known as the Male recode, where the unit of analysis was De Jure men interviewed.

**PR file:** Known as the Person or household members recode, where the unit of analysis was all usual household members. It included characteristics of household members, including age, sex, marital status, education, and some biomarker measurements, as well as anthropometry and anaemia status of children under five years.

**BR file:** Known as the Births recode, where the unit of analysis was all live births. It contained the history of all the births of each woman interviewed, including information on pregnancy and postnatal care, immunisation, nutrition, and health data for children under five years.

For the purposes of the analyses included in this thesis, the HR and KR datasets were considered.

### 3.3.7 Description of respondents

The household head was the respondent for the household questionnaire (as reported in Chapter 5). The household respondent was considered eligible to complete the survey if they were able to provide detailed information about their home and had the decision-making power in the household, if they were above 15 years of age, and if they were living in the selected house. The head of the household may be the grandfather, grandmother, father, mother, husband or wife. The household-level surveys had two primary aims: to provide information about household characteristics, such as their source of water, distance of their water source from their home, types of sanitation facilities, handwashing with soap facilities, and other facilities at the household level; and to provide data on age, sex, education, marital status, number of family members, place of residence, ecological zone, province, and wealth index at the household level.

All mothers aged 15–49 years with children under five years were selected for interview. Mothers were considered eligible as respondents if they were 15–49 years of age and if the location was their usual residence. However, mothers whose children died before reaching 36 months of age were excluded from this present study. The age and sex of the child, the age of mothers, their education, occupation, caste or ethnicity, religion, age at first birth, current breastfeeding, wealth index, media exposure, husband's education, place of residence, province, ecological zone, and disposal method for young children's stool were asked in the individual women's questionnaire. Information regarding the availability of an improved water source, distance to water source, types of toilet facilities, availability of soap and water, and fixed place for handwashing were taken from the household survey.

### 3.3.8 Definition of study variables and measurements

The following variables from the HR and KR datasets, collected from household heads and mothers with children under five years, were used in the analyses.

### 3.3.8.1 Variable drawn from the household recode (HR) datasets

**Age of the household head:** Age of the household head (hv220) was collected as a continuous variable and was then categorised into four groups, and the new variable. The new variable, *age_group,* was recoded and generated. These categories were 15–24=1, 25–34=2, 35–44=3, and 45 and above=4.

**Sex of the household head:** The sex of the household head (hv219) was originally categorised as Male=1 and Female=2, with no change from the NDHS category.

**Education of the household head:** The education level of the household head (hv106_01) was originally captured as: No education (unable to read or write) =1; Primary (year 5) =2; Secondary (year 8)=3; Higher (School Leaving Certificate (year 10; SLC) and above)=4

**Marital status of the household head:** The marital status of the household head (hv115_01) was originally labelled as Never married=1, Married=2, Widowed=3, Divorced=4 and a new variable, *marital_status*, was generated and grouped into three categories, Never married=1, Married=2, and Widowed and Divorced=3.

**Number of family members at home:** The original discrete distribution of the number of family members in the household (hv009) was recoded and a new variable, *family_member* was generated and categorised into 1–2 family members in the household = 1, 3–4 = 2, 5–6 = 3, and 7 or more family members in the household = 4.

**Place of residence:** The place of residence (hv025) was originally categorised as Urban = 1 and Rural = 2, with no change from the NDHS category.

**Ecological zone:** Ecological zones (shecoreg) were originally categorised as Mountains = 1, Hills = 2 and Plains (*terai*) = 3, with no change from the NDHS category.

**Province:** Provinces (hv024) were originally labelled as Province 1 (*Not named yet*)=1, Province 2 (*Not named yet*)=2, Province 3 (*Bagmati Pradesh*)=3, Province 4 (*Gandaki Pradesh*)=4, Province 5 (*Lumbini Pradesh* )=5, Province 6 (*Karnali Pradesh*)=6, and Province 7 (*Sudurpashchim Pradesh*)=7, moving from the eastern to the western parts of Nepal.

**Wealth index:** The household wealth index equates poor to mean an annual household consumption NPR 146,392, which is 55% less than the average annual household consumption NPR 322,730 in Nepal. Household wealth index was calculated based on household ownership of selected assets, such as television and cycles, flooring materials, water sources, sanitation facilities, and other household characteristics related to economics status. The household wealth index (hv270) was originally labelled as poorest=1, poorer=2, middle=3, richer=4, and richest=5. It was further recoded as poor[1]=1, middle[2]=2, and rich[3]=3 after collapsing poorest and poor into one, richest and rich into another, and middle as it is in the original category. The new variable: *wealth_index* was created.

**Distance to water source:** The proximity of the household from a water source is an important indicator of the availability of water to the household. The time required to collect water is determined by distance and geography, such as the quality of the road between the household and the water source. The time taken for water collection at the household level (hv204) had been originally categorized into water source within house premises, within 30 minutes, and

---

[1] Household assets, services, vehicles, flooring and ownership of dwelling are ranked in quintiles 1, 2 and 3. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient -.8477 and -.3385).

[2] The household assets, service, vehicles, and flooring and ownership of dwelling are ranked in quintile 2, 3 and 4. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient -.2859).

[3] The household assets, service, vehicles, and flooring and ownership of dwelling are ranked in quintile 3, 4 and 5. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient 1.0998).

more than 30 minutes walking distance from home. Water source within the home premises and ≤30 minutes were merged, and were considered as water source ≤30 minutes and the new variable, *distance_water*, was categorised into ≤30 minutes=1, or >30 minutes=2

**Source of water**: Improved sources of water (hv201) were originally labelled as piped to a dwelling=11; piped to yard/plot=12; piped to neighbor=13; a public tap/stand pipe=14; tube wells or bore holes=21; protected wells=31; protected springs=41; rain water=41; and bottled water=71. Unimproved sources of water were originally labelled as coming from unprotected dug wells=32; unprotected springs=42; rivers, dams, lakes, ponds, streams and canals=43; tanker trucks=61; carts with a small tank=62; and 'other'=96. The source of water was recoded, and new a variable, *water_source*, was generated and categorised as Improved water source = 1 or Unimproved water source = 0.

**Type of toilets:** The type of toilet facility (hv205) was originally labelled as sanitary when they were one of the following responses types: flush/pour flush toilets to piped sewer system=11; flush to septic tanks=12, flush to pit latrines=13; ventilated improved pit (VIP) latrines=21; pit latrines with slabs=22; and composting toilets=41 without sharing (and/or with sharing; n=2,404) with other households. As per JMP 2019 , any kind of sanitary type of toilet category including shared toilets were included in this analysis [11]. After 2018 the DHS also applied this definition [294]. The sharing toilets are possible to include under sanitary type of toilet category especially in developing countries such as Nepal due to their local culture, lack of available land for toilet construction and large families that live in multiple house [295]. Therefore this thesis includes household sharing toilet considered as a basic sanitation service and counted as sanitary toilet which might be socially acceptable, feasible, affordable and economically viable [296]. Unsanitary toilet facilities were originally labelled as those responses that flushed to somewhere else=14; flushed to an unknown location=15; pit latrines without slabs or open pits=23; those with no facilities at all, and use of bush or fields=31; hanging toilets or latrines=43; and “other”=96. The type of toilet was recoded, and a new variable, *toilet_type,* was generated and categorised as Sanitary toilet=1 (flush/pour flush toilets to piped sewer system; flush to septic tanks; flush to pit latrines; VIP toilets; pit latrines with slabs; and composting toilets) or Unsanitary toilet=0 (flushed to somewhere else; flushed to an unknown location; pit latrines without slabs or open pits; those with no facilities at all, and use of bush or fields; hanging toilets or latrines; and other services).

**Fixed place for handwashing:** The place where household members wash their hands in the home (hv230a) was originally labelled as observed, fixed place=1; observed, mobile place=2; not observed, not in dwelling=3; not observed, no permission to see=4; and not observed, other reason=5. Fixed place for handwashing was recoded, and a new variable *handwashing_place*, was generated and grouped into two categories, Fixed place (where the handwashing location is in a fixed location) =1 or Not having a fixed place (the handwashing location is anywhere in the home) =0. The original categories of 3, 4 and 5 were recorded as missing (.) and excluded from the analysis.

**Availability of soap and water:** The variables, availability of soap (hv232) and availability of water (hv230b), were merged into one. The new variable, *sw1*, was coded as soap water Available=1 or Not available=0

**3.3.8.2 Variables drawn from the child recode interviewed with mothers (KR) datasets**

**Age of the mother:** Age of the mother (v012) was collected as a continuous variable and was then categorized into three groups, and the new variable, *women_age,* was recoded, and generated. These categories were 15–24=1, 25–34=2, and 35 and above=3

**Education of the mother:** The education of the mother (v106) was originally categorised into four groups: No education (unable to read or write) =1, Primary (Year 5) =2, Secondary (Year 8) =3, and higher (at least School Leaving Certificate (Year 10) and above = 4.

**Occupation of the mother:** The occupation of mother (v717) was originally labelled as Does not work=0, Professional/technical/managerial=1, Clerical=3, Agricultural or self-employed=4, Skilled manual=8, and Unskilled manual=9. A new variable *occupation_women* was created and recoded into three categories, which were: No work=1, Agriculture or self-employed=2, and Non-agriculture (Professional/technical/managerial, clerical, Sales/Service, Skilled and unskilled manual) =3.

**Caste or ethnicity of the mother:** Caste or ethnicity (v131) was originally categorised as Hill Brahmin=1, Hill Chhetri=2, Plain Brahmin/Chhetri=3, Other Terai caste=4, Hill Dalit=5, Plain Dalit=6, Newar=7, Hill Janajati=8, Plain Janajati=9, Muslim=10, and Other=96. Later, the caste or ethnicity was recoded as (*ethnicity_category*) and labelled as Brahmin and Chhetri=1, Janajati/Vaishya=2, Scheduled or Shudra=3, and 'Other'=4.

**Religion of the mother:** The original category of religion (v130) was Hindu=1, Buddhist=2, Muslim=3, Kirat=4 and Christian=5. This variable was recoded (*religion*) and categorised into two groups, Hindu=1 and Non-Hindu=2.

**Education of the husband:** The education of the husband (v701) was originally captured as: No education (unable to read or write) =1, Primary (year 5) =2, Secondary (year 8) =3, Higher (School Leaving Certificate (year 10) and above) =4

**Exposure to newspapers**: Exposure to newspapers/magazines (v157) were originally categorised into three groups: Not at all=0, Less than once a week=1, and At least once a week=2. These were collapsed into two categories: Non-exposure=0 and Exposure=1 because of the low sample. The new variable was *newspaper*.

**Exposure to radio:** Exposure to radio (v158) was originally categorised into three groups: Not at all=0, Less than once a week=1, and At least once a week=2. These were collapsed into two categories: Non-exposure=0 and Exposure=1 because of the low sample size. The new variable was *radio*.

**Exposure to television:** Exposure to television (v159) was originally categorised into three groups: Not at all=0, Less than once a week=1, and At least once a week=2. These were collapsed into two categories: Non-exposure=0 and Exposure=1 because of the low sample size. The new variable was *TV*.

**Health Mothers' Group:** Health Mothers' Group (HMG) is a non-political women's organisation in the community. Each HMG in the mountains region of Nepal has at least 11 women, there are at least 15 women in the hills region, and at least 21 women in the plains region. The HMG (s1108bb) was originally categorised into three groups: HMG not available=0, HMG available=1, and Do not know=8, with no change from the NDHS category.

The variables of place of residence (v025), ecological zone (shecoreg), provinces (v024) and wealth index (v190) were available in KR datasets and coded same as HR dataset. The household WASH related variables, such as source of water (v113), type of toilet facilities (v116) and time to get to water source in minute (v115) were also available in KR datasets of NDHS 2016. These variables were labelled same as HR datasets.

**Combined WASH:** Individual components (improved water source, sanitary toilet, fixed place for handwashing, and availability of soap and water) were merged and became the new variable, *WASH*. This variable was labelled as Available combined WASH=1 or Not available combined WASH=0

**Diarrhoea**: The passing of liquid stool more than two times within 24 hours is defined as diarrhoea [28]. The NDHS questionnaire recorded the occurrence of diarrhoea in a two-week period. The diarrhea variable (h11) was originally labelled as No diarrhea=0, Yes, last two weeks=2 and Do not know=8. Later this was recoded, and a new variable (*diarrhea)* was generated and grouped into two categories, Yes=1 or No=0. The diarrhoea prevalence among children under five years was measured by two response options. The original category 8 was coded as missing (.) and excluded from the analysis.

**Malnutrition:** Malnutrition was measured in the NDHS dataset as stunting (height for age), wasting (weight for height), and underweight (weight for age). Z-scores were applied to measure these outcomes, with the cut-off point of SD/z-score <-2. The levels by which malnutrition was calculated were based on the World Health Organization (WHO) Global Database on Child Growth and Malnutrition criteria [297]: stunting (height for age if < -2 SD of the WHO Child Growth Standards median), wasting (weight for height if < -2 SD of the WHO Child Growth Standards median), and underweight (weight for age if < -2 SD of the WHO Child Growth Standards median) [298].

**Stunting (child's height for age):** Stunting was calculated using codebook hw70. The variable, *stunted,* was created, and the labels were Stunted=1 or Not stunted=0. The missing values (n=2,524) were of children whose height was not measured at the time of the survey.

**Wasting (child's weight for height):** Wasting was calculated using codebook hw72. The variable, *wasted,* was created, and the labels were Wasted=1 or Not wasted=0. The missing values (n=2,527) were of children whose weight and/or height were not measured at the time of the survey.

**Underweight (child's weight for age):** Child weight for age is the measured weight of the child (hw71) with the labels, Underweight=1 or Not underweight=0. The variable, *underweight*, was created. The missing values (n=2,517) were of children whose weight was not measured at the time of the survey.

**Age of the child:** The child's age was determined from the birth history provided during the survey as the current age in months (b19). This age group was recoded, and a new variable, *child_agegroup*, was generated with five categories from the original continuous variable.

These categories were <12 Months=1, 13–24 Months=2, 25–36 Months=3, 37–48 Months=4, and 49–59 Months=5.

**Sex of the child:** The sex of child under-five years (b4) was originally categorised into two groups: Male=1 and Female=2, with no change from the NDHS category.

**Mothers' age at first birth:** The original category of age at first birth (v212) was recoded, and a new variable *age_birth*, was generated with two groups from the original discrete distribution of age at first birth. These categories were <20 years=1 and >21 years=2.

**Current breastfeeding practice**: Current breast feeding by mothers with a child under five (v404) was categorised as No=0 and Yes=1, with no change from the NDHS category.

**Disposal of youngest child's stool:** The disposal children's stool (v465) was originally labelled as: used toilet/latrine=1, put/rinsed in toilet/latrine=2, put/rinsed into drain or ditch=3, throw into garbage=4, buried in the open/not disposed of=9, and other =96. This variable was recoded, a new variable *stool_disposal* was generated and grouped into two categories, Unsafe disposal=1 and safe disposal=2, which was formed after collapsing the NDHS categories. In accordance with WHO recommendations, categories 1, 2 and 5 were merged into Safe disposal, and categories 3, 4, 9 and 96 were merged into Unsafe disposal.

### 3.3.9 Merging datasets

The DHS dataset was disseminated separately (household, household member, women, men, and children under five years) in hierarchical formats. The current study investigated variables from the HR and KR files of the datasets. After exploring the study objectives, important variables were identified as not available from some dataset files. For example, there were no available outcome variables for diarrhoea and malnutrition in the HR file. Similarly, variables related to handwashing with soap were not found in the KR files. Data files were merged using common unique variables, such as hv001 with v001, hv002 with v002, and hv003 with v003, which are the cluster, household and line numbers, respectively; where hv001, v001, hv002, v002, hv003 and v003 (and so on) represent unique households. The steps adopted for merging data files were: (1) Determined unique variables within each dataset that were common across the datasets; (2) Sorted data files by using these unique, common variables; (3) Determined the primary dataset to be used as a base file; and (4) merged the datasets (files).

### 3.3.10 Management of missing values

Missing data occurred if respondents refused or were unable to provide a response for a particular survey item or questionnaire [299]. Both the independent and dependent variables had missing data. For options such as 'do not know' and 'missing due to not reporting' (.) with regard to household heads' and husband's education and Health Mother Group were excluded from the analysis. The fixed place for handwashing and availability of soap and water had missing data, were excluded from the analysis when these facilities were not observed by the data collector during the data collection. Don't know responses (unknown diarrhoeal status) was also excluded from the analysis. Stunting, wasting and underweight variables had missing values due to children's absence and/or refusal to participate in anthropometric measurements at the time of the survey. If the height was outside of plausible limits, data were excluded from the analysis of wasting. Children whose month or year of births were missing or unknown were flagged, which excluded from the analysis. Only respondents with complete data were included in the analysis. The frequency distribution, pattern, and reasons for missing data were checked before handling missing data.

### 3.3.11 Statistical analysis

The following section details the statistical analyses undertaken in Chapters 5, 6 and 7. All analyses were conducted in STATA 15 [300]. Table 3.2 reports the summary of methods which included study objectives, sources of data, sample size, study population, and data analysis techniques.

### 3.3.11.1 Descriptive and univariate analysis

A descriptive analysis was carried out to explore the current status of WASH in households (reported in Chapter 5) [301], and diarrhoea and malnutrition rates (reported in Chapter 7). Descriptive analyses were calculated as frequencies and percentages. The socio-demographic and WASH-related variables were analysed using univariate methods. Samples were weighted to match the population distribution by using STATA svy command during this analysis.

### 3.3.11.2 Logistic regression analysis

Logistic regression analyses were reported in Chapters 5, 6 and 7. The Pearson Chi-squared test for categorical variables and Paired t-test for continuous variables were applied to determine the bivariate association between exposure variables and outcome variables [302, 303]. These tests are used to evaluate tests of independence when using cross-tabulation, known as a 2x2 table [303]. Bivariate analysis was then conducted between dependent variables (diarrhoea and malnutrition) and individual covariates, followed by a Chi-squared ($X^2$) test to see the proportional difference between them [304]. The Chi-squared test was applied to fulfil the assumptions below [301, 303].

Data were distributed in frequencies, and each column and row cell count were greater than 5 numbers. Observations/data were independent. The study sample sizes were sufficient. Study variables were mutually exclusive.

The formula used for calculating the Chi-squared test was--

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

where $X^2$= Chi-squared test of independence, $Oi$=Observed value of two nominal variables, and $Ei$=Expected value of two nominal variables [302],

A multi-level mixed effects logistic regression analysis [305] was performed (reported in Chapter 6) to assess the relationship of explanatory variables (at individual, family and community levels) [234] with each binary outcomes (improved water source, sanitary toilet, fixed place for handwashing, availability of soap and water, and combined WASH).

Clustering by primary sampling units was accounted for by using random intercepts. Huber White (robust) standard errors were used, as these are robust to misspecification of the correlation structure. The NDHS employed a multistage cluster sampling technique, where mothers were hierarchical (nested) within households, which were nested within regions/provinces. Because of the hierarchical nature of the NDHS, a two-level hierarchical generalised linear model (HGLM) was used for the purposes of this study (reported in Chapter 6). The traditional logistic regression model assumes independency among observations. Data of a hierarchical nature, however, often have a dependency within a higher level of hierarchy. Multi-level modelling was applied to take this effect into account [305, 306].

This analysis was performed using STATA 15 [306] to estimate an hierarchical linearised model. The equation applied for this model is shown below:

$$Y_{ij} = \gamma_{00} + \gamma_{01} + W_j + \mu_{0j} + \gamma_{10} X_{ij} + \mu_{1j} X_{ij}$$

In this model, $Yij$ characterises the log odds of the mother available each WASH component facility $i$ in region $j$; $\boldsymbol{\gamma 00}$ provides the log odds of available WASH facilities in a typical region; $Wj$ is a region-level predictor for region $j$; $\boldsymbol{\gamma 01}$ is the slope related with this predictor; $\mu\boldsymbol{0j}$ is the level 2 error term, representing a unique effect associated with region $j$; $\boldsymbol{\gamma 10}$ is the average effect of the individual-level predictor; $X\boldsymbol{ij}$ is an individual-level predictor for mothers $i$ in region $j$; and $\mu\boldsymbol{1j}$ is a random slope for a level 1 predictor variable, $X\boldsymbol{ij}$, which allows the relationship between the individual-level predictor ($X\boldsymbol{ij}$) and the outcome variable ($Y\boldsymbol{ij}$) to differ across level 2 units.

Multivariate logistic regression analyses were applied (reported in Chapter 7) to calculate the odds ratio of the association between exposure variables, such as source of water, access to toilets, and handwashing facilities, and dependent variables, such as diarrhoea and malnutrition among children under five years. By conducting multivariate logistic regression analysis, researchers can adjust for multiple covariates as explanatory variables in regression models [307]. Crude odds ratios (CORs) and adjusted odds ratios (AORs) were calculated for each covariate at a 95% level of confidence at a 5% significant level [308].

### 3.3.11.3 Hot Spot Analysis

A spatial analysis was conducted using Aeronautical Reconnaissance Coverage Geographic Information System (ArcGIS) version 10.6.1, developed by the Environmental Systems Research Institute (Esri), and reported in Chapter 5. The Nepal shapefile and a map of Nepal were obtained from the mapping and visualisation software, Data-Interpolating Variational Analysis-Geographical Information System (DIVA-GIS), which is freely available at www. diva.gis.org.

The Nepal Universal Transverse Mercator (UTM) projected coordinate system used was based on the World Geodetic System 84 (WGS84), which is a projected coordinate system. The latitudes (26º22'N to 30º27'N) and longitudes (80º04'E to 88º12'E) of Nepal lie on the UTM zone between 44 degrees and 45 degrees North, and 0.9996 is the scale factor for the central meridian [309]. The projected coordinate system is based on a 2-dimensional plane and uses linear units, for example, feet or metres.

Autocorrelation is classified into positive and negative correlations through the local Getis-Ord Gi* statistic [310]. Positive autocorrelation occurs when similar values clustering together are organised on maps. This process has two different conditions, such as high values surrounded by neighbouring high values, and low values surrounded by neighbouring low values. Negative autocorrelation occurs when dissimilar values clustered together are organised on maps. This process also has the conditions of high value surrounded by neighbouring low values, and low values surrounded by neighbouring high values. The GIS pattern analysis was done in the following ways.

**1. Global Moran's I spatial autocorrelation analysing pattern:** Moran's I spatial autocorrelation analysis is performed to identify spatial patterns of observation. This statistic is used to assess correlation between neighbouring observations and spatial patterns, and spatial clustering levels among neighbouring features. The spatial autocorrelation statistic is calculated using the following equation [311].

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

Where $\boldsymbol{n}$ is the number of features (clusters in this study), $\boldsymbol{w_{ij}}$ is the weight between observations $i$, $\boldsymbol{x_I}$ and $\boldsymbol{x_j}$ are the referred attribute values of features $I$ and $j$, and $\boldsymbol{S_0}$ is equivalent to the sum of all $\boldsymbol{w_{ij}}$.

Global Moron's I spatial autocorrelation statistic does not answer the question of where the hot spots and cold spots cluster, but measures the overall spatial autocorrelation. Therefore, it is required to perform cluster analysis.

**2. Mapping cluster (Getis-Ord Gi* hot spot analysis):** Mapping cluster (Getis-Ord Gi* hot spot analysis) is carried out to identify the clusters of statistically significant hot spots and cold spots for the clusters in ecological zones of Nepal. This analysis separate clusters of high values from low-value clusters [312].

$$G(d) = \frac{\sum \sum wij(d)\, xi\, xj}{\sum \sum xi\, xj},\ i \neq j$$

Here $xj$ is a value for feature (clusters) $j$, $xi$ value refers to feature (clusters) $i$, and $wij\ (d)$ is the spatial weight.

Hot spot analysis, a local statistic, computed the Getis-Ord Gi* statistic which identified hot spot and cold spot spatial clusters for sources of water, toilet facilities and handwashing with soap facilities (WASH) prevalence. Local Getis-Ord Gi* statistical analyses [310] were carried out to identify hot spot and cold spot areas of households' WASH of 383 clusters in ArcGIS software, which used Geographic Positioning System (GPS) latitude and longitude coordinate interpretations [309] obtained from the nearest community centres for the 2016 NDHS clusters (Wards or Enumerations areas) [57]. They are used to assess the features of each neighbourhood and to compare the local context to the global context. Hot spots equate to the absence of improved WASH and cold spots equate to the presence of improved WASH.

The z-scores and p-values with 95% confidence interval determined the significance of autocorrelation (hot spot and cold spot areas). If the z-score is close to zero, it shows there is no clustering in the area. A positive z-score with a p-value less than 0.05 shows clustering of a high prevalence of unimproved WASH, while a negative z-score with a p-value less than 0.05 shows a clustering prevalence of low prevalence of unimproved WASH. A z-score measures accurately how many standard deviations above or below the mean the data points are. The formula used for calculating z-scores from spatial analysis [313] was—

$$Z = \frac{x - \mu}{\sigma}$$

Here, **z**=standard score, **x**=observed value, **μ**=mean of sample, and **σ**=standard deviation. The statistics options was chosen to calculate z-scores in the ArcGIS and attribute table shows output parameters and create new field for z-scores and obtain results for mean, observation and standard deviation.

The minimum or maximum distance between spots was estimated in metres, indicated by aero crosser in ArcGIS software. It helped to measure the distance from one hot spot to a cold spot, or from a hot spot to the nearest hot spot or cold spot.

The WASH proportions in 383 study clusters (survey cluster values) were linked with the corresponding GPS observations, which use latitude and longitude values in Geoda software. These values were imported into the ArcGIS software, and results were visualised at the clusters level. Boundaries were defined based on topographic references (ecology, regions and provinces) applied during the 2016 NDHS [314]. The locations of existing WASH facilities were used to visualise the current public health problem of unimproved water sources, unsanitary toilet facilities, and lack of available soap and water [315].

**Table 3.2: Summary of methods**

| Study Objectives | Sources | Sample | Population | Data analysis |
|---|---|---|---|---|
| Determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing. | Systematic literature search | 32,010 | Mothers | Narrative writing |
| Estimate the prevalence and correlates of households' level of WASH, including identification of areas where WASH facilities were unimproved. | NDHS | 11,040 | Household heads | Bivariate Logistic Regression Analysis |

| Study Objectives | Sources | Sample | Population | Data analysis |
|---|---|---|---|---|
| Identify the individual, family/household and community factors associated with households' WASH facilities in Nepal | NDHS | 4,887 | Mothers with children under five | Multi-level Logistic Regression Analysis |
| Assess the effects of households' WASH facilities on diarrhoea and malnutrition among children under five years. | NDHS | 4,887 | Children under five | Multivariate Logistic Regression Analysis |

### 3.3.12 Ethical considerations

Ethical approval for all the studies included in this thesis was obtained from the Human Research Ethics Committee (HREC) of the University of Newcastle (Ref. No. H-2018-0511).

The Inner City Fund (ICF) Institutional Review Board (IRB), the Demographic and Health Survey (DHS) Program in Maryland, USA, provided approval for the use of the NDHS data for this thesis (Appendix B.2). The Ethical Review Board of the Nepal Health Research Council (NHRC), Kathmandu, provided ethical approval prior to the NDHS in 2016. All study respondents were appropriately informed about what was involved in participating in the survey and gave written consent prior to interview and observation. Respondents were assured their personal details would remain confidential.

# Chapter 4. The State of Household Handwashing by Mothers of Children Aged Under Five and Associated Risk Factors in Nepal: A Systematic Review

## 4.1 Foreword

In Nepal, the rates of access to an improved water source and to sanitary toilet facilities are better than the rates of access to handwashing with soap facilities, and has been this way for a decade [57, 110, 160]. Nepal still faces problems with handwashing with soap facilities, as 53% of households do not use soap and water for handwashing. As discussed previously, (reported in Sections 1.3.3 and 2.4) the patriarchal nature of Nepalese society means that mothers are the key persons who take care of children and oversee their hygiene. Mothers are therefore ideally placed to teach their children about handwashing with soap and to model this behaviour, even though their ability to do this can be challenged by cultural and economic disempowerment. This chapter is a systematic review undertaken to meet the first research objective, which was to determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing.

## 4.2 Introduction

As the recent COVID-19 pandemic has highlighted, handwashing with soap is an effective, cheap, feasible, and straightforward way to prevent and control communicable diseases, especially in low-resource settings such as Nepal [7, 316, 317]. Handwashing with soap is a major component of prevention and control of skin infections, acute respiratory infections, and diarrhoea among children under five years [113, 316, 318]. This has been apparent at the global level with the campaigns related to COVID-19 transmission about prevention through handwashing with soap [209-211]. Reducing exposure to pathogens is a global health priority [319] demonstrated by the Sustainable Development Goals (SDGs 2016–30) that have given priority to achieving universal access to all aspects of WASH by 2030 [13, 320].

Handwashing at the household level is determined by a number of factors, such as knowledge of the importance of handwashing, risk communication, availability of water and soap, family ownership of soap, water and a fixed place for handwashing, installation of tippy taps (a hands-free way to wash hands – especially appropriate for water scarce rural areas – which is operated by a foot lever and may increase the rate of handwashing with soap), perceived cost, and an individual's 'busy schedule and tiredness' [151, 195, 221, 263, 321, 322]. Household handwashing in Nepal is also influenced by context-specific handwashing policies, strategies and guidelines, as well as geographical and environmental factors [160, 163, 323]. Handwashing within households as a common practice is still not widespread throughout the country. Despite these facilitators and challenges, handwashing remains a key method of reducing rates of communicable diseases [37, 318].

In Nepal, mothers are primarily the caregivers for their children. They teach children at home about handwashing with soap, and managing handwashing facilities with the support of family members [86, 87]. Handwashing with soap promotion campaigns have a positive impact on children's health [83]. Handwashing with soap practice provides children with safe and clean home environments [324]. Family members, such as the husband, father-in-law, and mother-in-law, can contribute to handwashing with soap by buying soap, and managing water and fixed places for handwashing. In this discourse, mothers are important persons, as they can be role models in the household.

The five key critical moments recommended to wash hands are: before eating or preparing food; before breastfeeding and feeding children; after defaecating or using the toilet; after cleaning a child faeces or handling nappies; and after touching a source of contamination [316]. In Nepal, overall handwashing knowledge of mothers was 60% in 2014 [71]. The rate of handwashing with soap by mothers before handling food was 67% after a three-month awareness program in Kavre district, while the baseline survey rate of handwashing with soap was only 5% in 2015 [205]. A study conducted in Rolpa district showed the self-reported prevalence of handwashing was 8% at baseline, 96% after a handwashing intervention, and 77% at follow-up, 30 months after the intervention [325]. However, the rates of handwashing with soap before preparing food, before feeding children or breastfeeding, and after cleaning children's bottoms was between 6-22% in Nepal [71]. The application of existing knowledge regarding handwashing, especially before child feeding and breastfeeding and after the disposal of child faeces, is a challenge and barrier to good hygiene practices.

With such varying rates of handwashing with soap during critical moments, it is important to systematically examine the evidence regarding this issue in Nepal. The aim of this paper is to determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing.

## 4.3 Methods

### 4.3.1 Search strategy and criteria selection

This systematic review adopted the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) checklist [326]. Published literature was searched in the following databases: PubMed/Medline, Embase, PsycINFO, and Cumulative Index to Nursing & Allied Health Literature (CINAHL) (Appendix C). Google Scholar was also searched. Keywords included *handwashing, situation, households, mothers, children, determinants, knowledge, soap, health education,* and *Nepal.* The grey literature (e.g. government reports, project reports, working papers, technical reports, and unpublished theses) was searched by using keywords that were the same as those used to search the peer-reviewed literature. Relevant papers were also hand-searched. Articles were included if i) the study was conducted in Nepal, ii) information was collected from mothers, and iii) the study was published in English. No limits were placed on the dates of data collection or publication. Articles were excluded if they were animal studies, non-mother samples, protocol papers, systematic reviews, abstracts only, or editorials. The search was completed in November 2019. The details of the screening of articles are in the PRISMA flow chart (Figure 4.1).

### 4.3.2 Data extraction, analysis and quality assessment

All eligible articles and records were extracted and recorded in an Excel spreadsheet. Extracted information included author, year of publication, study design, participants, age group, study place, study periods, and outcome measures.

Descriptive analysis was performed for this review paper. Two reviewers (SRD and TB) finalised the list of articles and records that would be included. Meta-analysis was impossible due to the low number of studies identified and the heterogeneity of the outcome measures. A quality assessment was done using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [291]. All required fields of the guidelines were completed by the first reviewer (SRD), and cross-verification was done by the second reviewer (TB). Once the extraction of eligible studies was completed, a narrative synthesis was made to provide evidence about handwashing with soap by mothers. The characteristics recorded for all eligible articles comprised first author's name, publication year, study design, study population, sample size, study periods, and key findings. The statement of the main findings, and strengths and limitations were carefully reviewed and reported in the conclusion section. Main results were presented to answer the study aim.

## 4.4 Results

### 4.4.1 Study flow and characteristics

Initially, 188 articles were identified from the database search, and 15 records through the grey literature search. Of the total 203 records, 83 were excluded because of duplication. The remaining 120 were screened, and further records (n=102) were excluded due to exclusion criteria of irrelevant titles or abstracts. A total of 18 records were assessed for eligibility. Then, 11 full text articles and records were excluded by protocol, planning tools, review articles, animal study and non-mothers studies. Finally, seven full- text articles met all inclusion criteria (Table 4.1). Of the seven studies found, three papers described randomised control trials, conducted in Kavre, Kathmandu, and Chitwan, Makwanpur, and Nuwakot districts. Three papers were cross sectional studies, conducted in a rural and urban settings. One paper described a cohort study, conducted in Sarlahi district. A summary of the results of the keywords searches can be found in Appendix C.

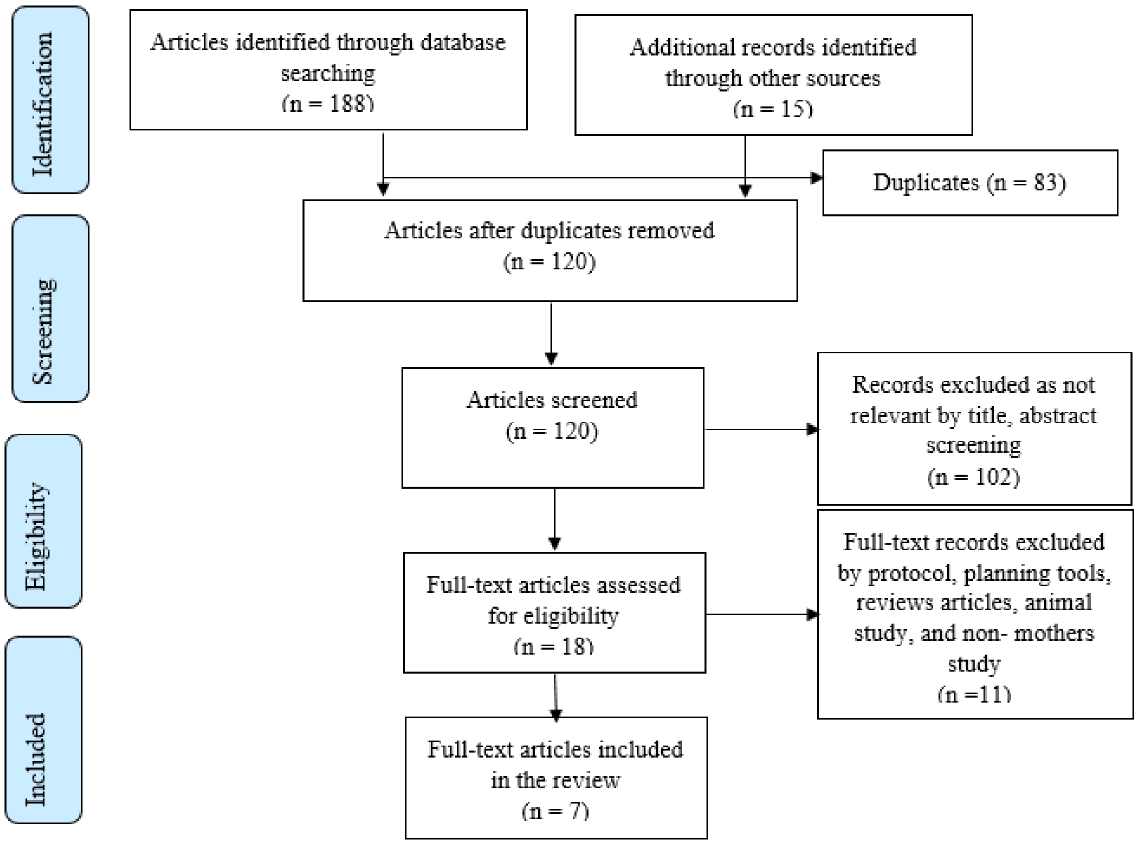



**Figure 4.1: PRISMA flow diagram**

### 4.4.2 Rates of household handwashing with soap by mothers in Nepal

Maternal rates of handwashing with soap varied during different critical moments in the eligible studies. A cross-sectional study conducted by Kafle and Pradhan in Makwanpur district among 178 households' mothers in 2018 reported that approximately 43% of mothers washed their hands with soap at critical moment while 79% of mothers had good knowledge about WASH [283]. Gautam et al conducted a randomised controlled trial (RCT) between October 2012 and December 2013 using structured observations of handwashing with soap among 239 mothers with children aged 6–59 months in Kavre showed that handwashing with soap before eating and feeding a child was 67% after a food hygiene campaign, which was significantly higher than the with 5% who undertook handwashing with soap before eating or feeding a child at baseline [205]. Langford and Panter-Brick conducted a RCT in the slum area of Kathmandu in 2013 and reported that the handwashing with soap rates were 100% after using the toilet and after cleaning children's bottoms, 71% before cooking food, 62% before child feeding, and 60% before eating in the handwashing intervention arms of the study; while the results for the control arms were 91% after using the toilet, 84% after cleaning children's bottoms, 19% before child feeding, 2.3% before cooking and zero percent before eating [206]. An observational prospective cohort study carried out in 2008 in one of the plains regions (Sarlahi district) showed that mothers' handwashing with soap prior to handling infants was only 15% [83]. Likewise, another retrospective cross-sectional study conducted in the Makwanpur district among 5,411 mothers aged 15–49 years who had live births in the previous year in 2002 showed that approximately 50% of the birth attendants washed their hands prior to attending the deliveries [139].

These results indicated that handwashing with soap rates had a wide variation depending on the areas, circumstances, education, and critical time point being assessed, with the majority of results showing far less than optimal rates of handwashing with soap across the country.

### 4.4.3 Factors associated with maternal handwashing in Nepal

A cross-sectional study carried out among randomly selected mothers from 178 households in Makwanpur district in 2018 found maternal knowledge and the household wealth index affect handwashing with soap practices [283]. In 2017, Kandel et al conducted a cross sectional study using the 2014 Multiple Indicator Cluster Survey (MICS) dataset among 1,421 households' mothers and reported that the faecal contamination of water was associated with the availability of adequate handwashing facilities with soap and water [327]. As mentioned above, an RCT carried out in a rural village in Kavre district in 2015 found mothers' participation in Health Mothers' Group meetings, and motivation through family support and rewards are enabling factors for handwashing with soap, while poor participation, demotivation, and punishment decrease handwashing with soap [205]. This study further found that an integrated health promotion campaign increased the rate of handwashing with soap. Miller et al conducted a RCT in Chitwan, Nawalparasi, and Nuwakot districts reported that women who attained higher-level of education had more frequent use of soap during handwashing compared with women with no education in 2017 and the participatory community development program was an effective way of increasing hygiene practices [328].

A study carried out in Kathmandu in 2013 showed that family and community beliefs, such as believing handwashing with soap is unnecessary, being unsure about good health after using soap, and the financial burden of buying soap, are barriers to effective handwashing with soap [206]. This study found beliefs that keeping children clean all the time causes illness, and cultural beliefs that some infectious diseases are caused by cold, fever, and evil spirits. These beliefs can have a negative health effect, as it may be believed that handwashing with soap may not be necessary for prevention of diseases. A further barrier to handwashing with soap is that household members need to spend money on food, and this takes priority over soap.

A cohort study carried out in 2008 in the plains region in Sarlahi district of Nepal indicated that the possible factors associated with maternal handwashing were lack of education, absence of a toilet at home, and having low-birthweight babies [83]. A study conducted by Osrin and colleagues in Makwanpur district among 4,511 mothers in 2002 found lack of knowledge about the importance of handwashing and hygiene, especially during breastfeeding and birth attendance, is a possible factor affecting effective handwashing in Nepal [139]. The key summary results of this review are shown in Table 4.1, including the first author's name, publication year, study design, sample size, study periods and main findings.

**Table 4.1: Summary of methods**

| First author, Year | Study design | Sample size | Study periods | Main findings |
|---|---|---|---|---|
| Kafle S,2018 [283] | Cross-sectional | 178 | Not specified | About 79% of the mothers had good knowledge about WASH, considering access to improved water source, sanitary toilet and handwashing with soap indicators. |
| Kandel P,2017 [327] | Cross sectional | 1,421 | Not specified | Availability of soap, water and a fixed place for handwashing was significantly associated with lower rates of faecal contamination in water sources. |
| Gautam OP,2017 [205] | RCT | 239 | 3 months | Handwashing at home prior to feeding the child/children and |

| First author, Year | Study design | Sample size | Study periods | Main findings |
| --- | --- | --- | --- | --- |
| | | | | before eating increased from 5% to 67%. |
| Miller LC, 2017 [328] | RCT | 1,011 | 48 months | The frequency of usage of soap and availability of water at home was higher among mothers compared with fathers. The participatory Community Development program was an effective way of increasing hygiene in households. |
| Langford R,2013 [206] | RCT | 88 | 6 months | Approximately 21% of mothers washed their hands with soap after defaecation and 14% after cleaning baby's bottom. No data were obtained about handwashing during/before cooking or feeding the child in non-intervention group. Intervention groups (baseline and post-intervention) showed that mothers washed their hands after |

| First author, Year | Study design | Sample size | Study periods | Main findings |
|---|---|---|---|---|
| | | | | defaecation (96% and 100%), after cleaning baby's bottom (82% and 100%), before cooking (12% and 71%), before feeding children (26% and 62%) and before eating (14% and 60%), respectively. |
| Rhee V, 2008 [83] | Cohort study | 23,662 | 40 months | Prevalence of maternal handwashing with soap prior to handling their infants was 15%. Maternal hand washing with soap was associated with significantly lower rates of neonatal mortality. |
| Osrin D, 2002 [139] | Cross-sectional | 5,411 | Not specified | Approximately 50% of mothers who attended a birth had washed their hands with soap. |

## 4.5 Discussion

This systematic review aimed to determine the rates of household handwashing with soap by mothers in Nepal and explore the factors associated with the uptake of handwashing.

Nepalese mothers typically take the primary caring role for children and family members as well as cleaning the home. These roles are traditionally established in Nepal. Handwashing should be performed by all family members; however, mothers feel more pressure to provide safe hygiene for their children [329]. The mother's role of caring for children is socially constructed in Nepal, and is not counted as work in the home [330].

The first and foremost issue for overall family education on handwashing is improving maternal handwashing knowledge. The Nepal Demographic and Health Survey (NDHS) 2016 results showed that handwashing facilities with soap and water at the household level was 47%, whereas the Multiple Indicator Cluster Survey (MICS) 2014 found that mothers' handwashing with soap knowledge varied depending on the specific critical moment being observed. For example, after cleaning children's bottoms or changing nappies, handwashing rates of 6% were found compared to before meal, when 92% washed their hands with soap [57, 71].

This review determined that maternal knowledge about the importance of handwashing with soap before eating or child feeding was higher after food hygiene intervention [205] compared to after cleaning a child who has defaecated [206], and this is one of Nepal's major public health challenges [71]. Similarly less than half of the mothers washed their hands with soap who attended a child birth [139]. The reason behind such low rates of handwashing by mothers may be related to the level of health knowledge about the threat and severity of not washing hands, unavailability of soap and water, financial crisis, and lastly, the cultural belief that communicable diseases (e.g. diarrhoea) exist because of colds, fever, or evil spirits, rather than lack of handwashing [206]. In Nepal, mothers who are poor and those in rural and hard-to-reach areas remain most vulnerable to communicable diseases, due to poor access to health education and handwashing services [71]. The gap between handwashing knowledge and access to handwashing facilities with soap and water is a further challenge in Nepal [283].

This review highlighted that the major factors and barriers to handwashing with soap are lack of knowledge, contrary beliefs, unavailability of soap and water, lack of money, demotivation of mothers, and low mother participation in planning and household decision-making. Maternal knowledge about handwashing is associated with handwashing practices [331]. Availability of soap, clean water, fixed places, adequate time, and family as well as community support encourage mothers to wash their hands while the absence of such factors are barriers to uptake of handwashing [150, 321]. These may be overcome by family support such as construction of fixed places for handwashing near or inside the home, buying soap, and provision of convenient improved water sources. Timely and accurate health education for household members by health workers contributes to counteracting barriers. For example, if mothers know about the need for handwashing at critical moments, they are likely to put this knowledge into practice. This statement is supported by a previous study carried out in Korea in 2013, which argued that providing education improved handwashing [332]. Mothers are the key role models who can change household handwashing conditions. The results of this review indicate that factors affecting handwashing were similar to a 2015 Nepal-specific study of four different plains districts (Mahottari, Siraha, Saptari and Sarlahi), which showed that participating mothers were more likely to wash their hands with soap when their hands looked dirty, to have their hands soft and smelling good, and to keep their dignity [333]. This review is further supported by a previous case study report in Nepal which found that the major challenges to proper handwashing with soap at the household level by mothers were providing high-quality education to mothers to increase health literacy about risks and threats, and to establish habits of utilising available resources, such as soap, water, and handwashing stations. Further potential factors which determine handwashing with soap by mothers at the household level are family roles and responsibilities, household structure, geography and climate [325].

A key factor in improving the rate of handwashing with soap is changing the mindset of individuals in the community. The changing of attitudes and behaviours, however, is complex, and can be hampered by a number of factors. For example, slow economic growth and societal inequalities are challenges for the development of a health system, health promotion, and the practice of handwashing. It became clear during this review that high-quality and results-oriented public health and health promotion campaigns are required to overcome such factors at the household level regarding handwashing by mothers and in turn the whole community. Context-specific handwashing promotional materials or facilities for mothers as well as families and households, timely high-quality health education on handwashing, and guidelines and policy documents are needed. Simple, affordable, feasible and practical interventions are required at the local level. During planning and designing handwashing messages and interventions, the local cultural, social, economic, geographical, and other contextual factors should be considered [334]. Community-based health promotion actions are recommended to deliver the handwashing message through processes of advocacy, services, and policy formulation and application approaches [335]. This review further recommends conducting multivariate and multi-level analyses on handwashing with soap and water, and sanitation facilities in Nepal. This review indicates that there is an association between community based WASH interventions and handwashing compliance. Policies and directives related to WASH, such as the Sector Development Plan [227],WASH Standards for health facilities [147]; the NHSS-IP (2016-21) have given priority to handwashing facilities [77]. The 15th five year plan [55] did not address handwashing with soap. Available WASH policies and guidelines also lack clear direction about handwashing during critical moments (i.e. after cleaning children's faeces, before feeding children, before preparing meals, and before breast feeding) and this health behaviour remains challenging to promote. The quality and scope of the studies in this review suggest that participant observation studies on handwashing with soap should be undertaken. Priorities for future research should take account of the effects of health education interventions, human resources and high-quality handwashing facilities.

The limitations of this review must be acknowledged. Firstly, not all household-level handwashing knowledge areas and facilities were covered. Secondly, none of the included studies reported the availability of soap and water at the household level for mothers in Nepal. Thirdly, information about corrective measures for effective improvement of handwashing knowledge and behavioural change through community efforts was lacking.

In conclusion, the previous studies suggested that handwashing is a cost-effective and affordable health promotion initiative to reduce communicable diseases like diarrhoea, skin infections, acute respiratory infections, and COVID-19 [37, 209, 318, 336], thus supporting the claim of the importance of handwashing with soap. Water and soap are the pre-requisites for good hygiene, and their availability is necessary. However, much more needs to be done if household handwashing is to become a habit among mothers, family members, and children. A few policies related to WASH in Nepal have focused on health and hygiene. However ensuring handwashing with soap is a regular habit remains a challenge in Nepal.

Studies related to handwashing with soap included in this review showed that adequate supply of soap, water and construction of fixed place for handwashing including proper health education can help mothers to practice handwashing. The family income, husband and mother-in-law's support for water fetching, construction of water sources near homes, construction of handwashing stations, and buying soap helps mothers to introduce and continue regular appropriate handwashing. Varies rates of handwashing with soap by mothers during critical moment remains a challenge and the participatory community development and health promotion programs require to improve knowledge about the risks and the provision of soap and water at home. Therefore, it is important to conduct further studies on the availability of improved water sources, sanitary toilets, and handwashing with soap facilities at the household level. The roles of non-health stakeholders for improving handwashing with soap practices, as well as factors associated with the barriers and challenges to handwashing with soap in Nepal, also require study.

# Chapter 5. Prevalence and Correlates of Water, Sanitation and Hygiene in Nepal

## 5.1 Foreword

Water, sanitation and hygiene (WASH) remains a challenging, important public health problem at the household level in Nepal. Despite some progress on WASH, 5% of households have unimproved water sources, 16% lack sanitation, and about 54% have no access to soap and water. Sustainable Development Goal 6 (SDG–6), 2016–30 and the NHSS–IP, (2016–21 have given priority to promoting WASH in Nepal. In the previous chapter it has been shown that the rates of handwashing with soap varied in different areas. Low rates of handwashing with soap were associated with lack of knowledge about diseases, an absence of WASH services (eg soap, water and places), economic constraints, and family and community cultural beliefs. The availability of services may not be sufficient for effective use of WASH. Therefore, further analysis has been undertaken to better understand the prevalence and correlates of WASH in Nepal. Furthermore, a spatial analysis, indicating the existing WASH facilities, is needed to visualise the current public health problem of unimproved WASH in Nepal to facilitate policy development.

## 5.2 Introduction

The promotion of WASH is important for human health, wellbeing, and overall development [78, 337], but has often been forgotten during health planning in developing countries, including Nepal [69]. Nepal is one of the most WASH-insecure countries in the South Asia Region (SAR), despite having one of the richest sources of river water in the world [59]. However, water sources are often polluted by the practice of open defaecation, and household and industrial waste being discarded in open spaces [60].

Unimproved WASH is a risk factor for communicable diseases [27], which increased the risk of diarrhoea by 50% globally in 2015 [82]. Communicable diseases can be reduced or eliminated through better WASH practices by all family members and visitors within the home [4, 68, 82]. Providing facilities for adequate WASH in a sustainable way is a cost-effective measure for the prevention and control of communicable diseases [4, 68]. About 10% of the total global burden of diseases can be prevented with improved WASH [42].

Previous studies have shown that the failure to provide improved WASH practices is due to lack of knowledge [108], poverty [109], lack of political commitment, lack of co-ordination and poor management of available WASH-related resources [68], gender bias [338], geographic constraints related to accessing or receiving WASH services, and socio-cultural factors [68, 111]. Family members' lack of knowledge about utilising improved WASH causes serious problems at the household level [321]. Household members find it difficult to have access to an improved water source, a sanitary toilet, and soap and other commodities for handwashing at home if the household is economically poor or under the poverty line [339].

The SDG–6 is the goal to achieve adequate and equitable sanitation and hygiene for all by 2030 [44]. Many countries have committed to meet the SDGs by 2030, including Nepal. Nepal set the goals of achieving universal and equitable access to safe and affordable drinking water, achieving access to adequate and equitable sanitation and hygiene, including ending open defaecation, achieving improved water quality, and implementing water resource management and protection. However, Nepal has not yet included measures to address handwashing with soap in their country-specific SDG plan [320].

In developing countries, including Nepal, most WASH activities are implemented by non-government organisations (NGOs) and/or private companies, which support GoN's programs [68]. Political instability increases the risk of temporary leadership, which influences the development and implementation of WASH policies and programs. The recent challenges of coordination and collaboration among local, provincial, and central governments in allocating WASH resources have impacted the effectiveness of program implementation in Nepal. In addition, the institutional responsibilities regarding WASH programs are unclear, causing confusion among the levels of government and ministries [340]. For example, in Nepal, The Ministry of Water Supply is responsible for water and sanitation, thus excluding the Ministry of Health and Population (MoHP), where health and hygiene experts are working. There is a lack of organisational coordination, resulting in WASH inefficiency.

Due to the lack of good transportation in remote areas, it is difficult for household members to collect improved water. This is particularly the case in the rural mountains and hills regions of Nepal [341]. Culture influences WASH behaviours and perceptions, which can create resistance to new hygiene and sanitation practices, facts, and ideas. Perceptions and understanding of hygiene and sanitation can vary according to gender, ethnicity and religion [68]. For example, in the Hindu Brahmin caste, a grandfather will typically not drink water from the same glass or jug used by 'inferior' members (e.g. a sister-in-law or grandchildren). In addition, during their menstrual periods, women are not allowed to use the toilet inside the home or share the water source and soap with other family members.

There are insufficient WASH studies addressing socio-demographic and contextual factors in Nepal. The unequal distribution of and access to WASH services between rich and poor, rural and urban, male and female, remains unstudied in Nepal. The few studies that have examined WASH at the household level had small sample sizes and focused on the regional community level, and thus may lack generalisability [283]. Consequently, nationally representative WASH studies using the latest Nepal Demographic and Health Survey (NDHS) data (2016) are required. Research on WASH is important in order to provide a clear direction for effective planning and development of interventions. The previous chapter showed handwashing with soap was a component of WASH with poor uptake. The availability of services did not determine improved WASH practices therefore further analysis has been undertaken to better understand the prevalence and correlates of household level of WASH in Nepal. Although the presence of WASH facilities is not sufficient to guarantee use of such facilities, they are necessary for WASH practices to occur. To date, there are no studies conducted on WASH facilities using spatial analysis to identify the area with high prevalence rates (high hot spots clusters) of unimproved WASH facilities in Nepal. Therefore, it is important to assess the geographic distribution of WASH facilities in order to plan for future WASH facility development. This study can play a significant role in the formulation of context-specific WASH policy at the local, provincial and country levels. The objective of this study were to estimate the prevalence and correlates of household-level of WASH in Nepal, including identification of areas where WASH facilities were unimproved.

## 5.3 Methods

### 5.3.1 Research design and sampling

A secondary analysis was conducted on data obtained from the 2016 NDHS [57], a nationally-representative household survey. The lead role of the NDHS was taken by the MoHP, with the financial assistance of the United States Agency for International Development (USAID) and technical support from the Inner City Fund (ICF) International (a global consulting and technology service company). The main implementation partner of this survey was New ERA, a non-government and non-profit research organisation. The survey was carried out from 19 June 2016 to 31 January 2017. A total of 11,040 households were selected using a two-stage cluster sampling technique in rural areas and a three-stage cluster sampling technique in urban areas. The unit of analysis used in this study was households, with scientific information collected from the head of each household. There were a total of 383 clusters (small geographically defined areas) representing the three ecological zones of Nepal. The seven provinces were further stratified into 14 strata (urban and rural). In rural areas, wards were considered as clusters known as primary sampling units of enumeration. The sampling frame was included as the primary unit (wards: smallest administrative block), type of residence (rural and urban), and estimated number of residential households and population. In urban areas, wards were also selected as primary sampling units, and one enumeration area (EA) was selected from each primary sampling unit. The households were selected from the sample of EAs. At first, 383 wards were selected, with probability proportional to the ward size. Consequently, a fixed number of 30 households in each cluster were selected, with equal selection from the household listing. The sampling weight frequency tabulation and percentage of study variables were executed for the selected independent variables. Household samples were non-proportionally allocated by provinces (regions) and towards their rural urban areas and where the interview response rates of respondents' were varied. Therefore, sampling weights were used to adjust the multi-stage sampling procedure to ensure the survey was representative at the national and cluster levels. Since the 2016 NDHS was a multi-stage stratified cluster sample, sampling weights were calculated based on sampling probabilities separately for each sampling stage and for each cluster. We created variables with the calculated weights and included weighted variables. The household weight was divided by 1,000,000 (e.g. gen sampwt=hv005/1,000,000). All analyses used the sampling weights calculated for each interviewed household.

### 5.3.2 Data sources and respondents

This study used data from the fifth series of the NDHS, collected in 2016. Permission to access the data was granted by the ICF/Demographic and Health Survey Program on 22 February 2019. The study variables of this study were obtained from the head of the household questionnaire. Therefore, the respondents of this study were the household heads.

### 5.3.3 Outcome variables

The outcome variables for this study included access to: an improved water source, a sanitary toilet, a fixed place for handwashing, and soap and water for washing (at the household level). In the NDHS, the WASH related information was taken from both household interviews and by observation by the data collector. Dichotomous variables for each WASH outcome were derived from the collected data. Access to an improved water source included: if the household had piped water (*piped into dwelling, piped to yard or plot, piped to neighbour*), a public tap (*stand pipe*), a tube well (*bore hole*), a protected dug well, a protected spring (*natural source*), rain water, and bottled water. Sanitary toilets were defined as those that flush or pour to a piped sewer system or septic tank, composting toilets, and those that flush or pour to a pit latrine, ventilated improved pit (VIP) latrine, and pit latrines with slabs. The type of toilet facilities was collected through observation. A fixed place for handwashing was defined as a dedicated, convenient location and a hand washing station where water and soap could be provided [342]. Availability of soap and water was categorised as being available when both were provided in a handwashing place. The information about handwashing facilities were collected through observation during data collection [57].

### 5.3.4 Predictor variables

Socio-demographic characteristics of respondents included age in years (15–24, 25–34, 35–44 or 45 and over), sex (male or female), education level (no education: unable to read or write; primary: completed Year 5; secondary: completed Year 8; or School Leaving Certificate (SLC) or higher: completed Year 10 or above), marital status (married or widowed/divorced/never married), number of household family members (1–2, 3–4, 5–6 and ≥7), place of residence (rural or urban), ecology (plains, hills, or mountains), province (1, 2, Bagmati Pradesh, Gandaki Pradesh, Lumbini Pradesh, Karnali Pradesh and Sudurpashchim Pradesh), household wealth index (poor[4], middle[5], or rich[6]) and distance to water source (≤30 minutes and >30 minutes' walk).

### 5.3.5 Data analysis

#### 5.3.5.1 Statistical analysis

STATA 15 was used to analyse data for this study [300]. A univariate analysis was conducted of the socio-demographic and WASH characteristics of respondents. The respondents' characteristics were presented in the form of weighted frequencies (n) and percentages weighted for sampling distribution (%). A Chi-squared test was performed to determine whether there was a significant difference between the predicted frequencies and the observed frequencies in each of the categories. Since some regions and provinces with large populations were under- or over-sampled, the weighted frequencies and percentages were computed as correlations. A bivariate analysis was performed to estimate crude odds ratios with 95% confidence intervals, using a 0.05 significance level.

---

[4] Household assets, services, vehicles, flooring and ownership of dwelling are ranked in quintiles 1, 2 and 3. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient -.8477 and -.3385).

[5] The household assets, service, vehicles, and flooring and ownership of dwelling are ranked in quintile 2, 3 and 4. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient -.2859).

[6] The household assets, service, vehicles, and flooring and ownership of dwelling are ranked in quintile 3, 4 and 5. Quintile 1 is the poorest, and quintile 5 is the richest (Gini coefficient 1.0998).

### 5.3.5.2 Hot Spot Analysis

A spatial analysis was conducted using ArcGIS 10.6.1 version. Nepal map was obtained using shapefile for the analysis. Nepal lies between latitudes (26º22'N to 30º27'N) and longitudes (80º04'E to 88º12'E) on the UTM zone between 44 degrees and 45 degrees North, and 0.9996 is the scale factor for the central meridian [309].

Proportionally distributed WASH-related data obtained from NDHS 2016 dataset were joined with each cluster to the corresponding geospatial location or survey cluster values. The values of NDHS data were merged with the Geographic Positioning System (GPS) dataset using Geoda software. The mapping clusters were estimated using hot spots analysis (Getit-Ord Gi*).

The positive and negative autocorrelation was applied to determine the high value and low value based on the z-score results [310]. The statistically significant autocorrelation was estimated based on z-scores with p-value with 95% CI. The positive autocorrelation indicates similar values clustered together on a map corresponding high rates surrounded by nearby high rates or low rates surrounded nearby low rates. The negative autocorrelation indicates dissimilar values clustered together on map corresponding high rates surrounded by nearby low rates or low rates surrounded by nearby high rates. The positive z-score (>2.58 at 0.01 significant level, 1.96-2.58 at 0.05 significant level, and 1.65-1.96 at 0.10 significant level) value indicates the high value for the unimproved WASH, while if the z-score is negative ((<-2.58 at 0.01significant level, -1.96- -2.58 at 0.05 significant level, and -1.65- -1.96 at 0.10 significant level), the clustering is smaller than expected clustering, that indicates the low values are clustered in the study. If the z-score is calculated between -1.65-1.65 indicates there is no significant relationship.

## 5.4 Results

### 5.4.1 Descriptive statistics

Table 5.1 summarises the socio-demographic and WASH characteristics of the respondents. Of the 11,040 household heads, the majority were aged 45 years or older (n=5,631, 50.8%). Nearly one-third (n=3,459, 31.3%) of households were headed by women. Approximately 39% of the respondents had no formal education, and the literacy rate was 61%. About 22.5% of the respondents had a primary level of education, 26.7% had a secondary level of education, and a minority (11.5%) had an SLC from high school, or a higher level of education. Approximately 86% of household heads were married, 10.9% were widowed and divorced and only 3.1% were never married.

Regarding the rural/urban setting, the majority of the interviewed households lived in a rural area (n=6,019, 54.5%). Respondents were from the plains (46.4%), hills (46.5%) and mountains (7.1%) regions. Provincial representation of respondents was unequal. The highest proportion of respondents lived in Province 3 (n=2,521; 22.9%). The percentages of people in the poor and rich categories on the wealth index were similar across the households (40.4% and 40.9% respectively), while the percentage in the middle category on the wealth index was much lower at 18.7%.

The prevalence rates of having an improved water source and a sanitary toilet were 95.5% and 83.8%, respectively. Of the households with a handwashing place was 80.9%, approximately 46.9% had both soap and water available. The majority (n=10,476, 94.9%) of households had a drinking water source less than 30 minutes' walk from their house, and only 5.1% of households spent more than 30 minutes walking to collect water.

**Table 5.1: Socio-demographic and WASH characteristics of respondents**

| Variables | Weighted frequencies (n=11040) | Weighted percentages (100%) |
|---|---|---|
| **Socio-demographic characteristics** | | |
| **Age of household heads (in years)** | | |
| 15–24 | 625 | 5.7 |
| 25–34 | 2240 | 20.3 |
| 35–44 | 2562 | 23.2 |
| 45 and above | 5613 | 50.8 |
| **Sex of household heads** | | |
| Male | 7581 | 68.7 |
| Female | 3459 | 31.3 |
| **Education of household heads** | | |
| No education | 4310 | 39.1 |
| Primary | 2492 | 22.5 |
| Secondary | 2947 | 26.7 |
| Higher | 1272 | 11.5 |
| Do not know | 19 | 0.2 |
| **Marital status of household head** | | |
| Married | 9499 | 86.0 |
| Never Married | 337 | 3.1 |
| Widowed and divorced | 1204 | 10.9 |
| **Number of family members at home** | | |
| 1–2 | 2160 | 19.6 |
| 3–4 | 4146 | 37.6 |
| 5–6 | 3048 | 27.6 |
| 7+ | 1685 | 15.2 |

| Variables | Weighted frequencies (n=11040) | Weighted percentages (100%) |
|---|---|---|
| **Place of residence** | | |
| Rural | 6019 | 54.5 |
| Urban | 5021 | 45.5 |
| **Ecological zone** | | |
| Plains | 5125 | 46.4 |
| Hills | 5134 | 46.5 |
| Mountains | 781 | 7.1 |
| **Province** | | |
| 1 | 2004 | 18.2 |
| 2 | 2014 | 18.2 |
| 3 | 2521 | 22.9 |
| 4 | 1173 | 10.6 |
| 5 | 1793 | 16.2 |
| 6 | 619 | 5.6 |
| 7 | 916 | 8.3 |
| **Wealth index of household** | | |
| Poor | 4459 | 40.4 |
| Middle | 2065 | 18.7 |
| Rich | 4516 | 40.9 |
| **WASH characteristics** | | |
| **Source of water** | | |
| Improved | 10543 | 95.5 |
| Unimproved | 497 | 4.5 |
| **Distance to water source** | | |
| ≤30 minutes' walk | 10476 | 94.9 |

| Variables | Weighted frequencies (n=11040) | Weighted percentages (100%) |
|---|---|---|
| >30 minutes' walk | 562 | 5.1 |
| Do not know | 2 | 0.1 |
| **Type of toilet** | | |
| Sanitary | 9246 | 83.8 |
| Unsanitary | 1794 | 16.2 |
| **Handwashing place** | | |
| Fixed | 8936 | 80.9 |
| Non-fixed | 2075 | 18.8 |
| Missing (not observed) | 29 | 0.3 |
| **Availability of soap and water** | | |
| Available | 5185 | 46.9 |
| Not available | 5827 | 52.8 |
| Missing (not observed) | 28 | 0.3 |

**Note:** Study samples (households) were weighted by each predictor variable to ensure consistency of sample distribution.

### 5.4.2 Correlates of having an improved water source

As shown in Table 5.2, household heads who had finished their SLC (high school) or had obtained a higher level of education had higher odds of having an improved water source relative to those with no education (COR= 3.51; 95% CI 1.86-6.62). Households who had to travel more than 30 minutes to their water source had reduced odds (COR=0.07; 95% CI: 0.04-0.12) of having an improved water source relative to those whose water source was within 30 minutes away from home. People from the hills communities had 68% lower odds (COR=0.32; 95% CI: 0.16-0.64) of having access to an improved water source relative to those living in the plains region. Households in Province 6 had lower odds of having access to an improved water source (COR=0.19; 95% CI: 0.09-0.43) relative to households in Province 1; there were no other significant associations by province. The poor category of household wealth had 78% lower odds of having access to an improved water source (COR=0.22; 95% CI: 0.10-0.50) relative to rich households. Age, sex, and marital status of the household head (respondent) and place of residence (rural/urban) were not significantly related to water source status.

**Table 5.2: Correlates of having access to an improved water source**

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi squared test |
|---|---|---|---|---|---|
| | 10,543,95.5 | 497,4.5 | COR (95% CI) | P-value | |
| **Age group (in years)** | | | | | 0.840 |
| 15-24 | 600(96.1) | 25(3.9) | 1.14(0.73-1.78) | 0.557 | |
| 25-34 | 2134(95.3) | 106(4.7) | 0.95(0.70-1.27) | 0.742 | |
| 35-44 | 2451(95.7) | 111(4.3) | 1.04(0.84-1.29) | 0.693 | |
| 45 and above | 5359(95.5) | 254(4.5) | 1 | | |
| **Sex of household head** | | | | | 0.172 |
| Male | 7254(95.7) | 327(4.3) | 1 | | |
| Female | 3289(95.1) | 170(4.9) | 0.87 (0.72-1.06) | 0.172 | |
| **Education** | | | | | <0.001 |
| No education | 4078(94.2) | 251(5.8) | 1 | | |
| Primary | 2363(94.8) | 129(5.2) | 1.11(0.90-1.38) | 0.322 | |
| Secondary | 2852(96.8) | 95(3.2) | 1.81(1.28-2.57) | 0.001 | |
| SLC and higher | 1251(98.3) | 22(1.7) | 3.51(1.86-6.62) | <0.001 | |
| **Marital status** | | | | | 0.160 |
| Married | 9067(94.5) | 431(4.5) | 1 | | |
| Never married | 331(98.2) | 6(1.8) | 2.59(0.94-7.16) | 0.65 | |
| Widowed and divorced | 1476(95.7) | 65(4.3) | 0.92(0.68-1.23) | 0.56 | |

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi squared test |
|---|---|---|---|---|---|
| | 10,543,95.5 | 497,4.5 | COR (95% CI) | P-value | |
| **Number of family members** | | | | | 0.012 |
| 1–2 | 2061(95.4) | 99(4.6) | 0.96(0.74-1.24) | 0.760 | |
| 3–4 | 3964(96.6) | 182(4.4) | 1 | | |
| 5–6 | 2887(94.7) | 161(5.3) | 0.83(0.65-1.05) | 0.125 | |
| 7+ | 1631(96.8) | 54(3.2) | 1.37(0.98-1.92) | 0.060 | |
| **Distance to water source** | | | | | <0.001 |
| ≤30 minutes | 10156(96.9) | 320(3.1) | 1 | | |
| >30 minutes | 387(68.9) | 175(31.1) | 0.07(0.04-0.12) | <0.001 | |
| **Place of residence** | | | | | 0.733 |
| Rural | 5759(95.7) | 259(4.3) | 1 | | |
| Urban | 4784(95.3) | 237(4.7) | 1.10(0.63-1.93) | 0.733 | |
| **Ecological zone** | | | | | 0.003 |
| Plains | 5006(97.7) | 118(2.3 | 1 | | |
| Hills | 4784(93.1) | 350(6.9) | 0.32(0.16-0.64) | 0.001 | |
| Mountains | 752(96.3) | 29(3.7) | 0.62(0.26-1.51) | 0.292 | |
| **Provinces** | | | | | <0.001 |
| 1 | 1945(97.1) | 60(2.9) | 1 | | |
| 2 | 1955(97.1) | 59(2.9) | 1.01(0.30-3.42) | 0.984 | |
| 3 | 2385(94.6) | 136(5.4) | 0.54(0.21-1.36) | 0.190 | |
| 4 | 1110(94.6) | 63(5.4) | 0.54(0.24-1.20) | 0.130 | |
| 5 | 1739(97.0) | 54(3.0) | 0.99(0.41-2.41) | 0.991 | |
| 6 | 534(86.4) | 84(13.6) | 0.19(0.09-0.43) | <0.001 | |
| 7 | 874(95.5) | 41(4.5) | 0.65(0.28-1.48) | 0.308 | |

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi squared test |
|---|---|---|---|---|---|
| | **10,543,95.5** | **497,4.5** | **COR (95% CI)** | **P-value** | |
| **Household wealth index** | | | | | <0.001 |
| Poor | 4100(92.5) | 359(8.5) | 0.22 (0.10-0.50) | <0.001 | |
| Middle | 2011(97.4) | 54(2.6) | 0.72(0.31-1.66) | 0.437 | |
| Rich | 4432(98.1) | 85(1.9) | 1 | | |

### 5.4.3 Correlates of having a sanitary toilet

Table 5.3 shows the association between possible predictor variables and having a sanitary toilet in the household. Having an SLC (high school) or higher education level was associated with higher odds of having a sanitary toilet (COR=13.43; 95% CI: 7.91-22.86) relative to those with no education. Never married household head had higher odds of having sanitary toilet (COR=2.25; 95% CI: 2.23-8.56) relative to those who were married. In this study, the higher the number of family members living in the home (≥7), the lower the odds of having a sanitary toilet (COR=0.56; 95% CI: 0.45-0.70). Those living in urban areas had higher odds (COR=2.30; 95% CI: 1.52-3.49) of having a sanitary toilet relative to households in rural areas. Those living in Provinces 4, 6 and 7 had higher odds of having sanitary toilet facilities compared with those living in Province 1 (COR=2.92; 95% CI: 1.52-5.61), (COR=2.69; 95% CI: 1.52-4.76 and (COR=1.93; 95% CI: 1.03-3.58), respectively. However, Province 2 had lower odds (COR=0.15; 95% CI: 0.08-0.28) of having a sanitary toilet at the household level compared with Province 1. Household wealth index groups from poor and middle had lower odds (COR= 0.17; 95% CI: 0.13-0.24 and COR= 0.13; 95% CI: 0.10-0.18 respectively) of having a sanitary toilet relative to households in the rich category. The age, sex and distance to water source of the household head were not significantly related to having a sanitary toilet.

**Table 5.3: Correlates of having access to a sanitary toilet**

| Variables | Yes (n,%) | No (n,%) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | 9246,83.7 | 1794,16.3 | COR(95% CI) | P-value | |
| **Age group (in years)** | | | | | 0.288 |
| 15–24 | 526(84.1) | 99(15.9) | 1.02(0.76-1.39) | 0.876 | |
| 25–34 | 1850(82.6) | 391(17.4) | 0.92(0.78-1.07) | 0.292 | |
| 35–44 | 2169(84.7) | 393(15.3) | 1.07(0.91-1.26) | 0.395 | |
| 45 and above | 4701(83.7) | 911(16.24) | 1 | | |
| **Sex of household head** | | | | | 0.172 |
| Male | 6343(83.7) | 1238(16.3) | 1 | | |
| Female | 2903(83.9) | 556(16.1) | 1.02 (0.85-1.22) | 0.827 | |
| **Education** | | | | | <0.001 |
| No education | 3200(74.2) | 1109(25.7) | 1 | | |
| Primary | 2117(84.9) | 375(15.1) | 1.95(1.63-2.33) | <0.001 | |
| Secondary | 2673(90.7) | 274(9.3) | 3.37(2.71-4.19) | <0.001 | |
| SLC and higher | 1240(97.5) | 32(2.5) | 13.43(7.91-22.86) | <0.001 | |
| **Marital Status** | | | | | <0.001 |
| Married | 7928(83.4) | 1571(16.6) | 1 | | |
| Never married | 223(95.8) | 14(4.2) | 2.50(2.36-8.56) | 0.001 | |
| Widowed and divorced | 995(82.6) | 209(17.4) | 0.95(0.73-1.15) | 0.554 | |
| **Number of family members at home** | | | | | <0.001 |
| 1–2 | 1850(85.6) | 310(14.4) | 0.96(0.81-1.14) | 0.680 | |
| 3–4 | 3569(86.1) | 577(13.9) | 1 | | |
| 5–6 | 2520(82.7) | 528(17.3) | 0.77(0.65-0.91) | 0.003 | |
| 7+ | 1307(77.6) | 378(22.4) | 0.56(0.0.45-0.70) | <0.001 | |

| Variables | Yes (n,%) | No (n,%) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | 9246,83.7 | 1794,16.3 | COR(95% CI) | P-value | |
| **Distance to water source** | | | | | 0.895 |
| ≤30 minutes | 8771(83.7) | 1705(16.3) | 1 | | |
| >30 minutes | 473(84.1) | 89(15.9) | 1.03(0.69-1.54) | 0.895 | |
| **Place of residence** | | | | | <0.001 |
| Rural | 4747(78.9) | 1272(21.1) | 1 | | |
| Urban | 4498(89.6) | 523(10.4) | 2.30(1.52-3.49) | 0.<001 | |
| **Ecological zone** | | | | | <0.001 |
| Plains | 3689(71.9) | 1436(28.1) | 1 | | |
| Hills | 4840(94.3) | 294(5.7) | 6.41(4.39-9.37) | <0.001 | |
| Mountains | 716(91.7) | 65(8.3) | 4.30(2.52-7.35) | <0.001 | |
| **Provinces** | | | | | <0.001 |
| 1 | 1752(87.4) | 252(12.6) | 1 | | |
| 2 | 1022(50.7) | 992(49.3) | 0.15(0.08-0.28) | <0.001 | |
| 3 | 2336(92.6) | 185(7.4) | 1.82(0.93-3.54) | 0.078 | |
| 4 | 1118(95.3) | 55(4.7) | 2.92(1.52-5.61) | 0.001 | |
| 5 | 1578(88.1) | 215(11.9) | 1.06(0.51-2.20) | 0.876 | |
| 6 | 587(94.9) | 31(5.1) | 2.69(1.52-4.76) | 0.001 | |
| 7 | 852(93.1) | 63(6.9) | 1.93(1.03-3.58) | 0.038 | |
| **Household wealth index** | | | | | <0.001 |
| Poor | 3459(77.6) | 1000(22.4) | 0.17(0.13-0.24) | <0.001 | |
| Middle | 1488(72.1) | 577(27.9) | 0.13(0.10-0.18) | <0.001 | |
| Rich | 4299(95.2) | 217(4.8) | 1 | | |

### 5.4.4 Correlates of having a fixed place for handwashing

Table 5.4 shows the correlates of having access to a fixed place for handwashing at the household level, respondents with a SLC (high school) or higher level of education had higher odds of having a fixed place for handwashing (COR=6.01; 95% CI: 4.47-8.07) relative to those with no education. Also, the respondents with a secondary level of education had higher odds (COR=2.41; 95% CI: 1.99-2.92) of having a fixed place for handwashing relative to those who had no formal education. The household heads who were never married had higher odds (COR=1.96; 95% CI: 1.32-2.90) and who were widowed and divorced had lower odds (COR=0.76; 95% CI: 0.62-0.94) of having a fixed place for handwashing relative to those who were married. Families with 1–2, 5–6 and ≥7 members had lower odds of having a fixed place for handwashing relative to households with 3–4 members (COR=0.83; 95% CI: 0.70-0.99), (COR=0.78; 95% CI: 0.68-0.88), and (COR=0.78; 95% CI: 0.68-0.93), respectively. Where a water source was a distance of more than 30 minutes away, households had lower odds (COR=0.37; 95% CI: 0.27-0.57) of having a fixed place for handwashing relative to households where the water source was available within 30 minutes walking distance from home. Urban dwellers had higher odds (COR=2.36; 95% CI: 1.82-3.06) of having a fixed place for handwashing compared with rural dwellers. Respondents from the hills region had higher odds (COR=1.33; 95% CI: 1.01-1.77) of having a fixed place for handwashing compared with plains regions. Respondents from the mountains region had lower odds (COR=0.61; 95% CI: 0.41-0.91) of having a fixed place for handwashing compared with those living in the plains region. Households in Province 4 had higher odds (COR=2.28; 95% CI: 1.50-3.46) of having a fixed place for handwashing relative to households in Province 1. Province 2 (COR= 0.44; 95% CI: 0.29-0.67) and Province 6 (COR=0.49; 95% CI: 0.31-0.77) had lower odds of having a fixed place for handwashing relative to Province 1. Households with a poor wealth index (COR=

0.25; 95% CI: 0.20-0.31) and middle wealth index had lower odds (COR=0.33; 95% CI: 0.26-0.42) of having a fixed place for handwashing relative to households categorised as rich.

**Table 5.4: Correlates of having access to a fixed place for handwashing**

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | 8936, 81.1 | 2075, 18.9 | COR (95% CI) | P-value | |
| **Age group (in years)** | | | | | 0.564 |
| 15–24 | 504(80.8) | 120(19.2) | 1.02(0.81-1.27) | 0.890 | |
| 25–34 | 1841(82.3) | 395(17.7) | 1.13(0.96-1.32) | 0.163 | |
| 35–44 | 2081(81.5) | 473(18.5) | 1.05(0.92-1.22) | 0.423 | |
| 45 and above | 4510(80.5) | 1087(19.6) | 1 | | |
| **Sex of household head** | | | | | 0.530 |
| Male | 6153(81.4) | 1407(18.6) | 1 | | |
| Female | 2784(80.6) | 668(19.4) | 0.95(0.83-1.09) | 0.530 | |
| **Education** | | | | | <0.001 |
| No education | 3146(73.2) | 1155(26.8) | 1 | | |
| Primary | 2025(81.6) | 457(18.4) | 1.62(1.39-1.89) | <0.001 | |
| Secondary | 2556(86.8) | 388(13.2) | 2.41(1.99-2.92) | <0.001 | |
| SLC and higher | 1192(94.3) | 73(5.7) | 6.01(4.47-8.07) | <0.001 | |
| **Marital status** | | | | | 0.001 |
| Married | 7711(81.4) | 1764(18.6) | 1 | | |
| Never married | 300(89.6) | 35(10.4) | 1.96(1.32-2.90) | 0.001 | |
| Widowed/ divorced | 925(76.9) | 277(23.1) | 0.76(0.62-0.94) | 0.010 | |
| **Number of family members at home** | | | | | <0.001 |
| 1–2 | 1736(80.6) | 419(19.4) | 0.83(0.70-0.99) | 0.030 | |
| 3–4 | 3447(83.4) | 686(16.6) | 1 | | |

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | 8936, 81.1 | 2075, 18.9 | COR (95% CI) | P-value | |
| 5–6 | 2417(79.5) | 624(20.5) | 0.78(0.68-0.88) | <0.001 | |
| 7+ | 1337(79.5) | 345(20.5) | 0.78(0.65-0.93) | 0.004 | |
| **Distance to water source** | | | | | <0.001 |
| ≤30 minutes | 8574(82.1) | 1875(17.9) | 1 | | |
| >30 minutes | 360(64.2) | 200(35.8) | 0.39(0.27-0.57) | <0.001 | |
| **Place of residence** | | | | | <0.001 |
| Rural | 4535(75.5) | 1470(24.5) | 1 | | |
| Urban | 4401(87.9) | 604(12.1) | 2.36(1.82-3.06) | <0.001 | |
| **Ecological zone** | | | | | <0.001 |
| Plains | 4080(79.8) | 1034(20.2) | 1 | | |
| Hills | 4307(84.1) | 815(15.9) | 1.33(1.01-1.77) | 0.042 | |
| Mountains | 549(70.8) | 226(29.2) | 0.61(0.41-0.91) | 0.012 | |
| **Provinces** | | | | | <0.001 |
| 1 | 1649(82.6) | 347(17.4) | 1 | | |
| 2 | 1361(67.6) | 653(32.4) | 0.44(0.29-0.67) | <0.001 | |
| 3 | 2181(86.7) | 336(13.3) | 1.36(0.87-2.11) | 0.167 | |
| 4 | 1073(91.6) | 98(8.4) | 2.28(1.50-3.46) | <0.001 | |
| 5 | 1489(83.4) | 295(16.6) | 1.06(0.68-1.66) | 0.791 | |
| 6 | 431(70.1) | 184(29.9) | 0.49(0.31-0.77) | 0.002 | |
| 7 | 751(82.6) | 159(17.4) | 0.99(0.61-1.63) | 0.982 | |
| **Household wealth index** | | | | | <0.001 |
| Poor | 3216(72.4) | 1228(27.6) | 0.25(0.20-0.31) | <0.001 | |
| Middle | 1605(77.7) | 459(22.3) | 0.33(0.26-0.42) | <0.001 | |
| Rich | 4115(91.4) | 388(8.6) | 1 | | |

### 5.4.5 Correlates of availability of soap and water at handwashing places

Not all households had both soap and water available at handwashing places. The current study results show that the overall soap and water availability at handwashing places was only 47%. Age, education, marital status, number of family members, distance to water source, place of residence, ecology, province, and wealth index were significantly related to having soap and water at handwashing places. Household heads aged 35–44 years had higher odds (COR=1.16; 95% CI: 1.04-1.29) of having soap and water at handwashing places relative to household heads aged 45 years and above. The coverage of soap and water at handwashing places in the plains region was 45.7%, in the hills region was 51.2%, and in the mountains region was 29.9% (Table 5.5). Heads of households with an SLC (high school) or higher education level had the highest odds (COR=7.02; 95% CI: 5.73-8.70) of having both soap and water available at handwashing places relative to those with no education. Respondents with a secondary level education had higher odds (COR=2.85; 95% CI: 2.49-3.26) of having soap and water at handwashing places compared with those who did not have any education. Respondents with a primary level of education also had higher odds (COR=1.78; 95% CI: 1.58-2.02) of having soap and water at handwashing places relative to those with no education.

The household heads who were never married had higher odds (COR=2.25; 95% CI: 1.66-3.31) and who were widowed and divorced had lower odds (COR=0.79; 95%CI: 0.69-0.92) of having soap and water at handwashing places relative to those with married. Households with 1–2, 5–6 and ≥ 7 family members had lower odds (COR=0.80; 95% CI: 0.69-0.92), (COR=0.77; 95% CI: 0.69-0.86), and (COR=0.71; 95% CI: 0.60-0.84), respectively, of having both soap and water available at handwashing places, compared with households with 3–4 family members. Households with a water source more than 30 minutes' travel time had lower odds (COR= 0.36; 95% CI: 0.25-0.52) of having soap and water at handwashing places relative to households where the water source was within 30 minutes' walk. Urban dwellers had higher odds (COR=3.58; 95% CI: 2.78-4.64) of having soap and water at handwashing places compared with those who were rural dwellers. There was about a 52% lower chance of having soap and water at handwashing places in the mountains region, compared with the plains region (COR=0.48; 95% CI: 0.31-0.75). Respondents from Province 3 had higher odds (COR=1.90; 95% CI: 1.26-2.86) of having soap and water at handwashing places relative to Province 1. Provinces 2 and 6 had lower odds (COR= 0.54; 95% CI: 0.37-0.79) and (COR=0.38; 95% CI: 0.25-58), respectively, of having soap and water at handwashing places relative to Province 1. Household wealth index was significantly associated with the availability of both soap and water at handwashing places (Table 5.5). Compared with the poorest group, all other wealth categories had strong statistically significantly increased odds of having soap and water available at handwashing places. Household head sex was not significantly related to having soap and water available at handwashing places.

**Table 5.5: Correlates of having access to a fixed place for handwashing**

| **Variables** | **Yes (n, %)** | **No (n, %)** | **Bivariate analysis** | | **Chi-squared test** |
|---|---|---|---|---|---|
| | **5185,47.08** | **5827,52.92** | **COR (95% CI)** | **P-value** | |
| **Age group (in years)** | | | | | 0.055 |
| 15–24 | 300(48.2) | 323(51.8) | 1.11(0.87-1.44) | 0.395 | |
| 25–34 | 1085(48.6) | 1151(51.4) | 1.13(0.99-1.28) | 0.059 | |
| 35–44 | 1254(49.1) | 1300(50.1) | 1.16(1.04-1.29) | 0.010 | |
| 45 and above | 2545(45.4) | 3052(54.6) | 1 | | |
| **Sex of household head** | | | | | 0.429 |
| Male | 3586(47.4) | 3974(52.6) | 1 | | |
| Female | 1599(45.6) | 1853(53.7) | 0.96(0.86-1.07) | 0.429 | |
| **Education** | | | | | <0.001 |
| No education | 1377(32.1) | 2924(67.9) | 1 | | |

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | 5185,47.08 | 5827,52.92 | COR (95% CI) | P-value | |
| Primary | 1133(45.6) | 1349 (54.4) | 1.78(1.58-2.02) | <0.001 | |
| Secondary | 1687(57.3) | 1257(42.7) | 2.85(2.49-3.26) | <0.001 | |
| SLC and higher | 973(76.9) | 291(23.1) | 7.09 (5.73-8.70) | <0.001 | |
| **Marital status** | | | | | <0.001 |
| Married | 4460 (47.1) | 5015(52.9) | 1 | | |
| Never Married | 227(67.6) | 109(32.4) | 2.25(1.66-3.31) | <0.001 | |
| Widowed/ divorced | 497(41.4) | 704(58.6) | 0.79(0.69-0.92) | 0.001 | |
| **Number of family members at home** | | | | | <0.001 |
| 1–2 | 984(45.6) | 1171(54.4) | 0.80(0.69-0.92) | 0.003 | |
| 3–4 | 2120(51.2) | 2013(48.7) | 1 | | |
| 5–6 | 1361(44.7) | 1680(55.3) | 0.77(0.69-0.86) | <0.001 | |
| 7+ | 720(42.8) | 692(57.2) | 0.71(0.60-84) | <0.001 | |
| **Distance to water source** | | | | | <0.001 |
| ≤30 minutes | 5041(48.2) | 5408(51.8) | 1 | | |
| >30 minutes | 142(25.3) | 419(74.7) | 0.36(0.25-0.52) | <0.001 | |
| **Place of residence** | | | | | <0.001 |
| Rural | 1984(33.1) | 4021(66.9) | 1 | | |
| Urban | 3200(63.9) | 1806(36.1) | 3.58(2.78-4.64) | <0.001 | |
| **Ecological zone** | | | | | <0.001 |
| Plains | 2337(45.7) | 2776(54.3) | 1 | | |
| Hills | 2623(51.2) | 2499(48.8) | 1.25(0.95-1.64) | 0.116 | |
| Mountains | 224(29.9) | 552(71.1) | 0.48(0.31-0.75) | 0.001 | |
| **Provinces** | | | | | <0.001 |
| 1 | 954(47.8) | 1042(52.2) | 1 | | |

| Variables | Yes (n, %) | No (n, %) | Bivariate analysis | | Chi-squared test |
|---|---|---|---|---|---|
| | **5185,47.08** | **5827,52.92** | **COR (95% CI)** | **P-value** | |
| 2 | 667(33.1) | 1347(66.9) | 0.54(0.37-0.79) | 0.002 | |
| 3 | 1600(63.5) | 918(36.5) | 1.90 (1.26-2.86) | 0.002 | |
| 4 | 621(52.9) | 551(47.1) | 1.23 (0.84-1.80) | 0.282 | |
| 5 | 756(42.3) | 1029(57.7) | 0.80(0.54-1.18) | 0.262 | |
| 6 | 160(25.9) | 456(74.1) | 0.38 (0.25-0.58) | <0.001 | |
| 7 | 427(46.9) | 484(53.1) | 0.96(0.64-1.45) | 0.858 | |
| **Household wealth index** | | | | | <0.001 |
| Poor | 1128(25.4) | 3116(74.6) | 0.13(0.10-0.15) | <0.001 | |
| Middle | 768(37.2) | 1296(62.8) | 0.22(0.18-0.26) | <0.001 | |
| Rich | 3288(73.0) | 1215(27.0) | 1 | | |

### 5.4.6 Hot Spot Analysis

The main two processes mapping cluster pattern and visualisation of hot spots and cold spots of absence of WASH are illustrated below:

This process identifies statistically significant spatial clusters of hot spots high values of unimproved water source, unsanitary toilets, and unavailability of handwashing facilities soap and water and fixed places (hot spot), and low values of unimproved water source, unsanitary toilets, and unavailability of handwashing facilities soap and water and fixed places (cold spot).

The high value (high risk) and low value (low risk) for unimproved WASH was determined based on the results of z-score value. The hot spot high value was estimated based on z-scored value of 1.65 to >2.58 and the cold spot low value based on the z-scored of -1.65 to <-2.58 (Figures 5.1 to 5.4).

#### 5.4.6.1 Mapping Cluster (Getis-Ord Gi*) Hot Spot Analysis

The mapping cluster analysis (Getis- Ord Gi*) identified the locations of statistically significant hot spots. The high/low clustering pattern for unimproved WASH facilities are explained below:

The figure 5.1 indicates that the z-score value is 1.41, which is below the positive critical value range (1.65->2.59), indicates that the pattern does not appear to be a significant different from the random.

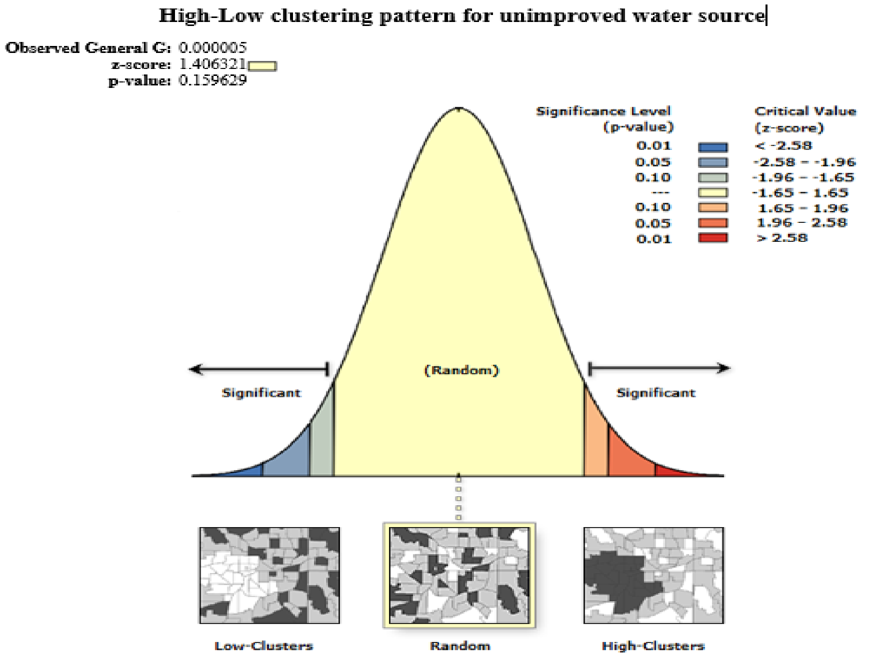



**Figure 5.1: Clustering patterns for unimproved water sources**

The below figure 5.2 indicates that the z-score 4.04 which is greater than positive critical value range, indicates that the pattern appear high clustered pattern could be the results of random chance.

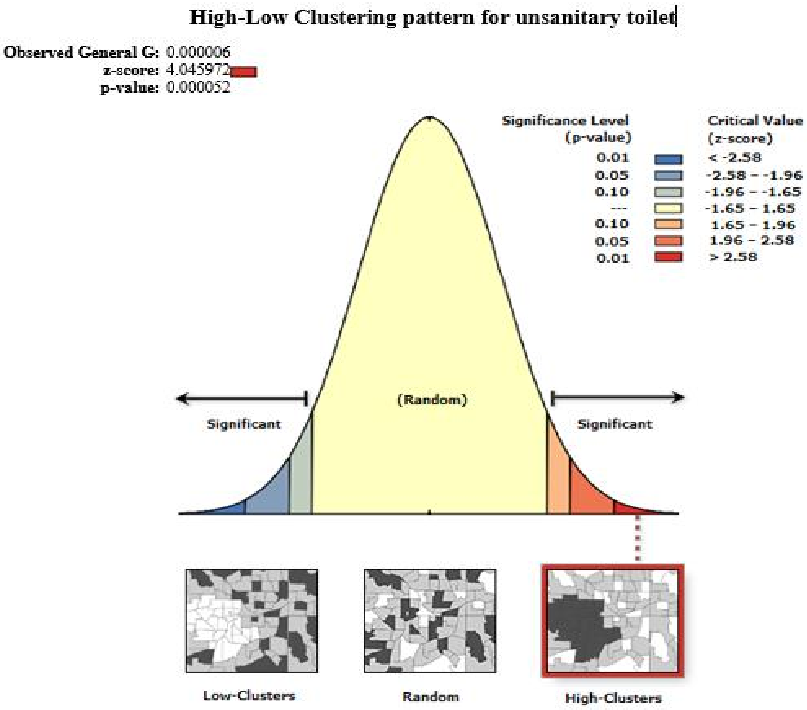



**Figure 5.2: Clustering patterns for unsanitary toilet**

Figure 5.3 showed that the z-score value -4.96 which indicates below the negative critical value (-1.96- -<2.56) that the pattern appear low- clustered patterns could be the results of random chance.

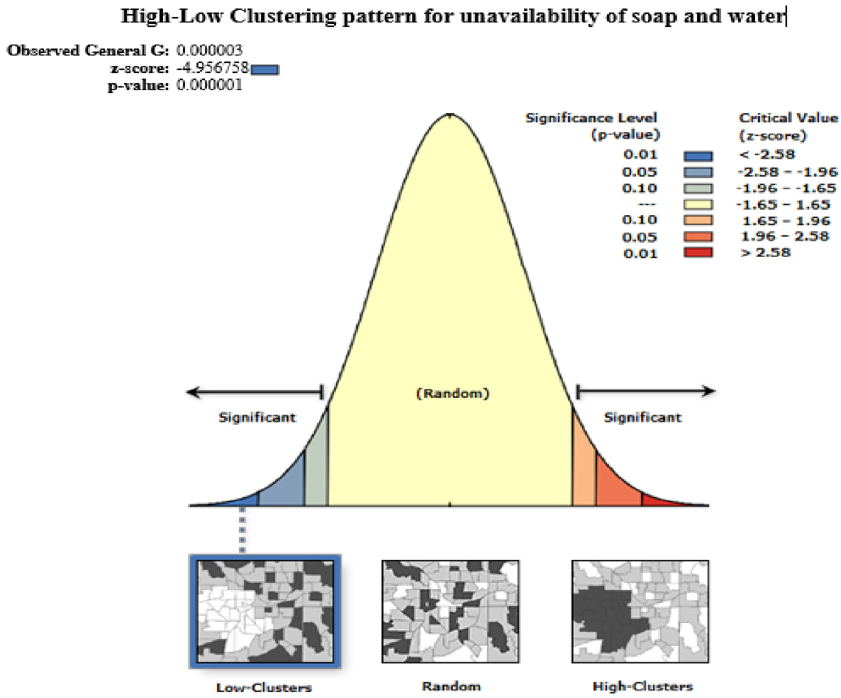



**Figure 5.3: Clustering patterns for unavailability of soap and water**

The figure 5.4 indicates that the z-score value is -0.95, which is not in between the negative critical value range (-1.65- -<2.59), indicates that the pattern does not appear to be a significant different from the random.

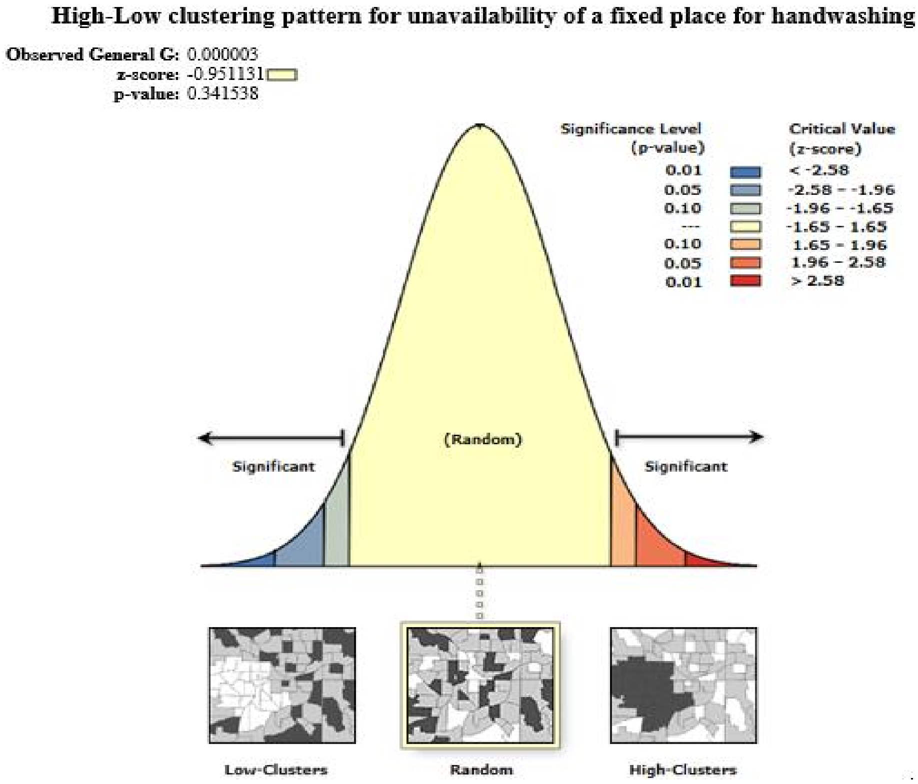



**Figure 5.4: Clustering patterns for unavailability of a fixed place for handwashing**

### 5.4.6.2 Visualisation of hot spots and cold spots of unimproved WASH

The distribution of unimproved water sources, unsanitary toilets, and unavailability of soap and water, and absence of a fixed place for handwashing were visualised in Figures 5.5 to 5.8. Figure 5.5 indicates the spatial variation of unimproved water sources at the cluster level, as described in Chapter 3. The spatial analysis at the cluster level indicates that statistically significant high values (hot spots) of unimproved water sources were found in the far and mid-western hills parts (Provinces 6 and 7) of the country, whereas statistically significant low values (cold spots) of unimproved water sources were found in the central hills and plains regions (Provinces 4 and 5) and south-east plains (Province 1 and 2) parts of the country.

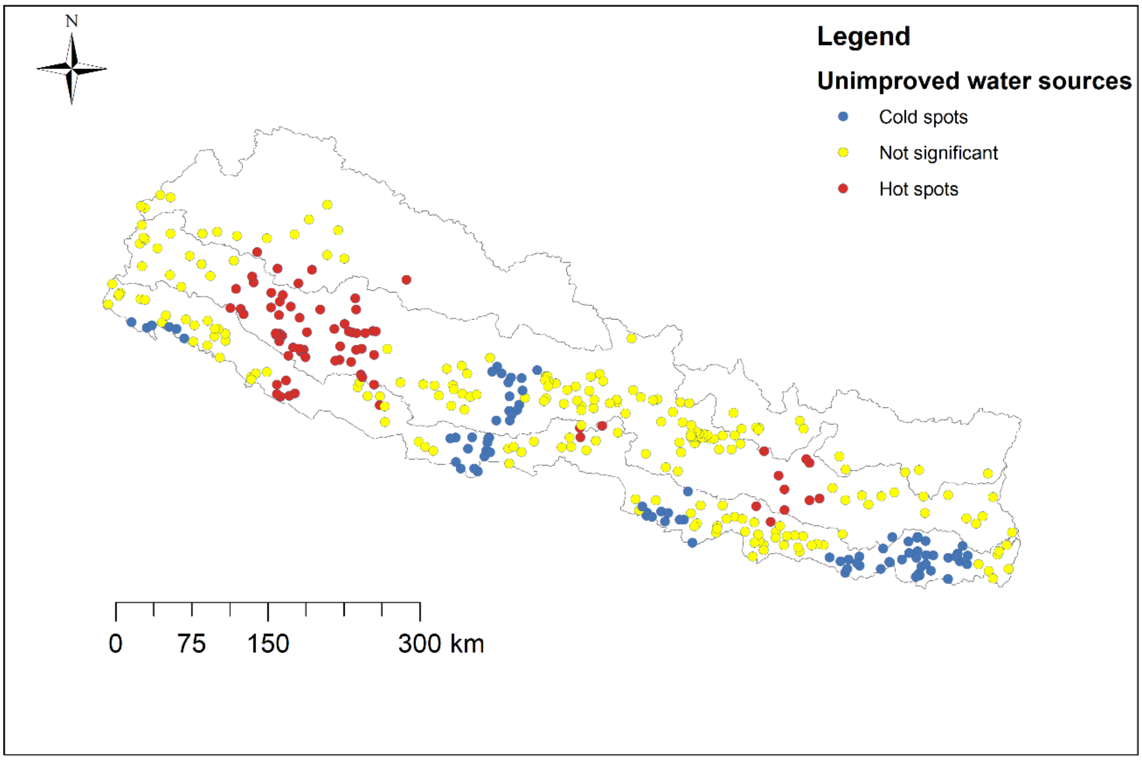



**Figure 5.5: Mapping cluster of unimproved water sources**

Figure 5.6 indicates the spatial variation of unsanitary toilet facilities at the cluster level. The spatial analysis at the cluster level indicates that statistically significant high values (hot spots) of unsanitary toilet facilities were found in the southern plains parts of the country (Province 2), whereas statistically significant low values (cold spots) of unsanitary toilet facilities were found in the central and western hills parts (Provinces 3, 5 and 6) of the country. The hot values (hot spots) are therefore states whose households are in high risk of communicable diseases.

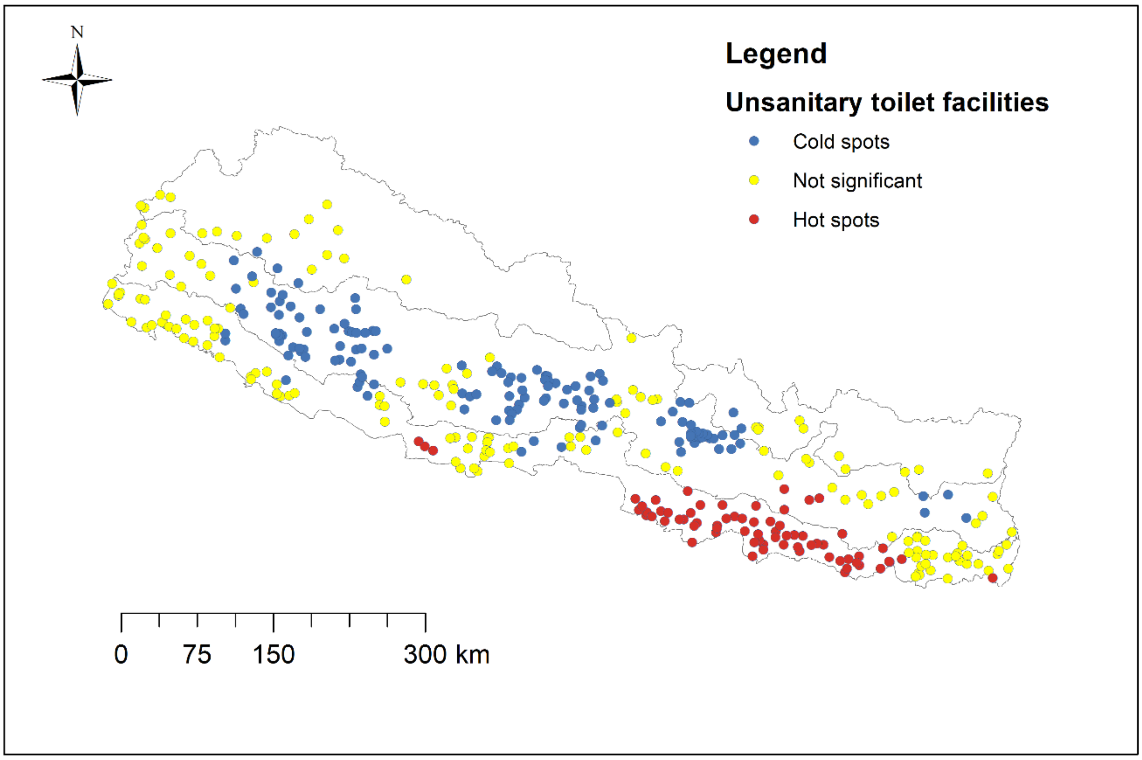



**Figure 5.6: Mapping cluster of unsanitary toilet facilities**

Figure 5.7 indicates the spatial variation of unavailability of soap and water at the cluster level. The spatial analysis at the cluster level indicates that statistically significant high values (hot spots) of unavailability of soap and water were found in the south plains (Province 2) and mid- and far-western hills and mountains (Provinces 6 and 7) parts of the country, whereas statistically significant low values (cold spots) of unavailability of soap and water were found in the eastern plains (Province 1), as well as in the central and western hills parts (Provinces 3, 5 and 6) of the country.

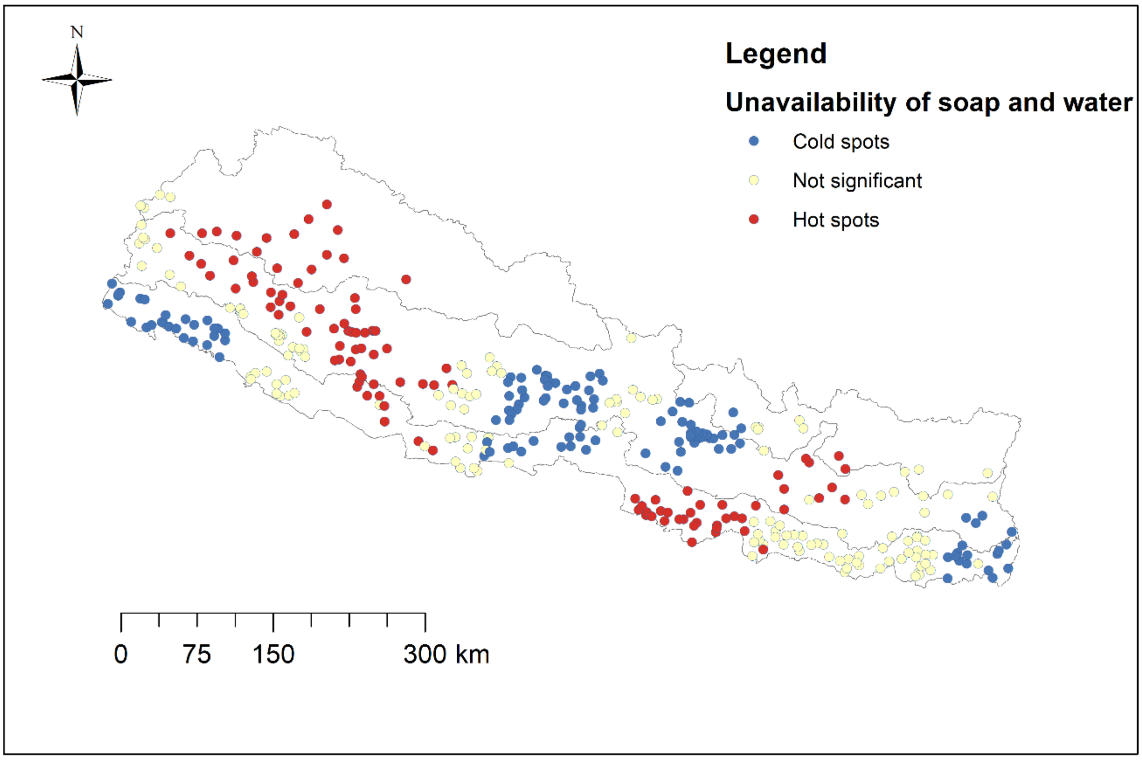



**Figure 5.7: Mapping cluster of availability of soap and water**

Figure 5.8 indicates the spatial variation of unavailability of fixed place for handwashing at the cluster level. The spatial analysis at the cluster level indicates that statistically significant high values (hot spots) of unavailability of fixed place for handwashing were found in the south plains (Province 2) and mid- and far-western hills and mountains (Provinces 6 and 7) parts of the country, whereas statistically significant low values (cold spots) of unavailability of soap and water were found in the eastern plains (Province 1), as well as in the central and western hills parts (Provinces 3,4, and 5) of the country.

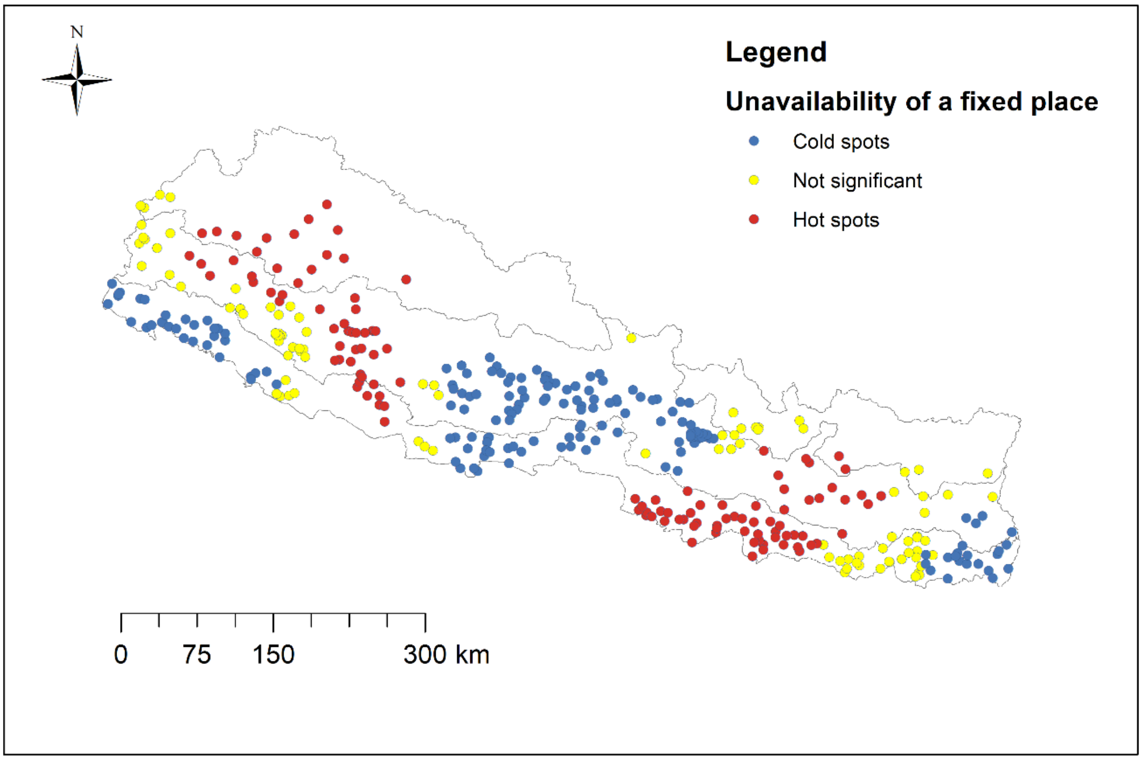



**Figure 5.8: Mapping cluster of unavailability of fixed place for handwashing**

The mapping cluster analyses found geographical locations of statistically significant hot spots. Figures 5.5–5.8 show the calculated probability of unimproved water sources, unsanitary toilets, unavailability of soap and water and absence of a fixed places for handwashing; the red marks indicate high value, while the blue marks indicate low value. The yellow spots are statistically insignificant areas at 95% CI. There were three categories (low, non, and high) in the maps of the results for water source, toilet type, availability of soap, and fixed place for handwashing. The visualised hot and cold spots can also be seen by provinces, and these provinces are clearly indicated by Figure 5.9.

The overall finding of this spatial analysis is the presence of unsanitary toilet and unavailable soap and water were statistically significant with high values and low value marks, respectively (figure 5.2 and 5.3). In summary, the high rate of unimproved WASH indicates that WASH is a public health problem in Nepal [310].

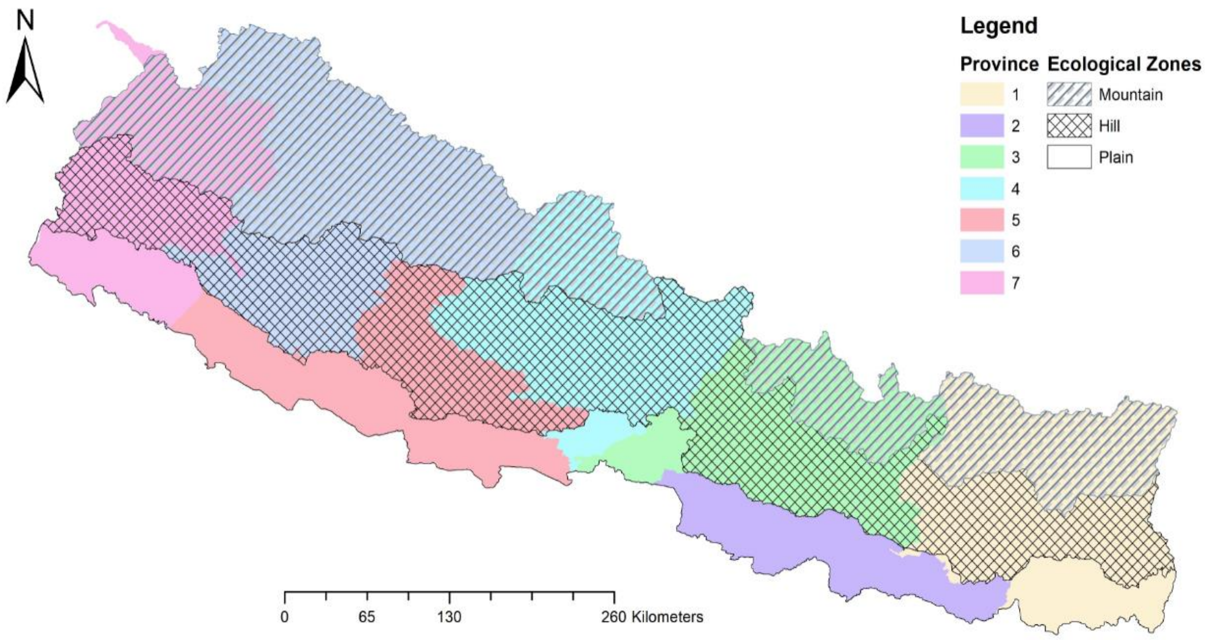



**Figure 5.9: Provincial division within ecological zones**

## 5.5 Discussion

The current study examined NDHS 2016 data to estimate the prevalence and correlates of household-level WASH in Nepal, including identification of areas where WASH facilities were unimproved**.** At the household level, the prevalence of having an improved water source was 95.5%, a sanitary toilet was 83.8%, a fixed place for handwashing was 80.9% and availability of both soap and water was 46.9%. Education, number of family members in the home, ecological zones, provinces, and family wealth index were statistically significantly associated with household WASH in Nepal. Marital status and rural/urban setting were also significant predictors of a household having a sanitary toilet, fixed place for handwashing, and availability of soap and water. The results show there was variation in the coverage of WASH which might be due to several contributing factors, including geographical discrepancies, number of family members in the home, level of education, and economic status.

The individual level factors (age, sex, education and the marital status), family/household-level factors (the number of family members at home and the household wealth index) and community-level factors (distance to water source, place of residence, ecology and province) were critically examined below.

The rate of having an improved water source in Nepal was higher than the global figure of 69% of households with improved water sources [343]. The high level of improved water sources in Nepal is most likely due to Nepal being a rich country in terms of water, as many rivers originate in the Himalayan Mountains [59]. Provinces 2, 4 and 5 had significantly higher rates of improved water source compared to Provinces 3 and 6. This may be due to Province 2 and 5 being in the plains region and most households using ground water which is easily available through a tube well. Province 4 has is an area with readily available pipe water and high rain fall. In another way the Province 6 (in the western hills region) and Province 3 (mostly the national capital) have less improved water sources because in the capital city of Nepal is polluted by sullage and sewage and it is mixed with water the connection pipe or reservoirs of water and the water has become contaminated. Province 6 is a dry region because there is less rainfall and water sources are limited, and ultimately people directly drink water from the river without any treatment.

Globally in 2010, 29% of rural residents and 80% of urban residents had access to an improved water source. In contrast, in the present study, the proportional distribution of improved water source in rural households was 54.6% and in urban households had 45.4%. The lower rates of urban improved water source compared with the global figure was due to the fact that Nepal's sullage and sewage disposal system is unsanitary, and when sullage and sewage enter a water source, this leads to water contamination [344].

The gap between rural and urban access to an improved water source in Nepal is due to a number of reasons. For instance, Nepal's rural areas have many springs which are sources of improved water [345, 346]. In rural areas there is a low population density compared with urban areas, meaning that rural areas are less exposed to water contamination. In a study conducted in Uttar Pradesh, rural India, in 2013, of the 1,088 households, fewer than half had access to an improved water source [347], whereas in the current study, more than double the households had access to an improved water source. This disparity is seen because the India-based study covered a small sample, and Uttar Pradesh is one of the poorer rural regions of India. In 2012, about four in five people in Bangladesh had access to an improved water source [348]. The present study findings were comparable with the Bangladesh-based report.

Improved water can also become contaminated during transportation and handling [349]. The improved water sources in Nepal could become polluted due to sewage where mostly Escherichia coli (E. coli) present, agricultural residues, industrial effluents and chemical substances [350]. Similar studies were carried out in 15 countries in sub-Saharan Africa (SSA), where improved water sources were estimated using a DHS dataset. The average improved water source was 74% (92% in urban areas, 62% in rural areas) in those 15 countries in SSA [351], indicating that the present results in Nepal were higher. This differential rate also indicates that in some African countries (e.g. Namibia), almost 90% of people have access to an improved water source, whereas in other African countries (e.g. Madagascar), only 50% or less have access to an improved water source. This present study's results differed from the pooled average result of the African base study [351]. Similarly, these multi-country-based differences might result from the varying time periods of measurement in the different countries. Another study found that 92% of households had access to an improved water source; the highest coverage was in the Bara district (100%), and the lowest access was in the Doti district (42%) [352]. Together with the current results, these findings highlight the large variation in access across the country and the need to assess drivers of access at the local level.

The benefits of using sanitary toilets for human excreta disposal as a cost-effective health promotion strategy are well-known. Evidence suggests that sanitary toilets reduce the incidence of diarrhoea by 50% [37]. The current research revealed that there were, overall, improved sanitation conditions, with a slight difference between mountains (92%), hills (94%), and plains (72%) regions, with an aggregate prevalence rate of 84% across Nepal. This means that 16% of households do not have sanitary toilet facilities. The households from the plains region (Province 2) had the lowest rate of available sanitary toilets. This may be due to overcrowding, urbanization, lack of knowledge about the importance of sanitary toilets, poverty, and socio-cultural influences. It is evident that less priority has been given to sanitation and hygiene from the GoN perspective [262, 353]. The present study results demonstrated there was a higher availability of sanitary toilets in Nepal than the Millennium Development Goals (MDG) global achievement of 68% in 2015 [13]. The overall figure was similar to the pooled result from 13 African countries of 75% of people with sanitary toilets [351]. The result of this present study pertaining to sanitation coverage in Nepal is similar to the status in India.

A few distinctions between this present study and previous studies were found due to time period differences, different approaches to public health, and context-specific issues. A study completed in 2018 showed that approximately 96% of people have access to sanitary disposal of human excreta in rural Bangladesh [353], a better result than in the present study. This is likely due to Bangladesh's Total Sanitation Led Program (TSLP) that was implemented in 1999, which approach was further applied by different stakeholders in line with support to the governmental sanitation program (open-defaecation- free campaign) in Nepal [354]. A study completed in Nepal using the 2011 NDHS dataset found that 57% of people had access to sanitary toilets; the highest rate was in Kathmandu (100%), and the lowest was in Mahottari (18%) district [352]. The present study found a 27% higher rate of available sanitary toilets compared with the previous similar study in Nepal [145]. This progress has occurred due to open-defaecation-free campaigns through community ownership and collaborative approaches. Every single household in Tehrathum, Lalitpur, Palpa, and Kaski districts had sanitary toilets, while in Sarlahi and Mahotari districts, only 64% of households had sanitary toilets [352]. This means the sanitation status of plain regions remains challenges to use sanitary toilets. The TSLP model could be further expanded in such areas and implement an effective and sustainable way.

Designating a fixed place for handwashing is considered pivotal in the prevention of communicable diseases and enabling health promotion. The 2016 NDHS data demonstrated ecological disparities in the maintenance of a fixed place for handwashing for households. The present study found that respondents with higher education, respondents living in the hills region, and respondents living in urban areas had a higher prevalence of fixed places for handwashing. Household heads aged 35–44 years were significantly more likely to report having soap and water available in handwashing places, compared with other age groups. This might be because men and women aged 35–44 years were more likely to have a higher employment rate (49%) in Nepal [355]. Improved WASH facilities are most likely available in households that have a rich wealth index. Additionally, employed parents might be able to afford soap [356].

The Nepal-specific 2014 Multiple Indicator Cluster Survey (MICS) reported that 97% of households had a fixed place for handwashing, whereas the present study's result was lower [71]. This difference may be due to the MICS study being a sub-population study, sample size, due to differences in geography and study period. The proportional distribution of a fixed place for handwashing in mid-far western hills and mountain regions were comparably lower than MICS. It can be assumed that establishment of a fixed place for handwashing motivates family members to wash their hands because people see the place where they actually can wash hands if there are presence of soap and water. The availability of soap and water at handwashing places was almost the same in Bhutan and Indonesia as in the present study [317]. Ethiopia has very few fixed places for handwashing, but household members wash their hands elsewhere, including outside in the yard. The availability of soap and water separately at the handwashing places was higher than for the 2014 MICS [71]. Handwashing may be less effective if only one of these commodities is present, and therefore both soap and water should be available at handwashing places to increase effectiveness.

The lower rates of availability of handwashing facilities may be due to lack of knowledge about the importance of soap, risk perception, high workload, scarcity of water and/or poor economic status [163]. Improved WASH facilities are therefore important and crucial practices for positive health outcomes, and the prevention and control of communicable diseases. Construction of toilets, buying soap and collecting water do not make any sense if the facilities are not used. These measures can only be achieved through service access and education.

The challenges of WASH in Nepal relate to proper management and sustainability of WASH resources. Based on this study's findings, in Nepal there is a geographical discrepancy in WASH, and Province 2 (which represents the plains region) and Province 6 (which represents both hills and mountains regions) have poor coverage of sanitation and hygiene. Understanding these geographical inequalities helps to identify the gaps and challenges for both financial and logistics management.

These findings have important policy implications for WASH implementers, researchers and policy-makers. The different rates of WASH coverage by predictor variables are an instrumental tool for future WASH program planning to ensure the equitable and affordable distribution of WASH in a sustainable way. This is the right time to explore WASH findings to communicate research-based concerns to authorities and to campaign for effective cost-effective WASH interventions. Based on the findings of this study, the GoN should give WASH priority to Province 2 and Province 6 of Nepal. People who have poor access to WASH services are those with low levels of education, people of low socioeconomic status, and those living in remote geographical areas. These study findings suggest that targeted education and services provision are important for improving WASH in Nepal.

## 5.6 Strengths and limitations

This study has a number of strengths. Firstly, this study shows a country-specific representation, where enough samples were available, thus allowing for the reflection of current trends of household-level WASH in Nepal. Secondly, the study respondents were household heads who are likely to provide accurate data about the household level of WASH since they are well-known persons in the family (Chapter 3, sub-section 3.3.3). A further strength is that data collectors observed a fixed place for handwashing and the presence of water and soap in the handwashing places, as well as the types of toilet that were available. This is a higher level of evidence than relying on self-report. Thirdly, the prevalence of low rates of improved WASH at the cluster level shows a public health problem in Nepal, and this result may help policy-makers to develop WASH plans and programs based on the severity of problem.

However, this study is not without limitations. Firstly, as the study was cross-sectional, the study results refer to a point in time, meaning it is not possible to determine any causation between explanatory variables and outcomes. Secondly, it is difficult to show results by type of family since "nuclear, joint and extended or mixed" families may have different prevalence rates and correlations with WASH in Nepal. Thirdly, there was no information on caste or ethnicity in the household survey data. Fourthly, there may be a sampling bias as there was a lower representation of urban households (45%) compared with rural households (55%). Fifthly, Use of self-reported household improved water sources facilities may have led to an overestimation of WASH practices, and this issue thus requires further study. Then, the proportion of women participants was low (31%) in this study, and women are key persons in Nepal who are at home and teach, care for, and support children and other family members in

WASH practices. It is important to note that this study was conducted before the onset of COVID-19. It is possible that the health promotion activities prompted by the pandemic have led to changes in WASH behaviour.

## 5.7 Conclusions

WASH are significantly associated with some individual-level factors (education and marital status); one family–level factor (household wealth index); and community-level factors (ecological zone, provinces, and distance to water source). The availability of improved water sources and sanitary toilets was higher than the availability of soap and water at handwashing places; however, there was good coverage of fixed places for handwashing. There are gaps in WASH services in rural compared with urban, poor compared with rich, and uneducated compared with educated respondents. To overcome these challenges and barriers, health promotion campaigns should be conducted on a needs basis and in an equitable way. The recommendation is made to extend WASH to hard-to-reach and remote areas, and disadvantaged communities. An individual's level of knowledge, adequate and affordable facilities and policies and plans related to WASH required to achieve universal access to WASH for all household members. Further study is recommended to explore multi-level factors considering sub-class populations (e.g. mothers and children) and organisational factors (e.g. health facilities and schools). Based on the findings of this study, the GoN should give WASH priority especially in Provinces 2 and 6 of Nepal.

# Chapter 6. Factors Associated with Households' Water, Sanitation and Hygiene among Mothers with children under 5 years in Nepal: A Multi-level Analysis

## 6.1 Foreword

The previous chapters have shown that handwashing rates were varied between 5-100% and the availability of soap, water and fixed places for handwashing encourage household members to form handwashing habits (Chapter 4), and the low level of education of household heads, and their marital status, wealth index, place of residence and distance to water source were associated with WASH facilities. Province 2 had high hot spot clusters of unsanitary toilet and handwashing facilities. Likewise, Province 6 had high spot clusters of unimproved water sources and unsanitary handwashing facilities (Chapter 5). This chapter will apply the ecological model to examine the factors associated with WASH in Nepal. Providing improved WASH at the household level remains a major public health challenge in Nepal. Access to WASH services can be influenced by individual-, family- and community- level factors. This study aimed to identify the individual-, family- and community-level factors associated with household WASH facilities in Nepal.

## 6.2 Introduction

Globally, approximately 29% (1.5 billion) of people do not have access to improved water sources, and about 892 million people practiced open defaecation in 2017 [9]. In developing countries, approximately 27% (1.9 billion) of people have basic handwashing facilities, 26% (1.8 billion) lack soap or water in handwashing places, and 47% (3.3 billion) do not have handwashing facilities [9].

Over the last decade, Nepal has made significant progress on WASH facilities, but in 2016 there was a lack of access to improved water for 5% of households, 85% of people consumed water that was not treated, 16% of households lacked access to sanitary toilets, and 54% did not have handwashing with soap facilities [57]. WASH issues were not explicitly addressed in the Millennium Development Goals (MDGs) of 2000–2015. However, in the Sustainable Development Goals (SDGs) of 2016–30, there is a focus on WASH. In particular, by the end of 2030, SDG–6 aims to achieve access to adequate and equitable sanitation and hygiene for all, particularly mothers of children under five years and those in vulnerable situations [357]. The 15th 5-year plan (2019-24) encouraged policy makers to: identify and map basic water and sanitation facilities; ensure that each home had a drinking water tap; ensure coordination, collaboration, facilitation and active community participation in WASH; identify alternative sources for WASH funds; and to promote use of sanitary toilets. The plan also recommended the formulation and amendment of WASH policies, regulations, standards and directives [55]. The main indicators related to WASH were defined as part of this plan: (1) the population should have access to drinking at the rate of 99% by the end of this plan; (2) households with access to basic sanitation should reach 100%; and (3) schools with drinking water and sanitary toilet facilities should reach 92%. Household WASH facilities are dependent on the demographic, geographical, economic, and socio-cultural factors [358]. A review in 2020 found that mothers from rural areas in Nepal are vulnerable to lack of access to WASH facilities and low participation in the policy process because of the patriarchal cultural system, traditional attitudes, and social expectations regarding the role of mothers (e.g. mothers are expected to provide water and manage hygiene at home) [85]. Mothers from developing countries, including Nepal, primarily undertake work as housewives and caretakers of their children and family members [359], are the primary carriers of water [360], ensure an adequate water supply, keep toilets clean, establish handwashing places [110], and repeatedly clean and dispose of children's faecal matter with limited resources [361]. However, mothers are prevented from touching water during menstruation or if they are from a scheduled caste in Nepal [110].

The previous study (Chapter 5) indicated deficiencies in WASH availability and use which might be impacted by individual level factors such as caste or ethnicity, and religion; and family level factors such as exposure to media in Nepal. This knowledge gap was fulfilled by analysing individual, family and community level factors in the current chapter.

Mothers are the first teachers of their children [86, 87], and family factors are closely associated with children's hygiene practice [332]; therefore mothers require family support to meet their child caring goals [20]. Mothers in Nepal can be informed of current WASH services through community Health Mothers' Group (HMG) discussions, female community health volunteers (FCHVs), local teachers, health workers, and mass media.

The influence of individual, family and community factors on households WASH access in Nepal are yet to be investigated. The socio-ecological model [234, 362] posits that the level of WASH uptake is subject to multiple risk factors, rather than a single risk factor, such as education. Consistent with Bronfenbrenner's model, this study proposes that multiple factors at each individual, family, and community levels can influence WASH uptake. Although previous research has indicated that mother's age, education, occupation, caste, religion, breastfeeding practices, and age at the birth of her first child [247-250] might influence WASH, the relative importance of these factors when considered with family and community level factors is unknown. Family- level-factors such as husband's education, household income, and access to mass media can influence the availability of WASH facilities [110]. The geographical inequalities [60] and the long distance between the home and the water source can lead to psychological and emotional stress among mothers in Nepal [329], which can subsequently impact not only mothers, but family and community health and wellbeing. In Nepal, the improvement of WASH facilities are expected through behaviour change communication programs but the utilisation of and access to improved hygiene has not been changed significantly [160].

To the best of my knowledge there is no multi-level analysis of households WASH availability for mothers having children under five in Nepal. Therefore, the objective of this study was to identify the individual-, family/househld- and community factors associated with households' WASH facilities in Nepal.

## 6.3 Methods

### 6.3.1 Data sources and respondents

For the purposes of this study, variables obtained from the children's recode (KR) dataset were considered. Variables available in KR file were generated from the individual women's questionnaire (Chapter 3, sub-section 3.3.3 and 3.3.6). The individual-level-factors such as age, education, occupation, caste or ethnicity, religion of mothers; the family-level-factors such as education of husband, household wealth index, exposure to newspaper, exposure to radio and exposure to television; and community-level-factors such as place of residence, ecological zones, provinces and distance to water sources were considered. The WASH variables such as source of water, type of toilets, handwashing facilities, and combined WASH facilities were taken from the household dataset (HR) file. Study variables were taken from interview respondents' (mothers') basic information. The datasets were merged into one, where the primary or base file KR file, which matched with the HR file from many entities to one entity (m:1) aimed to merge necessary household characteristics (Chapter 3, sub-section 3.3.9). The respondents were the household heads, mostly males, as well as usual resident mothers, aged 15–49 years, with a child under five years.

### 6.3.2 Inclusion and exclusion criteria

The study population included usual residents (De Jure residents) of the households who were mothers aged 15–49 years with children under five years, who were present on the day of the survey. Data from mothers whose children had died between birth and 36 months of age (n=177, unweighted sample; 173 after weighting the sample) were excluded from this analysis. There were no deaths recorded for children aged two to five years. Guest (De Facto residence) mothers were excluded from this study to avoid duplication of participants. The final study population was 4,887 (weighted sample).

### 6.3.3 Outcome variables

The outcome variables included in this study were an improved water source, a sanitary toilet, a fixed place for handwashing, and the availability of soap and water in the handwashing places. These variables were taken from household dataset, interviewed with household heads. Each outcome was analysed separately, and a composite outcome variable, 'combined WASH', was also created. A combined WASH outcome was considered for this study because the availability of clean water, a sanitary toilet facility, and adequate handwashing with soap are all required to prevent disease, and the absence of any single item resulted in incomplete WASH. If these four criteria were met, it was considered to be 'complete WASH'. Each dependent variable was categorised dichotomously as Yes=1, No=0.

### 6.3.4 Individual-, family- and community-level factors

Individual-level factors included age, education, occupation, caste or ethnicity and religion. Bivariate analysis was conducted and the relationship between individual-level factors and each outcome variable was identified.

Family-level factors included education level of husbands, wealth index, and exposure to newspapers, radio, and television. A bivariate analysis was conducted to identify the relationship between family- level factors and each outcome variable.

Community-level factors included place of residence, ecological zone, province, distance to water source, and HMGs. A bivariate analysis was conducted to identify the relationship between each community-level factor and the outcome variables.

The final full model assessed the effect of individual-, family- and community-level factors on the availability of an improved water source, a sanitary toilet, a fixed place for handwashing, and the availability of soap and water in the handwashing places.

All explanatory variables used in the multi-level analysis are explained in detail in Chapter 3, sub-section 3.3.8.

### 6.3.5 Data analysis

STATA 15 software was used to analyse the data [300]. The descriptive analysis was calculated using survey weights, and frequencies and percentages were reported (Table 6.1). All socio-demographic and contextual WASH-related characteristics were analysed through a univariate method. A weighted sample was considered for the analysis to match population distribution. A multi-level mixed effects logistic regression analysis [305] was performed to assess the relationship between explanatory variables at individual-, family-, and community levels [234] with each binary outcome.

### 6.3.6 Regression model fit test

Suitability for logistic models was assessed using the Hosmer-Lemeshow Goodness of Fit (GOF) test of model fitness [363], which assesses calibration, and the linktest, which assesses functional form.

Four models were fitted for the dependent variables using the 2016 NDHS dataset.

**Bivariate analysis:** Variables were evaluated individually with outcome variables by applying bivariate analysis. This model was unadjusted to determine the crude effect size of variables. Each variable was checked with a Chi-squared test, and the rows were merged if any values were missing in the cross-tabulation process to avoid zero cell counts.

**Model 1:** All individual-level variables were run together, and the difference between unadjusted models was observed. This model was run to examine the contribution of each individual-level factor on the outcomes. If effect sizes changed by more than 10% between the crude and adjusted models, this indicates there may be confounders. The Variance Inflation Factor (VIF) was checked to assess collinearity.

**Model 2:** All family-level variables were run together, and the difference between unadjusted models and individual-level- factors was observed. If effect sizes changed by more than 10% between the crude and adjusted models, this indicates there may be confounders. The VIF was checked to assess collinearity.

**Model 3:** All community-level variables were run together, and the difference between the unadjusted models and individual- and family-level factors was observed. If effect sizes changed by more than 10% between the crude and adjusted models, this indicates there may be confounders. The VIF was checked to assess collinearity.

**Model 4:** Individual-, family- and community-level variables were combined, and the model for final evaluation was run. Each outcome in this study was carefully analysed, adopting similar processes in Models 1, 2 and 3 above. The VIF was calculated to assess collinearity. The Hosmer-Lemeshow GOF test was applied [364].

In this model, an Adjusted Odds Ratio (AOR) with 95% Confidence Interval (CI) was reported, by controlling the effects of other predictors. A p-value of less than 0.05 in line with an odds ratio <1 or >1 was applied to identify factors significantly associated with improved water source, sanitary toilet, fixed places for handwashing, availability of soap and water, and combined WASH.

## 6.4 Results

### 6.4.1 Descriptive statistics

Descriptive results included the socio-demographic characteristics of the respondents. A total of 4,887 mothers with children under five years were included in this study (Table 6.1). The age group of 25–34 years had the highest representation (n=2,510, 51.3%). Approximately 32% of respondents had a secondary level of education, and 24% had no education. Most mothers participated in agricultural work at home (n=2,206, 45.2%), only 14.0% were in non-agricultural work, and 40.8% of mothers were not employed. In this study, 38.2% of respondents identified as Janajati or Vaishya caste (n=1,867), and approximately 85.2% of respondents (n=4,165) identified as Hindu.

Of the respondents' husbands, 14.7% had no education, 22.5% had a primary level of education, 44.5% were literate with a secondary level of education, and 17.4% were literate with SLC or higher level of education. Approximately 42.3% of respondents were classified as being in the poor wealth index category, with 35.4% classified as rich. The proportion of respondents in the middle wealth index was 22.3%. The proportions of respondents exposed to media at any time were 21.7% for newspapers, 50.3% for radio, and 61.5% for television. The proportions of respondents exposed to media at least once a week were 16.6%, 27.5%, and 20.5% for newspapers, radio and television, respectively. Regarding place of residence, 61.9% lived in rural areas, and 38.1% lived in urban areas. In terms of the respondents' ecological zone location, 55.0% were in the plains region, 38.0% in the hills region, and 7.0% in the mountains region. The provincial distribution of the study population was unequal, with the highest proportion (26.8%) being from Province 2 and the lowest (6.6%) from Province 6. Eighty-seven percent of respondents' homes were less than 30 minutes' walking distance from a water source and 32.8% of respondents had an HMG available in their community.

**Table 6.1: Socio-demographic characteristics of respondents**

| Variables | Weighted frequencies (n=4887) | Weighted percentages (100%) |
|---|---|---|
| **Age of mother** | | |
| 15–24 | 1973 | 40.4 |
| 25–34 | 2510 | 51.3 |
| 35+ | 404 | 8.3 |
| **Education of mother** | | |
| No education | 1663 | 34.1 |
| Primary | 981 | 20.0 |
| Secondary | 1564 | 32.0 |
| SLC or higher | 679 | 13.9 |
| **Occupation of mother** | | |
| No work | 1995 | 40.8 |
| Agriculture | 2206 | 45.2 |
| Non agriculture | 686 | 14.0 |
| **Caste or ethnicity of mother** | | |
| Brahmin and Chhetri | 1357 | 27.8 |
| Janajati /Vaishya | 1867 | 38.2 |
| Scheduled | 662 | 13.5 |
| Other | 1001 | 20.5 |
| **Religion** | | |
| Hindu | 4165 | 85.2 |
| Non-Hindu | 722 | 14.8 |
| **Education of husband** | | |
| No education | 718 | 14.7 |

| Variables | Weighted frequencies (n=4887) | Weighted percentages (100%) |
|---|---|---|
| Primary | 1100 | 22.5 |
| Secondary | 2175 | 44.5 |
| SLC or higher | 850 | 17.4 |
| Do not know | 44 | 0.9 |
| **Wealth Index** | | |
| Poor | 2069 | 42.3 |
| Middle | 1087 | 22.3 |
| Rich | 1731 | 35.4 |
| **Exposure to newspapers** | | |
| No exposure | 3825 | 78.3 |
| Exposure | 1002 | 21.7 |
| **Exposure to radio** | | |
| No exposure | 2427 | 49.7 |
| Exposure | 2460 | 50.3 |
| **Exposure to television** | | |
| No exposure | 1860 | 38.1 |
| Exposure | 3027 | 61.9 |
| **Place of residence** | | |
| Rural | 3028 | 61.9 |
| Urban | 1059 | 38.1 |
| **Ecological zone** | | |
| Plains | 2688 | 55.0 |
| Hills | 1857 | 38.0 |
| Mountains | 342 | 7.0 |
| **Provinces** | | |

| Variables | Weighted frequencies (n=4887) | Weighted percentages (100%) |
| --- | --- | --- |
| 1 | 794 | 16.2 |
| 2 | 1310 | 26.8 |
| 3 | 793 | 16.2 |
| 4 | 380 | 7.8 |
| 5 | 869 | 17.8 |
| 6 | 322 | 6.6 |
| 7 | 421 | 8.6 |
| **Distance to water source** | | |
| ≤30 minutes | 4250 | 87.0 |
| >30 minutes | 265 | 5.4 |
| Missing* | 372 | 7.6 |
| **Health Mothers' Group** | | |
| Not available | 2638 | 54.0 |
| Available | 1604 | 32.8 |
| Do not know | 645 | 13.2 |

### 6.4.2 Model fitness test for multi-level logistic regression analysis

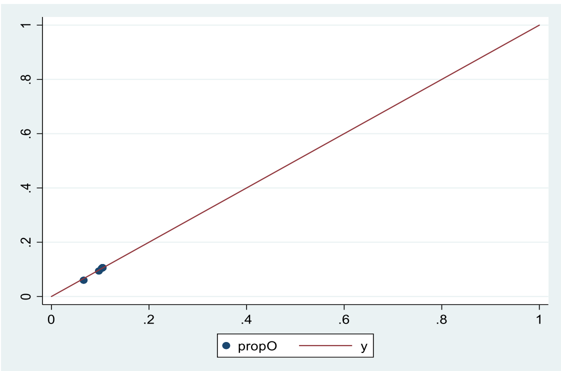
The following process was applied to test model fit in order to study individual-, family-, and community- factors associated with WASH.

#### 6.4.2.1 Variance Inflation Factor

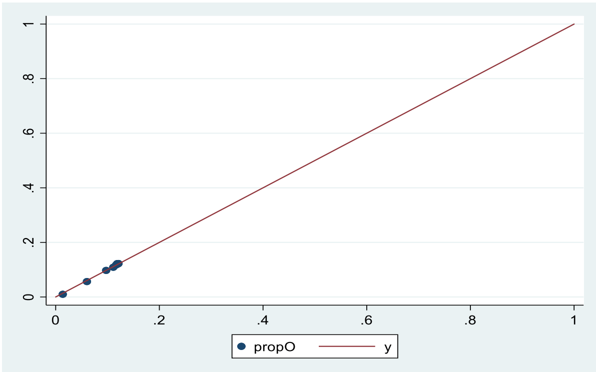
The cluster/community variance was measured through the VIF estimation after running the regression model to find the VIF value. This process quantifies the severity of multi-collinearity for the regression analysis. All levels of analysis of each outcome of interest have VIF values less than 5 in each explanatory variable with outcomes. This means there is moderate correlation between each variable. Therefore, there are no collinearity problems.

#### 6.4.2.2 Goodness of model fitness

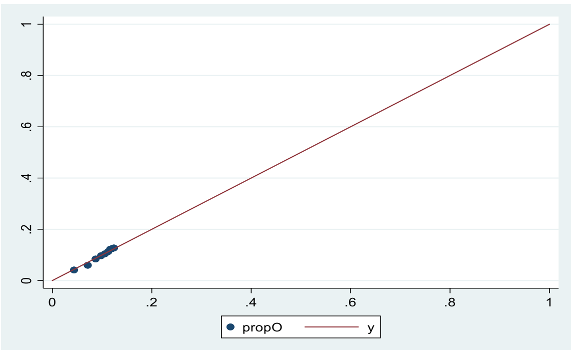
The Hosmer-Lemeshow GOF test p-value was <0.001 in each outcome, indicating problems with model fit. However, this test is sensitive to large sample sizes; upon assessing the observed and expected probabilities underlying the test, it was decided there was good agreement between the two, and model fit was deemed acceptable. A new variable grouped the observation into deciles of predicted outcome probability (after a melogit model was run), and then the researcher compared the number of predicted and observed positive outcomes in each group. All individual-, family-, and community-level factors were considered in the final model. If the predicted and observed frequencies are similar, then the model is a good fit. Figure 6.1 illustrates the predicted and observed proportions which have similar values. Therefore, this model is well-fitted for the multi-level logistic regression analysis.



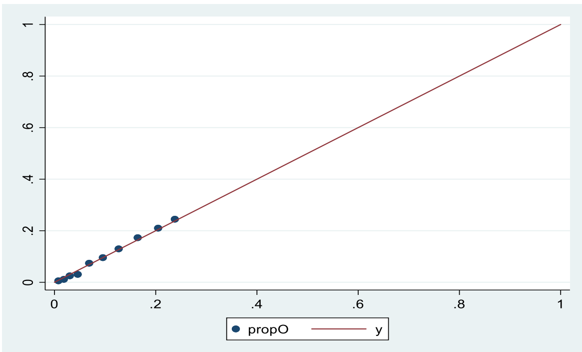

**A=Improved Water source**



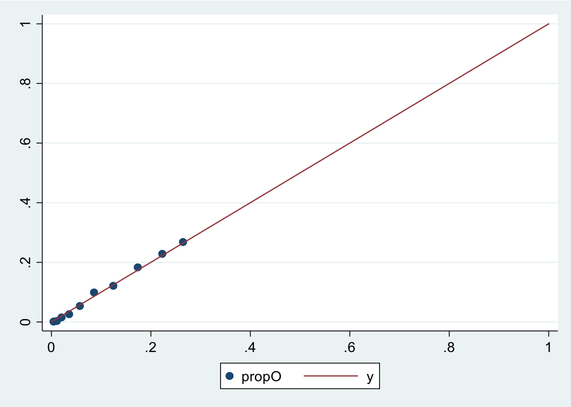

**B=Sanitary toilet**




**C=Fixed place for handwashing**




**D=Availability of soap and water**




**E=Combined WASH**

**Figure 6.1: Hosmer and Lemeshow's test of logistic model fitness: Observed proportion (X) and Predicted proportion (Y)**

The scale, 0 to 1, corresponds to the probability of each outcome. The variable, PropO, is the observed probability of the outcome, and the variable, PropE, is the expected probability. The above figures indicate that there is good correspondence between the observed and the modelled probabilities, and so the model explains all outcomes very well, and the model is calibrated as well-fitted for this multi-level logistic analysis. The Health Mothers' Group (HMG) variable was not included in Model A because it has no association with improved water source in the community.

### 6.4.3 Multi-level logistic regression analysis

#### 6.4.3.1 Results of individual, family and community factors relating to an improved water source

As shown in Table 6.2, economic status of the mother's household was positively associated with availability of an improved water source. Mothers that had a rich household wealth index had statistically significantly higher odds (AOR=3.23; 95% CI: 1.52-6.84) than those in the poor wealth index category of having access to an improved water source. Mothers with exposure to television at home were 1.5 times more likely to have access to an improved water source, with this result being close to statistical significance (AOR=1.51; 95% CI: 0.96-2.36).

The final model adjusting all individual, family and community factors showed that mothers from the hills region of Nepal had lower odds (AOR=0.20; 95% CI: 0.07-0.58) of having an improved water source, compared with those from the plains regions. Mothers whose homes were more than 30 minutes from a water source had 82% lower odds (AOR=0.18; 95% CI: 0.12-0.28) of having an improved water source, compared with mothers with a water source less than 30 minutes from their homes (Table 6.2). However, individual factors (age, education, occupation, caste or ethnicity, religion of mother and family- level factors (education of husband, exposure to newspaper and radio) and community factors (place of residence and province) were not significantly related to having an improved water source.

Table 6.2: Multi-level analysis of individual, family and community factors associated with an improved water source

| Variables | Bivariate analysis | Individual- level ( Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-, family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **INDIVIDUAL-LEVEL FACTORS** | | | | | | |
| **Age of mother (in years)** | | | | | | |
| 15–24 | 1 | 1 | | | 1 | |
| 25–34 | 0.91(0.62-1.34) | 0.89(0.62-1.27) | | | 0.85(0.58-1.24) | 0.387 |
| 35 and above | 0.95(0.54-1.66) | 1.26(0.68-2.32) | | | 1.48(0.76-2.88) | 0.245 |
| **Education of mother** | | | | | | |
| No education | 1 | 1 | | | 1 | |
| Primary | 0.64(0.37-1.17) | 0.78(0.50-1.23) | | | 0.68(0.42-1.10) | 0.117 |
| Secondary | 1.14(0.66-1.99) | 1.52(0.95-2.45) | | | 1.05(0.61-1.84) | 0.853 |
| SLC or higher | 1.55(0.75-3.20) | 1.82(0.93-3.52) | | | 1.03(0.45-2.32) | 0.952 |
| **Occupation of mother** | | | | | | |
| No work | 1 | 1 | | | 1 | |
| Agriculture | 0.32(0.20-0.52) | 0.67(0.43-1.04) | | | 0.82(0.52-1.30) | 0.404 |

| Variables | Bivariate analysis | Individual- level ( Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-, family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Non agriculture | 0.65(0.34-1.26) | 0.96(0.52-1.77) | | | 0.86(0.45-1.65) | 0.643 |
| **Caste/Ethnicity** | | | | | | |
| Brahmin/Chhetri | 1 | 1 | | | 1 | |
| Janajati/Vaishya | 1.39(0.82-2.35) | 1.36(0.82-2.25) | | | 1.39(0.81-2.38) | 0.227 |
| Scheduled | 0.87(0.49-1.53) | 0.99(0.60-1.62) | | | 1.42(0.82-2.43) | 0.208 |
| Other | 2.88(0.94-8.83) | 2.45(0.96-6.25) | | | 1.93(0.68-5.50) | 0.217 |
| **Religion** | | | | | | |
| Hindu | 1 | | | | 1 | |
| Non-Hindu | 1.78(0.98-3.26) | 1.12(0.72-1.75) | | | 0.77(0.39-1.52) | 0.448 |
| **FAMILY LEVEL FACTORS** | | | | | | |
| **Education of husband** | | | | | | |
| No education | 1 | | 1 | | 1 | |
| Primary | 0.75(0.41-1.36) | | 0.89(0.52-1.51) | | 1.04(0.59-1.84) | 0.886 |
| Secondary | 1.40(0.80-2.47) | | 1.28(0.75-2.20) | | 1.55(0.85-2.81) | 0.152 |

| Variables | Bivariate analysis | Individual- level ( Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-, family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| SLC or higher | 1.35(0.64-2.85) | | 1.33(0.67-2.64) | | 1.64(0.75-3.60) | 0.217 |
| **Wealth index** | | | | | | |
| Poor | 1 | | 1 | | 1 | |
| Middle | 3.18(1.67-6.04) | | 2.19(1.21-3.94) | | 1.75(0.94-3.25) | 0.076 |
| Rich | 5.31(2.60-10.83) | | 4.56(2.26-9.18) | | 3.23(1.52-6.84) | 0.002 |
| **Exposure to newspapers** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 1.59(0.88-2.86) | | 0.95(0.57-1.57) | | 0.88(0.51-1.51) | 0.633 |
| **Exposure to radio** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 0.74(0.48-1.13) | | 1.17(0.80-1.72) | | 1.32(0.88-1.98) | 0.174 |
| **Exposure to television** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 1.97(1.25-3.10) | | 1.46(0.95-2.23) | | 1.51(0.96-2.36) | 0.073 |

| Variables | Bivariate analysis | Individual- level ( Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-, family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **COMMUNITY-LEVEL FACTORS** | | | | | | |
| **Place of residence** | | | | | | |
| Rural | 1 | | | 1 | 1 | |
| Urban | 0.98(0.53-1.80) | | | 1.00(0.48-2.08) | 0.62(0.29-1.31) | 0.210 |
| **Ecological zone** | | | | | | |
| Plains | 1 | | | 1 | 1 | |
| Hills | 0.31(0.15-0.64) | | | 0.14(0.05-0.42) | 0.20(0.07-0.58) | 0.003 |
| Mountains | 0.76(0.17-3.47) | | | 1.16(0.21-6.40) | 2.44(0.43-13.91) | 0.314 |
| **Provinces** | | | | | | |
| 1 | 1 | | | 1 | 1 | |
| 2 | 1.63(0.43-6.19) | | | 0.95(0.18-5.07) | 1.00(0.19-5.14) | 0.997 |
| 3 | 0.76(0.28-2.06) | | | 1.39(0.33-5.78) | 1.06(0.27-4.24) | 0.932 |
| 4 | 0.83(0.30-2.30) | | | 1.33(0.32-5.42) | 1.16(0.30-4.51) | 0.827 |
| 5 | 1.09(0.42-2.81) | | | 0.75(0.19-2.95) | 0.72(0.19-2.73) | 0.628 |

| Variables | Bivariate analysis | Individual- level ( Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-, family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| 6 | 0.26(0.11-0.66) | | | 0.35(0.09-1.27) | 0.45(0.12-1.60) | 0.217 |
| 7 | 0.70(0.26-1.88) | | | 0.64(0.16-2.59) | 0.91(0.23-3.61) | 0.897 |
| **Distance to water source** | | | | | | |
| ≤30 minutes | 1 | | | 1 | 1 | |
| >30 minutes | 0.08(0.04-0.15) | | | 0.18(0.12-0.27) | 0.18(0.12-0.28) | <0.001 |

#### 6.4.3.2 Results of individual, family and community factors relating to sanitary toilets

As shown in Table 6.3, the individual factors (age, education, caste or ethnicity of mother), were statistically significantly associated with the availability of a sanitary toilet. Mothers aged 35 years or above were more likely to have a sanitary toilet (AOR=1.69; 95% CI: 1.06-2.69) than mothers aged 15–24 years. Mothers with a secondary level of education were more likely to have a sanitary toilet (AOR=1.78; 95% CI: 1.22-2.60) relative to mothers with no education. Mothers of the scheduled or Shudra caste had lower odds of having a sanitary toilet (AOR=0.45; 95%CI: 0.27-0.75) compared with the Brahmin and Chhetri caste mothers. Mothers of the other unknown castes also had lower rates of having a sanitary toilet (AOR=0.31; 95% CI: 0.18-0.55) compared with mothers of the Brahmin and Chhetri castes. Husbands with a secondary level of education had slightly higher odds (AOR=1.43; 95% CI: 661.00-2.03) of having a sanitary toilet relative to husbands who were not educated. Husbands with a School Leaving Certificate (SLC) or above level of education had higher odds (AOR=2.61; 95% CI: 1.43-4.76) of having a sanitary toilet in the home compared with husbands with no education. Household mothers in the middle and high wealth index levels had higher odds (AOR=2.96; 95% CI: 2.07-4.22 and AOR=15.35; 95% CI: 9.77-24.14, respectively) of having sanitary toilets relative to those in the poor wealth index. Mothers who listen radio at least once a week had higher odds (AOR=1.32; 95% CI: 0.99-1.76) of having sanitary toilet facilities at their households. However, reading newspaper and watching a television were not significantly related to having a sanitary toilet.

Community-level factors (place of residence, ecology, province, distance to a water source, and HMG) were statistically significantly associated with having a sanitary toilet. Combined WASH was more likely (AOR=2.09; 95% CI: 1.23-3.55) for mothers from urban areas than for mothers from rural areas. Mothers living in the hills and mountains regions had higher odds (AOR=7.69; 95% CI: 3.63-16.16 and AOR=6.32; 95% CI: 2.20-18.16, respectively) of having sanitary toilet facilities compared with mothers living in the plains regions. Mothers from Province 2 had lower odds (AOR=0.30; 95% CI: 0.13-0.69) while mothers from Provinces 5 and 6 had higher odds (AOR=2.63; 95% CI: 1.08-6.42 and AOR=2.95; 95% CI: 1.05-8.32, respectively) of having a sanitary toilet compared with those from Province 1 (Table 6.3). Where the distance to a water source was >30 minutes from home, mothers had lower odds (AOR=0.54; 95% CI: 0.32-0.91) of having a sanitary toilet compared with mothers who did not have to travel more than 30 minutes to a water source. Mothers with access to a HMG in their community had higher odds (AOR=1.52; 95% CI: 1.11-2.09) of having a sanitary toilet than mothers who did not have access to an HMG in their community.

Table 6.3: Multi-level analysis of individual, family and community factors associated with sanitary toilets

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **INDIVIDUAL-LEVEL FACTORS** | | | | | | |
| **Age of the mother (in years)** | | | | | | |
| 15–24 | 1 | 1 | | | 1 | |
| 25–34 | 1.09(0.86-1.40) | 1.22(0.96-1.57) | | | 1.13(0.86-1.47) | 0.378 |
| 35 and above | 1.02(0.71-1.47) | 1.50(0.99-2.27) | | | 1.69(1.06-2.69) | 0.027 |
| **Education of the mother** | | | | | | |
| No education | 1 | 1 | | | 1 | |
| Primary | 1.78(1.35-2.33) | 1.56(1.16-2.08) | | | 1.24(0.90-1.71) | 0.197 |
| Secondary | 5.93 (4.30-8.18) | 3.74(2.70-8.18) | | | 1.78(1.22-2.60) | 0.003 |
| SLC or higher | 17.34(8.26-36.44) | 7.42(3.91-14.09) | | | 2.00(0.97-4.14) | 0.060 |
| **Occupation of the mother** | | | | | | |
| No work | 1 | 1 | | | 1 | |
| Agriculture | 1.36(1.00-1.86) | 0.75(0.57-0.99) | | | 0.99(0.73-1.34) | 0.942 |
| Non agriculture | 1.96(1.30-2.96) | 1.06(0.71-1.58) | | | 0.80(0.51-1.24) | 0.317 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **Caste/Ethnicity** | | | | | | |
| Brahmin and Chhetri | 1 | 1 | | | 1 | |
| Janajati/Vaishya | 0.21(0.13-0.33) | 0.44(0.28-0.70) | | | 0.69(0.42-1.13) | 0.148 |
| Scheduled | 0.11(0.07-0.17) | 0.23(0.15-0.36) | | | 0.45(0.27-0.75) | 0.002 |
| Other | 0.05(0.03-0.08) | 0.21(0.12-0.34) | | | 0.31(0.18-0.55) | <0.001 |
| **Religion** | | | | | | |
| Hindu | 1 | 1 | | | 1 | |
| Non-Hindu | 0.93(0.55-1.58) | 1.12(0.72-1.75) | | | 1.13(0.70-1.82) | 0.619 |
| **FAMILY- LEVEL FACTORS** | | | | | | |
| **Education of the husband** | | | | | | |
| No education | 1 | | 1 | | 1 | |
| Primary | 2.13(1.58-2.90) | | 1.14(0.81-1.60) | | 1.10(0.78-1.55) | 0.596 |
| Secondary | 4.73(3.45-6.49) | | 1.78(1.27-2.49) | | 1.43(1.00-2.03) | 0.048 |
| SLC or higher | 16.68(9.66-28.81) | | 3.59(2.05-6.28) | | 2.61(1.43-4.76) | 0.002 |
| **Wealth index** | | | | | | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Poor | 1 | | 1 | | 1 | |
| Middle | 0.59(0.42-0.84) | | 2.14(1.52-3.04) | | 2.96(2.07-4.22) | <0.001 |
| Rich | 3.31(2.25-4.88) | | 11.87(7.67-18.36) | | 15.35(9.77-24.14) | <0.001 |
| **Exposure to newspapers** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 10.90(6.56-18.11) | | 1.92(1.18-3.13) | | 1.29(0.78-2.13) | 0.324 |
| **Exposure to radio** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 3.51(2.64-4.66) | | 1.21(0.92-1.60) | | 1.32(0.99-1.76) | 0.055 |
| **Exposure to television** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 2.35(1.75-3.16) | | 1.15(0.87-1.52) | | 1.19(0.90-1.57) | 0.229 |
| **COMMUNITY-LEVEL FACTORS** | | | | | | |
| **Place of residence** | | | | | | |
| Rural | 1 | | 1 | | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Urban | 2.04(1.29-3.25) | | | 4.02(2.35-6.88) | 2.09(1.23-3.55) | 0.007 |
| **Ecological zone** | | | | | | |
| Plains | 1 | | | 1 | 1 | |
| Hills | 6.75(4.00-11.39) | | | 5.67(2.68-11.97) | 7.69(3.63-16.16) | <0.001 |
| Mountains | 5.86(3.09-11.11) | | | 3.98(1.37-11.50) | 6.32(2.20-18.16) | 0.001 |
| **Provinces** | | | | | | |
| 1 | 1 | | | 1 | 1 | |
| 2 | 0.15(0.08-0.28) | | | 0.18(0.8-0.41) | 0.30(0.13-0.69) | 0.005 |
| 3 | 1.07(0.50-2.26) | | | 0.78(0.29-2.10) | 0.60(0.23-1.58) | 0.299 |
| 4 | 2.92(1.25-6.84) | | | 1.85(0.64-5.35) | 1.86(0.66-5.28) | 0.242 |
| 5 | 1.00(0.46-2.21) | | | 2.39(0.96-5.94) | 2.63(1.08-6.42) | 0.034 |
| 6 | 3.41(1.70-6.87) | | | 1.78(0.62-5.11) | 2.95(1.05-8.32) | 0.040 |
| 7 | 2.12(1.08-4.20) | | | 1.51(0.61-3.73) | 2.14(0.87-5.25) | 0.096 |
| **Distance to water source** | | | | | | |
| ≤30 minutes | 1 | | | 1 | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| >30 minutes | 0.87(0.38-2.00) | | | 0.37(0.22-0.61) | 0.54(0.32-0.91) | 0.023 |
| **Health Mothers' Group** | | | | | | |
| No | 1 | | | 1 | 1 | |
| Yes | 2.31(1.65-3.25) | | | 1.83(1.37-2.44) | 1.52(1.11-2.09) | 0.009 |
| Do not know | 1.86(1.21-2.85) | | | 0.95(0.66-1.36) | 0.84(0.56-1.26) | 0.411 |

#### 6.4.3.3 Results of individual, family and community factors related to having a fixed place for handwashing

The education of mothers, and their caste or ethnicity were statistically significantly associated with having a fixed place for handwashing (Table 6.4). Mothers who had secondary education and mothers who had an SLC or higher level of education had higher odds (AOR=1.52; 95% CI: 1.14-2.01 and AOR=1.98; 95% CI: 1.27-3.11, respectively) of having a fixed place for handwashing in the home compared with mothers with no education. Mothers from the Janajati and Vaishya castes had higher odds (AOR=1.45; 95% CI: 1.05-2.00) of having a fixed place for handwashing compared with those who belong to the Brahmin and Chhetri caste. However, age, occupation, and religion of mothers were not significantly associated with a fixed place for handwashing.

Family factors including education of husband, wealth index, and exposure to newspapers, were statistically significantly associated with a fixed place for handwashing. Women whose husbands had an education level of the SLC or higher had higher odds (AOR=2.15; 95% CI: 1.44-3.20) of having a fixed place for handwashing compared with women whose husbands had no education. Respondents in the middle and rich wealth index categories had higher odds (AOR=1.38; 95% CI: 1.05-1.82 and AOR=2.54; 95% CI: 1.83-3.53, respectively) of having a fixed place for handwashing compared with those in the poor category. Mothers who read a newspaper at least once a week were slightly more likely to have a fixed place for handwashing (AOR=1.39; 95% CI: 1.01-1.91) with a p-value of $<0.05$, compared with those who were not exposed to newspapers. However, exposure to radio, and exposure to television, were not associated with a fixed place for handwashing.

Mothers from urban areas had higher odds (AOR=1.58; 95% CI: 1.11-2.24) of having a fixed place for handwashing compared with rural mothers. Mothers from the mountains regions had lower odds (AOR=0.44; 95% CI: 0.22-0.88) of having a fixed place for handwashing compared with those from the plains regions. Mothers from Province 2 had lower odds (AOR=0.47; 95% CI: 0.26-0.86), while Provinces 3, 4 and 7 had higher odds (AOR=1.83; 95% CI: 0.95-3.53, AOR=3.18; 95% CI: 1.59-6.35, and AOR=2.29; 95%CI: 1.22-4.31, respectively) of having a fixed place for handwashing compared with mothers from Province 1. Mothers who resided further than a 30-minute walk from a water source were less likely (AOR=0.55; 95% CI: 0.39-0.78) to have a fixed place for handwashing compared with mothers residing within a 30-minute walk from a water source (). However, access to a community HMG was not found to be associated with mothers having a fixed place for handwashing.

**Table 6.4: Multi-level analysis of individual, family and community factors associated with a fixed place for handwashing**

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **INDIVIDUAL-LEVEL FACTORS** | | | | | | |
| **Age of the mother (in years)** | | | | | | |
| 15–24 | 1 | 1 | | | 1 | |
| 25–34 | 1.02(0.84-1.23) | 1.09(0.90-1.32) | | | 1.07(0.88-1.31) | 0.484 |
| 35 and above | 0.75(0.56-1.01) | 0.99(0.71-1.36) | | | 1.07(0.76-1.50) | 0.693 |
| **Education of the mother** | | | | | | |
| No education | 1 | 1 | | | 1 | |
| Primary | 1.48(1.16-1.89) | 1.48(1.18-1.87) | | | 1.27(0.99-1.63) | 0.062 |
| Secondary | 2.71(2.10-3.50) | 2.32(1.82-2.96) | | | 1.52(1.14-2.01) | 0.004 |
| SLC or higher | 6.44(4.18-9.92) | 4.45(3.07-6.45) | | | 1.98(1.27-3.11) | 0.003 |
| **Occupation of the mother** | | | | | | |
| No work | 1 | 1 | | | 1 | |
| Agriculture | 0.84(0.64-1.11) | 0.88(0.71-1.09) | | | 1.08(0.85-1.36) | 0.530 |
| Non agriculture | 1.65(1.09-2.49) | 1.08(0.80-1.48) | | | 1.03(0.74-1.44) | 0.855 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **Caste/Ethnicity** | | | | | | |
| Brahmin/Chhetri | 1 | 1 | | | 1 | |
| Janajati/Vaishya | 1.16(0.85-1.58) | 1.42(1.05-1.91) | | | 1.45(1.05-2.00) | 0.025 |
| Scheduled | 0.53(0.38-0.75) | 0.74(0.54-0.99) | | | 0.92(0.66-1.27) | 0.606 |
| Other | 0.60(0.40-0.91) | 1.04(0.73-1.49) | | | 1.24(0.82-1.87) | 0.301 |
| **Religion** | | | | | | |
| Hindu | 1 | 1 | | | 1 | 0.824 |
| Non-Hindu | 1.20(0.82-1.74) | 0.91(0.64-1.29) | | | 0.96(0.66-1.39) | |
| **FAMILY- LEVEL FACTORS** | | | | | | |
| **Education of the husband** | | | | | | |
| No education | 1 | | 1 | | 1 | |
| Primary | 1.52(1.12-2.06) | | 1.28(0.99-1.67) | | 1.22(0.92-1.61) | 0.162 |
| Secondary | 2.14(1.57-2.90) | | 1.48(1.12-1.87) | | 1.25(0.94-1.65) | 0.120 |
| SLC or higher | 4.60(3.10-6.85) | | 2.59 (1.82-3.68) | | 2.15(1.44-3.20) | <0.001 |
| **Wealth index** | | | | | | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Poor | 1 | | 1 | | 1 | |
| Middle | 1.19(0.89-1.60) | | 1.43(1.11-1.85) | | 1.38(1.05-1.82) | 0.022 |
| Rich | 3.32(2.41-4.59) | | 3.20(2.38-4.31) | | 2.54(1.83-3.53) | <0.001 |
| **Exposure to newspapers** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 3.93(2.83-5.45) | | 1.67(1.25-2.23) | | 1.39(1.01-1.91) | 0.044 |
| **Exposure to radio** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 1.36(1.10-1.69) | | 0.98(0.80-1.20) | | 0.89(0.72-1.11) | 0.304 |
| **Exposure to television** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 2.14(1.71-2.69) | | 1.25(1.02-1.54) | | 1.10(0.89-1.37) | 0.383 |
| **COMMUNITY-LEVEL FACTORS** | | | | | | |
| **Place of residence** | | | | | | |
| Rural | 1 | | | 1 | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Urban | 2.14(1.55-2.95) | | | 2.26(1.61-3.18) | 1.58(1.11-2.24) | 0.011 |
| **Ecological zone** | | | | | | |
| Plains | 1 | | | 1 | 1 | |
| Hills | 1.41(1.03-1.93) | | | 0.58(0.36-0.94) | 0.76(0.47-1.26) | 0.296 |
| Mountains | 0.63(0.40-0.99) | | | 0.31(0.16-0.61) | 0.44(0.22-0.88) | 0.021 |
| **Provinces** | | | | | | |
| 1 | 1 | | | 1 | 1 | |
| 2 | 0.52(0.33-0.83) | | | 0.33(0.19-0.60) | 0.47(0.26-0.86) | 0.015 |
| 3 | 1.81(1.17-2.82) | | | 2.19(1.14-4.20) | 1.83(0.95-3.53) | 0.073 |
| 4 | 2.81(1.69-4.68) | | | 3.58(1.79-7.17) | 3.17(1.59-6.35) | 0.001 |
| 5 | 1.35(0.82-2.23) | | | 1.35(0.75-2.44) | 1.49(0.82-2.71) | 0.187 |
| 6 | 0.53(0.33-0.87) | | | 0.83(0.44-1.54) | 1.08(0.57-2.02) | 0.818 |
| 7 | 1.03(0.61-1.76) | | | 1.69(0.91-3.14) | 2.29(1.22-4.31) | 0.010 |
| **Distance to water source** | | | | | | |
| ≤30 minutes | 1 | | | 1 | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| >30 minutes | 0.40(0.30-0.53) | | | 0.45(0.32-0.63) | 0.55(0.39-0.78) | 0.010 |
| **Health Mothers' Group** | | | | | | |
| No | 1 | | | 1 | 1 | |
| Yes | 1.00(0.75-1.33) | | | 1.00(0.81-1.25) | 0.96(0.76-1.20) | 0.696 |
| Do not know | 1.80(1.24-2.63) | | | 1.19(0.87-1.63) | 1.21(0.87-1.67) | 0.257 |

#### 6.4.3.4 Results of individual, family, and community factors related to the availability of soap and water

The education, and occupation of mothers, were significantly related to the availability of soap and water in the handwashing place. The secondary and SLC or above level of education of mothers were associated with greater availability of soap and water in handwashing places (Table 6.5). Mothers involved in non-agricultural activities had higher odds (AOR=1.31; 95% CI: 1.00-1.71) of availability of soap and water in the handwashing place compared with mothers who did not work.

The education of husbands, household wealth index, exposure to newspaper and television at household level were significantly related to the availability of soap and water in the handwashing place. Mothers in the middle and high household wealth index levels had higher odds (AOR=1.55; 95% CI: 1.21-2.00 and AOR=4.12; 95% CI: 3.10-5.47, respectively) of having both soap and water available at the handwashing place relative to mothers in the poor household wealth index category. Mothers who read newspapers and mothers who watched television at least once a week had higher odds (AOR=1.27; 95% CI: 1.00-1.61 and AOR=1.68; 95% CI: 1.37-2.06, respectively) of having both soap and water at the place of handwashing compared with mothers who were not exposed to mass media (Table 6.5).

Except for access to an HMG, community-level factors were found to be associated with the availability of soap and water at the place of handwashing. Mothers residing in urban areas had higher odds (AOR=1.78; 95% CI: 1.29-2.44) of having soap and water available at the place of handwashing compared with rural mothers, while mothers from the mountains regions had lower odds (AOR=0.50; 95% CI: 0.26-0.99) of having soap and water available at the place of handwashing compared with mothers from the plains regions. Mothers from Province 7 had higher odds (AOR=2.06; 95% CI: 1.17-3.62) of available soap and water at the place of handwashing compared with those from Province 1. Mothers who resided in households further than 30 minutes walking distance from a water source were less likely (AOR=0.53; 95% CI: 0.35-0.78) to have soap and water available at the place of handwashing compared with mothers within 30 minutes walking distance from their home.

**Table 6.5: Multi-level analysis of individual, family and community factors associated with the availability of soap and water**

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **INDIVIDUAL-LEVEL FACTORS** | | | | | | |
| **Age of the mother (in years)** | | | | | | |
| 15–24 | 1 | 1 | | | 1 | |
| 25–34 | 1.23(1.00-1.51) | 1.22(1.03-1.44) | | | 1.13(0.95-1.35) | 0.177 |
| 35 and above | 0.71(0.53-0.95) | 0.88(0.64-1.21) | | | 0.85(0.61-1.20) | 0.368 |
| **Education of the mother** | | | | | | |
| No education | 1 | 1 | | | 1 | |
| Primary | 1.39(1.09-1.79) | 1.38(1.09-1.74) | | | 1.15(0.89-1.48) | 0.288 |
| Secondary | 3.65(2.87-4.64) | 2.69(2.15-3.36) | | | 1.57(1.20-2.04) | 0.001 |
| SLC or higher | 8.65(6.27-11.94) | 5.21(3.91-6.93) | | | 2.40(1.67-3.45) | <0.001 |
| **Occupation of the mother** | | | | | | |
| No work | 1 | 1 | | | 1 | |
| Agriculture | 0.62(0.49-0.79) | 0.63(0.52-0.76) | | | 0.88(0.71-1.09) | 0.249 |
| Non agriculture | 2.18(1.68-2.82) | 1.36(1.06-1.73) | | | 1.31(1.00-1.71) | 0.051 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **Caste/Ethnicity** | | | | | | |
| Brahmin/Chhetri | 1 | 1 | | | 1 | |
| Janajati/Vaishya | 0.91(0.69-1.20) | 1.09(0.86-1.39) | | | 1.27(0.98-1.65) | 0.075 |
| Scheduled | 0.43(0.32-0.58) | 0.70(0.52-0.92) | | | 0.99(0.73-1.34) | 0.941 |
| Other | 0.50(0.32-0.78) | 1.08(0.78-1.51) | | | 1.08(0.74-1.59) | 0.694 |
| **Religion** | | | | | | |
| Hindu | 1 | 1 | | | 1 | |
| Non-Hindu | 1.09(0.76-1.57) | 1.13(0.85-1.52) | | | 1.12(0.82-1.52) | 0.491 |
| **FAMILY-LEVEL FACTORS** | | | | | | |
| **Education of the husband** | | | | | | |
| No education | 1 | | 1 | | 1 | |
| Primary | 1.51(1.10-2.06) | | 1.21(0.91-1.62) | | 1.20(0.88-1.63) | 0.255 |
| Secondary | 3.00(2.16-4.14) | | 1.62(1.25-2.12) | | 1.45(1.08-1.95) | 0.014 |
| SLC or higher | 6.20(4.44-8.65) | | 2.72(1.97-3.76) | | 2.17(1.50-3.15) | <0.001 |
| **Wealth index** | | | | | | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Poor | 1 | | 1 | | 1 | |
| Middle | 1.16(0.87-1.55) | | 1.74(1.37-2.21) | | 1.55(1.21-2.00) | 0.001 |
| Rich | 4.91(3.77-6.40) | | 5.33(4.13-6.88) | | 4.12(3.10-5.47) | <0.001 |
| **Exposure to newspapers** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 4.17(3.34-5.22) | | 1.63(1.31-2.02) | | 1.27(1.00-1.61) | 0.051 |
| **Exposure to radio** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 1.36(1.07-1.71) | | 0.93(0.78-1.12) | | 0.83(0.68-1.01) | 0.0.067 |
| **Exposure to television** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 3.93(3.20-4.83) | | 1.88(1.55-2.29) | | 1.68(1.37-2.06) | <0.001 |
| **COMMUNITY-LEVEL FACTORS** | | | | | | |
| **Place of residence** | | | | | | |
| Rural | 1 | | | 1 | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Urban | 3.18(2.30-4.39) | | | 3.67(2.68-5.06) | 1.78(1.29-2.44) | <0.001 |
| **Ecological zone** | | | | | | |
| Plains | 1 | | | 1 | 1 | |
| Hills | 1.50(1.08-2.07) | | | 0.84(0.54-1.31) | 1.31(0.84-2.06) | 0.234 |
| Mountains | 0.59(0.34-1.03) | | | 0.29(0.15-0.57) | 0.50(0.26-0.99) | 0.047 |
| **Provinces** | | | | | | |
| 1 | 1 | | | 1 | 1 | |
| 2 | 0.55(0.34-0.90) | | | 0.43(0.24-0.76) | 0.65(0.36-1.16) | 0.143 |
| 3 | 1.92(1.15-3.22) | | | 2.12(1.16-3.90) | 1.36(0.74-2.48) | 0.319 |
| 4 | 1.36(0.91-2.02) | | | 1.19(0.65-2.18) | 0.91(0.50-1.65) | 0.752 |
| 5 | 0.76(0.46-1.23) | | | 0.83(0.47-1.44) | 0.83(0.48-1.42) | 0.489 |
| 6 | 0.37(0.23-0.59) | | | 0.45(0.24-0.84) | 0.64(0.35-1.18) | 0.154 |
| 7 | 1.00(0.62-1.62) | | | 1.23(0.70-2.18) | 2.06(1.17-3.62) | 0.012 |
| **Distance to water source** | | | | | | |
| ≤30 minutes | 1 | | | 1 | 1 | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual-family-and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| >30 minutes | 0.40(0.26-0.61) | | | 0.39(0.26-0.56) | 0.53(0.35-0.78) | 0.002 |
| **Health Mothers' Group** | | | | | | |
| No | 1 | | | 1 | 1 | |
| Yes | 0.97(0.76-1.22) | | | 1.10(0.90-1.34) | 0.97(0.79-1.21) | 0.810 |
| Do not know | 1.81(1.35-2.42) | | | 1.23(0.96-1.59) | 1.11(0.85-1.47) | 0.440 |

#### 6.4.3.5 Results of individual, family, and community-level factors related to combined WASH

The age, education, caste or ethnicity of mothers were each significantly associated with combined WASH facilities at household level. Compared with mothers aged 15–24 years, mothers aged 25–34 years were more likely to have combined WASH services (AOR=1.21; 95% CI: 1.00-1.46). Mothers who obtained secondary education and mothers who obtained an SLC or higher level of education had higher odds (AOR=1.48; 95% CI: 1.12-1.96 and AOR=2.12; 95% CI: 1.48-3.08, respectively) of having combined WASH compared with mothers who had no education. Mothers identifying as Janajati and Vaishya castes had higher odds (AOR=1.47; 95% CI: 1.12-1.92) of having combined WASH compared with those identifying as Brahmin and Chhetri castes.

Family factors such as education of husband, wealth index and exposure to television were significantly associated with combined WASH for mothers at home (Table 6.6). Mothers whose husbands had no education were less likely to have access to combined WASH than mothers whose husbands had at least a low level of education. Mothers in the household rich wealth index had six-fold higher odds of combined WASH (AOR=6.29; 95% CI: 4.63-8.54) compared with those in the poor wealth index. Also, mothers in the household middle wealth index had two-fold higher odds of combined WASH (AOR=2.12; 95% CI: 1.61-2.79) compared with those in the poor wealth index. Mothers who had exposure to television at home had higher odds (AOR=1.75; 95% CI: 1.41-2.19) of having combined WASH than mothers without exposure to television.

Community factors such as place of residence, ecological zone, province, and distance to a water source were significantly associated with combined WASH. Mothers who lived in urban areas were 1.95 times more likely (AOR=1.95; 95% CI: 1.39-2.73) to have combined WASH compared with mothers residing in rural areas. Mothers residing in the hills regions had higher odds (AOR=1.67; 95% CI: 1.04-2.67) of having combined WASH compared with mothers in the plains regions. Mothers from Province 2 had lower odds (AOR=0.51; 95% CI: 0.27-0.94) and mothers from Province 7 had higher odds (AOR=1.99; 95% CI: 1.11-3.59) of having combined WASH compared with mothers from Province 1. Mothers who had to walk further than 30 minutes to reach a water source from home had lower odds (AOR=0.36; 95% CI: 0.22-0.58) of having combined WASH compared with mothers who lived 30 minutes or less from a water source.

However, individual factors (occupation and religion), family factors (exposure to newspaper and radio) and community factors (health mother group) were not significantly associated with combined WASH.

**Table 6.6: Multi-level analysis of individual, family and community factors associated with combined WASH**

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **INDIVIDUAL-LEVEL FACTORS** | | | | | | |
| **Age of the mother (in years)** | | | | | | |
| 15-24 | 1 | 1 | | | 1 | |
| 25–34 | 1.49(1.15-1.73) | 1.46(1.23-1.73) | | | 1.21(1.00-1.46) | 0.050 |
| 35 and above | 0.88(0.65-1.20) | 1.08(0.78-1.50) | | | 0.89(0.62-1.29) | 0.551 |
| **Education of the mother** | | | | | | |
| No education | 1 | 1 | | | 1 | |
| Primary | 1.51(1.14-1.99) | 1.41(1.10-1.81) | | | 1.06(0.81-1.40) | 0.663 |
| Secondary | 3.89(3.03-5.01) | 2.80(2.22-3.54) | | | 1.48(1.12-1.96) | 0.006 |
| SLC or higher | 8.19(5.94-11.32) | 4.51(3.39-6.01) | | | 2.12(1.46-3.08) | <0.001 |
| **Occupation of the mother** | | | | | | |
| No work | 1 | 1 | | | 1 | |
| Agriculture | 0.69(0.54-0.88) | 0.71(0.58-0.87) | | | 0.91(0.72-1.14) | 0.407 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Non agriculture | 2.14(1.66-2.75) | 1.36(1.07-1.73) | | | 1.15(0.87-1.52) | 0.327 |
| **Caste/Ethnicity** | | | | | | |
| Brahmin/Chhetri | 1 | 1 | | | 1 | |
| Janajati/Vaishya | 0.87(0.66-1.15) | 1.13(0.89-1.43) | | | 1.47(1.12-1.92) | 0.006 |
| Scheduled | 0.46(0.34-0.64) | 0.83(0.62-1.11) | | | 1.23(0.89-1.70) | 0.203 |
| Other | 0.37(0.23-0.60) | 0.85(0.60-1.19) | | | 0.99(0.66-1.49) | 0.954 |
| **Religion** | | | | | | |
| Hindu | 1 | 1 | | | | |
| Non-Hindu | 1.06(0.73-1.54) | 0.99(0.75-1.34) | | | 0.98(0.71-1.36) | 0.909 |
| **FAMILY-LEVEL FACTORS** | | | | | | |
| **Education of husband** | | | | | | |
| No education | 1 | | 1 | 1 | 1 | |
| Primary | 2.28(1.54-3.36) | | 1.64(1.18-2.28) | | 1.49(1.05-2.11) | 0.025 |
| Secondary | 4.66(3.18-6.83) | | 2.09(1.54-2.85) | | 1.86(1.33-2.59) | <0.001 |
| SLC or higher | 8.94(6.03-13.26) | | 3.02(2.12-4.30) | | 3.01(2.00-4.50) | <0.001 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **Wealth index** | | | | | | |
| Poor | 1 | | 1 | | 1 | |
| Middle | 1.23(0.91-1.67) | | 2.17(1.68-2.80) | | 2.12(1.61-2.79) | <0.001 |
| Rich | 5.50(4.24-7.13) | | 6.38(4.90-8.32) | | 6.29(4.63-8.54) | <0.001 |
| **Exposure to newspapers** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 4.11(3.29-5.14) | | 1.43(1.15-1.77) | | 1.14(0.90-1.46) | 0.279 |
| **Exposure to radio** | | | | | | |
| No exposure | 1 | 1 | 1 | | 1 | |
| Exposure | 1.51(1.20-1.92) | | 1.03(0.85-1.24) | | 1.02(0.83-1.26) | 0.838 |
| **Exposure to television** | | | | | | |
| No exposure | 1 | | 1 | | 1 | |
| Exposure | 3.93(3.15-4.89) | | 1.71(1.39-2.11) | | 1.75(1.41-2.19) | <0.001 |
| **COMMUNITY-LEVEL FACTORS** | | | | | | |
| **Place of residence** | | | | | | |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| Rural | 1 | | | 1 | 1 | |
| Urban | 3.35(2.48-4.52) | | | 4.37(3.11-6.13) | 1.95(1.39-2.73) | <0.001 |
| **Ecological zone** | | | | | | |
| Plains | 1 | | | 1 | 1 | |
| Hills | 1.66(1.23-2.23) | | | 0.97(0.60-1.56) | 1.67(1.04-2.67) | 0.033 |
| Mountains | 0.71(0.42-1.21) | | | 0.40(0.19-0.83) | 0.86(0.42-1.74) | 0.672 |
| **Provinces** | | | | | | |
| 1 | 1 | | | 1 | 1 | |
| 2 | 0.43(0.25-0.72) | | | 0.32(0.17-0.59) | 0.51(0.27-0.94) | 0.032 |
| 3 | 1.86(1.19-2.90) | | | 2.04(1.07-3.87) | 1.25(0.67-2.33) | 0.490 |
| 4 | 1.40(0.95-2.06) | | | 1.23(0.65-2.35) | 0.90(0.48-1.68) | 0.733 |
| 5 | 0.90(0.55-1.45) | | | 1.00(0.56-1.81) | 1.01(0.57-1.78) | 0.973 |
| 6 | 0.35(0.22-0.58) | | | 0.36(0.18-0.70) | 0.53(0.27-1.01) | 0.055 |
| 7 | 1.06(0.66-1.69) | | | 1.14(0.62-2.07) | 1.99(1.11-3.59) | 0.022 |

| Variables | Bivariate analysis | Individual-level (Model 1) | Family-level (Model 2) | Community-level (Model 3) | Individual, family and community-level (Model 4) | P-value (Model 4) |
|---|---|---|---|---|---|---|
| **Distance to water source** | | | | | | |
| ≤30 minutes | 1 | | | 1 | 1 | |
| >30 minutes | 0.21(0.11-0.40) | | | 0.26(0.17-0.41) | 0.36(0.22-0.58) | <0.001 |
| **Health Mothers' Group** | | | | | | |
| No | 1 | | | 1 | 1 | |
| Yes | 1.03(0.81-1.31) | | | 1.17(0.95-1.43) | 1.01(0.81-1.27) | 0.903 |
| Do not know | 1.65(1.25-2.17) | | | 1.24(0.95-1.61) | 1.11(0.83-1.48) | 0.488 |

## 6.5 Discussion

This is the first known study involving a multi-level analysis of household WASH facilities in Nepal. This study identified a number of factors which have significant effects on access to an improved water source, a sanitary toilet, a fixed place for handwashing, and availability of soap and water in the handwashing place, as well as access to the combination of these components, termed ‘combined WASH’, at the household level. The aim of this study was to identify the individual, family and community factors associated with households’ WASH facilities in Nepal. A multi-level hierarchical regression model was appropriate in this study, as the data were organised at more than one level (i.e. individual-, family-, and community- levels) [365].

### 6.5.1 Individual-level factors and WASH components

In this study, mothers’ age was found to be associated with having access to a sanitary toilet and combined WASH facilities, a finding which is supported by a previous study conducted in the hills district of Tanahun, Nepal, in 2016, where being aged 30–40 years had a positive association with having access to improved sanitation [366].

This study showed that mothers with at least a basic level of education had a greater understanding of the benefits of having a sanitary toilet, establishing a fixed place for handwashing, having soap and water available for handwashing, and having access to combined WASH facilities at households compared with mothers with no education. These findings are supported by evidence-based literature on developing countries, such as studies conducted in the South Asian Region, including Nepal [367]. The relationship between higher education and good access to sanitary toilets was observed in a previous similar study carried out in Katahari, in the Morang district of Nepal [368]. The results of the current study are also comparable with those of a previous study conducted in Ghana [369].

In the present study, the occupation of the mother in the household was significantly associated with only the outcome of availability of soap and water. In contrast, a previous study conducted in India showed mothers' occupation was significantly associated with all WASH components [370]. The difference in these results may be due to sample size, socio-demographic status, and/or contextual factors. A qualitative study conducted in Indonesia among women in 2019 supports the theory that economically secure women have decision-making power and networking, which can facilitate better access to improved WASH [371].

Mothers of the Janajati and Vaishya castes had a higher prevalence of having a fixed place for handwashing, and therefore greater access to combined WASH than mothers from other castes. This present study found mothers of the scheduled caste or Shudra had poor access to a sanitary toilet. This may be due to caste discrimination, which still exists in Nepalese communities. This cultural belief determines that those of the lower caste (Scheduled or Shudra) should always be dominated and treated as servants by those of the higher caste (Brahmin and Chhetri) [372]. The current study is similar to those conducted by WaterAid Nepal, which determined that Nepalese populations experience caste discrimination in relation to access to WASH services [341]. Contrary to these findings, the GoN has declared the country does not have a caste system, and that the country has become secular [373]. WaterAid's research raises issues regarding the GoN's commitment to achieving universal access to sanitation and hygiene, particularly for mothers, ethnic groups, those of lower caste, and disabled people in the country [341], all issues which support this present study's recommendation.

### 6.5.2 Family-level factors and WASH components

Family-level-factors such as husband's education, household wealth index and exposure to mass media were significantly related with both discrete and combined WASH outcomes. Mothers whose husband had attained at least a basic level of education had a positive impact on sanitary toilet and handwashing facilities including combined WASH facilities at household level. It is evident that education is crucial in improving WASH uptake at the household level, as educated family members may be more aware of the risks associated with poor WASH practices. Wealth index significantly associated with discrete and combined WASH outcomes. Mothers also experience a lack of autonomy in household WASH practices, because they have low priority for the use of these services in patriarchal rural communities of Nepal [341]. The present study is similar to a previous study conducted in Ghana in 2018 that showed households with the mother as its head demonstrated good sanitation and hygiene facilities and when mothers are the heads of households, they are more likely to be in the high wealth index and thereby improved WASH facilities [369]. Those of a lower wealth index have limited household WASH facilities, and poor living standards, and reside a long distance from water [374].

The present study found that exposure to newspapers is associated with the availability of soap and water, and a fixed place for handwashing. This may be due to those from urban areas having good access to newspapers, compared with rural dwellers. Similarly, exposure to television had a significant association with the availability of soap and water at the place of handwashing, and with combined WASH. It is possible that households with access to mass media experience further exposure to relevant information on hygiene and sanitation, potentially enabling them to seek adequate WASH services at home.

### 6.5.3 Community-level factors and WASH components

Mothers residing in urban areas had better access to all WASH services, except to an improved water source, than mothers from rural areas. The urban mothers were more likely be employed and were therefore in a higher wealth index than mothers in rural areas, and thus were more likely to have improved WASH services in the household. Urban households would be more likely to have the necessary resources to build sanitary toilets, install plumbing for water access inside the residence, and purchase soap and other cleaning and sanitary items compared to rural households. Mothers from the hills and mountains regions have significantly higher rates of access to sanitary toilet facilities than plains region. However, those in mountains regions have less access to soap and water and were less likely to have an established handwashing place in the home compared with plains region. Mothers from the hills had good availability of combined WASH. This study did not, however, find a significant association between geographical location of residence and access to an improved water source.

The distribution of WASH components by province was found to be varied, with the lowest levels of access to WASH experienced in Province 2 in the plains region. This may be due to the low level of mother's and husband's education, high poverty levels, gender discrimination, and low level of WASH provision in this province [375]. Households in Province 7 reported the highest access to a handwashing facilities with soap and water, which may be due to targeted WASH programs facilitated by government and non-government organisations, such as the Rural Village Water Resources Management Project, with technical support from the Finnish Government in this Province [110]. This results is supported by the Vietnam WASH services, where handwashing rate greatly improved [376] after the success of a pilot project which was due to the commitment of the Government of Vietnam, with the support of the Danish Government.

The community WASH management approach, through collective initiatives, strong local, provincial and federal governmental leadership, and institutional transparencies are required to make effective and sustainable WASH facilities in Nepal [377]. The current evidence can support policy makers to develop annual WASH programs and to advocate for budgeting by the Ministry of Health and Population Nepal.

Regarding the prevalence of an improved water source, sanitary toilets, and handwashing with soap facilities, the findings of this study are consistent with those of several previous studies [1, [71, 143]. People from rural areas, those who live a longer distance from a water source, and those who live in the plains region had poorer WASH access than those who lived in the hills region and urban areas.

The main findings of this study were that wealth index, ecology and distance to water source were significantly related to discrete and combined WASH facilities and education of mothers and their husbands, place of residence, and provinces were significantly associated with discrete and combined WASH except improved water sources in Nepal. The HMG is effective only for encouraging households to have sanitary toilets based on the result of it has 1.52 times higher chance of having sanitary toilet.

This study demonstrated the need for a multi-level approach to understanding WASH in Nepal, which takes account of individual-, family-, community-, and policy- level factors. While policy-level factors were not analysed in this study, as they were unavailable in the NDHS 2016 dataset, these findings have identified the need for context-specific policy to enable effective strategies for the promotion of WASH services in Nepal. Further research is required to determine the relationships between individual WASH components and combined WASH, and communicable diseases in Nepal (undertaken in Chapter 7). Additionally, geopolitically based surveys should be conducted in relation to the political structure of Nepal, for example, by conducting surveys in schools, colleges, health facilities, and public and private organisations, in line with SDG–6 targets related to WASH and beyond. This would provide a more comprehensive understanding of WASH.

## 6.6 Strengths and limitations

This study used the 2016 NDHS data which had a large sample size, as data were collected from 383 clusters from 14 rural and urban strata, which representative of all regions of Nepal. Respondents were selected from households using a systematic random selection procedure, which helps to reduce selection bias [378]. This study applied multi-level modelling which was more appropriate than classical logistic regression, as it helps with data reduction [378]. This study applied multi-level logistic analysis which allowed an understanding of the roles of individual-, family-, and community- level factors associated with WASH. The policy makers can consider an individual- family-, and community-level factors during the policy formulation process. Furthermore, this study considered discrete and combined WASH outcomes to provide further insight into each study outcome.

Despite the strengths of this study, some limitations have been identified. The NDHS data used in this study did not include responses from every mother in Nepal. The survey data are cross-sectional; therefore, causal inferences cannot be made about potential relationships between explanatory variables and WASH. This study excluded some potential participants such as De Facto residences, who were excluded from participating in the NDHS, and mothers with children over the age of five, and this may have affected the study results.

## 6.7 Conclusions

This study found that individual-, family-, and community-level factors had mixed effects on households' access to individual WASH components and to combined WASH services. Higher education levels of mothers, as well as their husbands, and a high household wealth index had significant positive associations with each component of WASH access. The age of the mother was significantly associated with access to a sanitary toilet and combined WASH. The occupation of the mother had a significant association with the availability of soap and water. Caste or ethnicity was significantly related to the level of access to a sanitary toilet, a fixed place for handwashing, and combined WASH. Exposure to newspapers and exposure to television were significantly associated with a fixed place for handwashing, available soap and water, and combined WASH. This study showed that wealth index, ecology, and distance to a water source were significantly associated with discrete WASH facilities and combined WASH facilities. Access to an HMG was significantly associated only with sanitary toilets in Nepal.

Further research is needed to assess the health effects of each individual WASH component on children, mothers, and other family members in Nepal. Tangible indicators for scientific measurement of each component of WASH are also needed. This could be through the observation of household activity, to accurately measure the prevalence of WASH access and practice by household mothers with children under five years. Critical evaluation of individual, family-, and community factors would provide understanding of their influence on actual use of WASH facilities.

Factors affecting WASH services were identified in this study. Geography, economic status, and level of education were important factors in access to a sanitary toilet, a fixed place for handwashing, the availability of soap and water, and combined WASH services. This supports the need to address the existing disparities in socioeconomic status, autonomy in the home, and level of education. The actions taken by both the health and other sectors may be instrumental in improving the quality of WASH services. Promotion of WASH practices, is required at all levels of the community. The outcome of this study advocates for the prioritisation of WASH programs for households considering individual-, family/household-, and community factors.

# Chapter 7. Effects of Household Water, Sanitation and Hygiene Facilities on Diarrhoea and Malnutrition among Children Under Five Years in Nepal

## 7.1 Foreword

The previous chapters have shown that handwashing rates varied in Nepal and factors such as availability of soap, water and a fixed place for handwashing enabled people to form hygienic handwashing habits (Chapter 4). The low level of education of household heads, and their marital status, wealth index, place of residence and distance to water sources were associated with an improved water source, sanitary toilets and handwashing facilities. Province 2 and 6 had clusters of unsanitary toilets facilities and unimproved water sources, respectively (Chapter 5) and an individual-, the family-, and the community-level factors had mixed effects on households' access to discrete water, sanitation and hygiene (WASH) and to combined WASH facilities in Nepal (Chapter 6). This chapter brings that information to bear on the outcomes of having limited or no access to improved water sources, sanitary toileting, and facilities for handwashing with soap. Diarrhoea is a major public health problem and ranks in the top ten diseases, according to the Health Management Information System (HMIS) of Nepal [52]. Approximately 50% of diarrhoeal diseases occur among children who are malnourished [41, 42], and frequent episodes of diarrhoea among children under five years can cause malnutrition [379]. The main risks factors for diarrhoeal diseases are poor access to and use of WASH by family members and carers at the household level [175, 380-382]. Improved WASH may reduce the burden of disease by as much as 10% [42]. The objective addressed in this chapter is to assess the effects of households' WASH facilities on diarrhoea and malnutrition among children under five years in Nepal.

## 7.2 Introduction

Diarrhoea is one of the leading causes of morbidity and mortality among children under five years worldwide [23]. The World Health Organization (WHO) estimates that approximately 1.7 billion children experience diarrhoea each year worldwide [383], and of these, 533,768 cases (a rate of 78 per 100,000 children) resulted in death in 2017 [384]. Severe episodes of diarrhoea among children under five years are at an unexpectedly high rate in the South East Asia Region (SEAR) (with a rate of 26%), and approximately 50% of child deaths due to diarrhoeal diseases occur in sub-Saharan Africa (SSA) [385]. The global mortality rate related to diarrhoea is 27% among children under five years, with approximately 90% of diarrhoeal deaths occurring in the SEAR and SSA in 2016 [23].

Nepal is one of the most diarrhoea risk-prone countries in the world [57]. Diarrhoea is ranked as the second highest in disease burden, and 38.5% of children under five years were infected in 2018 in Nepal [52]. Identified determinants of diarrhoea in Nepal are demographic, socio-cultural, economic, and environmental factors, as well as the inadequacy of health care services [175]. Children aged between 6 and 23 months in Kathmandu's Children's Hospital have a higher risk of diarrhoea (78%) compared with older children in the same hospital [386]. Female children from poor households experience episodes of diarrhoea at a higher frequency than male children [387, 388]. Inadequate breastfeeding practices lead to a higher risk of infants' contracting diarrhoea, while malnourished children are also more susceptible [389]. Mothers with a higher level of education are more aware of effective measures to prevent diarrhoea [390]. Cultural beliefs, such as giving a banana to a child during an episode of diarrhoea, can increase the health risk to the child during an episode of diarrhoea and cause death due to delay in accessing professional medical treatment [390-392]. In the rural communities of Nepal, some people believe diarrhoea is caused by cold, fever, and evil spirits [175, 393]. These beliefs can have a negative health effect, as handwashing with soap may not be seen as necessary in the prevention of diarrhoea [175]. Some also believe diarrhoea may be caused by the eruption of teeth, and that diarrhoea can be cured by eating curd [394].

Households with higher or sufficient incomes are more able to utilise better WASH [395]. Diarrhoea affects children unequally, and higher rates of diarrhoea among some populations can be attributed to location of residence, poor access to WASH, being from a low-income household and/or a marginalised population, and poor access to good-quality health care services [30]. Therefore, diarrhoea remains a major public health challenge for developing countries, including Nepal, and is caused by inadequate WASH, such as not handwashing with soap [29]. Diarrhoea prevalence is linked to WASH practices of children under five years [396]. Diarrhoea can be reduced by 17% with the use of an improved water supply, 36% with the use of sanitary toilets, and 47% with the practice of handwashing with soap [207].

Malnutrition is unacceptably high and continues to be a major global public health problem affecting children under five years, particularly in developing countries, including Nepal. In 2018, the global prevalence of stunting among children under five years was 22%, wasting was 7%, and obesity was 6% [397]. Approximately 45% of child deaths for those under five years occurred due to undernutrition [398].

Factors related to child malnutrition are the child's age, sex, dietary habits, access to health care services, maternal weight, maternal education, economic status, access to WASH facilities, geographical location, and access to resources and infrastructure [399-403]. A study conducted in Nepal, Bangladesh, Pakistan and Myanmar found a significant association of malnutrition with socio-demographic factors [403]. For example, children aged 24 to 59 months had higher rates of malnutrition compared with children aged less than 24 months, and children who were not breastfed had a higher proportion of malnutrition compared with children who were breastfed. Children with mothers undertaking informal work, including as manual labourers and street vendors, had a higher risk of malnutrition compared with children of full-time workers in Nepal [404]. Inadequate WASH conditions are closely linked to childhood growth and development, but improved WASH alone does not reduce malnutrition [405].

There is strong evidence of the impact of WASH on diarrhoea prevalence; however, the impact of WASH on child malnutrition is unclear, and its relationship to mortality remains to be studied [1]. Malnutrition and diarrhoea are bidirectional and interrelated [213]. Diarrhoea can lead to malnutrition, and malnourished children have a higher risk of contracting diarrhoea and infections compared with children who have adequate WASH and adequate nutrition, and were breastfed. [406]. Approximately 50% of all deaths occur due to malnutrition [407], with the same rates of malnutrition cases as the rates of diarrhoea, as a result of unimproved WASH globally [41, 42]. Approximately 50% of under-five mortality is associated with malnutrition in Nepal [31]. An earlier study has shown households' WASH facilities are influenced by socio-demographic and other contextual factors [408], as are access to WASH, as shown in Chapter 6. Previous studies have suggested that only discrete WASH practices were associated with diarrhoea [39, 207], and nutritional status among children under five years [36, 39]. However the impact of both discrete and combined WASH facilities on diarrhoea and malnutrition remains unknown, especially after adjusting potential confounders identified using Directed Acyclic Graphs (DAG) technique [248]. These WASH components were independently associated with diarrhoea and malnutrition which lacks adjusting combined WASH components could lacking study findings. Therefore, it is required to study updated scientific study about household WASH facilities and diarrhoea and malnutrition in Nepal. The objective of this study was to assess the effects of household WASH facilities on diarrhoea and malnutrition among children under five years in Nepal.

## 7.3 Methods

### 7.3.1 Data source and respondents

This study used the 2016 Nepal Demographic and Health Survey (NDHS), which provided a detailed overview of mothers' and children's health as well as their household characteristics. The identified study variables were taken from the children's recode (KR) file, and additionally, WASH variables from the household recode (HR) file were merged into the KR file. The respondents were the household heads, mostly males, as well as usual resident mothers, aged 15–49 years, with a child under five years.

### 7.3.2 Inclusion and exclusion criteria

Interviews were conducted with mothers aged 15–49 years who had at least one child under five years of age. Children who were physically present during the survey and who had their height and weight measured at the time were included in this study. The exposure variables related to WASH were obtained from household heads during NDHS. The youngest child of each mother was included in this analysis. Once data concerned with deceased children were excluded, the weighted sample for this study was 4,887 children. Data about children were excluded if their mothers were visiting another household on the day of the survey, if their mother did not know if there had been a diarrhoea episode in the previous two weeks or if they were not weighed or measured. Data from children where values for height (n=2,524) and value for weight (n=2,517) were missing and excluded from the analysis the data for stunting and underweight outcomes. Data from children with missing height and/or weight (n=2,527) were excluded from the analysis for wasting outcomes. Data that were flagged due to unknown dates of birth and/or implausible measurements[7] were also excluded.

### 7.3.3 Outcome variables

The outcome variables of this study were diarrhoea and malnutrition among children under five years. The diarrhoea outcome was measured if mothers reported children passing watery stool more than twice in 24 hours in the two weeks prior to the day of survey.

Malnutrition was measured as stunting (height for age), wasting (weight for age), and underweight (weight for height). Z-scores were applied to measure these outcomes, with the cut-off point of SD/z-score <-2. The levels by which malnutrition was calculated were based on the World Health Organization (WHO) Global Database on Child Growth and Malnutrition criteria [297]: stunting (height for age if < -2 SD of the WHO Child Growth Standards median), wasting (weight for height if < -2 SD of the WHO Child Growth Standards median), and underweight (weight for age if < -2 SD of the WHO Child Growth Standards median) [298]. Both diarrhoea and malnutrition outcomes were scored dichotomously.

### 7.3.4 Exposure variables

Potential exposure variables for this study included source of water (improved or unimproved), type of toilet facilities (sanitary or unsanitary), status of handwashing place (fixed place or not fixed/mobile place), availability of soap and water (available or not available), and combined WASH (available or not available) facilities at households level. All discrete and combined WASH variables were coded dichotomously.

---

7 Children with height-for-age z-scores below -6 SD or above +6 SD, with weight-for-age z-scores below -6 SD or above +5 SD, or with weight for height z-scores below -5 SD or above +5 SD were considered as flagged.

### 7.3.5 Identification of confounders

The potential confounders for the diarrhoea outcome included age of the child, education of the mother and her husband, mother's occupation, wealth index, caste or ethnicity, breastfeeding, exposure to newspapers, exposure to radio, exposure to television, place of residence, ecology, province, distance to water source, and access to Health Mothers' Groups (HMG) in the community. These confounders were also included in the malnutrition model with the addition of mother's age. The potential variables were adjusted in the multivariate analysis, based on a significant p-value at 0.05 in the bivariate analysis, and existing statistical and research knowledge and practice. Possible confounders were identified using DAG [289]. Identified confounding variables were adjusted in the multiple logistic regression model. Minimal sufficient adjustment sets for estimating the total effect of WASH on diarrhoea and malnutrition are illustrated as the red circles in  Figure 7.1 and 7.2 below.

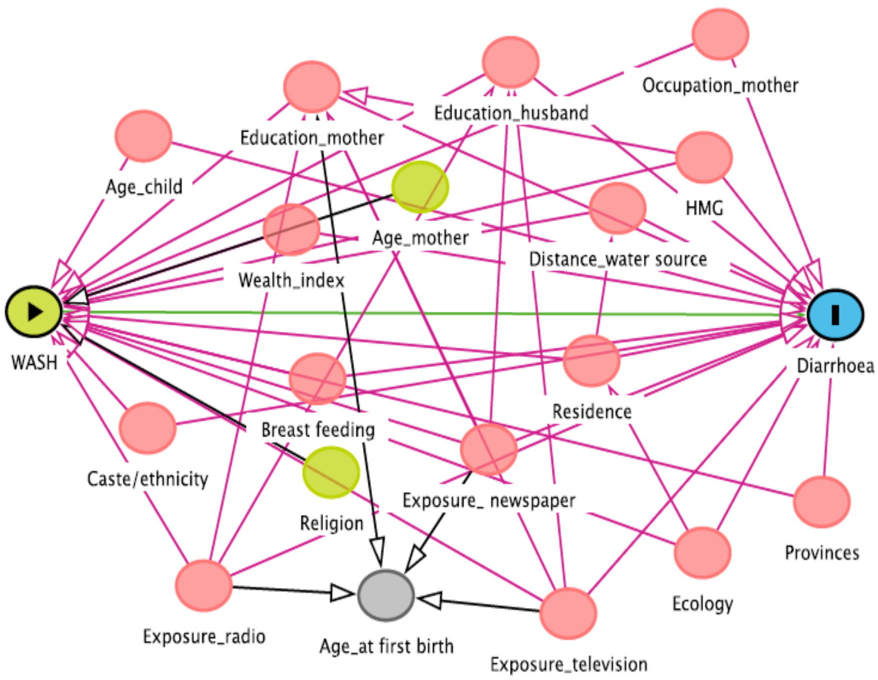



**Figure 7.1: Directed acyclic graph showing possible confounders on the diarrhoea**

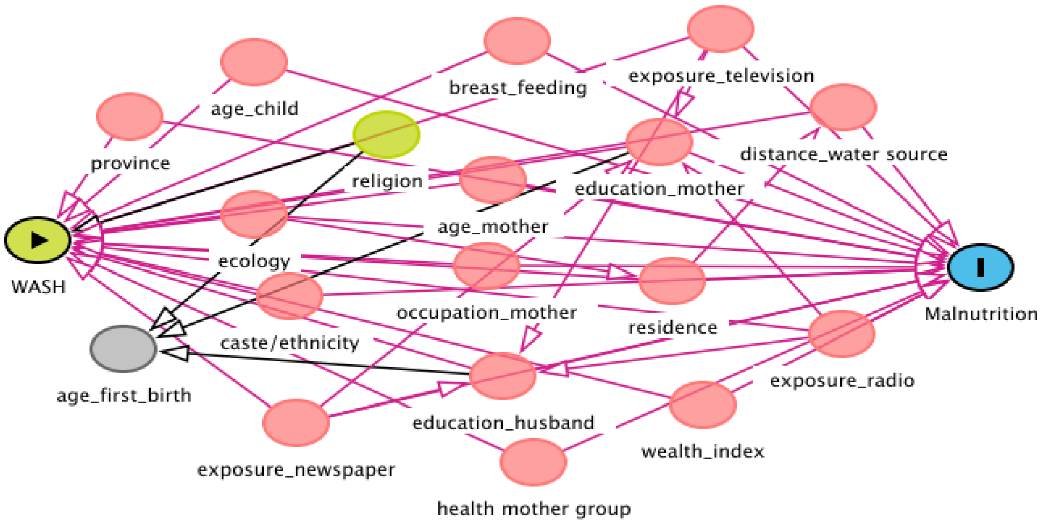



**Figure 7.2: Directed acyclic graph showing possible confounders on malnutrition**

### 7.3.6 Data analysis

Data were analysed using STATA 15 software [300]. The prevalence of diarrhoea and malnutrition were calculated by percentage through univariate analysis. A weighted sample was used to analyse the data, which provided consistencies in the sample distribution by region and cluster. A bivariate analysis was performed, and after careful identification of confounding variables using DAG, adjusted odds ratios at a 95% confidence interval with a 0.05 significance level were calculated. The socio-demographic characteristics were analysed descriptively and are shown in numbers and percentages. A multivariate logistic regression analysis was performed to examine the effects of household WASH facilities on diarrhoea and malnutrition among children under five years in Nepal.

## 7.4 Results

### 7.4.1 Respondents' characteristics and the prevalence of diarrhoea among children under five years

The sample consisted of the youngest child aged under 5 years old for the mother of each sampled household. Data were analysed for 4,846 children after exclusion criteria were applied. The overall prevalence of diarrhoea in the two weeks prior to data collection among children under five years was 7.6% (Table 7.1). The percentage of the male and female children were 52.6% and 47.4% respectively. Approximately 51.3% of mothers were aged 25 to 34 years. Approximately 34.1% of mothers and 14.8% of their husbands had no education. The highest percentage of mothers in the workforce were in the agricultural profession (45.3%). The majority (42.3%) of respondents representing from household poor wealth index score. The highest prevalence of diarrhoea (8.4%) was in the children in the middle wealth index category. Approximately 85.1% of mothers identified as being Hindu, and the remainder were non-Hindu (Buddhist, Muslim, Kirat or Christian). The prevalence of diarrhoea was higher (8.2%) among children who were breastfed compared with non-breastfed children. Children of mothers who were exposed to any one form of mass media (newspapers, radio, or television) at least once a week had lower rates of diarrhoea compared with children of mothers who were not exposed. Community factors, such as place of residence, ecology and province, showed discrepancies in the rates of diarrhoea distribution. Approximately 59.2% of all children from rural residences reported diarrhoeal infections compared with 40.8% of all children from urban residences, but the prevalence of diarrhoea among children under five years was higher in urban residences (8.2%) compared with rural residences (7.3%). The highest distribution of diarrhoea among children under five years by province was seen in Province 2 (30.2%). Approximately 32.9% of mothers reported that an HMG was accessible in the community. For children who resided

>30 minutes from a water source, there was a prevalence of diarrhoea of 16.4%, whereas for those who resided ≤30 minutes from a water source, there was a prevalence of 7.1%. Household mothers who disposed of their children's stool by unsafe methods, including putting it in a ditch, the garbage, or an open space, had children with a higher rate of diarrhoea (10.1%) compared with children of mothers who used safe disposal methods, such as putting it in the toilet or burying it (6.6%).

**Table 7.1: Respondents' characteristics by the prevalence of diarrhoea among children under five years**

| Variables | Diarrhoea (n=4846)[8] | | | |
|---|---|---|---|---|
| | **No (n, %)** | **Yes (n, %)** | **Total (n, %)** | **PR (%)** |
| **Overall** | 4474 (92.3) | 372(7.6) | 4846(100) | 7.6 |
| **Age of child (in months)** | | | | |
| <12 | 919(20.6) | 116(31.0) | 1035(21.4) | 11.1 |
| 13–24 | 911(20.3) | 94(25.2) | 1005(20.7) | 9.3 |
| 25–36 | 857(19.2) | 66(17.7) | 923(19.1) | 7.1 |
| 37–48 | 892(19.9) | 55(14.9) | 947(19.5) | 5.9 |
| 49–59 | 895(20.0) | 41(11.1) | 936(19.3) | 4.4 |
| **Sex of child** | | | | |
| Male | 2350(52.5) | 196(52.9) | 2546(52.6) | 7.7 |
| Female | 2125(47.5) | 175(47.1) | 2299(47.4) | 7.6 |
| **Age of mother** | | | | |
| 15–24 | 1809(40.4) | 149(40.1) | 1958(40.4) | 7.6 |
| 25–34 | 2293(51.3) | 191(51.5) | 2485(51.3) | 7.7 |
| 35+ | 372(8.3) | 31(8.4) | 403(8.3) | 7.8 |

[8] Samples were included after excluding the data for the unknown diarrhoea status (n=41).

| Variables | Diarrhoea (n=4846)[8] | | | |
|---|---|---|---|---|
| | No (n, %) | Yes (n, %) | Total (n, %) | PR (%) |
| **Education of mother** | | | | |
| No education | 1509(33.7) | 142(38.1) | 1651(34.1) | 8.6 |
| Primary | 893(19.9) | 83(22.1) | 976(20.1) | 8.4 |
| Secondary | 1452(32.5) | 96(25.9) | 1548(31.9) | 6.2 |
| SLC or higher | 620(13.9) | 51(13.9) | 671(13.9) | 7.7 |
| **Occupation of mother** | | | | |
| No work | 1804(40.3) | 169(45.5) | 1973(40.7) | 8.6 |
| Agriculture | 2066(46.1) | 129(34.7) | 2195(45.3) | 5.9 |
| Non-agriculture | 604(13.5) | 74(19.8) | 678(14.0) | 10.9 |
| **Education of husband** | | | | |
| No education | 641(14.4) | 70(19.2) | 711(14.8) | 9.8 |
| Primary | 1012(22.8) | 83(23.0) | 1095(22.8) | 7.6 |
| Secondary | 2014(45.3) | 142(39.0) | 2156(44.8) | 6.6 |
| SLC or higher | 776(17.5) | 69(18.8) | 845(17.6) | 8.1 |
| **Wealth index** | | | | |
| Poor | 1906(42.6) | 144(38.7) | 2050(42.3) | 7.0 |
| Middle | 988(22.1) | 91(24.5) | 1079(22.3) | 8.4 |
| Rich | 1580(35.3) | 137(36.8) | 1717(35.4) | 7.9 |
| **Caste or ethnicity** | | | | |
| Brahmin | 1274(28.5) | 76(20.3) | 1350(27.9) | 5.6 |
| Janajati | 1692(37.8) | 150(40.3) | 1842(38.0) | 8.1 |
| Scheduled | 609(13.6) | 50(13.6) | 659(13.6) | 7.6 |
| Other | 899(20.1) | 96(25.8) | 995(20.5) | 9.6 |
| **Religion** | | | | |

| Variables | Diarrhoea (n=4846)[8] | | | |
|---|---|---|---|---|
| | **No (n, %)** | **Yes (n, %)** | **Total (n, %)** | **PR (%)** |
| Hindu | 3813(85.2) | 315(84.9) | 4128(85.1) | 7.6 |
| Non-Hindu | 661(14.8) | 57(15.1) | 718(14.9) | 7.8 |
| **Age at first birth** | | | | |
| ≤20 years | 2892(64.4) | 234(62.9) | 3126(64.5) | 7.4 |
| >21 years | 1582(35.6) | 138(37.1) | 1720(35.5) | 8.0 |
| **Currently breastfeeding** | | | | |
| Yes | 3408(76.1) | 306(82.5) | 3714(76.7) | 8.2 |
| No | 1066(23.8) | 65(17.5) | 1131(23.3) | 5.7 |
| **Exposure to newspapers** | | | | |
| No exposure | 3489(78.0) | 301(80.9) | 3790(78.2) | 9.8 |
| Exposure | 985(22.0) | 71(19.1) | 1056(21.8) | 6.7 |
| **Exposure to radio** | | | | |
| No exposure | 2200(49.2) | 203(54.6) | 2403(49.6) | 8.4 |
| Exposure | 2274(50.8) | 169(45.4) | 2443(50.4) | 6.9 |
| **Exposure to television** | | | | |
| No exposure | 1685(37.7) | 167(44.9) | 1852(38.2) | 9.0 |
| Exposure | 2789(62.3) | 205(55.1) | 2993(61.8) | 6.8 |
| **Place of residence** | | | | |
| Rural | 2787(62.3) | 220(59.2) | 3007(62.1) | 7.3 |
| Urban | 1687(37.7) | 152(40.8) | 1839(37.9) | 8.2 |
| **Ecological zone** | | | | |
| Plains | 2435(54.4) | 234(63) | 2669(55.0) | 8.8 |
| Hills | 1719(38.4) | 120(32.2) | 1838(38.0) | 6.5 |
| Mountains | 321(7.2) | 18(4.8) | 339(7.0) | 5.2 |

| Variables | Diarrhoea (n=4846)[8] | | | |
|---|---|---|---|---|
| | No (n, %) | Yes (n, %) | Total (n, %) | PR (%) |
| **Province** | | | | |
| 1 | 727(16.2) | 57(15.5) | 784(16.1) | 7.3 |
| 2 | 1190(26.6) | 112(30.2) | 1302(26.8) | 8.6 |
| 3 | 710(15.9) | 71(19.1) | 781(16.1) | 9.1 |
| 4 | 362(8.1) | 14(3.8) | 376(7.8) | 3.8 |
| 5 | 791(17.7) | 71(19.2) | 862(17.8) | 8.2 |
| 6 | 301(6.7) | 19(5.2) | 320(6.6) | 6.0 |
| 7 | 393(8.8) | 26(7.0) | 419(8.7) | 6.2 |
| **Health Mothers' Group (HMG)** | | | | |
| HMG not available | 2397(53.6) | 212(57.1) | 2609(53.8) | 8.1 |
| HMG available | 1486(33.2) | 109(29.4) | 1595(32.9) | 8.9 |
| Do not know | 592(13.2) | 50(13.5) | 642(13.3) | 7.8 |
| **Source of water (n=4479)[9]** | | | | |
| Improved | 3959(95.4) | 315(95.4) | 4274(95.4) | 7.3 |
| Unimproved | 190(4.6) | 15(4.6) | 205(4.6) | 7.4 |
| **Distance to water source (n=4479)[10]** | | | | |
| ≤30 minutes | 4074(98.2) | 316(95.6) | 4390(98.0) | 7.1 |
| >30 minutes | 75(1.8) | 15(4.5) | 89(2.0) | 16.4 |
| **Toilet type** | | | | |
| Sanitary | 3209(77.3) | 231(69.8) | 3440(76.8) | 6.7 |
| Unsanitary | 939(22.6) | 100(30.2) | 1039(23.2) | 9.6 |

[9] Mothers excluded (n=373) from study due to De Facto (guest) status.

[10] Mothers excluded (n=373) from study due to De Facto (guest) status.

| Variables | Diarrhoea (n=4846)[8] | | | |
|---|---|---|---|---|
| | No (n, %) | Yes (n, %) | Total (n, %) | PR (%) |
| **Child's stool disposal method (n=3081)[11]** | | | | |
| Safe | 1291(45.8) | 91(34.9) | 1382(44.9) | 6.6 |
| Unsafe | 1528(54.2) | 171(65.1) | 1699(55.1) | 10.1 |
| **Handwashing place (n=4835)[12]** | | | | |
| Fixed | 3523(78.9) | 261(70.5) | 3785(78.3) | 6.9 |
| Not fixed | 941(21.1) | 110(29.5) | 1051(21.7) | 10.4 |
| **Soap and water status (n=4835)[13]** | | | | |
| Available | 1790(40.1) | 123(33.2) | 1913(39.6) | 6.4 |
| Not available | 2675(59.9) | 247(66.8) | 2922(60.4) | 8.4 |
| **Combined WASH** | | | | |
| Available | 1484(33.2) | 85(22.9) | 1569(32.4) | 5.4 |
| Not available | 2991(66.8) | 286(77.1) | 3277(67.6) | 8.7 |

### 7.4.2 Effects of household WASH facilities on diarrhoea among children under five years

Table 7.2 shows the effects of WASH components with other explanatory variables on diarrhoea rates among children under five years. Both the crude odds ratios and adjusted odds ratios are presented. Children of households without access to a fixed place for handwashing

[11] Survey data for latest stool disposal methods was recorded for children under 2 years.

[12] Mothers excluded (n=11) from this study due to no observed handwashing place.

[13] Mothers excluded (n=11) from this study due to not observing whether there is soap and water available.

were more likely (AOR=1.62; 95% CI: 1.19-2.18) to experience diarrhoea relative to children of mothers with a fixed place for handwashing in the home. The absence of combined WASH facilities in the household meant children under five years had more than a two times higher chance of contracting diarrhoea (AOR=2.19; 95% CI: 1.04-4.61) compared with those with combined WASH facilities. Children of mothers who disposed of their children's stool in an unsanitary manner were more likely to experience diarrhoea (COR=1.57; 95% CI: 1.16-2.14) compared with those whose children's stool was disposed of in a sanitary manner. Other covariates such as age of the child, occupation of mother, caste/ethnicity and exposure to television were significantly associated with diarrhoea (Appendix E). However, the source of water, type of toilet, and availability of soap and water, and distance to water source were not significantly related to the prevalence of diarrhoea.

**Table 7.2: Bivariate and multivariate logistic regression analysis on the effects of WASH variables on diarrhoea among children under five years**

| Variables | Bivariate | Multivariate | |
|---|---|---|---|
| | COR | AOR | P value |
| **Source of water** | | | |
| Improved | **1** | **1** | |
| Unimproved | 1.01(0.57-1.80) | 0.70(0.30-1.65) | 0.412 |
| **Type of toilet** | | | |
| Sanitary | **1** | **1** | |
| Unsanitary | 1.47(1.00-2.18) | 0.99(0.62-1.59) | 0.981 |
| **Fixed place for handwashing** | | | |
| Available | **1** | **1** | |
| Unavailable | 1.57(1.21-2.04) | 1.62(1.19-2.18) | 0.002 |
| **Soap and water** | | | |

| Variables | Bivariate | Multivariate | |
|---|---|---|---|
| | **COR** | **AOR** | **P value** |
| Available | **1** | | |
| Unavailable | 1.34(0.96-1.88) | 0.62(0.32-1.18) | 0.146 |
| **Combined WASH services** | | | |
| Available | | **1** | |
| Unavailable | 1.67(1.26-2.21) | 2.19(1.04-4.61) | 0.038 |
| **Distance to water source** | | | |
| ≤30 minutes | **1** | **1** | |
| >30 minutes | 2.54(0.97-6.67) | 1.50 (0.67-3.33) | 0.322 |
| **Child's stool disposal method** | | | |
| Safe | **1** | | |
| Unsafe | 1.57(1.16-2.14) | - | - |

**Note**: Regression models were adjusted for all significant factors in the bivariate analysis (age of child, occupation of mother, caste or ethnicity, breastfeeding, ecology and province) and other potential confounders (education of mother and husband, wealth index, exposure to newspapers, exposure to radio, exposure to television, residence location, distance to water source, and presence of HMG), which were identified using a DAG. All odds are from combined models, which were adjusted for confounders of each predictor variable with the outcomes.

### 7.4.3 Respondents' characteristics by the prevalence of malnutrition among children under five years

Of the survey respondents the weighted number of children under five years included the outcome measure for stunting (n=2,363) and for underweight (n=2,370) after excluding children due to flagged data and absence of children for height and weight measurement, respectively; for wasting (n=2,360) after excluding children due to flagged data, implausible measurement and absence of children for weight and/or height measurement. Malnutrition (stunting, wasting and underweight) was measured using an anthropometric approach (a systematic measurement of the children's weight and height). The weighted number of the children's distribution of stunting, wasting and underweight is illustrated in the Venn diagram in **Error! Reference source not found.**. The prevalence of stunting among children under five years was 36%, for wasting it was 10%, and for underweight it was 27%. Of the children categorised as stunted, 17% were also underweight and 3% had wasting. Of the wasting children, 4% also suffering from being underweight and 3% were stunted. Of the children who were underweight, 17% were also stunted, 4% had wasting, and 3% were stunted and had wasting.

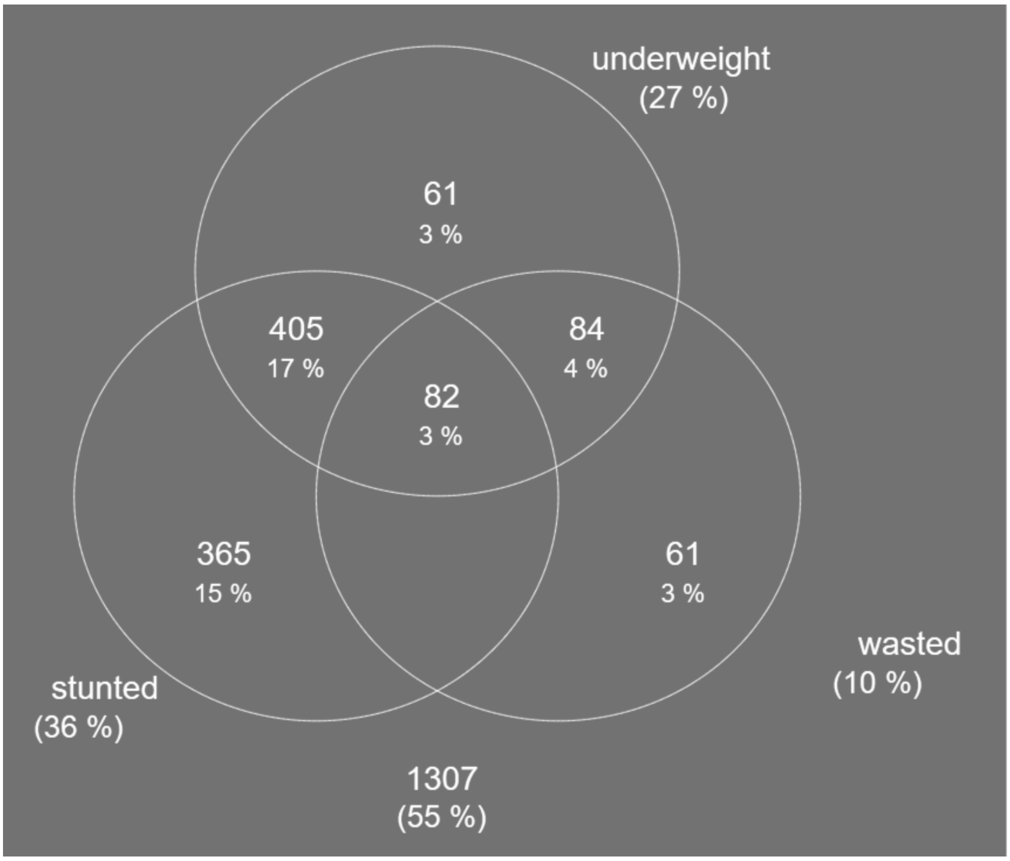



**Figure 7.3: Venn diagram of the distribution of stunting, wasting and underweight**

Table 7.3 shows the socio-demographic and WASH characteristics of household mothers associated with the prevalence of malnutrition among children under five years. Children aged 25–36 months had the highest prevalence of stunting (44.4%) and underweight (30.0%); however, the age group with the highest prevalence of wasting was the younger than 12 months group at 17.5%. The highest representation of children in the study were males (52.2%), and the prevalence of stunting of all children in this study was 36%, with almost equal distribution among male and female children. The wasting and underweight rates for female children were 10% and 27.2%, respectively, slightly higher than for male children (9.6% and 26.9%, respectively). The stunting and underweight categories were higher among the children whose mothers and their husbands had no education (Table 7.3). The distributions of study participants by wealth index and rates of malnutrition were 42% in the poor category, 22% in the middle category, and 35% in the rich category. In relation to caste or ethnicity, study participants identified as Brahmin (26.9%), Janajati (38.1%), scheduled or Shudra caste (14.3%), and other unidentified castes (20.7%). The highest prevalence of stunting was among children of mothers who were of other unidentified castes (40.7%), followed by the scheduled or Shudra caste (39.1%).

The highest rate of wasting was among children of mothers who were of the scheduled or Shudra caste (12.1%), and the highest rate of underweight was among children of mothers of the other unidentified castes (36%). Eighty-six percent of mothers identified as being Hindu, and children of mothers of this religion were found to have a higher prevalence of stunting and underweight than mothers of other religions. However, the highest wasting rate was among respondents of non-Hindu religions. Sixty-six percent of mothers had their first child when they were in their twenties or younger. The highest prevalences of stunting, wasting, and underweight were among children of mothers who were under 20 years when they had their first child. More than 76% of mothers were breastfeeding during the survey period, and these mothers' children had the highest prevalence rates of stunting (36.5%), wasting (10.8%), and underweight (29%) compared with mothers who did not breastfeed their children. Of children whose mothers were exposed to newspapers, radio, and television at least once a week, 22% were categorised as having stunting, 50% as having wasting, and 62% as underweight. Children whose mothers were not exposed to such mass media forms had a higher prevalence rate of malnutrition. In this group, the prevalence rates of stunting were 39.7% (rural 39.7% and urban 29.2%), for wasting were 9.8% (rural 10.4% and urban 8.7%), and for underweight were 27.1% (rural 30.4% and 21.5%) in Nepal. The highest stunting rate was found among children from the mountains region, while those in the plains region had the highest rates of wasting and underweight (Table 7.3). Children from Province 2 had the highest prevalence of wasting (14.8%) and underweight (36.8%) of all provinces, and children from Province 6 had the highest rate of stunting (54%). Children from Province 6 also had similar prevalence rates of underweight (35.5%) as those from Province 2. Children of mothers who had no HMG available to them had higher rates of stunting (37.4%), wasting (11%), and underweight (28.8%) compared with children of mothers who did have access to an HMG (Table 7.3).

This study found children whose mothers had an unimproved water source had a higher prevalence of stunting (43.1%), wasting (9.7%), and underweight (31.4%) compared with children of mothers with access to an improved water source. The children of mothers who had no access to a sanitary toilet had a higher prevalence of stunting (49.7%), wasting (13.1%), and underweight (40.95%) compared with those who had access to a sanitary toilet. Children whose mothers had a mobile place for handwashing had a higher prevalence of stunting (40.8%), wasting (14.1%), and underweight (33.4%) compared with those whose mothers had a fixed place for handwashing. The prevalences of stunting, wasting, and underweight among children under five years were higher (42.2%, 11.1%, and 33.1%, respectively) for those whose mothers did not have soap and water available in the handwashing place, compared with those who did have soap and water available in the handwashing place. Of children whose mothers did not have combined WASH services, 40% were categorised as having stunting, 11% as having wasting, and 32.3% as underweight. These prevalence rates are higher than for children whose mothers had combined WASH services available at home (Table 7.3).

**Table 7.3: Characteristics of respondents by malnutrition type, and prevalence of stunting, wasting and underweight among children under five years**

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| **Age of child (in months)** | | | | | | | | | | | | |
| <12 | 418(27.5) | 92(10.8) | 509(21.6) | 18.0 | 417(19.6) | 89(38.5) | 506(21.4) | 17.5 | 409(23.6) | 102(15.9) | 511(21.5) | 20.0 |
| 13–24 | 307(20.3) | 191(22.6) | 498(21.1) | 38.4 | 442(20.8) | 55(24.0) | 498(21.1) | 11.1 | 358(20.7) | 142(22.1) | 500(21.1) | 28.4 |
| 25–36 | 253(16.6) | 202(23.8) | 455(19.2) | 44.4 | 426(20.0) | 29(12.6) | 455(19.3) | 6.4 | 320(18.5) | 137(21.3) | 457(19.3) | 30.0 |
| 37–48 | 289(19.0) | 190(22.5) | 479(20.2) | 39.4 | 449(21.1) | 30(13.0) | 479(20.1) | 6.3 | 346(20.0) | 135(21.1) | 481(20.3) | 28.1 |
| 49–59 | 251(16.6) | 171(20.2) | 422(17.9) | 40.4 | 394(18.5) | 28(11.9) | 422(17.9) | 6.5 | 296(17.1) | 126(19.6) | 422(17.8) | 29.8 |
| **Sex of child** | | | | | | | | | | | | |
| Male | 792(52.2) | 442(52.3) | 1234(52.2) | 35.8 | 1113(52.3) | 118(51.1) | 1231(52.2) | 9.6 | 905(52.4) | 334(52.0) | 1239(52.3) | 26.9 |

[14] Children included after excluding data for the flagged data and absence of children for height measurement(n=2524)

[15] Children included after excluding data for the flagged data, implausible measurement and absence of children for weight measurement(n=2527)

[16] Children included after excluding data for the flagged data and absence of children for the measurement of whether weight or height (n=2517)

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| Female | 725(47.8) | 403(47.7) | 1129(47.8) | 35.7 | 1015(47.7) | 112(48.9) | 1128(47.8) | 10.0 | 824(47.6) | 308(48.0) | 1131(47.7) | 27.2 |
| **Age of mothers** | | | | | | | | | | | | |
| 15–24 | 674(44.4) | 327(38.8) | 1001(42.4) | 32.7 | 894(42.0) | 107(46.3) | 1000(42.3) | 10.7 | 769(44.5) | 235(36.6) | 1004(42.4) | 23.4 |
| 25–34 | 717(47.3) | 424(50.1) | 1141(48.3) | 37.2 | 1037(48.7) | 102(44.3) | 1139(48.3) | 9.9 | 805(46.6) | 340(53.0) | 1145(48.3) | 29.7 |
| 35+ | 127(8.3) | 94(11.1) | 221(9.3) | 42.6 | 199(9.3) | 22(9.4) | 221(9.4) | 9.9 | 155(9.0) | 67(10.4) | 222(9.3) | 30.1 |
| **Education of mothers** | | | | | | | | | | | | |
| No education | 441(29.1) | 374(44.2) | 815(34.4) | 45.8 | 713(33.5) | 102(44.2) | 815(34.5) | 12.5 | 518(30.0) | 301(46.9) | 819(34.6) | 36.7 |
| Primary | 299(19.7) | 173(20.5) | 472(20.0) | 36.7 | 428(20.1) | 42(18.3) | 471(20.0) | 9.0 | 340(19.7) | 132(20.6) | 472(19.9) | 27.9 |
| Secondary | 527(34.7) | 227(26.8) | 753(31.9) | 30.1 | 689(32.3) | 64(27.5) | 752(31.9) | 8.4 | 595(34.4) | 160(24.9) | 755(31.8) | 21.2 |
| SLC/higher | 250(16.5) | 72(8.5) | 323(13.7) | 22.4 | 299(14.1) | 23(9.9) | 322(13.6) | 7.1 | 276(16.0) | 49(7.6) | 325(13.7) | 15.0 |
| **Occupation of mothers** | | | | | | | | | | | | |
| No work | 657(43.3) | 281(33.2) | 938(39.7) | 29.9 | 823(38.7) | 114(49.2) | 937(39.7) | 12.1 | 706(40.8) | 235(36.6) | 941(39.7) | 24.9 |
| Agriculture | 647(42.7) | 442(52.2) | 1089(46.1) | 40.6 | 991(46.5) | 95(41.0) | 1086(46.0) | 8.7 | 762(44.1) | 329(51.3) | 1091(46.1) | 30.2 |
| Non-agriculture | 213(14.0) | 123(14.6) | 336(14.2) | 36.7 | 315(14.8) | 23(9.8) | 337(14.3) | 6.7 | 261(15.1) | 78(12.1) | 338(14.2) | 23.0 |
| **Education of husband** | | | | | | | | | | | | |

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| No education | 194(12.9) | 167(19.9) | 361(15.4) | 46.3 | 327(15.5) | 36(15.7) | 363(15.5) | 10.0 | 225(13.1) | 139(21.9) | 364(15.5) | 38.3 |
| Primary | 320(21.2) | 216(25.8) | 535(22.8) | 40.3 | 470(22.2) | 62(27.0) | 532(22.7) | 11.7 | 374(21.8) | 162(25.4) | 535(22.8) | 30.2 |
| Secondary | 685(45.4) | 351(41.9) | 1035(44.2) | 33.9 | 932(44.2) | 101(43.8) | 1033(44.1) | 9.8 | 782(45.6) | 255(40.0) | 1038(44.1) | 24.6 |
| SLC/higher | 309(20.5) | 104(12.4) | 412(17.6) | 25.2 | 382(18.1) | 31(13.5) | 413(17.7) | 7.6 | 334(19.5) | 81(12.8) | 415(17.6) | 19.6 |
| **Wealth index** | | | | | | | | | | | | |
| Poor | 563(37.1) | 435(51.4) | 998(42.2) | 43.6 | 905(42.5) | 91(42.3) | 996(42.2) | 9.1 | 697(40.3) | 305(47.6) | 1002(42.3) | 30.5 |
| Middle | 345(22.8) | 189(22.4) | 534(22.6) | 35.4 | 478(22.4) | 57(24.8) | 536(22.7) | 10.7 | 362(20.9) | 175(27.2) | 536(22.6) | 32.6 |
| Rich | 609(40.1) | 222(26.2) | 830(35.1) | 26.7 | 746(35.1) | 83(35.9) | 828(35.1) | 10.0 | 671(38.8) | 162(25.2) | 832(35.1) | 19.4 |
| **Caste or ethnicity** | | | | | | | | | | | | |
| Brahmin | 416(27.4) | 220(26.0) | 636(26.9) | 34.6 | 590(27.7) | 44(19.3) | 634(26.9) | 7.0 | 485(28.0) | 154(24.0) | 638(26.9) | 24.1 |
| Janajati | 605(39.9) | 294(34.8) | 900(38.1) | 32.7 | 811(38.1) | 87(37.8) | 899(38.1) | 9.7 | 696(40.2) | 206(32.2) | 902(38.1) | 22.9 |
| Scheduled | 207(13.6) | 133(15.7) | 339(14.3) | 39.1 | 298(14.0) | 41(17.8) | 339(14.4) | 12.1 | 236(13.7) | 105(16.4) | 341(14.4) | 30.9 |
| Other | 289(19.1) | 199(23.5) | 488(20.6) | 40.7 | 430(20.2) | 58(25.1) | 488(20.6) | 11.9 | 313(18.1) | 176(27.4) | 489(20.6) | 36.0 |
| **Religion** | | | | | | | | | | | | |
| Hindu | 1295(85.4) | 730(86.3) | 2025(85.7) | 36.0 | 1830(85.9) | 192(83.3) | 2022(85.7) | 9.5 | 1467(84.8) | 564(87.9) | 2030(85.7) | 27.8 |

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** | **No(n,%)** | **Yes(n,%)** | **Total** | **PR(%)** |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| Non-Hindu | 222(14.6) | 116(13.7) | 338(14.3) | 34.3 | 299(14.1) | 38(16.7) | 337(14.3) | 11.4 | 262(15.2) | 78(12.1) | 340(14.3) | 22.9 |
| **Age at first birth** | | | | | | | | | | | | |
| ≤20 year | 978(64.5) | 587(69.5 | 1565(66.2) | 37.5 | 1407(90.0) | 157(10.0) | 1564(66.4) | 10.0 | 1128(65.3) | 441(68.8) | 1569(66.2) | 28.1 |
| >21 year | 539(35.5) | 258(30.5) | 797(33.7) | 32.4 | 722(90.8) | 74(9.2) | 795(33.7) | 9.2 | 601(34.7) | 200(31.2) | 801(33.8) | 25.0 |
| **Currently breastfeeding** | | | | | | | | | | | | |
| Yes | 1150(75.8) | 661(78.2) | 1811(76.6) | 36.5 | 1613(75.8) | 195(84.4) | 1808 (76.6) | 10.8 | 1291(74.6) | 528(82.3) | 1818(76.7) | 29.0 |
| No | 368(24.2) | 185(21.8) | 552(23.4) | 33.4 | 516(24.2) | 36(15.6) | 552(23.4) | 6.5 | 438(25.4) | 114(17.7) | 552(23.3) | 20.6 |
| **Exposure to newspapers** | | | | | | | | | | | | |
| No exposure | 1134(74.8) | 706(83.5) | 1840(77.9) | 38.4 | 1640(77.0) | 197(85.4) | 1837(77.8) | 10.7 | 1285(74.3) | 561(87.4) | 1845(77.9) | 30.4 |
| Exposure | 383(25.2) | 139(16.5) | 522(22.1) | 26.7 | 489(223.0) | 34(14.6) | 523(22.2) | 6.5 | 444(25.7) | 81(12.6) | 525(22.1) | 15.4 |
| **Exposure to radio** | | | | | | | | | | | | |
| No exposure | 707(46.6) | 468(55.3) | 1174(49.7) | 39.8 | 1034(48.6) | 142(61.3) | 1173(49.8) | 12.0 | 810(46.9) | 367(57.2) | 1177(49.7) | 31.2 |
| Exposure | 811(53.4) | 378(44.7) | 1188(50.3) | 31.8 | 1095(51.4) | 89(38.7) | 1184(50.2) | 7.5 | 919(53.1) | 275(42.8) | 1193(50.3) | 23.0 |
| **Exposure to television** | | | | | | | | | | | | |
| No exposure | 469(31.0) | 430(50.9) | 900(38.1) | 47.8 | 789(37.1) | 109(47.1) | 898(38.1) | 12.1 | 574(33.2) | 329(51.3) | 903(38.1) | 36.4 |

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| Exposure | 1048(69.0) | 415(49.1) | 1463(61.9) | 28.4 | 1340(62.9) | 122(52.9) | 1462(61.9) | 8.4 | 1155(66.8) | 313(48.7) | 1468(61.9) | 21.3 |
| **Place of residence** | | | | | | | | | | | | |
| Rural | 893(58.9) | 588(69.6) | 1481(62.7) | 39.7 | 1327(62.3) | 154(66.7) | 1481(62.8) | 10.4 | 1036(59.9) | 451(70.4) | 1487(62.7) | 30.4 |
| Urban | 624(41.1) | 257(30.4) | 881(37.3) | 29.2 | 802(37.7) | 77(33.3) | 879(37.2) | 8.7 | 693(40.1) | 190(29.7) | 883(37.3) | 21.5 |
| **Ecology** | | | | | | | | | | | | |
| Plain | 845(55.7) | 485(57.4) | 1330(56.3) | 36.5 | 1165(54.7) | 165(71.5) | 1330(56.4) | 12.4 | 900(52.0) | 433(67.4) | 1333(56.2) | 32.4 |
| Hill | 585(38.6) | 284(33.6) | 869(36.8) | 32.7 | 809(38.0) | 56(24.1) | 865(36.6) | 6.4 | 709(41.0) | 162(25.2) | 871(36.8) | 18.6 |
| Mountains | 87(5.8) | 77(9.0) | 164(6.9) | 46.7 | 154(7.3) | 10(4.4) | 165(7.0) | 6.3 | 120(7.0) | 47(7.3) | 166(7.0) | 28.2 |
| **Province** | | | | | | | | | | | | |
| 1 | 254(16.7) | 123(14.6) | 377(15.9) | 32.7 | 331(15.6) | 45(19.4) | 376(15.9) | 11.9 | 286(16.6) | 92(14.3) | 378(16.0) | 24.3 |
| 2 | 407(26.9) | 235(27.8) | 643(27.2) | 36.6 | 548(25.7) | 95(41.2) | 643(27.3) | 14.8 | 407(23.6) | 237(37.0) | 645(27.2) | 36.8 |
| 3 | 250(16.5) | 110(13.1) | 361(15.3) | 30.6 | 347(16.3) | 14(6.15) | 361(15.3) | 3.9 | 311(18.0) | 52(8.1) | 363(15.3) | 14.3 |
| 4 | 129(8.5) | 53(6.2) | 182(7.7) | 29.0 | 170(8.0) | 11(4.7) | 181(7.7) | 6.0 | 154(8.9) | 28(4.4) | 182(7.7) | 15.4 |
| 5 | 276(18.2) | 169(20) | 445(18.9) | 38.0 | 410(19.3) | 34(14.9) | 444(18.8) | 7.8 | 324(18.8) | 121(18.9) | 445(18.8) | 27.2 |
| 6 | 68(4.5) | 82(9.7) | 150(6.3) | 54.9 | 139(6.5) | 12(5.1) | 150(6.4) | 7.8 | 96(5.6) | 55(8.6) | 151(6.4) | 36.5 |

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| 7 | 132(8.7) | 73(8.6) | 205(8.7) | 35.4 | 184(8.7) | 20(8.5) | 204(8.7) | 9.6 | 150(8.7) | 56(8.7) | 206(8.7) | 27.1 |
| **Distance to water source** | | | | | | | | | | | | |
| ≤30 minutes | 1336 (95.5) | 750(94.3) | 2086(95.1) | 36.4 | 1883(94.9) | 202(96.9) | 2085(95.1) | 9.6 | 1528(94.7) | 566(96.0) | 2094(95.1) | 26.9 |
| >30 minutes | 63(4.5) | 45(5.7) | 108(4.9) | 27.9 | 101(5.1) | 6(3.1) | 107(4.9) | 4.9 | 85(5.3) | 23(4.0) | 108(4.9) | 16.9 |
| **Health Mothers' Group** | | | | | | | | | | | | |
| Not available | 800(52.7) | 477(56.4) | 1277(54.1) | 37.4 | 1135(53.3) | 140(60.8) | 1276(54.1) | 11.0 | 912(52.8) | 368(57.4) | 1280(54.0) | 28.8 |
| Available | 491(32.4) | 283(33.5) | 775(32.8) | 36.6 | 710(33.4) | 64(28.0) | 775(32.8) | 8.3 | 567(32.8) | 212(33.1) | 779(32.9) | 27.2 |
| Do not know | 226(14.9) | 85(10.1) | 311(13.2) | 27.4 | 284(13.3) | 26(11.2) | 310(13.1) | 8.4 | 250(14.4) | 61(9.5) | 311(13.1) | 19.6 |
| **Source of water** | | | | | | | | | | | | |
| Improved | 1337(95.6) | 748(94.1) | 2086(95.1) | 35.9 | 1885(95.0) | 202(96.6) | 2086(95.1) | 6.7 | 1538(95.4) | 555(94.2) | 2093(95.1) | 26.5 |
| Unimproved | 62(4.4) | 47(5.9) | 108(4.9) | 43.1 | 99(5.0) | 7(3.4) | 106(4.9) | 9.7 | 74(4.6) | 34(5.8) | 108(4.9) | 31.4 |
| **Toilet type** | | | | | | | | | | | | |
| Sanitary | 1135(81.1) | 534(67.2) | 1669(76.1) | 32.0 | 1528(77.0) | 140(67.1) | 1668(76.1) | 8.4 | 1301(80.7) | 374(63.4) | 1675(76.1) | 22.3 |
| Unsanitary | 264(18.9) | 261(32.8) | 525(23.9) | 49.7 | 456(3.0) | 69(32.9) | 525(23.9) | 13.1 | 312(19.3) | 215(36.6) | 525(23.9) | 40.9 |
| **Handwashing place** | | | | | | | | | | | | |

| Variables | Stunting(n=2363)[14] | | | | Wasting(n=2360)[15] | | | | Underweight(n=2370)[16] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) | No(n,%) | Yes(n,%) | Total | PR(%) |
| **Overall** | **1517(64.2)** | **845(35.8)** | **2363** | **35.8** | **2129(90.2)** | **231(9.8)** | **2360** | **9.8** | **1729(72.9)** | **641(27.1)** | **2370** | **27.1** |
| Fixed | 1218(80.5) | 641(76.0) | 1859(78.9) | 34.5 | 1695(79.9) | 161(69.6) | 1856(78.9) | 8.6 | 1398(81.1) | 465(72.7) | 1864(78.8) | 25.0 |
| Not fixed | 295(19.5) | 203(24.0 | 497(21.1) | 40.8 | 427(20.1) | 70(30.4) | 497(21.1) | 14.1 | 326(18.9) | 175(27.3) | 500(21.2) | 34.9 |
| **Soap and water status** | | | | | | | | | | | | |
| Available | 666(44.0) | 225(26.7) | 891(37.8) | 25.3 | 823(38.8) | 68(29.3) | 891(37.8) | 7.6 | 744(43.2) | 149(23.3) | 893(37.8) | 16.7 |
| Not available | 846(56.0) | 619(73.3) | 1465(62.2) | 42.2 | 1299(61.2) | 163(70.7) | 1462(62.2) | 11.1 | 980(56.8) | 491(76.7) | 1471(62.2) | 33.4 |
| **Combined WASH** | | | | | | | | | | | | |
| Available | 547(36.1) | 173(20.5) | 720(30.5) | 24.0 | 670(31.5) | 50(21.8) | 721(30.5) | 7.0 | 614(35.5) | 109(17.0) | 722(30.5) | 15.1 |
| Not available | 970(63.9) | 672(79.5) | 1642(69.5) | 40.0 | 1459(68.5) | 180(78.2) | 1639(69.5) | 11.0 | 1115(64.5) | 533(83.0) | 1648(69.5) | 32.3 |

Key: PR: Prevalence Rate

### 7.4.4 Effects of household WASH facilities on malnutrition among children under five years

As shown in Table 7.4, children of households with unsanitary toilet facilities were more likely to experience stunting (AOR=1.78; 95% CI: 1.25-2.56) compared with children of households with sanitary toilets, after adjusting for age of children and mothers, education of mothers and their husbands, occupation, wealth index, caste or ethnicity, current breastfeeding status, exposure to newspapers, exposure to radio, exposure to television, place of residence, geography, province, distance to a water source, and availability of an HMG. Underweight children were associated with unsanitary toilet facilities after adjusting potential variables, and the results showed that children of households with unsanitary toilet facilities had a 46% higher chance of being underweight (AOR=1.46; 95% CI: 1.03-2.07) than children whose households did have sanitary toilet facilities.

Children under five years whose households did not have a fixed place for handwashing were more likely to experience wasting (AOR=1.51; 95% CI: 1.00-2.30) compared with children whose households did have a fixed place for handwashing. Without adjusting other variables, the children of households who did not have soap and water available at home were more likely to experience stunting (COR=2.16; 95% CI: 1.75-2.68), wasting (COR=1.53; 95% CI: 1.11-2.11), and being underweight (COR=2.50; 95% CI: 1.95-3.20) compared with those of households who did have soap and water available.

Distance to a source of water, availability of soap and water, and overall combined WASH had no significant effects on each outcome variable. Without adjusting other variables, the children of mothers who disposed of their under two years children's stool in an unsanitary manner were more likely to experience stunting (COR=1.41; 95% CI: 1.06-1.88), wasting (COR=1.56; 95% CI: 1.08-2.26), and underweight (COR=1.70; 95% CI: 1.27-2.26) compared with those whose mothers disposed of their children's stool in a sanitary manner. However, the unimproved source of water was not significantly related to prevalence of stunting, wasting, and underweight with or without adjusting variables.

**Table 7.4: Bivariate and multivariate logistic regression analysis on the effects of WASH variables on malnutrition among children under five years**

| Variables | Stunting | | | Wasting | | | Underweight | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bivariate | Multivariate | | Bivariate | Multivariate | | Bivariate | Multivariate | |
| | COR | AOR | P-value | COR | AOR | P-value | COR | AOR | p-value |
| **Source of water** | | | | | | | | | |
| Improved | 1 | 1 | | 1 | 1 | | 1 | 1 | |
| Unimproved | 1.36(0.90-2.04) | 1.14(0.73-1.77) | 0.561 | 0.67(0.3-1.41) | 0.71(0.28-1.80) | 0.390 | 1.27(0.83-1.94) | 1.35(0.86-2.12) | 0.193 |
| **Type of toilet** | | | | | | | | | |
| Sanitary | 1 | 1 | | 1 | 1 | | 1 | 1 | |
| Unsanitary | 2.10(1.59-2.76) | 1.78(1.25-2.56) | 0.002 | 1.65(1.18-2.29) | 1.05(0.69-1.62) | 0.811 | 2.41(1.82-3.19) | 1.46(1.03-2.07) | 0.033 |
| **Fixed place for handwashing** | | | | | | | | | |
| Available | 1 | 1 | | 1 | 1 | | 1 | 1 | |
| Unavailable | 1.31(1.04-1.64) | 0.77(0.57-1.04) | 0.084 | 1.74(1.22-2.47) | 1.51(1.00-2.30) | 0.051 | 1.61(1.24-2.09) | 0.93(0.68-1.27) | 0.647 |
| **Soap and water** | | | | | | | | | |
| Available | 1 | 1 | | 1 | 1 | | 1 | 1 | |
| Unavailable | 2.16(1.75-2.68) | 1.54(0.91-2.62) | 0.107 | 1.53(1.11-2.11) | 0.84(0.39-1.78) | 0.628 | 2.50(1.95-3.20) | 1.62(0.96-2.75) | 0.071 |

| Variables | Stunting | | | Wasting | | | Underweight | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bivariate | Multivariate | | Bivariate | Multivariate | | Bivariate | Multivariate | |
| | COR | AOR | P-value | COR | AOR | P-value | COR | AOR | p-value |
| **Combined WASH services** | | | | | | | | | |
| Available | 1 | | | 1 | | | 1 | | |
| Unavailable | 2.19(1.73-2.7) | 0.99(0.56-1.75) | 0.968 | 1.64(1.17-2.32) | 1.39(0.60-3.20) | 0.436 | 2.69(2.04-3.55) | 1.00(0.55-1.81) | 0.988 |
| **Distance to water source** | | | | | | | | | |
| ≤30 minutes | 1 | 1 | | 1 | 1 | | 1 | 1 | |
| >30 minutes | 0.68(0.32-1.46) | 1.04(0.63-1.70) | 0.879 | 0.49(0.14-1.75) | 0.67(0.25-1.80) | 0.430 | 0.53(0.22-1.27) | 0.60(0.39-1.23) | 0.209 |
| **Child's stool disposal method** | | | | | | | | | |
| Safe | 1 | - | | 1 | - | | 1 | | - |
| Unsafe | 1.41(1.06-1.88) | - | | 1.56(1.08-2.26) | - | | 1.70(1.27-2.26) | | - |

**Note:** Regression models are adjusted for potential confounders (age of child, age of mother, occupation of mother, education of mother, education of husband, caste or ethnicity, wealth index, media exposure, breastfeeding status, residence, ecology, province, distance to water source, and access to a Health Mothers' Group). Confounders were identified using DAGs. All odds are from separate models which adjusted for confounders of each predictor variable with the outcome variables.

## 7.5 Discussion

This study investigated the prevalence of diarrhoea and malnutrition among children under five years in Nepal. In this study, the prevalence of diarrhoea for children under five years was 7.6%, which is different from the findings of Nepal's first micronutrient status survey conducted in 2016 [409]. The difference between these two studies is likely to be due to a difference in sample size and the exclusion of children under 6 months from the micronutrient survey. The prevalence of diarrhoea among children under five years in the present study was more than five times lower than a study conducted in the urban slum of the Tansen Municipality in Palpa district of Nepal [410]. The different reported rates of diarrhoea of these two studies could be due to the season of data collection, geography, and the local context. The average prevalence of diarrhoea among children under five years in this study was different from findings of previous studies. For example, the prevalence of diarrhoea among children under five years was 8.8% in India in 2015–2016 [75], 19% in Pakistan in 2016–2017 [411], and 6% in Bangladesh in 2014 [412]. A cross-sectional study in Ethiopia found the prevalence of diarrhoea among children under five years was 13.6% in 2019 [413], and the pooled prevalence of diarrhoea from 31 studies was 22% in 2018 [414]. The morbidity of diarrhoea in the above-mentioned studies was found to vary by geography, location, population size and nature, seasons, mothers' education, mothers' occupation, household wealth index, and WASH-related services.

A study conducted in Pakistan concluded that diarrhoea can be prevented with adequate handwashing with soap [415]. This evidence supports the present study. A study conducted in Nepal in 2013 supported the suggestion that diarrhoea is prevented through handwashing with soap [416]. The present study found that ensuring access to family/household-level-factors (combined WASH facilities) is important in reducing diarrhoea among children under five years. If all WASH facilities are present at the household level, there is a low risk of diarrhoeal infection. This result indicates that managing comprehensive WASH package (i.e. ensure improved water sources, sanitary toilets and proper handwashing facilities with soap) services is important for better health outcomes. The stunting, wasting, and underweight rates found in the present study are consistent with those of the micronutrient status survey conducted in Nepal in 2016, which found prevalence rates of stunting (39%), wasting (12%), and underweight (35%) [409]. The latest global figures from UNICEF state that in 2018, more than one in five children under five years were categorised as stunted, and one in fourteen children had wasting, but the present study's rates were higher than these global prevalence rates [397]. When compared with the results of a study conducted in India in 2017, in which the prevalence of stunting among children under five years was 39.9%, wasting at 19.0%, and underweight at 32.7% [417], the results of the current study are almost identical, except for the lower prevalence of wasting. A study conducted in the Banke district of Nepal in 2015 found a higher proportion of stunting (55.7%), wasting (18.6%) and underweight (41.4%) than the present study [418]. The different rates of stunting, wasting, and underweight are possibly due to the different socioeconomic status of the study participants, the different geographical areas and the homogeneity of the study population.

The current study shows WASH components have mixed effects on malnutrition among children under five years in Nepal. It is evident that the establishment of a handwashing place has a significant positive effect on wasting. A fixed place for handwashing is a primary indicator of the standard of living and health of family members and their children under five years. Mothers and other family members with children need to have effective practices of handwashing with soap, using toilets, and using safe and clean water sources. The present study found unavailability of sanitary toilet facilities at home had a significant effect of stunting and underweight. Similarly, unsanitary disposal of child faeces had a significant relationship with on malnutrition. While WASH has no direct effect on child malnutrition, it may indirectly affect rates of malnutrition. Poor WASH facilities at the household level may lead to diarrhoea among children under five years, which can progress to further infection, resulting in malnutrition from severe diarrhoea. Other covariates, such as individual-level factors (children's age, maternal age, maternal breastfeeding practices), one family/household-level factor (exposure to television), and community-level factors (ecological zones, and provinces), have significant effects on stunting and underweight among children under five years (Appendix E). This study revealed that children older than 12 months had a higher chance of becoming stunting and underweight. This may be because older children who lose weight are at greater risk of being overlooked in the provision of supplemental food in this crucial growth and development phase.

Unsanitary methods of child stool disposal, such as disposing of stool in an open area, have a negative impact on water and environmental health, as subsequent bacteria and viruses can cause child illnesses and wider public health issues [419, 420]. Children affected by these illnesses have a higher chance of becoming malnourished [407].The present study's findings are consistent with those of previous studies in Pakistan [421], Ethiopia [422], and the plains region of Nepal [218].

Use of available WASH services is crucial for reducing diarrhoea rates. The reduction in the prevalence of diarrhoea will in turn reduce the incidence of malnutrition by way of preventing diarrhoea. Communicable diseases are still a public health challenge in Nepal, and yet most current efforts target non-communicable diseases [423, 424]. Giving equal attention to communicable diseases, particularly through health promotion programs and interventions, would benefit a large proportion of the world's population, especially in developing countries like Nepal. As a result of this study, it is recommended that strategies for reducing communicable diseases should be prioritised in conjunction with a combined WASH approach for effective prevention and control of diarrhoea and malnutrition. Such initiatives should be practiced by all individuals, with promotion and support from GoN, stakeholders, and communities. Context-specific hygiene plans and strategies should be formulated as a matter of urgency. This study can be of benefit to researchers in the development of innovative models, approaches, and concepts consistent with the new public health/health promotion approach, such as the Health Promotion Intervention Mapping [425] and Social Behaviour Change Communication approach [278].

The ecological model has been linked to measure the effects of each individual-family/households and community-level factors on diarrhoea and malnutrition outcomes. Other behavioural change theories (mentioned in chapter 2) are relevant in understanding the relationship between each independent variables and outcome of interest.

Overall the findings demonstrated the value of viewing factors related to watch through an ecological lens. Individual level factors can be addressed through health belief model [426]. Household level factors, by contract, can be addressed by communication theory[427]. Community level factors are more complex, yet illustrate the need for a top down approach to community participation approaches [428]. Lack of WASH is a complex issue that requires a multifaceted approach [429] and behavioural change communication theories. The ecological model provided a comprehensive frameworks for understanding each level of factors related to WASH.

## 7.6 Strengths and limitations

The findings from this study are representative of the household mothers of children in Nepal, as the NDHS data were collected from different parts of provinces and clusters within the diverse geography of Nepal. The NDHS data are valid and were analysed using weighted values, which helped to minimise errors in sample distribution. The biomarker questionnaire included in the NDHS allowed data collectors to record the weight and height of children in the households. These results provided objective data on child malnutrition categories of stunting, wasting, and underweight.

Nonetheless, some limitations of this study have been identified. Data were not available for all children of the interviewed mothers, as children may have been absent at the time of data collection or may have refused to provide anthropometric measurements. This may have affected the results for malnutrition outcomes. It is possible that households at high risk of not having access of WASH facilities had lost children due to diarrhoea and/or malnutrition, and thus these children would not have been included in the study. It is also possible that losing a child to diarrhoea and/or malnutrition may lead to increased WASH facilities in that household. Using national and region-specific measures might be possible in future studies. The WHO criteria applied in this thesis was consistent with national micronutrient status survey 2016 [409]. This study's data cannot be used for the analysis of mothers' or children's WASH behaviour over time due to the cross-sectional study design. This study was conducted before the onset of COVID-19. Results of an examination into current WASH facilities and health behaviour with regard to WASH might now be different in Nepal.

## 7.7 Conclusions

The present study confirmed that diarrhoea and malnutrition are still major public health problems for children under five years in Nepal. The lack of availability of fixed places for handwashing has statistically significant associations with diarrhoea and wasting. Household family members, including mothers and children, may wash their hands elsewhere without using soap or taking the recommended time (20 seconds) for scrubbing both hands; however, the rates of availability of a fixed place for handwashing were higher than the rates for availability of soap and water in a fixed place in Nepal. This indicates that most households keep soap and water for handwashing elsewhere, rather than at fixed places. In rural remote areas of Nepal, people tend to keep soap inside their private rooms rather than at a visible handwashing place. The previous study showed that if family members properly use an establish a fixed place for handwashing, they will form the habit of keeping soap and water in the handwashing place, allowing them to wash their hands effectively [430]. The construction of a handwashing place and toilet does not mean that people will use them properly. Therefore, it is important to provide high-quality education to household members and communities on the importance of handwashing in a fixed place, and properly using a toilet which is regularly cleaned. It must be a habit to wash hands with soap in a fixed place and to use sanitary toilets. Similarly, the use of unsanitary toilets is associated with stunting and underweight, indicating that good sanitation improves the health status of children and reduces the incidence of malnutrition.

Combined WASH is important for the prevention and control of diarrhoea and malnutrition among children under five years in Nepal. The regular habit and practice of using WASH components is vital. The provision of a single WASH component cannot be seen as evidence that households have improved hygiene and sanitation. This finding is consistent with a recent systematic and meta-analysis study, which showed that provision of combined WASH components was more effective in improving child nutritional status than a single WASH component services [34]. Therefore, health promotion planners, policy-makers, and policy-implementers should strengthen evidence-based practice in order to improve the health status of children in a cost-effective way. This can be achieved by implementing WASH interventions at the household level. If households have good-quality WASH facilities, mothers and children will have good opportunities of utilising them. In the development of strategies for the prevention and control of diarrhoea and malnutrition, the policy-makers should consider integrated WASH and nutrition public health programs to be delivered through primary health care outreach clinics to reach rural and remote areas. Further research, using a randomised controlled trial, is recommended to investigate the association between the single exposure variables of water, sanitation and hygiene, and overall combined WASH, with diarrhoea and malnutrition affecting children under five years in Nepal. It is recommended that further research be undertaken with the consideration of the Sustainable Development Goals (2016-30) and beyond.

# Chapter 8. General Discussion

## 8.1 Foreword

This thesis aimed to identify the availability of household-level WASH facilities and to examine individual-, family/household,- and community-level factors associated with WASH, and to assess the effects of households' WASH facilities on diarrhoea and malnutrition (stunting, wasting and underweight) among children under five years in Nepal. This chapter discusses the overview of each significant finding, contextualises the findings in light of previous studies, identifies strengths and limitations, and specifies implications of this thesis's findings for policy, health promotion programs, and research.

## 8.2 Main findings

The rates of household handwashing with soap and the factors affecting it were determined. The rates of handwashing with soap were found to vary in the literature (Chapter 4). Lack of knowledge, inadequate availability of soap and water at handwashing places, weak management of available resources, and cultural beliefs were identified risk factors for mothers not washing their hands at home at critical moments (reported in Chapter 4).

At the household level in Nepal, the prevalence of an improved water source was 95.5%, for sanitary toilet facilities it was 83.9%, for available soap and water it was 46.9%, and for a fixed place for handwashing it was 80.9%. Education, wealth index, number of family members in the home, and geographical areas such as ecological zone, province and distance to a water source were correlated with WASH services at the household level (reported in Chapter 5).

Individual-level factors that influence WASH in Nepal were found to be education, caste or ethnicity, while other individual factors did not influence access to an improved water source. Family- level factors such as household wealth index was significantly associated a discrete

WASH facilities and combined WASH facilities at the household level. Community-level factors that influence sanitation and hygiene were found to be place of residence, ecology, province, and distance to water source, while ecology and distance to water sources did not influence access to an improved water source for household mothers (reported in Chapter 6). Diarrhoea among children under five years in Nepal was more likely to occur when a fixed place for handwashing was absent, and when not all WASH services were available at the household level. WASH services have different effects on different malnutrition types for children. The rates of stunting and underweight in children were significantly associated with unsanitary toilets compared with sanitary toilets, while unavailability of a fixed place for handwashing was associated with wasting rates among children under five years in Nepal (reported in Chapter 7).

## 8.3 Handwashing with soap and associated factors

Firstly, a systematic review of mothers' existing household handwashing rates and the factors associated with the uptake of handwashing in Nepal was conducted. Effective handwashing is a public health concern, and handwashing with soap is a major component of WASH [7, 316, 317] and needs to be addressed as a priority. The gap between the availability of soap and water, and handwashing knowledge and practice has been reported in previous studies [325, 334]. The systematic review showed that handwashing with soap is important for improved standards of living, health promotion, and disease prevention. There are insufficient studies with a specific focus on handwashing with soap for household mothers in Nepal. Nevertheless, a few studies have reported on the different rates of handwashing with soap in Nepal [83, 139, 143, 205, 206]. The factors preventing handwashing with soap include the absence of soap, water and a fixed place for handwashing, and low education levels of mothers and their husbands [328]. The practice of handwashing with soap is important for all family members, but it is of great importance for a mother with a child under five years, as children of this age are susceptible to diarrhoea and other communicable diseases. This is because mothers have the role of primary caregivers to their children in Nepal.

In Nepal, mothers who are poor and mothers from rural and hard-to-reach areas remain the most vulnerable to poor access to handwashing facilities at home, which is a cause of communicable diseases among children under five years [71].The six steps of handwashing with soap recommended by the World Health Organization [47] are:

1. Wet hands with water;
2. Apply enough soap to cover all surfaces;
3. Rub hands for at least 20 seconds;
4. Rinse hands with water;
5. Dry thoroughly with a single-use towel and use towel to turn off faucet/tap; and
6. The whole handwashing process should be between 40 and 60 seconds.

This handwashing technique may be confusing to apply; therefore, handwashing with soap with adequate rubbing of the hands for at least 20 seconds is recommended as a practical measure [431].

## 8.4 Status of household WASH

Nepal has made significant progress in WASH since 1990 and after the formulation of the national sanitation policy in 1994 [432]. The results of this thesis are different to those included in the WHO/UNICEF-JMP 2019 reports, approximately 71% of world population have access to improved water, 90% have sanitary toilet and 60% have handwashing facilities with soap·[11]. Whereas the JMP report indicated that basic water access in Nepal was 80%, the findings of this thesis indicated 95%. The JMP report also indicated that a basic sanitary disposal of human faeces was 76%, while this thesis finding indicated that the sanitary disposal of human excreta is 80%. The basic hand washing facilities was 48% in Nepal, reported by JMP report and this thesis report indicated this rate just 47%. Nepal's sanitation and hygiene status is lower than global data, but sources of water facilities are higher. However, there are gaps in WASH utilisation between educated and uneducated, rural and urban, poor and rich, male and female, and higher and lower caste populations in Nepal [160]. The availability of an improved water source in Nepal doubled in the two decades prior to 2019 [433], with the rate now consistent with a 2019 study conducted in the Nuwakot district of Nepal [408] and a study conducted in India [434]. This study showed that availability of an improved water source was higher than for a study based in Namibia [351]. However, an improved water source does not always mean the water is definitively safe, as there is a risk of contamination during transportation, storage, and handling [435]. This thesis concluded that individual-level factors (such as education of respondents), family level factors (number of family members in the home and wealth index), and community-level factors (such as distance to water source, ecology, and province) influence to have access of all discrete WASH facilities at household level in Nepal (reported in Chapter 5).

In Nepal, the majority of rural households have a natural spring as their main water source, and in recent years, the drying up of springs in mid-hill regions has caused a water crisis and led to the unequal distribution of improved water sources by households' geographical region [436]. Education is a powerful tool for keeping water sources safe, taking initiative for the making of clean water sources through community participation, and safe handling and utilisation of water [437]. Having to collect water from a long distance causes a lack of improved water, poor sanitation and lack of handwashing practice. Women, who are responsible for fetching water in Nepal, can face problems of physical pain due to fetching water from long distances, mental stress, and sometimes partner violence in Nepal [85, 329].

Nepal's geography is diverse, ranging from mountains to plains. This thesis revealed that households in mountains regions and remote areas have less improved water sources than plains regions and urban areas, because the location of these scattered households mean there are few adequate sources of improved water. It is also difficult to establish sanitary toilet facilities due to the terrain. A long distance between a water source and the home is likely to result in a shortage of water at home, and therefore, these households are also unlikely to have sanitary toilets, thus increasing the risk of diarrhoea among children [207]. The urbanization and population growth increases the risk of having unimproved water sources in Nepal [438]. The scattered distribution of households increases the cost of installing an improved water source closer to or within the household premises.

From the analysis of individual WASH components, it is not sufficient just to provide access to improved water and sanitation facilities. Without proper handwashing with soap facilities at the household level, children under five years will still be vulnerable to communicable diseases [62]. Sufficient improved WASH must be managed by all households in order to develop positive habits by parents and children towards the prevention and control of communicable diseases. Two major indicators, the availability of soap anywhere in the dwelling, and access to a fixed place for handwashing with soap and water, were introduced after a large-scale review conducted in 2017 [317]. This thesis also intended to determine the status of the availability of soap and water, and a fixed place for handwashing near the home.

The results in Chapter 5 indicate there is a gap in improved water sources and handwashing with soap facilities in Nepal. Interestingly, the sanitation status is improving in Nepal because of the open-defaecation-free campaign through the toilet construction campaign, so that Nepal has been declared open-defaecation-free country on 30 September 2019 [232]. However, the western part of the hills region (Provinces 6) has a major public health problem of unimproved water sources and a lack of handwashing with soap facilities, while the south-eastern part of the plains region (Province 2) has a sanitation problem. Household poverty is a family level risk factor for lack of improved WASH, while the ecology and distance to water sources are community-level factors affecting WASH utilisation at the household level in Nepal.

## 8.5 Individual-, family-, and community-level factors relating to accessible household WASH facilities

This thesis investigated individual-, family-, and community-level factors which influence access to WASH at the household level. The ecological model was the basis for this thesis, and was used to identify the individual-level, family-level, and community-level factors (reported in Chapter 2, sub-section 2.7). However, the policy- and structural-level factors were not included in this thesis because of the lack of variables and data available in the 2016 NDHS.

Individual-level-factor such as education had significantly association with hygiene and sanitation supported by a previous evidence of poor education which is associated with a lack of WASH facilities [94]. Household access to combined WASH facilities was influenced by individual-level factors of age, education, and caste. Higher levels of education are consistent with WASH uptake, a finding confirmed by previous studies [263, 283, 321].

Family factors play significant roles in WASH access by the members of household. Wealth index is a subjective measure of socioeconomic status, and strongly influences household-level WASH commodities. Households with a high wealth index had more adequate WASH infrastructure than households with a lower wealth index, a finding which is supported by a previous study conducted in Malawi in 2010 [439]. WASH inequality is primarily caused by the unequal distribution of wealth [440]. The household mothers and family members who are economically strong have the capacity to buy soap and manage water for handwashing. This thesis showed that respondents from non-agricultural backgrounds had better socioeconomic status and support to increase the rates of improved WASH status. In Nepal, approximately two in three households depend on agriculture-related employment, which creates an economic burden and causes poor WASH facilities [110].

The community-level-factors such as distance to water source, geography, place of residence and health mother group are included in this thesis. The time consumed by travelling longer distances to collect water affects children's health, care, education, and nutrition, and the employment and productivity of the household [441]. Relative to respondents from the plains regions, those in mountains regions had lower rates of available soap, water, and a fixed place for handwashing in Nepal. This is because the mountains region has less market access due to the difficult geography and high poverty rate, which reduces the ability to buy soap and obtain adequate water. This thesis revealed that households in Province 7 had good access to WASH component services. This is due to the implementation of empowerment programs with WASH advocacy through multi-sectorial approaches. However, households in Provinces 2 and 6 were less likely to have access to improved WASH than in other provinces, due to the lack of knowledge of husbands and mothers (reported in Chapter 6). Province 6 is the most geographically difficult and also has the second lowest literacy rate of all provinces, and therefore has a lower access to WASH compared with the national figures [160]. Similarly, half of the people in Province 2 had the lowest level of education of the seven provinces included in the study.

This thesis found that education level, ecology, distance to water source, province, and wealth index were statistically significantly related to access to WASH. Household WASH is reliant on a number of social factors of health, such as education, employment, income, health care services, living standards, and government support [442]. The current levels of funding for the provision of WASH facilities are limited to basic services. Increased expenditure is needed for the provision of good-quality WASH facilities [443].

Household mothers usually get to wash their hands last due to a hierarchy set in families in Nepal. The mother comes in after her husband and the in-laws. They count mothers' utilisation of WASH services in low esteem, but they expect the mothers to ensure all WASH services at home. This results in a negative effect on mothers' WASH with in household and causes child health problems. Therefore, family and community support must be ensured for equal access to WASH facilities at home. This result is supported by a previous study on delaying factors for maternal service utilisation, and family and community support to overcome barriers of poor social networking and passive community involvement [444].

Although mothers are ideally placed to model WASH behaviours and advocate for WASH facilities, their frequent lack of individual power and autonomy within the family and community structures are barriers to this potential response. Women, including mothers, can be enabled to advocate for WASH behaviour to assist in preventing disease at every level of the ecological model, through policy change, community engagement with families, and family engagement and empowerment with female household members.

Further timely lobbying of local government and concerned authorities for WASH infrastructure development must be ensured in Nepal. A number of recent studies have indicated that both individual-family-, and community-level factors can influence a household's use of WASH services. A Social Behaviour Change Communication approach needs to be applied to develop sustainable WASH facilities for all family members within the household. Providing only traditional awareness activities is ineffective in promoting further change in WASH practices. Active community participation, such as involving mothers, husbands, youth groups, school teachers, students, and local leaders in planning, is crucial for change in all preventive health behaviours of family members, particularly in relation to WASH service utilisation and communicable diseases in Nepal. This claim is supported by the latest intervention study conducted in 2017 in the Parbat district of Nepal [445]. Maximum utilisation of locally available resources with regard to WASH Product, Price, Promotion, and Place [446] must be ensured.

## 8.6 Effects of WASH on diarrhoea and malnutrition

Inadequate WASH is a common risk factor for diarrhoeal disease and other communicable diseases. Previous studies have shown that good-quality WASH practices reduce the risk of diarrhoea among children. The use of sanitary toilets reduces diarrhoea rates by half and is an effective health promotion intervention. Rates of child deaths due to diarrhoeal disease are higher for children of poor socioeconomic status [82]. This thesis revealed that diarrhoeal disease is more likely to occur when access to combined WASH is limited (reported in Chapter 7). The absence of a fixed place for handwashing was highly significantly associated with the prevalence of diarrhoea among children under five years, as an established handwashing place is conducive to maintaining sanitary and hygienic conditions within the home. This is evident in a literature review conducted by Kumar and colleagues in 2017, which showed that developed countries had higher rates of fixed places for handwashing within the household compared with those in developing countries [317]. Those households which have a fixed place for handwashing are more likely to have access to a sanitary toilet and an improved water source. This thesis found that household family members without access to combined WASH services were twice as likely to have children under five years who had diarrhoea than household family members who did have access to WASH services. To prevent diarrhoeal infection, the principle of the 5F (Flies, Fingers, Faeces, Foods, and Fomites) must be satisfied [435]. Sanitation barriers are the process of segregation of human excreta in such a way as to break the communicable disease transmission cycle from reservoir to new host [48]. The sanitation barriers are interconnected with 5F, and the combined WASH components support sanitation barriers.

Malnutrition is categorised as stunting, wasting and underweight, and in this thesis it was measured in relation to four different WASH components after adjusting for identified possible confounders (reported in Chapter 7). This thesis's results are consistent with those from a randomised controlled trial conducted in Bangladesh and Kenya, which showed that combined interventions related to WASH had no impact on stunting rates [447, 448]. In this thesis, children of mothers with access to sanitary toilets for excreta disposal were found to have a significant association with stunting and being underweight, while two recent studies conducted in Bangladesh and Kenya did not [447, 448]. The unsanitary disposal of human excreta increases the risk of diarrhoea among children under five years, and it can cause linear growth faltering and chronic malnutrition [449]. This indicates that malnutrition can increase the risk of contracting diarrhoea [379]. Unsanitary toilets can affect children's linear growth by contributing to the frequent infection of diarrhoea [287]. This thesis found a significant association between toilet facilities and stunting. It also revealed that wasting of children under five years was significantly associated with a fixed place for handwashing. Households with available improved WASH facilities had a higher chance of practicing good hygiene and sanitation. Such households are likely to have nutrient-rich food and good eating practices, which help to improve children's health status. This thesis found a gap in available WASH facilities according to ecology, distance to a water source, and level of education and poverty in Nepal.

## 8.7 Strengths and limitations

This thesis has a number of strengths. Firstly, this thesis used both a systematic review and the 2016 NDHS data, thus providing a high level of evidence for the findings. The data from the 2016 NDHS were collected from a large sample, thus providing good generalisability of the results. The data collection procedure was standardised across the country, had high response rates, and was kept confidential. Secondly, the clusters and households were selected from provinces, and rural-urban settings, accounting for the whole territory of Nepal. A cluster-based cross-sectional study design shows population hierarchies and permits data analysis that distinguishes between individual-, family-, and community-level factors [294, 450]. Thirdly, multistage cluster sampling techniques were systematically applied for the selection of participants, and thus reduced selection bias. Anthropometric measurements taken during the survey gave accurate results of stunting, wasting, and underweight of children under five years [57]. This thesis is the first study in Nepal that used multi-level factor analysis, and provides insight into the individual-, family-, and community-level factors which affect WASH, unlike previous studies. This thesis employed a multi-level logistic regression analysis, which enabled identification of the effects of predictors and outcomes of interest. The Directed Acyclic Graphs assisted with identification of the presence of confounders for the causal question, by adjusting variables in the multivariate analysis [289]. Also, the analysis of the combination of individual WASH components provided further accurate information about the current WASH status of households, in the first study of its kind in Nepal. Finally, this thesis raises the public health importance of WASH, including handwashing with soap, which is supported by the current global COVID–19 prevention and control initiatives. Evidence from the current global COVID–19 pandemic has emphasised that handwashing with soap is one of the best disease-prevention public health measures [451]. In 2020 the international handwashing day on 15th of October slogan "hand hygiene for all" further demonstrates its importance.

Along with these strengths, the research included in this thesis has limitations. Firstly, as the thesis involved analysis of a secondary source of data, it was only possible to consider the study variables available in the 2016 NDHS data, thus limiting the study areas of WASH and communicable diseases. For example, WASH variables were related to facilities availability and access at the household level, and thus did not allow study of the actual practice of WASH, which may be lacking. Access and practice are different things. Secondly, the data collected from a cross-sectional survey of the respondents was based on their past experiences, behaviour and outcomes, which might be subject to recall bias. Similarly, because of the cross-sectional design of the study, the data analysis provides evidence of associations between WASH and diarrhoea and malnutrition, but it cannot display temporal or causal relationships [452]. Thirdly, the measurement of WASH components by frequent observations is a more reliable method than single observation data, as was used in this study, and thus, there may be some inaccuracy in the data. Then, due to the missing data in the survey, the outcome results may be underestimated in this thesis. For example, some children had missing values for height and weight due to their absence or refusal to participate during data collection. Finally, the health status of children under five years in this study is limited to diarrhoea and malnutrition. Therefore, further study is required to understand children's physical, mental, and social health status in relation to WASH in Nepal. The WHO/UNICEF's 'Hand Hygiene for All' road map must be adopted through political commitment and leadership, creating enabling environments and increasing the supply and demand for handwashing with soap at multiple settings in Nepal.

## 8.8 Implications for further research

Further research should address the following issues.

Firstly, this thesis showed different rates of WASH coverage by an individual-, family- and community factors, showing the value of this approach as an instrumental tool for further research. For example, spatial analysis of unimproved WASH in Nepal could be expanded to consider factors at each level, in addition to area. Critical evaluation of multi-level factors would provide understanding of the influences on actual use of WASH services. Secondly, there are now further opportunities for analysing policy level factors using primary sources of data, which were unavailable in the 2016 NDHS. Thirdly a greater understanding of the individual drivers of WASH uptake is needed to develop policies and practices that will encourage use of WASH at the individual level. Finally, qualitative investigations in those areas with WASH facilities and poor WASH uptake are warranted.

## 8.9 Implications for policy and practice

This thesis has implications for health promotion practice and policy. The thesis found that the individual-level factors that influence WASH uptake included poor knowledge of husbands and mothers, as well as family-level factors, including poverty. Community-level factors included ecology and distance to water source, and this has significant implications for future research. Other individual factors, such as age of mothers and children, occupation, caste or ethnicity, and family-level factors exposure to newspapers and television, were found to be significant factors for sanitation and hygiene. Community-level factors, such as rural-urban residence and province, were also influencing factors for sanitation and hygiene in Nepal. Mothers who were connected with Health Mothers' Groups (HMGs) had a higher chance of having a sanitary toilet in the home. Similarly, both a fixed place for handwashing with soap and combined WASH facilities had significant implications in relation to diarrhoea, type of toilet played a significant role in stunting, and fixed place for handwashing played a significant role in wasting. Other identified individual- family-, and community-level factors, such as age of children and mothers, current breastfeeding practice, exposure to television, and ecology and province, have considerable implications for diarrhoea and malnutrition in Nepal.

From the above, it can be seen that research into WASH must take account of individual, family, and community factors, noting that not all factors are responsible for improving WASH and reducing rates of diarrhoea and malnutrition. The GoN must consider the most important factors when developing WASH-related policies and program implementation strategies. Further studies should be undertaken to explore these issues in more detail.

Within this discourse, firstly, the local, provincial and central governments should set a clear target, in line with the Nepal Health Sector Strategy-Implementation Plan and SDG–6, to improve household-level WASH facilities, particularly with a focus on handwashing with soap. Secondly, WASH facilities must be based on WHO criteria. Then individual factors, such as knowledge of WASH and diseases risks, must be improved through targeted health promotion and education interventions. Poverty must be reduced through income generation programs and community participation. Furthermore, traditional cultural beliefs related to WASH utilisation by gender, and caste or ethnicity should be changed through family and community education. Finally, the GoN should construct roads, bridges, and other community development projects, with community partnership and ownership, to help households gain access to improved water sources. This suggests that policies which consider individual, family and community factors (education, poverty, geography and distance) and make use of mass media may be successful in improving WASH facilities. To achieve this, advocacy and education about WASH, provision of WASH services, and WASH policy development must be implemented in Nepal.

Mass media, such as television and newspapers, have a positive influence on household members and the wider community with regard to increasing awareness of WASH services. Newspapers are more effective for communicating with those with higher levels of education, while television is more effective for those with lower education levels. The type of mass media must take into account the target population and the geography of their area. The HMG is an effective means of delivering health messages to mothers, particularly regarding the benefits of using sanitary toilets. For other WASH components, such as improved water source and handwashing with soap, community discussions are more effective. Therefore, further study must be undertaken to determine the effectiveness of HMG and discussion sessions. An observational study of behaviour in the household would address the inadequacies of single observations and self-reports of WASH facilities and practices. Behavioural studies must be conducted to address the gap in knowledge due to use of self-reported behaviour of WASH facilities. The most effective methods for public health intervention, therefore, would be those that tackle behavioural changes of all household family members including mothers and children. The timing of the intervention also plays a significant role, in that health education requires repetition to reinforce its message. A WASH service approach, such as the provision of toilets, soap, water and a fixed place for handwashing, an information centre, and supermarkets or grocery shops, must be ensured through maximising available resources. It is important to motivate local leaders and community members to provide improved water sources and adequate sanitation facilities. Appropriate handwashing policy must be formulated by GoN in Nepal, since the rate of handwashing with soap is almost half the rates of provision of improved water sources and sanitary toilet facilities, and handwashing with soap has been proven to be an important method for prevention and control of communicable diseases.

## 8.10 Conclusions

In Nepal, WASH is significantly associated with individual-, family-, and community-level factors. Household heads and mothers with higher levels of education have better WASH access. Those with a water source further than 30 minutes' distance from their households had lower rates of access to WASH. Wealth index, ecology and remoteness of the household influence access to WASH. This thesis concludes there are gaps in access to WASH between rural and urban, poor and rich, and educated and uneducated people.

The use of a sanitary toilet in the household is negatively associated with stunting and underweight in children under five years. Similarly, a fixed place for handwashing is significantly negatively associated with diarrhoea and wasting. Households without a fixed place for handwashing are likely to be of low economic status and uneducated, and its members are likely to have poor hygiene status. Due to poor hygiene, a child living in such a household may become infected with diarrhoea, and chronic diarrhoea may cause nutrient depletion and wasting. Therefore, hygiene and sanitation are interconnected with the income of people and their food consumption, and deficiencies in these factors can lead to diarrhoea and malnutrition. Combined WASH has a positive impact by reducing the prevalence of diarrhoea, but does not reduce overall malnutrition rates. Well-designed and well-implemented interventions on handwashing behaviours, adequate improved water sources and sanitary disposal of human excreta, and addressing local culture, norms and resources, can result in significant improvements in WASH facilities in Nepal. Child mortality in Nepal will be addressed when WASH facilities are available to and used by all. Community-based WASH initiatives aimed to improve household-level WASH facilities should be strengthened. Therefore, it can be concluded that the combination of good WASH and good nutrition must be ensured for a healthy family and their children.

## 8.11 Key recommendations

From the results of this thesis, the following key recommendations have been developed for the GoN, MoHP, MoSD, political authorities, municipalities and rural municipalities, and all concerned stakeholders:

1. Further research on household-level WASH behaviours is required to fill the knowledge gap regarding WASH facilities and how they are used within households by individuals and families. It is important to investigate the effectiveness of handwashing with soap, both using and not using the six steps. This thesis identifies the need to initiate further study on uptake of improved water sources and toilet facilities which ultimately support effective handwashing with soap practices at the household level.
2. Health promotion and education interventions are important for all citizens to establish sound WASH practices at the household level, and television is one effective mass

medium for delivering WASH messages and thereby preventing from diarrhoea, stunting and underweight among children under five years. Traditional folk media interventions are further investigated at local level.

3. In this thesis, the hills region had access to less improved water sources, and in the mountains region, there was less availability of soap, water and fixed handwashing places. Therefore, the establishment of fixed places for handwashing and improved water purification techniques at the household level must be a priority in these ecological zones, through community participation and under the leadership of local government. Province 2, in the plains region, is a sanitation and hygiene 'dark zone'. There are still high rates of absence of handwashing facilities, and poor environments Therefore, health education programs are needed here. The Sanitation and Hygiene in Priority (SHP) program is proposed to introduce and implement WASH in sustainable ways. Province 2 and Karnali are priority areas in need of an effective and sustainable implementation of the SHP program.

4. The use of sanitary toilets must be promoted and provided.

5. The lack of combined WASH facilities increase the risk of diarrhoea among children under five years but not with malnutrition. Therefore, combined WASH activities should be implemented to prevent communicable diseases.

6. A fixed place for handwashing is an indicator of a health-minded household and helps to prevent diarrhoea and wasting among children under five years. Handwashing with soap is seen as one of the best methods for preventing diarrhoea. Therefore, local governments should develop a handwashing policy for households adopting the WHO/UNICEF "Hand Hygiene for All" road map, including the use of soap and the establishment of a fixed place for handwashing.

7. WASH services should be accessible for all family members, including mothers and children, and the wider society. It is an individual's responsibility, with family support, to maintain safe water, sanitary toileting and handwashing practices.
8. Collective initiatives strong leadership, political willpower and transparency remain unstudied. These issues warrant further investigation.

Low levels of education, poverty, geography are the barriers for improved WASH facilities in Nepal. Family and community support must be provided to improve WASH facilities and thereby improve child health status of Nepal. Additionally, a better understanding of individual drivers of WASH uptake must be developed to ensure a reduction in child morbidity and mortality. In addition to policies focusing on soap, water, and effective handwashing, provision of education is recommended. This is consistent with the Ottawa Charter for Health Promotion strategies [453] for high-quality health services and to meet the SDGs.

# Chapter 9. Policy Brief: 'The Importance of Handwashing and Opportunities for Improvement'

## 9.1 Background

Globally, in 2016, one in five deaths occurred due to communicable diseases, and 99% of these deaths occurred in developing countries, including Nepal. Approximately 10% of these deaths were mainly associated with lack of handwashing practices. Absence of a fixed place for handwashing is associated with higher rates of diarrhoea and wasting among children under five years. Combined WASH facilities, that is an improved water source, a sanitary toilet, and available handwashing facilities with soap and water, promote handwashing with soap behaviour of household family members. Less than half of the households have handwashing with soap facilities; this is a lower percentage than sanitary toilets and improved water sources in Nepal. Most available previous policies, guidelines, strategies and directives related to WASH addressed water and sanitation but handwashing issue is yet to be addressed. This limitation can fulfill the gap of formulating handwashing policy in line with SDG-6 and the constitution of Nepal. However handwashing with soap is becoming a habit among population after COVID-19 but its sustainability remains challenging and therefore this is important to explore handwashing policy in Nepal.

## 9.2 Introduction

Handwashing with soap remains a health promotion challenge. It is an issue that has been historically neglected in health policy and also by the general population [323]. Approximately 53% of Nepalese people do not use soap and water for handwashing on any occasion. A conducive environment, incorporating factors such as motivation, knowledge, behaviour, income, and a fixed place for handwashing [454], is crucial for the prevention of communicable diseases, such as diarrhoea and, most recently COVID–19 [130]. In Nepal, 47% of household members including mothers use soap and water and 20% of households did not have access to soap and/or other cleaning agents at the handwashing place [57]. The absence of a fixed place for handwashing precludes available soap and water. This policy briefing was conducted using available existing WASH related plans, policies, guidance, strategies, procedures and standard.

Firstly the intended audience for these policy recommendations are political leaders [76]. In addition, the recommendations may be relevant to the government and non-government authorities that represent education, agriculture, water and sanitation, transport, planning, and health. Then, media organisations are instrumental in delivering information regarding handwashing with soap to the general public, and they also have the capacity to influence political leaders. Therefore, the media should be included in the target audience. Finally, the general population can benefit from this policy.

Handwashing was not addressed in 15th five year plan of Nepal as well as in the district, municipality and village WASH strategies plans. Advocating this issue in the future will draw attention to keep it prioritized in the periodic national plan.

The general population tends not to undertake preliminary precautions, and policy-makers are not proactive in the preparation and implementation of plans to combat the risk of communicable diseases [455]. This policy briefing seeks to report health promotion evidence on the "importance of handwashing and opportunities for improvement in Nepal".

## 9.3 Critical reflection

### 9.3.1 To What extent do existing WASH policies support handwashing with soap?

Existing policies related to WASH indirectly support handwashing by providing access to water and toilet facilities. In 2019, the Ministry of Water Supply developed a guideline for WASH plan which aimed to get implemented at all local level but it remains challenging to do so due to the situational alteration in different regions [456]. There is a guidance note on minimum WASH requirements in COVID-19 quarantine and isolation centers [457], however, there remains a need to develop a standard national hand washing policy in Nepal.

The Rural Water Supply Policy of 2004 supported good handwashing practices by ensuring adequate water supplies. The communication of this policy was via locally accepted channels, which increased awareness of it [222]. The Urban Water Supply and Sanitation Policy in 2008 endorsed core principles, such as public health, economic growth, social inclusion, protecting and optimising investment, environmental protection, urban water supply, and sanitation [223]. The Sanitation and Hygiene Master Plan of 2011 emphasised the importance of handwashing with soap at critical moments [106]. Significantly, none of these initiatives included strategies for handwashing in households or institutions. However, the Constitution of Nepal, the NHSS–IP (2016-21), and the Sustainable Development Goals (SDGs) have given priority to this issue [231]. The Sector Development Plan (2016-30) addressed the importance of handwashing with soap [227]. The National Standard for WASH in health facilities of Nepal 2018 has also considered handwashing with soap as a priority action [147]. The School WASH procedure was launched to promote WASH at public and private schools, which encourages students, teachers and parents to practice handwashing with soap. However the household members might have obstacle to access handwashing with soap practice due to lack of knowledge about handwashing with soap, lack of soap and water in the handwashing places and absence of a clear plan of handwashing. The WASH policy must include the burden of communicable diseases, health care system, efficiency gains and value of money. The magnitude and burden of diseases help to estimate budget and WASH intervention plans during the planning phase. Therefore these components are interconnection and need to consider during planning. Available directives and strategies communication related to handwashing must be implemented throughout the country and timely revised them. A handwashing policy is urgently required but yet to be developed. Communities would best benefit from locally appropriate handwashing policy and implementation.

### 9.3.2 What action can policy-makers take towards improving rates of handwashing with soap?

This is the right time to give importance to handwashing by policy-makers in Nepal. A proposed handwashing policy in Nepal should be consistent with the main mandate of the Constitution of Nepal, NHSS–IP (2016-21), Nepal's SDGs-6, and policy recommendations discussed here. Policy-makers should work to ensure all people are aware of the principles and practices of good handwashing with soap. A situational analysis of handwashing must first be conducted through context-specific workshops and studies. Secondly, culturally appropriate health promotion handwashing approaches should be adopted, including providing education on the rules of handwashing and ensuring the availability of soap, water and fixed handwashing places. Then, collaboration and coordination between health and non-health actors should be tailored to the needs of the lower socioeconomic population, as this group would benefit most from these interventions. Finally, handwashing policy needs to be compared with those of WHO, Centre for Disease Control and Prevention and the United Nations Children's Fund to ensure its effectiveness and validity, while remaining culturally appropriate to Nepalese communities.

## 9.4 Policy recommendations

1. Formulate National, Provincial and Local level WASH steering committees to function at all levels.
2. All levels of health education must include the topic of handwashing with soap and create an enabling environment. Other WASH components such as improved water and sanitary toilet provision must be ensured to establish sustainable handwashing practices

by all.

3. Audio-visual communication methods and media for health promotion of handwashing practices are more effective than printed materials, so a focus on multimedia channels is recommended. All health facilities must establish health education corner with television broadcasting which helps to recall the importance of handwashing. This might be feasible through the joint leadership of municipalities and district health offices.
4. Health literacy regarding handwashing with soap must be provided in multiple languages since Nepal is a multilingual nation.
5. It is important to provide access to an improved water source, soap, and a fixed place for handwashing through a multi-sectorial approach for all households.
6. The Price, Product, Promotion and Place approach for promotion of use of soap and water must be applied in the development of handwashing strategies and programs.
7. A comprehensive health promotion and risk reduction plan must be formulated.
8. Empowering marginalized group of people such as women, children and people living with disability must be the champions of handwashing with soap in the households by heads of the household, family members and community to support them in this endeavor.
9. Handwashing should be promoted as an individual responsibility and a GoN's strategy.

# References


1. Headey DP, G. Water, Sanitation, and Child Health: Evidence from subnational panel data in 59 countries. Demography. 2019;56(2):729-52.
2. Russell F, Azzopardi P. WASH: a basic human right and essential intervention for child health and development. Lancet Glob Health. 2019;7(4).
3. Joshi A, Amadi C. Impact of water, sanitation, and hygiene interventions on improving health outcomes among school children. J Environ Public Health. 2013;2013:984626.
4. Cairncross S, Bartram J, Cumming O, Brocklehurst C. Hygiene, sanitation, and water: what needs to be done? PLoS Med. 2010;7(11):e1000365.
5. Curtis V, Cairncross S. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. The Lancet infectious diseases. 2003;3(5):275-81.
6. Borghi J, Guinness L, Ouedraogo J, Curtis V. Is hygiene promotion cost-effective? A case study in Burkina Faso. Tropical Medicine and International Health. 2002;7(11):960–9.
7. Curtis VA, Danquah, L.O., Aunger, R.V. . Planned, motivated and habitual hygiene behaviour: an eleven country review. Health Educ Res. 2009;24(4):655-73.
8. World Health Organization. Sanitation and Hygiene Promotion. Geneva, Switzerland: WHO; 2005.
9. World Health Organization, United Nations Children's Fund. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines Geneva, Switzerland: WHO; 2017.
10. Mulenga JN, Bwalya BB, Kaliba-Chishimba K. Determinants and inequalities in access to improved water sources and sanitation among the Zambian households. Int J of Dev and Sustainability. 2017;6(8):746-62.
11. World Health Organization and United Nations Children's Fund. Progress on household drinking water, sanitation and hygiene 2000-2017: special focus on inequalities: WHO; 2019.
12. World Health Organization. Global status: Global Water Supply and Sanitation Assessment 2000 Report: WHO; 2000.
13. Hutton G, Chase C. The Knowledge Base for Achieving the Sustainable Development Goal Targets on Water Supply, Sanitation and Hygiene. Int J Environ Res Public Health. 2016;13(6).
14. Water Aid. South Asia regional strategy 2016-20. Kathmandu, Nepal: Water Aid; 2019.
15. United Nations. The Millennium Development Goals Report. New York: UN; 2015.
16. United Nations Children's Fund. A snapshot of sanitation, hygiene and drinking water safety in south asia 2015 update [ accessed on 8 May 2019 from GoogleScholar]. 2015.
17. United Nations Children's Fund. Water, sanitation and hygiene challenges South Asia: UNICEF; 2020 [Available from: https://www.unicef.org/rosa/water-sanitation-and-hygiene-wash.
18. Clasen T, Boisson S, Routray P, Torondel B, Bell M, Cumming O, et al. Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: a cluster-randomised trial. Lancet Glob Health. 2014;2(11):e645-e53.
19. Freeman MC, Stocks ME, Cumming O, Jeandron A, Higgins JP, Wolf J, et al. Hygiene and health: systematic review of handwashing practices worldwide and update of health effects. Trop Med Int Health. 2014;19(8):906-16.
20. Galiani S, Gertler P, Ajzenman N, Orsola-Vidal A. Promoting Handwashing Behavior: The Effects of Large-scale Community and School-level Interventions. Health Econ. 2016;25(12):1545-59.

21. Waters E, Goldfeld S, Hopkins S. Indicators for child health, development and wellbeing: a systematic review of the literature and recommendations for population monitoring. Centre for Community Child Health. 2002.
22. World Health Organization. Global status reports on noncommunicable diseases. Switzerland: WHO; 2014.
23. Naghavi M, Abajobir AA, Abbafati C, Abbas KM, Abd-Allah F, Abera SF, et al. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1151-210.
24. Campbell OM, Benova L, Gon G, Afsana K, Cumming O. Getting the basic rights - the role of water, sanitation and hygiene in maternal and reproductive health: a conceptual framework. Trop Med Int Health. 2015;20(3):252-67.
25. World Health Organization. Sanitation: World Health Organization; 2019 [Available from: https://www.who.int/news-room/fact-sheets/detail/sanitation.
26. Chakravarty I, Bhattacharya A, Das S. Water, sanitation and hygiene: the unfinished agenda in the World Health Organization South-East Asia Region. WHO South-East Asia J Public Health. 2017;6(2):22.
27. Forouzanfar MH, Afshin A, Alexander LT, Anderson HR, Bhutta ZA, Biryukov S, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1659-724.
28. Troeger C, Blacker BF, Khalil IA, Rao PC, Cao S, Zimsen SRM, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Infect Dis. 2018;18(11):1211-28.
29. World Health Organization. World Health Organization (WHO) country cooperation strategy 2013-2017. Nepal; 2013. Report No.: 9290224282.
30. Troeger C, Forouzanfar M, Rao PC, Khalil I, Brown A, Reiner RC, et al. Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Infect Dis. 2017;17(9):909-48.
31. Pravana NK, Piryani S, Chaurasiya SP, Kawan R, Thapa RK, Shrestha S. Determinants of severe acute malnutrition among children under 5 years of age in Nepal: a community-based case-control study. BMJ Open. 2017;7(8):e017084.
32. Lin A, Arnold BF, Afreen S, Goto R, Huda TMN, Haque R, et al. Household environmental conditions are associated with enteropathy and impaired growth in rural Bangladesh. Am J Trop Med Hyg. 2013;89(1):130-7.
33. Fenn B, Bulti AT, Nduna T, Duffield A, Watson F. An evaluation of an operations research project to reduce childhood stunting in a food-insecure area in Ethiopia. Public Health Nutr. 2012;15(9):1746-54.
34. Gizaw Z, Worku A. Effects of single and combined water, sanitation and hygiene (WASH) interventions on nutritional status of children: a systematic review and meta-analysis. Ital J Pediatr. 2019;45(1):77.
35. Pickering AJ, Djebbari H, Lopez C, Coulibaly M, Alzua ML. Effect of a community-led sanitation intervention on child diarrhoea and child growth in rural Mali: a cluster-randomised controlled trial. The Lancet Global Health. 2015;3(11):e701-e11.
36. Shrestha SK, Vicendese D, Erbas B. Water, sanitation and hygiene practices associated with improved height-for-age, weight-for-height and weight-for-age z-scores among under-five children in Nepal. BMC Pediatr. 2020;20(1):134.

37. Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, & Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: a randomized controlled trial. Journal of American Medical Association,. 2004;291(21):2547-54.
38. Bowen A, Agboatwalla M, Luby S, Tobery T, Ayers T, Hoekstra RM. Association between intensive handwashing promotion and child development in Karachi, Pakistan: a cluster randomized controlled trial. Arch Pediatr Adolesc Med. 2012;166(11):1037-44.
39. Shrestha A, Six J, Dahal D, Marks S, Meierhofer R. Association of nutrition, water, sanitation and hygiene practices with children's nutritional status, intestinal parasitic infections and diarrhoea in rural Nepal: a cross-sectional study. BMC Public Health. 2020;20(1):1241.
40. World Health Organization. Monitoring health for the Sustainable Development Goals. Switzerland: WHO; 2016.
41. Pruss-Ustun A, Bartram J, Clasen T, Colford JM, Jr., Cumming O, Curtis V, et al. Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. Trop Med Int Health. 2014;19(8):894-905.
42. Prüss-Üstün A, Bos R, Gore F, Bartram J. Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva, Switzerland: WHO; 2008.
43. Wazny K, Zipursky A, Black R, Curtis V, Duggan C, Guerrant R, et al. Setting research priorities to reduce mortality and morbidity of childhood diarrhoeal disease in the next 15 years. PLoS Med. 2013;10(5):e1001446.
44. Flores Baquero Ó GGR, Pérez Foguet A, Jiménez Fdez de Palencia A. . Post-2015 WASH targets and indicators: A review from a human rights perspective. Spain University Research Institute for Sustainability Science And Technology; 2013.
45. Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand washing promotion for preventing diarrhoea. Cochrane Database Syst Rev. 2015(9):CD004265.
46. Jamison DT BJ, Measham AR, Alleyne G, Claeson M, Evans D, et al. Disease control prioritise in developing countries,. 2nd ed. Washington DC: World Bank and Oxford University Press; 2006. 1448 p.
47. Pittet D, Allegranzi B, Boyce J, World Health Organization World Alliance for Patient Safety First Global Patient Safety Challenge Core Group of E. The World Health Organization Guidelines on Hand Hygiene in Health Care and their consensus recommendations. Infect Control Hosp Epidemiol. 2009;30(7):611-22.
48. Park K. Park's textbook of preventive and social medicine. India: Banarasidas Bhanot; 2017.
49. Ministry of Population and Environment. Nepal Population Survey. Kathmandu, Nepal: MoPE; 2017.
50. Langford RM. Hand-washing and its impact on child health in Kathmandu, Nepal 2009.
51. Amouzou A, Kozuki N, Gwatkin DR. Where is the gap?: the contribution of disparities within developing countries to global inequalities in under-five mortality. BMC Public Health. 2014;14(1):216.
52. Department of Health Service. Annual report 2017/18. 24, editor. Kathmandu, Nepal: DoHS; 2018.
53. Cunningham K, Headey D, Singh A, Karmacharya C, Rana PP. Maternal and Child Nutrition in Nepal: Examining drivers of progress from the mid-1990s to 2010s. Global Food Security. 2017;13:30-7.

54. Langford R, Lunn P, Panter-Brick C. Hand-washing, subclinical infections, and growth: a longitudinal evaluation of an intervention in Nepali slums. Am J Human Biol. 2011;23(5):621-9.
55. National Planning Commission. The Fifteenth Plan. Kathmandu: Government of Nepal; 2020. 759 p.
56. National Steering Committee for Nepal Action. Nepal State of Sanitation Report 1999/2000. Kathmandu, Nepal: Steering Committee for Nepal Sanitation Action, Kathmandu; 2000.
57. Ministry of Health and Population. Nepal Demographic and Health Survey. Kathmandu: Ministry of Health and Population, New ERA and Inner City Fund International; 2016.
58. The Rising Nepal. Government to meet basic drinking water coverage in three years Kathmandu: The Rising Nepal; 2019 [Available from: https://risingnepaldaily.com/main-news/govt-to-meet-basic-drinking-water-coverage-in-three-years.
59. Upadhyay SN, Gaudel P. Water Resources Development in Nepal: Myths and Realities. Hydro Nepal: Journal of Water, Energy and Environment. 2018;23:22-9.
60. Wang C, Pan J, Yaya S, Yadav RB, Yao D. Geographic Inequalities in Accessing Improved Water and Sanitation Facilities in Nepal. Int J Environ Res Public Health. 2019;16(7).
61. World Health Organization. World Heath Statistics: Monitoring Health for the SDGs. Switzerland; 2017.
62. Water Aid Nepal. Country Strategy 2017-21. Kathmandu: Water Aid; 2017.
63. Randle J, Metcalfe J, Webb H, Luckett JC, Nerlich B, Vaughan N, et al. Impact of an educational intervention upon the hand hygiene compliance of children. J Hosp Infect. 2013;85(3):220-5.
64. Khanal S AJ. Dental caries status and oral health practice among 12-15 year old children in Jorpati, Kathmandu. Nepal Med Coll J,. 2014;16(1):84-7.
65. World Health Organization. Handwashing with soap data by country 2017 [Global Health Observatory data repository]. Available from: https://apps.who.int/gho/data/node.main.WSHHYGIENE?lang=en.
66. Sagan S, Tolani F, O'Reilly M, Daryanani A, Unni A. Assessing emotional motivators for handwashing with soap in emergencies: results from three Asian countries. Waterlines. 2019;38(1):20-35.
67. Bank W. Beyond Raising Awareness: Promoting Handwashing in Nepal Amid COVID 19 Crisis. World Bank; 2020.
68. Kumwenda S. Challenges to Hygiene Improvement in Developing Countries. The Relevance of Hygiene to Health in Developing Countries: IntechOpen; 2019.
69. World Health Organization. The sanitation challenge: turning commitment into reality. Geneva, Switzerland: WHO; 2004.
70. World Health Organization. Progress on sanitation and drinking water–2015 update and MDG assessment. 2015. Report No.: 9241509147.
71. Central Bureau of Statistics. Nepal Multiple Indicator Cluster Survey (MICS) 2014, Final Report. Kathmandu: National Planning Comission,Central Bureau Statistics (CBS), UNICEF; 2014.
72. Singh S, Gambhir Shrestha, Deepak Joshi, and Tesfayi Gebreselassie,. Childhood Illness and Mortality in Nepal: Trends and Determinants. DHS Further Analysis, Reports No 120. Rockville, Maryland, USA: ICF.2019.
73. Pant PD SB, Pradhan A, Hulton L, Matthews Z, Maskey M,. Investigating Recent Improvements in Maternal Health in Nepal: Further Analysis of the 2006 Nepal Demographic and Health Survey,. Calverton, Maryland, USA: Macro International Inc; 2008.

74. Nepal Health Research Council. National Health Research Council and National Health Research Priorities in Nepal. Kathmandu,Nepal; 2013.
75. Nilima, Kamath A, Shetty K, Unnikrishnan B, Kaushik S, Rai SN. Prevalence, patterns, and predictors of diarrhea: a spatial-temporal comprehensive evaluation in India. BMC Public Health. 2018;18(1):1288.
76. Government of Nepal. The Constitution of Nepal. Kathmandu: Government of Nepal, Nepal Gazette; 2015.
77. Ministry of Health. Nepal Health Sector Strategy Implementation Plan (NHSS-IP 2016-21). Kathmandu, Nepal: Government of Nepal, Ministry of Health(MoH); 2017.
78. Bartram J, Cairncross S. Hygiene, sanitation, and water: forgotten foundations of health. PLoS Med. 2010;7(11):e1000367.
79. Kunwar L, Kunwar B, Jain V, Subedi S. Hygiene practices in rural area of Doti district, Nepal. 2014.
80. Als D, Meteke S, Stefopulos M, Gaffey MF, Kamali M, Munyuzangabo M, et al. Delivering water, sanitation and hygiene interventions to women and children in conflict settings: a systematic review. BMJ Glob Health. 2020;5(Suppl 1).
81. WaterAid. WASH financing in Nepal 2018/19. WaterAid fact sheet. Kathmandu, Nepal: WaterAid. 2018.
82. World Health Organization. Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low-and middle-income countries: WHO; 2014.
83. Rhee V, Mullany LC, Khatry SK, Katz J, LeClerq SC, Darmstadt GL, et al. Maternal and birth attendant hand washing and neonatal mortality in southern Nepal. Arch Pediatr Adolesc Med. 2008;162(7):603-8.
84. Xheneti M, Karki ST, Madden A. Negotiating business and family demands within a patriarchal society – the case of women entrepreneurs in the Nepalese context. Entrep Region Dev. 2018;31(3-4):259-78.
85. Wali N, Georgeou N, Simmons O, Gautam MS, Gurung S. Women and WASH in Nepal: a scoping review of existing literature. Water International. 2020;45(3):222-45.
86. Freiburger MA. Mothers as Children's" First and Best Teachers: "An Institutional Ethnography (Doctoral dissertation, University of Kansas). Kansas; 2010.
87. Lam W, Fowler C, Dawson A. The approaches Hong Kong Chinese mothers adopt to teach their preschool children to prevent influenza: a multiple case study at household level. BMC Nurs. 2016;15(1):51.
88. Mshida HA, Kassim N, Kimanya ME, Mpolya E. Influence of Water, Sanitation, and Hygiene Practices on Common Infections among Under-Five Children in Longido and Monduli Districts of Arusha, Tanzania. J Environ Public Health. 2017;2017:9235168.
89. The World Bank and United Nations children's Fund. Water and Sanitation Program: Research Brief. 2015.
90. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. The Lancet. 2016;388(10063):3027-35.
91. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). Levels & Trends in Child Mortality. New York: United Nations Children’s Fund; 2018.
92. Srivastava M, Sharma A. Democratic experience in South Asia: case study of Nepal. Int journal of South Asian studies. 2010;3(3):399-410.
93. Mahara G, Dhital S. Analysis of health sector gender equality and social inclusion strategy 2009 of Nepal. Kathmandu Univ Med J. 2014;46(2):157-60.
94. Ministry of Education. Education in figures 2017: at a glance. Kathmandu. Nepal: Ministry of Education, Science and Technology. Planning and Monitoring Division; 2017.
95. Central Bureau of Statistics. Nepal in figures. Kathmandu, Nepal: CBS; 2016.

96. The Kathmandu Post. 8,848.86 metres. That’s the height of Mt Everest now, Kathmandu, Nepal: The Kathmandu Post; 2020 [Available from: https://kathmandupost.com/national/2020/12/08/it-s-official-mount-everest-is-8-848-86-metres-tall.
97. Acharya KK. Local Governance Restructuring in Nepal: From Government to Governmentality. Dhaulagiri Journal of Sociology and Anthropology. 2018;12:37-49.
98. Thapa R, Bam K, Tiwari P, Sinha TK, Dahal S. Implementing Federalism in the Health System of Nepal: Opportunities and Challenges. Int J Health Policy Manag. 2018;8(4):195-8.
99. Acharya K. Local Governance Restructuring in Nepal: From Government to Governmentality. Dhaulagiri Journal of Sociology and Anthropology. 2018;12:37-49.
100. Asian Development Bank. Country Poverty Analysis, Country Partnership Strategy: Nepal, 2013-2017. Asian Development Bank (ADB), Nepal; 2017.
101. Central Bureau of Statistics. Nepal living standard survey 2010-2011. Kathmandu, Nepal: Central Bureau Staticstics and National Planning Comission Secretariat,; 2011. 193 p.
102. Uprety P. Measures, Distribution and Decomposition of Poverty: An Empirical Analysis in Nepal. Nepalese Journal of Statistics. 2020;4:1-16.
103. Wagle N, Acharya TD. Past and Present Practices of Topographic Base Map Database Update in Nepal. Int J Geoinf. 2020;9(6).
104. Khatri RB, Mishra SR, Khanal V. Female Community Health Volunteers in Community-Based Health Programs of Nepal: Future Perspective. Front Public Health. 2017;5:181.
105. Pyakurel P, Amgain K, Kc H, Sah A, Shrestha S, Parajuli SB. Role of Female Community Health Volunteers for Prevention and Control of COVID-19 in Nepal. Journal of Karnali Academy of Health Sciences. 2020;3(1).
106. National Planning Comission. Sanitation and Hygiene Master Plan Kathmandu Government of Nepal, National Planning Comission,; 2011.
107. Mortal G. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;385(9963):117-71.
108. Sah RB, Bhattarai S, Baral D, Pokharel P. Knowledge and practice towards hygiene and sanitation amongst residents of Dhankuta Municipality. Health Renaissance. 2014;12(1):44-8.
109. Akter T, Ali A. Factors influencing knowledge and practice of hygiene in Water, Sanitation and Hygiene (WASH) programme areas of Bangladesh Rural Advancement Committee. Rural & Remote Health. 2014;14(3).
110. Gautam MS, Georgeou, N., Phillips, M., Pyakurel, U., Wali, N., & Clayton, E.,. Women and WASH in Nepal: Key Issues and Challenges, Humanitarian and Development Research Initiative, Western Sydney University, Australia. Nepal; 2018.
111. Wasonga J, Okowa M, Kioli F. Sociocultural Determinants to Adoption of Safe Water, Sanitation, and Hygiene Practices in Nyakach, Kisumu County, Kenya: A Descriptive Qualitative Study. Journal of Anthropology. 2016;2016:1-5.
112. D'Mello-Guyett L, Gallandat K, Van den Bergh R, Taylor D, Bulit G, Legros D, et al. Prevention and control of cholera with household and community water, sanitation and hygiene (WASH) interventions: A scoping review of current international guidelines. PLoS One. 2020;15(1):e0226549.
113. Luby SP AM, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. The Lancet. 2005;366:255-33.

114. World Health Organization. Preventing diarrhoea through better water, santation and hygiene: Exposures and impacts in low- and middle-income countries. Geneva, Switzerland: WHO; 2014.
115. McMichael C. Toilet Talk: Eliminating Open Defecation and Improved Sanitation in Nepal. Med Anthropol. 2018;37(4):294-310.
116. Underwood CR, Broaddus ET, Kc S, Thapa RK. Community Theater Participation and Nutrition-Related Practices: Evidence from Nepal. J Health Commun. 2017;22(4):327-36.
117. University of Newcastle. Introduction to EndNote X9. Australia: The University of Newcastle Library; 2019.
118. United Nations. The Sustainable Development Goals report. New York: UN; 2018.
119. Warner NR, Levy J, Harpp K, Farruggia F. Drinking water quality in Nepal's Kathmandu Valley: a survey and assessment of selected controlling site characteristics. Hydrogeol J. 2007;16(2):321-34.
120. Shrestha S, Semkuyu DJ, Pandey VP. Assessment of groundwater vulnerability and risk to pollution in Kathmandu Valley, Nepal. Sci Total Environ. 2016;556:23-35.
121. Chapagain SK, Pandey VP, Shrestha S, Nakamura T, Kazama F. Assessment of Deep Groundwater Quality in Kathmandu Valley Using Multivariate Statistical Techniques. Water Air Soil Pollut. 2009;210(1-4):277-88.
122. Shakya B, Nakamura T, Kamei T, Shrestha D, Nishida K. Seasonal Groundwater Quality Status and Nitrogen Contamination in the Shallow Aquifer System of the Kathmandu Valley, Nepal. Water. 2019;11(10).
123. Thakur JK, Thakur RK, Ramanathan AL, Kumar M, Singh SK. Arsenic Contamination of Groundwater in Nepal—An Overview. Water. 2010;3(1):1-20.
124. Karn SK, Harada H. Surface water pollution in three urban territories of Nepal, India, and Bangladesh. Environ Manage. 2001;28(4):483-96.
125. Koirala S, Fang Y, Dahal NM, Zhang C, Pandey B, Shrestha S. Application of Water Poverty Index (WPI) in Spatial Analysis of Water Stress in Koshi River Basin, Nepal. Sustainability. 2020;12(2).
126. Panthi J, Dahal P, Shrestha M, Aryal S, Krakauer N, Pradhanang S, et al. Spatial and Temporal Variability of Rainfall in the Gandaki River Basin of Nepal Himalaya. Climate. 2015;3(1):210-26.
127. Dahal P, Shrestha NS, Shrestha ML, Krakauer NY, Panthi J, Pradhanang SM, et al. Drought risk assessment in central Nepal: temporal and spatial analysis. Natural Hazards. 2015;80(3):1913-32.
128. Regmi B, Shrestha K. Policy gaps and insfitutional arrangements for water resources management in Nepal. HI-AWARE Working Paper; 2018.
129. Budhathoki SS, Shrestha G, Bhattachan M, Singh SB, Jha N, Pokharel PK. Latrine coverage and its utilisation in a rural village of Eastern Nepal: a community-based cross-sectional study. BMC Res Notes. 2017;10(1):209.
130. Alzyood M, Jackson D, Aveyard H, Brooke J. COVID-19 reinforces the importance of handwashing. J Clin Nurs. 2020;29(15-16):2760-1.
131. Ragusa R, Marranzano M, Lombardo A, Quattrocchi R, Bellia MA, Lupo L. Has the COVID 19 Virus Changed Adherence to Hand Washing among Healthcare Workers? Behavioral Sciences. 2021;11(4).
132. Bauza V, Sclar GD, Bisoyi A, Majorin F, Ghugey A, Clasen T. Water, Sanitation, and Hygiene Practices and Challenges during the COVID-19 Pandemic: A Cross-Sectional Study in Rural Odisha, India. Am J Trop Med Hyg. 2021.
133. MITRA Samaj. Rapid Research on Handwashing Promotion during COVID-19 Pandemic in Nepal. Kathmandu: Water Aid Nepal; 2020.

134. McMichael C, Robinson P, Manandhar S. Sustained Hygiene Behaviour Change: An Evaluative Research Report Conducted in Kotgaun VDC, Nepal. 2015.
135. New ERA. New ERA's 49th Anniversary 2019 [Available from: https://www.newera.com.np/our-history/.
136. UNICEF. Child and Family Tracker Tracking the Socio-Economic Impact of COVID-19 on Children and Families in Nepal2021.
137. Central Bureau of Statistics. Multiple Indicator Cluster Survey 2019. Kathmandu, Nepal: National Planning Comission,Central Bureau Statistics (CBS), UNICEF; 2020.
138. Crowe S, Prost A, Hossen M, Azad K, Kuddus A, Roy S, et al. Generating Insights from Trends in Newborn Care Practices from Prospective Population-Based Studies: Examples from India, Bangladesh and Nepal. PLoS One. 2015;10(7):e0127893.
139. Osrin D, Tumbahangphe KM, Shrestha D, Mesko N, Shrestha BP, Manandhar MK, et al. Cross sectional, community based study of care of newborn infants in Nepal. Bmj. 2002;325(7372):1063.
140. Falle TY, Mullany LC, Thatte N, Khatry SK, LeClerq SC, Darmstadt GL, et al. Potential role of traditional birth attendants in neonatal healthcare in rural southern Nepal. J Health Popul Nutr. 2009;27(1):53.
141. Parajuli R, Fujiwara T, Umezaki M, Konishi S, Takane E, Maharjan M, et al. Prevalence and risk factors of soil-transmitted helminth infection in Nepal. Trans R Soc Trop. 2014;108(4):228-36.
142. Ng L, Jost C, Robyn M, Dhakal IP, Bett B, Dhakal P, et al. Impact of livestock hygiene education programs on mastitis in smallholder water buffalo (Bubalus bubalis) in Chitwan, Nepal. Prev Vet Med. 2010;96(3-4):179-85.
143. Pradhan B, Kafle S. Situation of Water, Sanitation and Hygiene and Diarrhoeal Disease After Open Defecation Free Declaration and Associated Factors of Makwanpur District, Nepal. J Nepal Health Res Counc. 2018;16(2):160-4.
144. Parajuli RP, Umezaki M, Watanabe C. Behavioral and nutritional factors and geohelminth infection among two ethnic groups in the Terai region, Nepal. Am J Hum Biol. 2009;21(1):98-104.
145. Ministry of Health and Population. Nepal Demographic and Health Survey Kathmandu: Ministry of Health and Population, New ERA and Inner City Fund International; 2011.
146. Devkota GP, Bastien S, Jenssen PD, Pandey MK, Devkota B, Maharjan SK. Immediate influences of hygiene education sessions on handwashing behaviors of selected Nepali students. Journal of Water, Sanitation and Hygiene for Development. 2020.
147. Ministry of Health and Population. National Standards for WASH in Health Care Facilities. Kathmandu: The Government of Nepal; 2018.
148. World Health Organization. Water, sanitation and hygiene in health care facilities: status in low and middle income countries and way forward2015.
149. Water Aid. Summary – Assessment of WASH services in healthcare facilities in Nepal. Kathmandu: Water Aid Nepal.
150. Baral KP, Sagtani RA, Rajbhandari AK. Hand hygiene compliance among rural healthcare workers of Nepal. Journal of Patan Academy of Health Sciences. 2018;5(1):90-5.
151. Aunger R, Schmidt WP, Ranpura A, Coombes Y, Maina PM, Matiko CN, et al. Three kinds of psychological determinants for hand-washing behaviour in Kenya. Soc Sci Med. 2010;70(3):383-91.
152. Dreibelbis R, Peter JW, Leontsini E, Hulland K, Ram K, Unicomb L, et al. The Integrated Behaviour Model for Water, Sanitation, and Hygiene: a systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure - restricted settings. BMC Public Health. 2013;13(1015):1-13.

153. Chasekwa B, Maluccio JA, Ntozini R, Moulton LH, Wu F, Smith LE, et al. Measuring wealth in rural communities: Lessons from the Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) trial. PLoS One. 2018;13(6):e0199393.
154. SNV Netherlands Development Organisation. Learning brief:Sustainable Sanitation and Hygiene for All (SSH4A) in Nepal. Kathmandu, Nepal: SNV and Australian Aid,; 2017. 6 p.
155. Shrestha A, Joshi D, Roth D. The hydro-social dynamics of exclusion and water insecurity of Dalits in peri-urban Kathmandu Valley, Nepal: fluid yet unchanging. Contemporary South Asia. 2020;28(3):320-35.
156. Coyle D, Shrestha R, Thapa C. Women's insecurities and the workplace in Nepal: A study from Banke and Bara districts. Nepal: Forum for Women, Law and Development, Informal Sector Service Center, Institute of Human Rights Communication Nepal, International Alert, NationalBusiness Initiative, Saferworld, February 2014; 2014.
157. Lee T. WASH experiences of people with disabilities: Beyond The Finish Line Formative Research SNV Nepal and CBM Australia. Nepal: SNV Netherlands Development Organisation and CBM Australia an international Christian development organisation; 2019. 32 p.
158. Udmale P, Ishidaira H, Thapa B, Shakya N. The Status of Domestic Water Demand: Supply Deficit in the Kathmandu Valley, Nepal. Water. 2016;8(5).
159. Shamila J, Jane W. Women and WASH: Water, Sanitation and Hygiene for women's rights and gender equality.: WaterAid; 2013.
160. Budhathoki CB. Water Supply, Sanitation and Hygiene Situation in Nepal: A Review. J of Health Promotion. 2019;7:65-76.
161. Roskosky M, Sekine K. Emergency response in water, sanitation and hygiene to control cholera in post-earthquake Nepal in 2016. J Water Sanit Hyg Dev. 2018;8(4):799-802.
162. Sharma R, Gulati S. Water Quality Issues and Solutions in India. 2014.
163. White S, Thorseth AH, Dreibelbis R, Curtis V. The determinants of handwashing behaviour in domestic settings: An integrative systematic review. Int J Hyg Environ Health. 2020;227:113512.
164. Paul Jackway. 2017. [cited 2020]. Available from: https://info.debgroup.com/blog/keep-colds-away-this-winter-with-an-effective-hand-hygiene-programme.
165. Bolisani E, Bratianu C. The Elusive Definition of Knowledge. Emergent Knowledge Strategies. Knowledge Management and Organizational Learning2018. p. 1-22.
166. Otaki Y, Sakura O, Otaki M. Advocating water literacy. MIJET. 2015;1(1):36-40.
167. Dean AJ, Fielding KS, Newton FJ. Community Knowledge about Water: Who Has Better Knowledge and Is This Associated with Water-Related Behaviors and Support for Water-Related Policies? PLoS One. 2016;11(7):e0159063.
168. Tumwebaze IK, Mosler H-J. Shared toilet users' collective cleaning and determinant factors in Kampala slums, Uganda. BMC public health. 2014;14(1):1260.
169. Sah RK SP, Sah JK, Chiluwal S and Sah SK,. Assessment of the Knowledge, Attitude and Practice Regarding Water, Sanitation and Hygiene among Mothers of Under-five Children in Rural Households of Saptari District, Nepal. Am J Public Health Res. 2017;5(5):163-9.
170. Shrestha S, Nakamura T, Magome J, Aihara Y, Kondo N, Haramoto E, et al. Groundwater use and diarrhoea in urban Nepal: novel application of a geostatistical interpolation technique linking environmental and epidemiologic survey data. Int Health. 2018;10(5):324-32.
171. Alemu F, Kumie A, Medhin G, Gasana J. The role of psychological factors in predicting latrine ownership and consistent latrine use in rural Ethiopia: a cross-sectional study. BMC Public Health. 2018;18(1):229.

172. Butt I, Kumar U, Kumar V. An Empirical Investigation of Factors Influencing the Development of Positioning Strategy. Procedia Comput Sci. 2017;122:629-33.
173. Junias MS, Mukono J, Purnomo W. Factors of Knowledge and Toilet Availability in Affecting Behavior of Open Defecation. Int J Sci Res Publ. 2016;6(5):440-3.
174. Helgegren I, Rauch S, Cossio C, Landaeta G, McConville J. Importance of triggers and veto-barriers for the implementation of sanitation in informal peri-urban settlements - The case of Cochabamba, Bolivia. PLoS One. 2018;13(4):e0193613.
175. Budhathoki SS, Bhattachan M, Yadav AK, Upadhyaya P, Pokharel PK. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Trop Med Health. 2016;44:7.
176. WaterAid. People's perception on sanitation: Finding From Nepal. Kathmandu: WaterAid Nepal; 2011. 74 p.
177. Jha DK, Jha T. Factors Contributing to Management of Open Defecation-Free Movement of Sanitation in Mahottari District in Nepal. J Adv Res Busi Law Tech Mgmt. 2019;2(1):21-35.
178. Hulland K, Martin N, Dreibelbis R, DeBruicker Valliant J, Winch P. What factors affect sustained adoption of safe water, hygiene and sanitation technologies? A systematic review of literature. London: EPPI-Centre, Social Science Research Unit, UCL Institute of Education, University College London.; 2015.
179. Victoria. Department of Health. Health: Report to the Minister for Health from the Expert Panel on Hand Hygiene. Australia; 2013.
180. Parveen S, Nasreen S, Allen JV, Kamm KB, Khan S, Akter S, et al. Barriers to and motivators of handwashing behavior among mothers of neonates in rural Bangladesh. BMC Public Health. 2018;18(1):483.
181. SNV Netherlands Development Organisation. Barriers and Facilitators to Hygienic Use and Maintenance of Latrines and Handwashing with Soap in Sarlahi, Mahotari, Siraha and Saptari Districts of the Terai, Nepal. Kathmandu, Nepal: SNV Netherland Development Organization; 2015.
182. Buck ED, Remoortel HV, Hannes K, Govender T, Naidoo S, Avau B, et al. Approaches to promote handwashing and sanitation behaviour change in low- and middle-income countries: a mixed method systematic review. 2017:447.
183. Sabogal RI, Medlin E, Aquino G, Gelting RJ. Sustainability of water, sanitation and hygiene interventions in Central America. J Water Sanit Hyg Dev. 2014;4(1):89-99.
184. Ginja S, Gallagher S, Keenan M. Water, sanitation and hygiene (WASH) behaviour change research: why an analysis of contingencies of reinforcement is needed. Int J Environ Health Res. 2019:1-14.
185. Lally P, van Jaarsveld CHM, Potts HWW, Wardle J. How are habits formed: modelling habit formation in the real world. Eur J Psychol. 2010;40(6):998-1009.
186. Gardner B, Lally P, Wardle J. Making health habitual: the psychology of 'habit-formation'and general practice. British Journal of General Practice. 2012;62(605):664-6.
187. Floyd DL, Prentice-Dunn S, Rogers RW. A meta-analysis of research on protection motivation theory. Journal of applied social psychology. 2000;30(2):407-29.
188. Martin NA, Hulland KRS, Dreibelbis R, Sultana F, Winch PJ. Sustained adoption of water, sanitation and hygiene interventions: systematic review. Trop Med Int Health. 2018;23(2):122-35.
189. Irianti S, Prasetyoputra P, Sasimartoyo TP, Lee A. Determinants of household drinking-water source in Indonesia: An analysis of the 2007 Indonesian family life survey. Cogent Medicine. 2016;3(1).

190. Israr M, Faraz A, Ahmad S. Determinants of safe Drinking Water Supply in Nowshera District of Khyber Pakhtunkhwa. Am J Water Resour. 2017;5(3):63-71.
191. Shaheed A, Orgill J, Montgomery MA, Jeuland MA, Brown J. Why "improved" water sources are not always safe. Bull World Health Organ. 2014;92(4):283-9.
192. Dinka MO. Safe drinking water: concepts, benefits, principles and standards2018. 163-81 p.
193. Apanga PA, Garn JV, Sakas Z, Freeman MC. Assessing the Impact and Equity of an Integrated Rural Sanitation Approach: A Longitudinal Evaluation in 11 Sub-Saharan Africa and Asian Countries. Int J Environ Res Public Health. 2020;17(5).
194. Panday S, Bissell P, Teijlingen EV, Simkhada P. Perceived barriers to accessing Female Community Health Volunteers' (FCHV) services among ethnic minority women in Nepal: A qualitative study. PLoS One. 2019;14(6):e0217070.
195. Seward N, Prost A, Copas A, Corbin M, Li L, Colbourn T, et al. Using Observational Data to Estimate the Effect of Hand Washing and Clean Delivery Kit Use by Birth Attendants on Maternal Deaths after Home Deliveries in Rural Bangladesh, India and Nepal. PLoS One. 2015;10(8):e0136152.
196. Burton J. Methods and media in health education. Health Educ J. 1954;12(3):131-41.
197. Gyawali M, Rama P, Safala M, Ravi R. Knowledge on acute respiratory infection among mothers of under five year children of Bhaktapur District, Nepal IJSRP. 2016;6(2):85-9.
198. Onta S, Yengden B. What do mothers know about Acute Respiratory Infection: a case from eastern Nepal. J Inst Med. 2003:5-9.
199. Paolo M. Development Communication Sourcebook, broadening the boundaries of communication. Washington DC: The International Bank for Reconstruction and Development/The World Bank; 2008.
200. Halcrow G, Rowland C, Willetts J, Crawford J, Carrard N. Working effectively with women and men in water, sanitation and hygiene programs: Learnings from research on gender outcomes from rural water, sanitation and hygiene projects in Vanuatu and Fiji. 2010.
201. Marta Cali. Nepal: good practices towards social and gender inclusion. Kathmandu: UNICEF Nepal; 2008.
202. Regmi SC, Fawcett B. Men's roles, gender relations, and sustainability in water supplies: some lessons from Nepal. Men’s Involvement in Gender and Development Policy and Practice Edited by Caroline Sweetman, Oxfam Working Papers, Oxfam, UK. 2001.
203. Zwarteveen M, Meinzen-Dick R. Gender and property rights in the commons: Examples of water rights in South Asia. Agric Human Values. 2001;18(1):11.
204. Carrard N, Crawford J, Halcrow G, Rowland C, Willetts J. A framework for exploring gender equality outcomes from WASH programmes. Waterlines. 2013;32(4):315-33.
205. Gautam OP, Schmidt WP, Cairncross S, Cavill S, Curtis V. Trial of a Novel Intervention to Improve Multiple Food Hygiene Behaviors in Nepal. American Journal of Tropical Medicine and Hygiene. 2017;96(6):1415-26.
206. Langford R, Panter-Brick C. A health equity critique of social marketing: where interventions have impact but insufficient reach. Soc Sci Med. 2013;83:133-41.
207. Cairncross S, Hunt C, Boisson S, Bostoen K, Curtis V, Fung IC, et al. Water, sanitation and hygiene for the prevention of diarrhoea. Int J Epidemiol. 2010;39 Suppl 1:i193-205.
208. Division of Foodborne W, and Environmental Diseases at CDC,. Cholera, Typhoid,and other Waterborne Infections: Centers for Disease Control and Prevention; 2021.

209. Brauer M, Zhao JT, Bennitt FB, Stanaway JD. Global Access to Handwashing: Implications for COVID-19 Control in Low-Income Countries. Environ Health Perspect. 2020;128(5):57005.
210. Hannah DM, Lynch I, Mao F, Miller JD, Young SL, Krause S. Water and sanitation for all in a pandemic. Nature Sustainability. 2020;3(10):773-5.
211. Amegah AK. Improving handwashing habits and household air quality in Africa after COVID-19. The Lancet Global Health. 2020;8(9):e1110-e1.
212. Stocks ME, Ogden S, Haddad D, Addiss DG, McGuire C, Freeman MC. Effect of water, sanitation, and hygiene on the prevention of trachoma: a systematic review and meta-analysis. PLoS Med. 2014;11(2):e1001605.
213. Roy S, Buis M, Weersma R, Khatun W, Chowdhury S, Begum A, et al. Risk factors of mortality in severely-malnourished children hospitalized with diarrhoea. J Health Popul Nutr 2011;29(3):229.
214. Bhandari G, Bhusal C. Cholera outbreak in far-western region of Nepal. J Nepal Health Res Counc. 2013;11(23):6-8.
215. Nepal Health Research Council. Assessment of Effects of Climate Factors on Diarrheal Diseases at National and Sub-national Levels in Nepal. Kathmandu, Nepal; 2016.
216. George CM, Perin J, Neiswender de Calani KJ, Norman WR, Perry H, Davis TP, Jr., et al. Risk factors for diarrhea in children under five years of age residing in peri-urban communities in Cochabamba, Bolivia. Am J Trop Med Hyg. 2014;91(6):1190-6.
217. Kibria GMA. Prevalence and factors affecting underweight, overweight and obesity using Asian and World Health Organization cutoffs among adults in Nepal: analysis of the Demographic and Health Survey 2016. Obes Res Clin Pract. 2019;13(2):129-36.
218. Sah N. Determinants of child malnutrition in Nepal: a case analysis from Dhanusha, Central Terai of Nepal. J Nepal Health Res Counc. 2008.
219. Asian Develoment Bank. Reducing Child Malnutrition through Social Protection in Nepal. Manila, Philippines: ADB; 2011.
220. Adhikari R. Knowledge on legislation of abortion and experience of abortion among female youth in Nepal: a cross sectional study. Reprod Health. 2016;13:1-9.
221. Langford R, Lunn P, Brick CP. Hand-washing, subclinical infections, and growth: A longitudinal evaluation of an intervention in Nepali slums. American Journal of Human Biology. 2011;23(5):621-9.
222. Ministry of Physical Planning and Works. Rural Water Supply and Sanitation National Policy 2004 & Rural Water Supply and Sanitation National Strategy 2004. Kathmandu, Nepal: Ministry of Physical Planning and Works; 2004.
223. Ministry of Physical Planning and Works. National Urban Water Supply and Sanitation sector Policy of Nepal. Kathmandu, Nepal: Ministry of Physical Planning and Works; 2008.
224. Government of Nepal. Sanitation and Hygiene master plan. In: Action SCfNS, editor. Kathmandu2011.
225. Nepal Law Commission. The Public Health Service Act,. Kathmandu: Government of Nepal; 2018.
226. National Planning Comission. Multi-Sector Nutrition Plan-II (2018-2022). Kathmandu: Government of Nepal, National Planning Commission; 2017.
227. Ministry of Water Supply and Sanitation. Nepal Water Supply, Sanitation and Hygiene Sector Development Plan ( 2016 – 2030 ). Kathmandu, Nepal.
228. Nepal-Finland Cooperation. Rural Water Supply and Sanitation Project in Western Nepal Phase II 2021 [Available from: https://www.rwsspwn.org.np/.
229. Department of Health Service. Annual report 2018/19. Kathmandu, Nepal: DoHS; 2020.

230. Halfon N, Newacheck PW, Hughes D, Brindis C. Community health monitoring: taking the pulse of America's children. Matern Child Health J. 1998;2(2):95-109.
231. Waage J, Yap C, Bell S, Levy C, Mace G, Pegram T, et al. Governing the UN Sustainable Development Goals: interactions, infrastructures, and institutions. Lancet Glob Health. 2015;3(5):e251-e2.
232. World Health Organization. World Toilet Day 2019 South-East-Asia: WHO; 2019 [Available from: https://www.who.int/southeastasia/news/speeches/detail/world-toilet-day-2019.
233. Water for Women Fund. The journey to a sanitation milestone in Nepal 2019 [Available from: https://www.waterforwomenfund.org/en/news/the-journey-to-a-sanitation-milestone-in-nepal.aspx.
234. McLeroy K, Steckler A, Bibeau D. The social ecology of health promotion interventions. Health Educ Q. 1988;15(4):351-77.
235. Bronfenbrenner U. Toward an experimental ecology of human development. American psychologist. 1977;32(7):513.
236. Dahlgren GMW. Policies and strategies to promote social equity in health Revised. Sweden: Institute of Future Studies; 1991 2007.
237. Wold B, Mittelmark MB. Health-promotion research over three decades: the social-ecological model and challenges in implementation of interventions. Scand J Public Health. 2018;46(20_suppl):20-6.
238. Newes-Adeyi G, Helitzer D, Caulfield L, Bronner Y. Theory and practice: applying the ecological model to formative research for a WIC training program in New York State. Health Educ Res. 2000;15(3):283-91.
239. Salihu HM, Wilson RE, King LM, Marty PJ, Whiteman VE. Socio-ecological model as a framework for overcoming barriers and challenges in randomized control trials in minority and underserved communities. Int J MCH AIDS. 2015;3(1):85.
240. Hernandez LM, Rosenstock L, Gebbie K. Who will keep the public healthy?: educating public health professionals for the 21st century: National Academies Press; 2003.
241. Richard L, Gauvin L, Raine K. Ecological models revisited: their uses and evolution in health promotion over two decades. Annu Rev Public Health. 2011;32:307-26.
242. Bunch MJ. Ecosystem Approaches to Health and Well-Being: Navigating Complexity, Promoting Health in Social-Ecological Systems. Syst Res Behav Sci. 2016;33(5):614-32.
243. Raphael D, Brassolotto J. Understanding action on the social determinants of health: a critical realist analysis of in-depth interviews with staff of nine Ontario public health units. BMC Res Notes. 2015;8:105.
244. Ssemugabo C, Halage AA, Namata C, Musoke D, Ssempebwa JC. A socio-ecological perspective of the facilitators and barriers to uptake of water, sanitation and hygiene interventions in a slum setting in Kampala, Uganda: a qualitative study. J Water Sanit Hyg Dev. 2020;10(2):227-37.
245. Golden SD, Earp JA. Social ecological approaches to individuals and their contexts: twenty years of health education & behavior health promotion interventions. Health Educ Behav. 2012;39(3):364-72.
246. Campbell SJ, Nery SV, Wardell R, D'Este CA, Gray DJ, McCarthy JS, et al. Water, Sanitation and Hygiene (WASH) and environmental risk factors for soil-transmitted helminth intensity of infection in Timor-Leste, using real time PCR. PLoS Negl Trop Dis. 2017;11(3):e0005393.
247. Alan D. Lopez SB, Ed Bos,. Global Burden of Disease and Risk Factors: The World Bank; 1990-2001.

248. Aunger R, Greenland K, Ploubidis G, Schmidt W, Oxford J, Curtis V. The Determinants of Reported Personal and Household Hygiene Behaviour: A Multi-Country Study. PLoS One. 2016;11(8):e0159551.
249. Novotny J, Hasman J, Lepic M. Contextual factors and motivations affecting rural community sanitation in low- and middle-income countries: A systematic review. Int J Hyg Environ Health. 2018;221(2):121-33.
250. He Z, Bishwajit G, Zou D, Yaya S, Cheng Z, Zhou Y. Burden of Common Childhood Diseases in Relation to Improved Water, Sanitation, and Hygiene (WASH) among Nigerian children. Int J Environ Res Public Health. 2018;15(6).
251. Kristyna Hulland NM, Robert Dreibelbis and Peter Winch,. What factors affect sustained adoption of safe water, hygiene, and sanitation technologies? United Kingdom,: Instutute of Education, University of London. Contract No.: 75.
252. Curtis V. Hygiene: how myths, monsters, and mothers-in-law can promote behaviour change. J Infect. 2001;43(1):75-9.
253. Pattanayak SK, Yang J-C, Dickinson KL, Poulos C, Patil SR, Mallick RK, et al. Shame or subsidy revisited: social mobilization for sanitation in Orissa, India. Bull World Health Organ. 2009;87(8):580-7.
254. Lilje J, Mosler H-J. Continuation of Health Behaviors: Psychosocial Factors Sustaining Drinking Water Chlorination in a Longitudinal Study from Chad. Sustainability. 2016;8(11).
255. Kuncel NR, Rose M, Ejiogu K, Yang Z. Cognitive ability and socio-economic status relations with job performance. Intelligence. 2014;46:203-8.
256. Cowling K, Dandona R, Dandona L. Social determinants of health in India: progress and inequities across states. Intern. 2014;13:88.
257. William A. Household Access to Safe and Improved Drinking Water and Basic Sanitation in Wa Municipality. EJBM. 2013;5(23):4-25.
258. Malebo H, Makundi E, Mussa R, Mushi A, Munga M, Mrisho M, et al. Outcome and impact monitoring for scaling up Mtumba sanitation and hygiene participatory approach in Tanzania. Sanitation Hyg Res Equit. 2012.
259. Mohamed N, Zulkifli Amin NN, Ramli S, Isahak I, Mohamed Salleh N. Knowledge, attitudes and practices of hand hygiene among parents of preschool children. 2016.
260. Assefa M, Kumie A. Assessment of factors influencing hygiene behaviour among school children in Mereb-Leke District, Northern Ethiopia: a cross-sectional study. BMC public health. 2014;14(1):1000.
261. Fernandez-Haddad M, Ingram M. Factors that Influence the Effectiveness of Sanitation Programs. Front Public Health. 2015;3:201.
262. Dahal KR AB, & Tamang J. Sanitation coverage and impact of open defecation free (ODF) zone with special reference to Nepal: a review. Int J Eng Res Appl. 2014;4(8):1-11.
263. Schmidt WP, Aunger R, Coombes Y, Maina PM, Matiko CN, Biran A, et al. Determinants of handwashing practices in Kenya: the role of media exposure, poverty and infrastructure. Trop Med Int Health. 2009;14(12):1534-41.
264. Komarulzaman A, Smits J, de Jong E. Clean water, sanitation and diarrhoea in Indonesia: Effects of household and community factors. Glob Public Health. 2017;12(9):1141-55.
265. Debesay N, Ingale L, Gebresilassie A, Assefa H, Yemane D. Latrine Utilization and Associated Factors in the Rural Communities of Gulomekada District, Tigray Region, North Ethiopia, 2013. Journal Community Med Health Education. 2013;5(2).
266. Gedefaw M, Amsalu Y, Tarekegn M, Awoke W. Opportunities, and Challenges of Latrine Utilization among Rural Communities of Awabel District, Northwest Ethiopia, 2014. EPOJ. 2015;05(02):98-106.

267. Mara DD. Water, sanitation and hygiene for the health of developing nations. Public Health. 2003;117(6):452-6.
268. De Jesus M, Puleo E, Shelton RC, Emmons KM. Associations between perceived social environment and neighborhood safety: health implications. Health Place. 2010;16(5):1007-13.
269. Corsi DJ, Chow CK, Lear SA, Rahman MO, Subramanian SV, Teo KK. Shared environments: a multilevel analysis of community context and child nutritional status in Bangladesh. Public Health Nutr. 2011;14(6):951-9.
270. Raquiba A. Jahan. Promoting health literacy: a case study in the prevention of diarrhoeal disease from Bangladesh. Health Promot Internation. 2000;15(4):1-8.
271. Castle B, Wendel M, Kelly Pryor BN, Ingram M. Assessing Community Leadership: Understanding Community Capacity for Health Improvement. J Public Health Manag Pract. 2017;23 Suppl 4 (Suppl), Community Health Status Assessment:S47-S52.
272. Trevor et al. Global Change and Public Health: Addressing the Ecological Determinants of Health. Canadian Public Health Association; 2015.
273. Ekane N, Kjellén M, Noel S, Fogde M. Sanitation and Hygiene: Policy, Stated Beliefs and Actual Practice. A Case Study in the Burera District, Rwanda. Stockholm Environmental Institute Working Paper; 2012.
274. Fredriksson PG, Svensson J. Political instability, corruption and policy formation: the case of environmental policy. J Public Econ. 2003;87(7-8):1383-405.
275. Evangelia Chatzinikolaou. Use and limitations of ecological models. Greece: Institute of Marine Biology, Biotechnology and Aquaculture, Hellenic Centre for Marine Research,; 2012.
276. Jørgensen SE. State of the art of ecological modelling in limnology. Ecological Modelling. 1995;78(1-2):101-15.
277. Winch P. Ecological models and multilevel interventions2012.
278. Biran A, Schmidt W-P, Varadharajan KS, Rajaraman D, Kumar R, Greenland K, et al. Effect of a behaviour-change intervention on handwashing with soap in India (SuperAmma): a cluster-randomised trial. The Lancet Global Health. 2014;2(3):e145-e54.
279. Aunger R, Curtis V. Behaviour Centred Design: towards an applied science of behaviour change. Health Psychol Rev. 2016;10(4):425-46.
280. Coombes Y, Devine J. Introducing FOAM: A Framework to Analyze Handwashing Behaviors to Design Handwashing Programs: World Bank; 2010.
281. EHP UW, USAID, World Bank/WSP, WSSCC,. The Hygiene Improvement Framework: A Comprehensive Approach for Preventing Childhood Diarrhea: Washington, DC: Environmental Health Project; 2004.
282. Wood S, Foster J, Kols A. Understanding why women adopt and sustain home water treatment: insights from the Malawi antenatal care program. Soc Sci Med. 2012;75(4):634-42.
283. Kafle S, Pradhan B. Situation of Water, Sanitation and Hygiene and Diarrhoeal Diseases After Open Defecation Free Declaration. J Nepal Health Res Counc. 2018;16(2):160-4.
284. Dickinson LM, Basu A. Multilevel modeling and practice-based research. Ann Fam Med. 2005;3 Suppl 1:S52-60.
285. Smith T, Shively G. Multilevel analysis of individual, household, and community factors influencing child growth in Nepal. BMC Pediatr. 2019;19 (1) (no pagination)(91).
286. Van Cooten MH, Bilal SM, Gebremedhin S, Spigt M. The association between acute malnutrition and water, sanitation, and hygiene among children aged 6-59 months in rural Ethiopia. Matern Child Nutrition. 2018:e12631.

287. United States Agency for International Development. Improving nutrition outcomes with better water, sanitation and hygiene: practical solutions for policies and programmes. WHO,UNICEF,USAID; 2015.
288. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. Am J Epidemiol. 1993;138(11):923-36.
289. Suttorp MM, Siegerink B, Jager KJ, Zoccali C, Dekker FW. Graphical presentation of confounding in directed acyclic graphs. Nephrol Dial Transplant. 2015;30(9):1418-23.
290. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ. 2009;339:b2700.
291. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. The Lancet. 2007;370(9596):1453-7.
292. Fabic MS, Choi Y, Bird S. A systematic review of Demographic and Health Surveys: data availability and utilization for research. Bull World Health Organ 2012;90:604-12.
293. Devkota D, Rauniyar GP, Parker W. The role of gender and ethnicity in household decision-making: Evidence from rural Nepal. 1999.
294. Croft TN, Marshall AM, Allen CK, Arnold F, Assaf S, Balian S. Guide to DHS statistics. Rockville: ICF. 2018.
295. Rheinlander T, Konradsen F, Keraita B, Apoya P, Gyapong M. Redefining shared sanitation. Bull World Health Organ. 2015;93(7):509-10.
296. Günther I, Niwagaba CB, Lüthi C, Horst A, Mosler H-J, Tumwebaze IK. When is shared sanitation improved sanitation?-The correlation between number of users and toilet hygiene. 2012.
297. De Onis M, Blossner M, Organization WH. WHO global database on child growth and malnutrition. Geneva: World Health Organization; 1997.
298. World Health Organization. WHO Child Growth Standards Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Method and development. France WHO; 2006. 336 p.
299. Rubin DB. Multiple imputation for nonresponse in surveys: John Wiley & Sons; 2004.
300. Kenneth L. Simons. Useful Stata Commands (for Stata versions 13, 14, & 15) 2019.
301. Pagano M, Gauvreau K, Yescas Milanés J. Principles of biostatistics. Fundamentos de Bioestadística2001.
302. Kirkwood BR, Sterne JA. Essential medical statistics: John Wiley & Sons; 2010.
303. McHugh ML. The chi-square test of independence. Biochem Med (Zagreb). 2013;23(2):143-9.
304. Bertani A, Di Paola G, Russo E, Tuzzolino F. How to describe bivariate data. J Thorac Dis. 2018;10(2):1133-7.
305. Lehtonen R. Multilevel Statistical Models . Harvey Goldstein. J Am Stat Assoc. 2005;100:354-5.
306. Rabe-Hesketh S, Skrondal A. Multilevel and longitudinal modeling using Stata: STATA Press; 2008.
307. Nojima M, Tokunaga M, Nagamura F. Quantitative investigation of inappropriate regression model construction and the importance of medical statistics experts in observational medical research: a cross-sectional study. BMJ Open. 2018;8(5):e021129.
308. Szumilas M. Explaining odds ratios. J Can Acad Child Adolesc Psychiatry. 2010;19(3):227.

309. Map Tiler Team. Coordinate Reference System 2019 [Available from: https://epsg.io/?q=Nepal.%20kind%3APROJCRS.
310. Ord JK GA. Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. Ohio State University Press Geographical Analysis. 1995;27.
311. Paradis E. Moran's autocorrelation coefficient in comparative methods2020.
312. Getis A, Ord JK. The Analysis of Spatial Association by Use of Distance Statistics. Geographical Analysis. 2010;24(3):189-206.
313. DeVore GR. Computing the Z Score and Centiles for Cross-sectional Analysis: A Practical Approach. J Ultrasound Med. 2017;36(3):459-73.
314. Demographic and Health Survey Program. Spatial data repository DHS; 2016 [Available from: https://spatialdata.dhsprogram.com/boundaries/#view=table&countryId=NP.
315. Burgert CR, Prosnitz D. Linking DHS household and SPA facility surveys: Data considerations and Geospatial Methods: ICF International; 2014.
316. Curtis V, Cairncross S. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. Lancet Infect Dis. 2003;3.
317. Kumar S, Loughnan L, Luyendijk R, Hernandez O, Weinger M, Arnold F, et al. Handwashing in 51 Countries: Analysis of Proxy Measures of Handwashing Behavior in Multiple Indicator Cluster Surveys and Demographic and Health Surveys, 2010-2013. Am J Trop Med Hyg. 2017;97(2):447-59.
318. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis. Am J Public Health. 2008;98(8):1372-81.
319. Biran A, Rabie T, Schmidt W, Juvekar S, Hirve S, Curtis V. Comparing the performance of indicators of hand-washing practices in rural Indian households. Trop Med Int Health. 2008;13(2):278-85.
320. National Planning Comission. Sustainable Development Goals 2016-30. Kathmandu, Nepal; 2015.
321. Rabbi SE, Dey NC. Exploring the gap between hand washing knowledge and practices in Bangladesh: a cross-sectional comparative study. BMC public health. 2013;13(1):89.
322. Zhang C, Mosa AJ, Hayward AS, Matthews SA. Promoting clean hands among children in Uganda: a school-based intervention using 'tippy-taps'. Public Health. 2013;127(6):586-9.
323. Gammon J, Hunt J. The neglected element of hand hygiene - significance of hand drying, efficiency of different methods and clinical implication: a review. J Infect Prev. 2019;20(2):66-74.
324. Mitlin D. Equity and gender. Pathfinder report. 2011.
325. McMichael C, Robinson P. Drivers of sustained hygiene behaviour change: a case study from mid-western Nepal. Soc Sci Med. 2016;163:28-36.
326. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.
327. Kandel P, Kunwar R, Lamichhane P, Karki S. Extent of Fecal Contamination of Household Drinking Water in Nepal: Further Analysis of Nepal Multiple Indicator Cluster Survey 2014. Am J Trop Med Hyg. 2017;96(2):446-8.
328. Miller LC, Joshi N, Lohani M, Rogers B, Mahato S, Ghosh S, et al. Women's education level amplifies the effects of a livelihoods-based intervention on household wealth, child diet, and child growth in rural Nepal. Intern. 2017;16(1):183.
329. Aihara Y, Shrestha S, Sharma J. Household water insecurity, depression and quality of life among postnatal women living in urban Nepal. J Water Health. 2016;14(2):317-24.
330. Mccarthy j. and Edward R. Key Concepts in Family Studies. London: Sage; 2011.

331. Suen LKP, Rana T. Knowledge Level and Hand Hygiene Practice of Nepalese Immigrants and Their Host Country Population: A Comparative Study. Int J Environ Res Public Health. 2020;17(11).
332. Song IH, Kim SA, Park WS. Family factors associated with children's handwashing hygiene behavior. J Child Health Care. 2013;17(2):164-73.
333. Nguyen NK, Gurung H. Barriers and Facilitators to Hygienic Use and Maintenance of Latrines and Handwashing with Soap in Sarlahi, Mahottari, Siraha and Saptari Districts of the Terai, Nepal. Netherland: SNV Smart Development Work,; 2015.
334. Ghimire M, Pradhan YV, Maskey MK. Community-based interventions for diarrhoeal diseases and acute respiratory infections in Nepal. Bull World Health Organ. 2010;88(3):216-21.
335. Green LW, Kreuter MW. Health program planning: An educational and ecological approach: McGraw-Hill Companies; 2005.
336. Luby SP, Halder AK, Huda T, Unicomb L, Johnston RB. The effect of handwashing at recommended times with water alone and with soap on child diarrhea in rural Bangladesh: an observational study. PLoS Med. 2011;8(6):e1001052.
337. Schwemlein S, Cronk R, Bartram J. Indicators for Monitoring Water, Sanitation, and Hygiene: A Systematic Review of Indicator Selection Methods. Int J Environ Res Public Health. 2016;13(3).
338. White S, Kuper H, Itimu-Phiri A, Holm R, Biran A. A Qualitative Study of Barriers to Accessing Water, Sanitation and Hygiene for Disabled People in Malawi. PLoS One. 2016;11(5):e0155043.
339. Bloomfield SF, Nath KJ, editors. Use of ash and mud for handwashing in low income communities International Scientific Forum on Home Hygiene (IFH). Somerset, England: International Scientific Forum on Home Hygiene; 2009.
340. Tearfund. Sanitation and hygiene in developing countries: a case study from Burkina Faso identifying and responding to barriers. 2007.
341. Sarwar MB, Mason N. How to reduce inequalities in access to WASH rural water and sanitation in Nepal. London: Overseas Development Institute; 2017.
342. Hulland KR, Leontsini E, Dreibelbis R, Unicomb L, Afroz A, Dutta NC, et al. Designing a handwashing station for infrastructure-restricted communities in Bangladesh using the integrated behavioural model for water, sanitation and hygiene interventions (IBM-WASH). BMC public health. 2013;13(1):877.
343. United Nations Educational Scientific and Cultural Organisation. The United Nations World Water Development Report 2019: Leaving No One Behind. Paris; 2019.
344. Asian Develoment Bank. Drainage and Sanitation. Kathmandu: Padeco Co. Ltd. in association with Metcon Consultants, Nepal Tokyo, Japan; 2010.
345. Sharma B, Nepal S, Gyawali D, Pokharel GS, Wahid S, Mukherji A, et al. Springs, storage towers, and water conservation in the midhills of Nepal. ICIMOD Working Paper. 2016(2016/3).
346. Poudel DD, Duex TW. Vanishing Springs in Nepalese Mountains: Assessment of Water Sources, Farmers' Perceptions, and Climate Change Adaptation. Mountain Research and Development. 2017;37(1).
347. Johri M, Sylvestre MP, Kone GK, Chandra D, Subramanian SV. Effects of improved drinking water quality on early childhood growth in rural Uttar Pradesh, India: a propensity-score analysis. PLoS One. 2019;14(1):e0209054.
348. Mahmud I, Mbuya N. Water, Sanitation, Hygiene, and Nutrition in Bangladesh: Can Building Toilets Affect Children's Growth?: The World Bank; 2015.

349. Bain R, Cronk R, Wright J, Yang H, Slaymaker T, Bartram J. Fecal contamination of drinking-water in low- and middle-income countries: a systematic review and meta-analysis. PLoS Med. 2014;11(5):e1001644.
350. Bhattarai R, Dahal K. Review of water pollution with special focus on Nepal J Emerg Tech Innov Res. 2020;7(5).
351. Armah FA, Ekumah B, Yawson DO, Odoi JO, Afitiri AR, Nyieku FE. Access to improved water and sanitation in sub-Saharan Africa in a quarter century. Heliyon. 2018;4(11):e00931.
352. He WJ, Lai YS, Karmacharya BM, Dai BF, Hao YT, Xu DR. Geographical heterogeneity and inequality of access to improved drinking water supply and sanitation in Nepal. Int J Equity Health. 2018;17(1):40.
353. Vyas S, Spears D. Sanitation and religion in South Asia: What accounts for differences across countries? J Dev Stud. 2018;54(11):2119-35.
354. WaterAid. Community led total sanitation in Nepal getting us back on track. Kathmandu: WaterAid Nepal; 2006.
355. Central Bureau of Statistics. Report on the Nepal Labour Force Survey 2017/18. Kathmandu, Nepal: National Planning Commission 2018.
356. Low S, Spindler PG. Child Care Arrangements of Working Mothers in the United States. 1968.
357. Stuart L. Transforming our world: The 2030 Agenda for Sustainable Development A/RES/70/1: THEME: statement,'Do not leave Indigenous Australians behind'. 2017.
358. Angoua ELE, Dongo K, Templeton MR, Zinsstag J, Bonfoh B. Barriers to access improved water and sanitation in poor peri-urban settlements of Abidjan, Cote d'Ivoire. PLoS One. 2018;13(8):e0202928.
359. Musil CM, Youngblut JM, Ahn S, Curry VL. Parenting stress: A comparison of grandmother caretakers and mothers. J Ment Health Aging. 2002;8(3):197.
360. Narayan D. Contribution of people's participation: evidence from 121 rural water supply projects. Environmentally sustainable development ocassional paper series: World Bank; 1994.
361. Wendland C, Yadav M, Stock A, Seager J, Rose J, Jiménez-Cisneros B. Gender, Women and Sanitation. Global Water Pathogen Project2019.
362. Bronfenbrenner U. Toward an experimental ecology of human development. Am Psychol. 1977;32(7):513.
363. Hosmer DW, Lemesbow S. Goodness of fit tests for the multiple logistic regression model. Commun Stat Theory Methods. 1980;9(10):1043-69.
364. Hansen AM. Goodness-of-Fit Tests for Autoregressive Logistic Regression Models and Generalized Linear Mixed Models: UC Riverside; 2012.
365. Snijders TA. Multilevel analysis: Springer; 2011.
366. Banks LM, White S, Biran A, Wilbur J, Neupane S, Neupane S, et al. Are current approaches for measuring access to clean water and sanitation inclusive of people with disabilities? Comparison of individual- and household-level access between people with and without disabilities in the Tanahun district of Nepal. PLoS One. 2019;14(10):e0223557.
367. Prakash A, Vs S, Chourey J. Interlacing water and human health: case studies from south asia: SAGE Publications India; 2012.
368. Karn RR, Bhandari B, Jha N. A study on personal hygiene and sanitary practices in a rural village of Mornag District of Nepal. JoNMC. 2011;1(2):39-44.
369. Agbadi P, Darkwah E, Kenney PL. A Multilevel Analysis of Regressors of Access to Improved Drinking Water and Sanitation Facilities in Ghana. J Environ Public Health. 2019;2019:3983869.

370. Reddy BV, Kusuma YS, Pandav CS, Goswami AK, Krishnan A. Water and Sanitation Hygiene Practices for Under-Five Children among Households of Sugali Tribe of Chittoor District, Andhra Pradesh, India. J Environ Public Health. 2017;2017:7517414.
371. Indarti N, Rostiani R, Megaw T, Willetts J. Women's involvement in economic opportunities in water, sanitation and hygiene (WASH) in Indonesia: Examining personal experiences and potential for empowerment. Dev Stud Res. 2019;6(1):76-91.
372. Subedi M. Caste System: Theories and Practices in Nepal. Himalayan Journal of Sociology and Anthropology. 2011;4:134-59.
373. Secretariat CA, Durbar S. Constitution of Nepal 2015. Kathmandu: Constituent Assembly Secretariat. 2015.
374. WaterAid. WASH and poverty: Post-2015 toolkit: Water Aid; 2015.
375. Dhungel S. Provincial Comparison of Development Status in Nepal: An Analysis of Human Development Trend for 1996 to 2026. Journal of Management and Development Studies. 2018;28:53-68.
376. Kien Gia To J-KL, You-Seon Nam, Oanh Thi Hoang Trinh and Dung Van Do. Hand washing behavior and associated factors in Vietnam based on the Multiple Indicator Cluster Survey, 2010-2011. Glob Health Action. 2016;9:29207.
377. Franceys R, Tamekawa C, Mesa B, Ezbakhe F, Cuadrado L, Chan MY, et al. A systematic review of success factors in the community management of rural water supplies over the past 30 years. Water Policy. 2015;17(5):963-83.
378. Gelman A. Multilevel (Hierarchical) Modeling: What It Can and Cannot Do. Technometrics. 2006;48(3):432-5.
379. Brown KH. Diarrhea and malnutrition. J Nutr. 2003;133(1):328S-32S.
380. Omona S, Malinga GM, Opoke R, Openy G, Opiro R. Prevalence of diarrhoea and associated risk factors among children under five years old in Pader District, northern Uganda. BMC Infect Dis. 2020;20(1):37.
381. Wolf J, Hunter PR, Freeman MC, Cumming O, Clasen T, Bartram J, et al. Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: updated meta-analysis and meta-regression. Trop Med Int Health. 2018;23(5):508-25.
382. Reiner RC, Wiens KE, Deshpande A, Baumann MM, Lindstedt PA, Blacker BF, et al. Mapping geographical inequalities in childhood diarrhoeal morbidity and mortality in low-income and middle-income countries, 2000–17: analysis for the Global Burden of Disease Study 2017. The Lancet. 2020;395(10239):1779-801.
383. World Health Organization. Diarrhoral diseases fact sheet 2017 WHO; 2017 [Available from: https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease.
384. Troeger CE, Khalil IA, Blacker BF, Biehl MH, Albertson SB, Zimsen SRM, et al. Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. The Lancet Infectious Diseases. 2020;20(1):37-59.
385. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, et al. Global burden of childhood pneumonia and diarrhoea. The Lancet. 2013;381(9875):1405-16.
386. Ansari S, Sherchand J, Parajuli K, Mishra S, Dahal R, Shrestha S, et al. Bacterial etiology of acute diarrhea in children under five years of age. J Nepal Health Res Counc. 2013.
387. Pokhrel S, Snow R, Dong H, Hidayat B, Flessa S, Sauerborn R. Gender role and child health care utilization in Nepal. Health Policy. 2005;74(1):100-9.
388. Pokhrel S. Determinants of parental reports of children's illnesses: empirical evidence from Nepal. Soc Sci Med. 2007;65(6):1106-17.
389. Strand TA, Sharma PR, Gjessing HK, Ulak M, Chandyo RK, Adhikari RK, et al. Risk factors for extended duration of acute diarrhea in young children. PLoS One. 2012;7(5):e36436.

390. Mukhtar A, Mohamed Izham MI, Pathiyil RS. A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. Australas Med J. 2011;4(9):474-9.
391. Ansari M, Ibrahim MIM, Hassali MA, Shankar PR, Koirala A, Thapa NJ. Mothers' beliefs and barriers about childhood diarrhea and its management in Morang district, Nepal. BMC research notes. 2012;5(1):576.
392. Ansari M, Palaian S, Izham M, Ibrahim M. The role of mothers in the management of childhood diarrhoea in Nepal. Australas Medical J. 2008:235-8.
393. Stapleton MC. Diarrhoeal diseases: perceptions and practices in Nepal. Social Science & Medicine. 1989;28(6):593-604.
394. Tieari S, Paudel A, Rawal L. Socio-cultural factors influencing in care seeking practices during diarrhoea in Tharu community. Journal of Nepal Health Research Council. 2008.
395. Joshi A, Shrestha RPB. Study of Viral Diarrhoea and Associated Risk Factors Among Under Five Years Old Children in Dhulikhel Hospital, Kathmandu University Hospital. Clin Chem Lab Med. 2015;1(2):15-22.
396. United Nations Children's Fund How WASH relates to health, education and development 2015 [Available from: https://www.unicef.org/wash/index_healthandeducation.html.
397. United Nations Children's Fund Monitoring the situation of children and women 2019 [Available from: https://data.unicef.org/topic/nutrition/malnutrition/.
398. World Health Organization. Malnutrition: Key facts 2018 [Available from: https://www.who.int/news-room/fact-sheets/detail/malnutrition.
399. Dorsey JL, Manohar S, Neupane S, Shrestha B, Klemm RD, West Jr KP. Individual, household, and community level risk factors of stunting in children younger than 5 years: findings from a national surveillance system in Nepal. Matern Child Nutr. 2018;14(1):e12434.
400. Habimana S, Biracyaza E. Risk Factors Of Stunting Among Children Under 5 Years Of Age In The Eastern And Western Provinces Of Rwanda: Analysis Of Rwanda Demographic And Health Survey 2014/2015. Pediatric Health Med Ther: Dove Press. 2019;10:115.
401. Pravana NK, Piryani S, Chaurasiya SP, Kawan R, Thapa RK, Shrestha S. Determinants of severe acute malnutrition among children under 5 years of age in Nepal: a community-based case–control study. BMJ open. 2017;7(8):e017084.
402. Jha N, Bhattarai S, Rajput S, Sharma S, Khanal S, Ghimire S, et al. Prevalence and associated risk factors with malnutrition among under-five Nepalese children of Borbote village, Ilam. Health Renaissance. 2013;11(2):111-8.
403. Anik AI, Rahman MM, Rahman MM, Tareque MI, Khan MN, Alam MM. Double burden of malnutrition at household level: A comparative study among Bangladesh, Nepal, Pakistan, and Myanmar. PLoS One. 2019;14(8):e0221274.
404. Nakahara S, Poudel KC, Lopchan M, Ichikawa M, Poudel-Tandukar K, Jimba M, et al. Availability of childcare support and nutritional status of children of non-working and working mothers in urban Nepal. Am J Human Biol. 2006;18(2):169-81.
405. Cumming O, Cairncross S. Can water, sanitation and hygiene help eliminate stunting? Current evidence and policy implications. Matern Child Nutr. 2016;12 Suppl 1:91-105.
406. Keusch GT. Symposium: nutrition and infection, prologue and progress since 1968. American Society for Nutritional Sciences. 2003(133):336S-3405S.
407. Rice AL, Sacco L, Hyder A, Black RE. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. Bull World Health Organ. 2000;78:1207-21.
408. Bhandari P, Bak J, Lee KS, Chon Y, Bhattachan A, Rimal P, et al. Assessment of Socio-Demographic Factors, Mother and Child Health Status, Water, Sanitation, and Hygienic

Conditions Existing in a Hilly Rural Village of Nepal. Int J Environ Res Public Health. 2019;16(20).
409. Ministry of Health and Population. Nepal National Micronutrient Status Survey: Ministry of Health and Population, New ERA, UNICEF, EU, USAID, and CDC. Kathmandu; 2016.
410. Jain KC, Panthee K, Kalakheti B. Risk Factors of Diarrhea in Children Under Five Years in Urban Slums. JLMC. 2016;4(2).
411. National Institute of Population Service & Inner City Fund. Pakistan Demographic and Health Survey 2017-18. Islamabad, Pakistan: National Institute of Population Service , Inner City Fund.; 2019.
412. Das S, Chandra H, Saha UR. District level estimates and mapping of prevalence of diarrhoea among under-five children in Bangladesh by combining survey and census data. PLoS One. 2019;14(2):e0211062.
413. Melese B, Paulos W, Astawesegn FH, Gelgelu TB. Prevalence of diarrheal diseases and associated factors among under-five children in Dale District, Sidama zone, Southern Ethiopia: a cross-sectional study. BMC Public Health. 2019;19(1):1235.
414. Alebel A, Tesema C, Temesgen B, Gebrie A, Petrucka P, Kibret GD. Prevalence and determinants of diarrhea among under-five children in Ethiopia: a systematic review and meta-analysis. PLoS One. 2018;13(6):e0199684.
415. Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, et al. Effect of handwashing on child health: a randomised controlled trial. The Lancet. 2005;366(9481):225-33.
416. Khanal V, Bhandari R, Karkee R. Non medical interventions for childhood diarrhoea control: way forward in Nepal. Kathmandu Univ. 2013;11(3):256-61.
417. Swaminathan S, Hemalatha R, Pandey A, Kassebaum NJ, Laxmaiah A, Longvah T, et al. The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. Lancet Child Adolesc Health. 2019;3(12):855-70.
418. Khatri RB, Mishra SR, Khanal V, Choulagai B. Factors Associated with Underweight among Children of Former-Kamaiyas in Nepal. Front Public Health. 2015;3:11.
419. Bawankule R, Singh A, Kumar K, Pedgaonkar S. Disposal of children's stools and its association with childhood diarrhea in India. BMC Public Health. 2017;17(1):12.
420. Bauza V, Guest JS. The effect of young children's faeces disposal practices on child growth: evidence from 34 countries. Trop Med Int Health. 2017;22(10):1233-48.
421. Asim M, Nawaz Y. Child malnutrition in Pakistan: evidence from literature. Children (Basel). 2018;5(5).
422. Amare ZY, Ahmed ME, Mehari AB. Determinants of nutritional status among children under age 5 in Ethiopia: further analysis of the 2016 Ethiopia demographic and health survey. Global Health. 2019;15(1):62.
423. Schwarz D, Dhungana S, Kumar A, Acharya B, Agrawal P, Aryal A, et al. An integrated intervention for chronic care management in rural Nepal: protocol of a type 2 hybrid effectiveness-implementation study. Trials. 2020;21(1):119.
424. Dhimal M, Bista B, Bhattrai S, Dixit L, Hyder M, Agrqal N, et al. Report of Noncommunicable diseases risk factors STEPS survey Nepal 2019. Kathmandu: Nepal Health Research Council; 2020.
425. Fernandez ME, Ruiter RAC, Markham CM, Kok G. Intervention Mapping: Theory- and Evidence-Based Health Promotion Program Planning: Perspective and Examples. Front Public Health. 2019;7:209.
426. Champion VL, Skinner CS. The health belief model2008. 45-65 p.

427. Van Ruler B. Communication Theory: An Underrated Pillar on Which Strategic Communication Rests. International Journal of Strategic Communication. 2018;12(4):367-81.
428. Fraser H. Four different approaches to community participation. Community Development Journal. 2005;40(3):286-300.
429. Dotse F, Laryea N, editors. Multi-faceted participa-tory approaches in rural water and sanitation projects. People-centred approaches to water and environmental sanitation: Proceedings of the 30th WEDC International Conference, Vientiane, Laos; 2004: cc WEDC, Loughborough University.
430. Devine J, Karver J, Coombes Y, Chase C, Hernandez O. Behavioral determinants of handwashing with soap among mothers and caretakers: emergent learning from Senegal and Peru. Water and Sanitation Program Washington, DC: Learning note. 2012.
431. Wang C, Sarsenbayeva Z, Chen X, Dingler T, Goncalves J, Kostakos V. Accurate Measurement of Handwash Quality Using Sensor Armbands: Instrument Validation Study. JMIR mHealth uHealth. 2020 Mar 26; 8 (3): e17001. doi: 10.2196/17001.
432. Shrestha GR, Tayler K, Scott RE. Assessing Nepal's national sanitation policy. 2005.
433. Central Bureau of Statistics. National Population and Housing Census 2011, . Kathmandu, Nepal: National Planning Commission Secretariat, Central Bureau of Statistics (CBS) 2012.
434. Cronin AA, Prakash A, Sridhar P, Coates S. Drinking Water Supply in India: Context and Prospects. Indian Water Policy at the Crossroads: Resources, Technology and Reforms: Glob. Issues Water Policy; 2016. p. 49-71.
435. Shaheed A, Orgill J, Montgomery MA, Jeuland MA, Brown J. Why? improved? water sources are not always safe. Bull World Health Organ. 2014;92:283-9.
436. Gurung A, Adhikari S, Chauhan R, Thakuri S, Nakarmi S, Ghale S, et al. Water crises in a water-rich country: case studies from rural watersheds of Nepal's mid-hills. Water Policy. 2019;21(4):826-47.
437. Shordt KA. Hygiene education in the community and school: Assessment of the Volta programme. Netherland: IRC International Water and Sanitation Centre; 1997.
438. Wang SW, Gebru BM, Lamchin M, Kayastha RB, Lee W-K. Land Use and Land Cover Change Detection and Prediction in the Kathmandu District of Nepal Using Remote Sensing and GIS. Sustainability. 2020;12(9).
439. Howe LD, Hargreaves JR, Ploubidis GB, De Stavola BL, Huttly SR. Subjective measures of socio-economic position and the wealth index: a comparative analysis. Health Policy Plan. 2011;26(3):223-32.
440. Mason N, Mosello B. How to reduce inequalities in access to WASH London, UK: WaterAid; 2017.
441. World Health Organization. UN-Water global analysis and assessment of sanitation and drinking-water (GLAAS) 2017 report: financing universal water, sanitation and hygiene under the sustainable development goals. 2017. Report No.: 9241512199.
442. Welfare A. Australia's health: Social Determinants of Health. Canberra,Australia: Australian Institute of Health and Welfare; 2016.
443. World Bank Group and UNICEF. Sanitation and Water for All: How Can the financing gap be filled? A discussion paper. Washington, DC: World Bank; 2017.
444. Tesfaye G, Chojenta C, Smith R, Loxton D. Delaying factors for maternal health service utilization in eastern Ethiopia: A qualitative exploratory study. Women Birth. 2020;33(3):e216-e26.
445. Sharma BB, Loxton DJ, Murray H, Angeli GL, Oldmeadow C, Chiu S, et al. A first step to improving maternal mortality in a low-literacy setting; the successful use of singing

to improve knowledge regarding antenatal care. Am J Obstet Gynecol. 2018;219(6):615 e1- e11.
446. Mah MW, Tam YC, Deshpande S. Social marketing analysis of 20 [corrected] years of hand hygiene promotion. Infect Control Hosp Epidemiol. 2008;29(3):262-70.
447. Luby SP, Rahman M, Arnold BF, Unicomb L, Ashraf S, Winch PJ, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. Lancet Glob Health. 2018;6(3):e302-e15.
448. Null C, Stewart CP, Pickering AJ, Dentz HN, Arnold BF, Arnold CD, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. Lancet Glob Health. 2018;6(3):e316-e29.
449. Checkley W, Buckley G, Gilman RH, Assis AM, Guerrant RL, Morris SS, et al. Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol. 2008;37(4):816-30.
450. Mahmoud Elkasabi RR, and Thomas W. Pullum,. Multilevel modeling Using DHS Surveys: A Framework to Approximate Level-Weights. DHS Methodological Reports no 27. Rockville, Maryland, USA; 2020.
451. World Health Organization. Report of the World Health Organization-China Joint Mission on Coronavirus Disease 2019 (COVID-19). 2020. 2020.
452. Wang X, Cheng Z. Cross-Sectional Studies: Strengths, Weaknesses, and Recommendations. Chest. 2020;158(1S):S65-S71.
453. World Health Organization. Ottawa charter for health promotion: WHO, Europe; 1986.
454. Hirai M, Graham JP, Mattson KD, Kelsey A, Mukherji S, Cronin AA. Exploring Determinants of Handwashing with Soap in Indonesia: A Quantitative Analysis. Int J Environ Res Public Health. 2016;13(9).
455. World Health Organization. Health is a fundamental human right Switzerland WHO; 2017 [Available from: https://www.who.int/mediacentre/news/statements/fundamental-human-right/en/.
456. Ministry of water supply. Guideline for water, sanittaion and hygiene plan (in Nepali). Kathmandu Nepal: Department of water supply and sewerage management; 2019.
457. Ministry of drinking water supply. Nepal WASH Cluster: Guidance Note on Minimum WASH Requirements in COVID19 Quarantine and Isolation Centers. Kathmandu: Department of drinking water supply and sewerage management; 2020.

# Appendices

## Appendix A. Nepal Demographic and Health Survey questionnaires

### Appendix A.1 Household Questionnaire used for this study

Formatting Date: 20 May 2015

English Language: 5 June 2016

Nepal

Ministry of Health and Population

**Nepal Demographic and Health Survey 2016**

**Household questionnaires used for this study**

| **Identification** |
| --- |
| Name and code of district:<br><br>Name and code of village/municipality:<br><br>Ward Number:<br><br>Name of household head:<br><br>Cluster number:<br><br>Household number:<br><br>Household selected for man's survey? (1=Yes, 2=No) |

## INTRODUCTION AND CONSENT

Hello. My name is ______________________________________. I am working with Ministry of Health. We are conducting a survey about health and other topics all over Nepal. The information we collect will help the government to plan health services. Your household was selected for the survey. I would like to ask you some questions about your household. The questions usually take about 20 to 30 minutes. All of the answers you give will be confidential and will not be shared with anyone other than members of our survey team. No part of this interview is being recorded in tape or video. You don't have to be in the survey, but we hope you will agree to answer the questions since your views are important. If I ask you any question you don't want to answer, just let me know and I will go on to the next question or you can stop the interview at any time.

Do you have any questions?

May I begin the interview now?

Signature of interviewer …………………………………………Date……………………

Respondent doesn’t agree to be interviewed. 2 (End)

Respondent agree to be interviewed…1 (Continue)

Record the time: Hours ………………………................ Minutes…................................

| ID | Questions | Options |
|---|---|---|
| V104 | What is current age? | ………… Years |
| V103 | Sex of the household heads | Male (1) Female (2) |

| ID | Questions | Options |
| --- | --- | --- |
| V60 | What is the highest level of school (NAME) has attended? | 0=Preschool<br>1=Primary<br>2=Secondary<br>3= SLC or higher<br>8= Don't know |
| V69 | What is (NAME)'s current marital status? | 1= Currently married<br>2=Divorced/separated/<br>3= Widowed<br>4= Never married |
| | No of household members? | ….. |
| V85 | Place of residence | 1= Urban, 2= Rural |
| V185 | Place name | **Ecology:**<br>1=Mountain, 2= Hills, 3= Plain |
| V27 | Place name | **Provinces:**<br>1,2,3,4,5,6,7 |
| V174 | Wealth Index | Calculated based on household assets |
| | How long does it take to go there, get water, and come back? | Minutes… , Don't Know… 998 |
| V85 | What is the main source of drinking water for members of your household? | **Piped water**<br>11=Piped into dwelling<br>12=Piped to yard/plot<br>13=Piped to neighbour<br>14=Public tap/standpipe<br>**Tube well water**<br>21=Tube well or borehole |

| ID | Questions | Options |
| --- | --- | --- |
| | | **Dug well (open/protected)**<br>31=Protected well<br>32=Unprotected well<br>**Surface from spring**<br>41=Protected spring<br>42=Unprotected spring<br>43=River/dam/pond/stream/canal<br>51=Rainwater<br>61=Tanker truck<br>62=Cart with small tank<br>71=Bottled water<br>96=Other |
| V89 | What kind of toilet facility do members of your household usually use?<br><br>If not possible to determine, ask permission to observe the facility. | **Flush toilet**<br>11=Flush to piped sewer system<br>12=Flush to septic tank<br>13=Flush to pit latrine<br>14=Flush to somewhere else<br>15=Flush, don't know where<br>**Pit toilet latrine**<br>21=Ventilated Improved Pit latrine<br>22=Pit latrine with slab<br>23=Pit latrine without slab/open pit<br>**No facility**<br>31=No facility/bush/field<br>41=Composting toilet<br>42=Bucket toilet<br>43=Hanging toilet/latrine<br>96=Other |

| ID | Questions | Options |
|---|---|---|
| V110 | We would like to learn about the places that households use to wash their hands. Can you please show me where members of your household most often wash their hands? | 1=Observed, fixed place<br>2=Observed, mobile place<br>3=Not observed: not in dwelling<br>4=Not observed: no permission to see<br>5=Not observed: other reason |
| | Observe presence of soap, detergent, or other cleansing agent at the place for handwashing.<br>Record observation. | a= soap or detergent<br>(bar, liquid, powder, paste)<br>b = ash, mud, sand<br>y= None. |
| | Observe presence of water at the place for handwashing.<br>Record observation. | 1=Water is available<br>2= Water is not available |

Source: https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf (Nepal Demographic and Health Survey 2016 report, Appendix F, pp 413-425)

## Appendix A.2 Women's Questionnaire used for this study

Formatting Date: 20 May 2015

English Language: 5 June 2016

Nepal

Ministry of Health and Population

**Nepal Demographic and Health Survey 2016**

**Women's questionnaire used for this study**

| **Identification** |
|---|
| Name and code of district: |
| Name and code of village/municipality: |
| Ward Number: |
| Name of household head: |
| Cluster number: |
| Household number: |
| Name and Line Number of women: |
| Check Cover page of household questionnaire: Household selected for man's survey/DV module? (1=Yes, 2=No) |
| Check Household questionnaire DVH01: Women selected for DV Module? (1= Yes,2=No) |

**INTRODUCTION AND CONSENT**

Hello. My name is ________________________________________. I am working with the Ministry of Health. We are conducting a survey about health and other topics all over Nepal. The information we collect will help the government to plan health services. Your household was selected for the survey. I would like to ask you some questions about your household. The questions usually take about 20 to 30 minutes. All of the answers you give will be confidential and will not be shared with anyone other than members of our survey team. No part of this interview is being recorded on tape or video. You don't have to be in the survey, but we hope you will agree to answer the questions since your views are important. If I ask you any question you don't want to answer, just let me know and I will go on to the next question or you can stop the interview at any time.

Do you have any questions?

May I begin the interview now?

Signature of interviewer ……………………………………………Date……………………

Respondent doesn't agree to be interviewed. 2(End)

Respondent agrees to be interviewed…1 (Continue)

Record the time: Hours …………………………................ Minutes…...................................

| ID | Questions | Options |
|---|---|---|
| V102 | In what month and year were you born? | Month…..<br>Don't know Month….<br>Year……. |

| ID | Questions | Options |
|---|---|---|
| | | Don't know year… |
| V593 | What is the highest grade you have completed?<br>If completed less than one grade, record 00 | Grade……. |
| V1418 | Respondent's occupation | |
| V1410 | Husband's education | |
| V644 | Wealth Index | |
| V609 | What is your caste/ethnicity?<br>Write caste/ethnicity in the line | ……………………………<br>(Caste/ethnicity) |
| V608 | What is your religion? | Hindu…………………..1<br>Buddhist………………..2<br>Muslim…………………3<br>Kirat……………………4<br>Christian ………………5<br>Other……………………6 |
| V686 | Age of respondent at 1st birth | |
| V1003 | Are you still breastfeeding? | Yes……………….........1<br>No…………………….....2 |
| V631 | Do you read a newspaper or magazine at least once a week, less than once a week or not at all | At least once a week…….1<br>Less than once a week…..2<br>Not at all………………...3 |
| V632 | Do you listen to the radio at least once a week, less than once a week or not at all | At least once a week…….1<br>Less than once a week…..2<br>Not at all………………...3 |

| ID | Questions | Options |
|---|---|---|
| V633 | Do you watch television at least once a week, less than once a week or not at all | At least once a week…….1<br>Less than once a week…..2<br>Not at all………………...3 |
| V1925 | Place of residence | 1=Urban, 2=Rural |
| V1714 | Place name | Ecology:<br>1= Mountain, 2=Hill, 3= Plain |
| V449 | Place name | Provinces:<br>1, 2, 3, 4, 5, 6, 7 |
| V1908 | Health Mothers' Group in this ward | Yes……………..1<br>No……………....2<br>Don't know…….8 |
| V1098 | Disposal of youngest child's stools when not using toilet | 1=use toilet/latrine<br>2=put/rinsed in toilet/latrine<br>3=put/rinsed into drain or ditch<br>4=throw into garbage<br>5=bury<br>9=leave in the open/do not disposed of it<br>96=Other |
| | Child's date of birth | Day….. Month…… Year |
| V657 | Sex of Child | 1=Male<br>2=Female |
| V469 | Had diarrhoea recently among children under five | 0=No<br>2=Yes, last two weeks<br>8=Don't know |
| V1321 | Child's weight in kilograms | ………….. |

| ID | Questions | Options |
|---|---|---|
| | | 9994=Not present<br>9995=Refused<br>9996=Other |
| V1322 | Child's height in centimetres | ……………<br>9994=Not present<br>9995=Refused<br>9996=Other |

**Source:** https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf ((Nepal Demographic and Health Survey 2016 report, Appendix F, pp. 429–432, 544–547, and 575).

# Appendix B. Ethical approval letters

## Appendix B.1 Ethical approval from the University of Newcastle

**HUMAN RESEARCH ETHICS COMMITTEE**

**Notification of Expedited Approval**

| | |
|---|---|
| To Chief Investigator or Project Supervisor: | **Professor Deb Loxton** |
| Cc Co-investigators / Research Students: | **Mr Shalik Dhital**<br>**Doctor Catherine Chojenta** |
| Re Protocol: | **Water,Sanitation and Hygiene and Under Five Child Health of Nepal** |
| Date: | **20-Feb-2019** |
| Reference No: | **H-2018-0511** |
| Date of Initial Approval: | **20-Feb-2019** |

Thank you for your **Initial Application** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under **L1 Low Risk Research Expedited** review by the Ethics Administrator.

I am pleased to advise that the decision on your submission is **Approved** effective **20-Feb-2019**.

In approving this protocol, the Human Research Ethics Committee (HREC) is of the opinion that the project complies with the provisions contained in the National Statement on Ethical Conduct in Human Research, 2007, and the requirements within this University relating to human research.

Approval will remain valid subject to the submission, and satisfactory assessment, of annual progress reports. *If the approval of an External HREC has been "noted" the approval period is as determined by that HREC.*

The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal *Certificate of Approval* will be available upon request. Your approval number is **H-2018-0511**.

**If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to potential participants** You may then proceed with the research.

**Conditions of Approval**

This approval has been granted subject to you complying with the requirements for *Monitoring of Progress*, *Reporting of Adverse Events*, and *Variations to the Approved Protocol* as detailed below.

PLEASE NOTE:
In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, or a Renewal of approval, you will apply to the External HREC for approval in the first instance and then Register that approval with the University's HREC.

- ***Monitoring of Progress***

**HUMAN RESEARCH ETHICS COMMITTEE**

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

## Progress Report Acknowledgement

| | |
|---|---|
| To Chief Investigator or Project Supervisor: | **Professor Deb Loxton** |
| Cc Co-investigators / Research Students: | **Mr Shalik Dhital**<br>**Doctor Catherine Chojenta** |
| Re Protocol: | **Water,Sanitation and Hygiene and Under Five Child Health of Nepal** |
| Date: | **05-Feb-2020** |
| Reference No: | **H-2018-0511** |

Thank you for submitting your **Annual Progress Report** to the Human Research Ethics Committee (HREC) in relation to the above protocol.

Your report has been accepted and your HREC approval for the above research remains valid. Continuation of this approval will again be subject to the provision of an annual progress report by the due date approximately one year from now.

The timely submission of your report is greatly appreciated.

**Human Research Ethics Administration**

Research & Innovation Services
Research Integrity Unit
The University of Newcastle
Callaghan NSW 2308
T +61 2 492 17894
Human-Ethics@newcastle.edu.au

RIMS website - https://RIMS.newcastle.edu.au/login.asp

# Appendix B.2 Approval letter for the use of NDHS 2016 dataset

ICF

Feb 22, 2019

Shalik Ram Dhital
The University of Newcastle
Australia
Phone: 0424341540
Email: c3264329@uon.edu.au
Request Date: 02/21/2019

Dear Shalik Ram Dhital:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Water,Sanitation, and Hygiene (WASH) and Under Five Child Health of Nepal ":

**Nepal**

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. Users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: archive@dhsprogram.com.

Sincerely,

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program

# Appendix C. Summary of article search strategy

Database(s): **Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily** 1946 to November 07, 2019
Search Strategy:

| # | Searches | Results |
|---|---|---|
| 1 | Handwashing.mp. or Hand Disinfection/ | 6303 |
| 2 | Situation.mp. | 149716 |
| 3 | households.mp. or Family Characteristics/ | 48061 |
| 4 | 1 or 2 or 3 | 202641 |
| 5 | Mothers/ or Mothers.mp. | 150026 |
| 6 | Children.mp. or Child/ | 2012115 |
| 7 | 5 or 6 | 2104630 |
| 8 | Determinants.mp. | 151783 |
| 9 | Knowledge/ or Health Knowledge, Attitudes, Practice/ | 116543 |
| 10 | Soap.mp. or Soaps/ | 5976 |
| 11 | Health education.mp. or Health Education/ | 85051 |
| 12 | 8 or 9 or 10 or 11 | 343876 |
| 13 | Nepal.mp. or Nepal/ | 10711 |
| 14 | 4 and 7 and 12 and 13 | 58 |

Database(s): **PsycINFO** 1806 to October Week 4 2019
Search Strategy:

| # | Searches | Results |
|---|---|---|
| 1 | Handwashing.mp. | 162 |
| 2 | Situation.mp. | 95719 |
| 3 | households.mp. | 11444 |
| 4 | Mothers.mp. or exp Mothers/ | 95720 |

| | | |
|---|---|---|
| 5 | children.mp. | 514655 |
| 6 | 1 or 2 or 3 | 107032 |
| 7 | 4 or 5 | 565155 |
| 8 | Determinants.mp. | 41239 |
| 9 | Knowledge.mp. | 300762 |
| 10 | soap.mp. | 713 |
| 11 | Health education.mp. or exp Health Education/ | 29176 |
| 12 | 8 or 9 or 10 or 11 | 360295 |
| 13 | Nepal.mp. | 1296 |
| 14 | 6 and 7 and 12 and 13 | 10 |

Database(s): **Embase** 1947 to 9 Nov 2019
Search Strategy:

| # | Searches | Results |
|---|---|---|
| 1 | Handwashing.mp. or handwashing/ | 13721 |
| 2 | Situation.mp. | 246330 |
| 3 | households.mp. or household/ | 56559 |
| 4 | 1 or 2 or 3 | 314617 |
| 5 | Mothers.mp. or mother/ | 219548 |
| 6 | Children.mp. or child/ | 2341181 |
| 7 | 5 or 6 | 2476177 |
| 8 | Determinants.mp. or "social determinants of health"/ | 187215 |
| 9 | Knowledge.mp. | 873291 |
| 10 | Soap/ or Soap.mp. | 9349 |
| 11 | Health education.mp. or health education/ | 120991 |
| 12 | 8 or 9 or 10 or 11 | 1157688 |

| | | |
|---|---|---|
| 13 | Nepal.mp. or Nepal/ | 13087 |
| 14 | 4 and 7 and 12 and 13 | 76 |

Database(s): **CINAHL** until 9 Nov 2019

**Search History/Alerts**

Print Search History   Retrieve Searches   Retrieve Alerts   Save Searches / Alerts

Select / deselect all   **Search with AND**   **Search with OR**   **Delete Searches**   **Refresh Search Results**

| Search ID# | Search Terms | Search Options | Actions |
|---|---|---|---|
| S5 | S1 AND S2 AND S3 AND S4 | **Expanders** - Apply equivalent subjects<br>**Search modes** - Boolean/Phrase | View Results (43) View Details Edit |
| S4 | Nepal | **Expanders** - Apply equivalent subjects<br>**Search modes** - Boolean/Phrase | View Results (3,126) View Details Edit |
| S3 | Determinants OR knowledge OR Soap OR Health Education | **Expanders** - Apply equivalent subjects<br>**Search modes** - Boolean/Phrase | View Results (310,347) View Details Edit |
| S2 | Mothers OR children | **Expanders** - Apply equivalent subjects<br>**Search modes** - Boolean/Phrase | View Results (680,617) View Details Edit |
| S1 | handwashing OR Situation OR households | **Expanders** - Apply equivalent subjects<br>**Search modes** - Boolean/Phrase | View Results (90,962) View Details Edit |

**Refine Results**   Search Results: 1 - 43 of 43   Relevance ▾   Page Options ▾   Share ▾   Plumprint ▾

## Appendix D. Strengthening the reporting of observational studies in epidemiology (STROBE) checklist, including paper grading

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| **Title and abstract** | | | | | | | | | |
| | 1 | a) Indicates the study's design with a commonly used term in the title or the abstract. | X | X | X | X | X | X | X |
| | | b) Provides in the abstract an informative and balanced summary of what was done and what was found | X | X | X | X | X | X | X |
| **Introduction** | | | | | | | | | |
| Background/ rationale | 2 | Explains the scientific background and rationale for the investigation being reported | X | X | X | X | X | X | X |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| Objectives | 3 | States specific objectives, including any respecified hypotheses | X | X | X | X | X | X | X |
| **Methods** | | | | | | | | | |
| Study design | 4 | Presents key elements of study design early in the paper/report | X | X | X | | X | X | X |
| Setting | 5 | Describes the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | X | X | X | | X | X | X |
| | | b) Cohort study: For matched studies, gives matching criteria and number of exposed and unexposed Case-control study: For matched studies, gives matching criteria and | | | | | | | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | the number of controls per case | | | | | | | |
| Variables | | Clearly defines all outcomes, exposures, predictors, potential confounders, and effect modifiers. Gives diagnostic criteria, if applicable | X | X | X | | X | X | |
| Data sources/ measurement | 8 | For each variable of interest, gives sources of data and details of methods of assessment (measurement). Describes comparability of assessment methods if there is more than one group | X | X | | X | X | X | |
| Bias | 9 | Describes any efforts to address potential sources of bias | X | | X | | X | | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| Study size | 10 | Explains how the study size was arrived at | X | X | X | X | X | | X |
| Quantitative variables | 11 | Explains how quantitative variables were handled in the analyses. If applicable, describes which groupings were chosen and why | X | X | X | X | X | | |
| Statistical methods | 12 | a) Describes all statistical methods, including those used to control for confounding | X | X | | X | X | X | |
| | | b) Describes any methods used to examine subgroups and interactions | | | | | | | |
| | | c) Explains how missing data were addressed | | | | | | | |
| | | d) Cohort study: If applicable, explains how loss to follow-up was addressed | | | | | | | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | Case-control study: If applicable, explains how matching of cases and controls was addressed | | | | | | | |
| | | Cross-sectional study: If applicable, describes analytical methods, taking account of sampling strategy | | | X | | | X | X |
| | | e) Describes any sensitivity analyses | | | | | | | |
| **Results** | | | | | | | | | |
| Participants | 13 | a) Reports numbers of individuals at each stage of study, e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | X | X | X | X | X | X | X |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | b) Gives reasons for non-participation at each stage | | | | | | | |
| | | c) Considers use of a flow diagram | | | | | | | |
| Descriptive data | 14 | a) Gives characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders | X | X | X | X | X | X | X |
| | | b) Indicates number of participants with missing data for each variable of interest | | | | | | | |
| | | c) Cohort study: Summarises follow-up time (e.g. average and total amount) | | X | | | | | |
| Outcome data | 15 | Cohort study: Reports numbers of outcome events | | | | | | | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | or summary measures over time | | | | | | | |
| | | Case-control study: Reports numbers in each exposure category, or summary measures of exposure | X | | | | | | |
| | | Cross-sectional study: Reports numbers of outcome events or summary measures | | | X | | | X | |
| Main results | 16 | a) Reports the numbers of individuals at each stage of the study, e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | X | X | | X | X | X | |
| | | b) Gives reasons for non-participation at each stage | | | | | | | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | c) Considers use of a flow diagram | | | | | | | |
| Other analyses | 17 | Reports other analyses done, e.g. analyses of subgroups and interactions, and sensitivity analyses | | | | | | | |
| **Discussion** | | | | | | | | | |
| Key results | 18 | Summarises key results with reference to study objectives | X | X | X | X | X | X | X |
| Limitations | 19 | Discusses limitations of the study, taking into account sources of potential bias or imprecision. Discusses both direction and magnitude of any potential bias | X | X | X | X | X | | |
| Interpretation | 20 | Gives a cautious overall interpretation of results, considering objectives, limitations, multiplicity of analyses, results from | X | X | X | X | X | X | |

| STROBE | Item No. | Recommendation | Gautam et al. (X) | Rhee and Mullany (X) | Osrin et al. (X) | Langford and Penter-Brick (X) | Miller et al (X) | Kafle and Pradhan (X) | Kandel P. |
|---|---|---|---|---|---|---|---|---|---|
| | | similar studies, and other relevant evidence | | | | | | | |
| Generalisability | 21 | Discusses the generalisability (external validity) of the study results | | | | | X | | |
| **Other information** | | | | | | | | | |
| Funding | 22 | Gives the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | X | X | X | X | X | | |
| | | **Total score** | **21/22** | **20/22** | **18/22** | **15/22** | **19/22** | **17/22** | **14/22** |
| | | **Percentage** | **95%** | **91%** | **82%** | **68%** | **86%** | **77%** | **67%** |

**Appendix E. Bivariate and multivariate logistic regression analysis on the effects of covariates on diarrhoea and malnutrition among children under five years**

| Variables | Diarrhoea | | Stunting | | Wasting | | Underweight | |
|---|---|---|---|---|---|---|---|---|
| | COR | AOR | COR | AOR | COR | AOR | COR | AOR |
| **Age of the children** | | | | | | | | |
| <12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13–24 | 0.82(0.59-1.14) | 0.82(0.54-1.24) | 2.84(2.05-3.94) | 2.85(2.01-4.04) | 0.58(0.39-0.88) | 0.66(0.42-1.04) | 1.59(1.18-2.14) | 1.65(1.19-2.23) |
| 25–36 | 0.61(0.39-0.95) | 0.61(0.40-0.95) | 3.64(2.69-4.94) | 4.00(2.92-5.49) | 0.32(0.20-0.51) | 0.31(0.18-0.55) | 1.72(1.25-2.36) | 1.83(1.27-2.63) |
| 37–48 | 0.50(0.35-0.70) | 0.44(0.30-0.66) | 3.01(2.17-4.17) | 3.38(2.34-4.90) | 0.31(0.20-0.49) | 0.34(0.19-0.59) | 1.57(1.15-2.14) | 1.78(1.21-2.61) |
| 49–59 | 0.37(0.22-0.61) | 0.35(0.18-0.69) | 3.10(2.18-4.41) | 5.59(2.45-5.25) | 0.32(0.20-0.54) | 0.35(0.21-0.59) | 1.70(1.25-2.32) | 2.15(1.45-3.17) |
| **Age of mother** | | | | | | | | |
| 15-24 | | | 1 | 1 | 1 | 1 | 1 | 1 |
| 25-34 | | | 1.22(0.96-1.54) | 1.09(0.86-1.37) | 0.83(0.60-1.14) | 0.90(0.61-1.33) | 1.38(1.08-1.77) | 1.39(1.05-1.83) |
| 35+ | | | 1.53(1.05-2.22) | 1.04(0.69-1.58) | 0.92(0.57-1.46) | 0.96(0.55-1.69) | 1.41(0.97-2.05) | 1.35(0.86-2.12) |
| **Education of mother** | | | | | | | | |
| No education | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Primary | 0.98(0.73-1.31) | 1.27(0.69-2.31) | 0.68(0.53-0.88) | 0.82(0.61-1.11) | 0.69(0.42-1.14) | 0.61(0.35-1.08) | 0.67(0.50-0.89) | 0.95(0.68-1.33) |

| Variables | Diarrhoea | | Stunting | | Wasting | | Underweight | |
|---|---|---|---|---|---|---|---|---|
| | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** |
| Secondary | 0.71(0.52-0.96) | 1.20(0.66-2.18) | 0.51(0.40-0.64) | 0.89(0.63-1.26) | 0.64(0.43-0.96) | 0.63(0.38-1.06) | 0.46(0.35-0.60) | 0.99(0.68-1.44) |
| SLC or higher | 0.88(0.51-1.52) | 0.96(0.60-1.55) | 0.34(0.24-0.48) | 0.71(0.42-1.20) | 0.53(0.31-0.91) | 0.66(0.31-1.40) | 0.30(0.21-0.44) | 0.69(0.38-1.26) |
| **Occupation of mother** | | | | | | | | |
| No work | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Agriculture | 0.67(0.48-0.91) | 0.77(0.55-1.09) | 1.60(1.29-1.97) | 1.15(0.88-1.49) | 0.69(0.52-0.92) | 0.93(0.65-1.32) | 1.30(1.01-1.67) | 1.33(0.98-1.80) |
| Non-agriculture | 1.30(0.91-1.86) | 1.44(1.00-2.09) | 1.36(0.99-1.86) | 1.62(1.11-2.38) | 0.52(0.31-0.87) | 0.91(0.51-1.65) | 0.90(0.61-1.33) | 1.44(0.90-2.31) |
| **Education of husband** | | | | | | | | |
| No education | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Primary | 0.76(0.49-1.17) | 0.81(0.54-1.23) | 0.78(0.58-1.07) | 1.01(0.69-1.49) | 1.20(0.72-2.01) | 1.62(0.91-2.89) | 0.70(0.50-0.97) | 1.12(0.79- 1.59) |
| Secondary | 0.65(0.44-0.94) | 0.77(0.49-1.20) | 0.59(0.45-0.79) | 1.02(0.72-1.46) | 0.98(0.61-1.56) | 1.39(0.82-2.38) | 0.53(0.40-0.70) | 0.98(0.68-1.42) |
| SLC or higher | 0.81(0.54-1.22) | 1.02(0.62-1.68) | 0.39(0.27-0.58) | 0.84(0.51-1.40) | 0.74(0.40-1.37) | 1.19(0.56-2.51) | 0.39(0.27-0.58) | 1.19(0.73-1.97) |
| **Wealth index** | | | | | | | | |
| Poor | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Middle | 1.22(0.81-1.84) | 1.28(0.86-1.93) | 0.71(0.54-0.92) | 0.78(0.56-1.08) | 1.19(0.80-1.77) | 0.78(0.46-1.32) | 1.10(0.82-1.48) | 0.96(0.66-1.41) |
| Rich | 1.15(0.86-1.54) | 1.30(0.89-1.91) | 0.47(0.37-0.60) | 0.75(0.53-1.06) | 1.11(0.78-1.57) | 1.17(0.73-1.86) | 0.55(0.42-0.72) | 0.82(0.56-1.21) |
| **Breast feeding** | | | | | | | | |

| Variables | Diarrhoea | | Stunting | | Wasting | | Underweight | |
|---|---|---|---|---|---|---|---|---|
| | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** |
| No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 1.48(1.08-2.02) | 1.06(0.70-1.61) | 1.14(0.90-1.46) | 1.37(1.03-1.79) | 1.74(1.08-2.80) | 1.06(0.64-1.75) | 1.58(1.19-2.10) | 1.75(1.23-2.47) |
| **Caste or ethnicity** | | | | | | | | |
| Brahmin/Chhetri | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Janajati | 1.49(1.03-2.16) | 1.64(1.10-2.44) | 0.92(0.71-1.19) | 0.92(0.67-1.27) | 1.43(0.97-2.08) | 1.11(0.71-1.75) | 0.93(0.68-1.28) | 0.83(0.60-1.16) |
| Scheduled | 1.39(0.81-2.40) | 1.44(0.88-2.36) | 1.21(0.87-1.69) | 0.94(0.64-1.39) | 1.83(1.11=3.02) | 1.17(0.67-2.05) | 1.41(0.97-2.05) | 0.89(0.60-1.32) |
| Other | 1.80(1.08-2.99) | 1.82(1.01-3.28) | 1.30(0.97-1.73) | 1.06(0.69-1.63) | 1.79(1.21-2.64) | 0.79(0.41-1.52) | 1.77(1.33-2.36) | 0.86(0.53-1.39) |
| **Exposure to newspaper** | | | | | | | | |
| No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 0.83(0.56-1.24) | 1.05(0.69-1.59) | 0.58(0.44-0.77) | 1.10(0.74-1.62) | 0.57(0.37-0.89) | 1.12(0.63-2.01) | 0.42(0.31-0.57) | 0.86(0.59-1.27) |
| **Exposure to radio** | | | | | | | | |
| No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 0.81(0.63-1.04) | 1.28(0.85-1.72) | 0.71(0.57-0.87) | 0.85(0.66-1.10) | 0.60(0.43-0.83) | 0.86(0.56-1.33) | 0.66(0.52-0.84) | 0.99(0.74-1.32) |
| **Exposure to television** | | | | | | | | |
| No | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 0.75(0.49-1.12) | 0.63(0.42-0.96) | 0.43(0.35-0.53) | 0.59(0.45-0.78) | 0.66(0.49-0.90) | 0.74(0.51-1.06) | 0.47(0.37-0.61) | 0.63(0.46-0.85) |

| Variables | Diarrhoea | | Stunting | | Wasting | | Underweight | |
|---|---|---|---|---|---|---|---|---|
| | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** |
| **Place of residence** | | | | | | | | |
| Rural | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Urban | 1.14(0.77-1.68) | 1.23(0.92-1.65) | 0.62(0.50-0.79) | 0.96(0.75-1.23) | 0.82(0.60-1.14) | 1.09(0.76-1.57) | 0.63(0.49-0.81) | 1.05(0.82-1.34) |
| **Ecological zone** | | | | | | | | |
| Plain | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Hills | 0.72(0.46-1.13) | 0.84(0.55-1.28) | 0.84(0.67-1.06) | 0.83(0.60-1.17) | 0.48(0.34-0.70) | 0.86(0.47-1.58) | 0.48(0.37-0.61) | 0.58(0.40-0.83) |
| Mountains | 0.58(0.38-0.88) | 0.64(0.38-1.10) | 1.52(1.07-2.18) | 1.18(0.75-1.85) | 0.47(0.25-0.89) | 0.54(0.23-1.26) | 0.82(0.54-1.23) | 0.61(0.37-1.00) |
| **Provinces** | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1.19(0.77-1.85) | 0.76(0.45-1.27) | 1.19(0.87-1.63) | 0.87(0.57-1.33) | 1.29(0.78-2.11) | 1.00(0.55-1.84) | 1.82(1.19-2.77) | 1.30(0.76-2.22) |
| 3 | 1.27(0.65-2.48) | 1.34(0.82-2.20) | 0.91(0.59-1.41) | 1.09(0.71-1.67) | 0.30(0.14-0.66) | 0.35(0.15-0.82) | 0.52(0.28-0.98) | 0.78(0.47-1.27) |
| 4 | 0.49(0.26-0.93) | 0.68(0.34-1.36) | 0.84(0.54-1.32) | 1.12(0.70-1.78) | 0.47(0.23-0.98) | 0.47(0.22-1.00) | 0.57(0.33-1.00) | 0.79(0.46-1.37) |
| 5 | 1.14(0.75-1.73) | 1.13(0.72-1.80) | 1.26(0.84-1.89) | 1.31(0.87-1.95) | 0.62(0.35-1.11) | 0.60(0.32-1.12) | 1.17(0.74-1.84) | 1.10(0.71-1.72) |
| 6 | 0.82(0.53-1.26) | 0.95(0.53-1.70) | 2.51(1.74-3.63) | 1.91(1.22-2.98) | 0.62(0.34-1.16) | 0.66(0.32-1.39) | 1.79(1.16-2.76) | 1.71(1.07-2.74) |
| 7 | 0.84(0.55-1.29) | 1.26(0.76-2.08) | 1.13(0.77-1.66) | 1.04(0.67-1.61) | 0.79(0.43-1.43) | 0.86(0.43-1.70) | 1.16(0.76-1.77) | 1.14(0.72-1.81) |

| Variables | Diarrhoea | | Stunting | | Wasting | | Underweight | |
|---|---|---|---|---|---|---|---|---|
| | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** | **COR** | **AOR** |
| **Health mother group** | | | | | | | | |
| No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 0.83(0.62-1.11) | 1.05(0.74-1.50) | 0.97(0.77-1.22) | 1.03(0.78-1.36) | 0.73(0.51-1.05) | 0.86(0.57-1.29) | 0.93(0.73-1.18) | 1.03(0.78-1.36) |
| Do not know | 0.96(0.64-1.43) | 0.88(0.58-1.37) | 0.63(0.44-0.92) | 0.73(0.50-1.07) | 0.74(0.45-1.21) | 0.94(0.52-1.71) | 0.60(0.43-0.86) | 0.67(0.44-1.03) |

## Appendix F. Letter of statistical support

I, Tiffany-Jane Evans from the Hunter Medical Research Institute CReDITSS unit, provided statistical and Stata software advice to Shalik Dhital during his PhD candidature. Advice given relates specifically to the methods phrasing and model specifications for the below components:

1. Chapter 5 - Prevalence of household Water, Sanitation and Hygiene (WASH) of Nepal. Bivariate analysis and chi-square tests using appropriate weights to show the rates of WASH by socio-demographic variables in Nepal
2. Chapter 6 - Multi Level analysis of households' mothers' WASH. Multi-level (mixed effects) logistic regression analyses to assess the relationship of WASH with individual and community level variables. Goodness of model fit assessed by manually deriving the Hosmer-Lemeshow statistic from mixed model.
3. Chapter 7 - effects of WASH on diseases among children. Hypothesising potential confounders using a DAG (directed acyclic graph) in DAGitty software followed by multivariate logistic regression analysis.

Digitally signed by
Tiffany Evans
Date: 2020.08.17
11:48:19 +10'00'

Date: 17 August 2020

Tiffany-Jane Evans
Senior Statistician

Clinical Research Design and Statistical Support (CReDITSS)
Hunter Medical Research Institute