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

Master Thesis

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Submitted by:
Jeanne Six

Supervisor:
Regula Meierhofer
SANDEC-EAWAG, Dübendorf

Tutor:
Prof. Michael Zimmermann
ETH, Zürich

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ABBREVIATIONS

AIC	Akaïke information criterion
CFU	Colony forming unit
DHS	Demographic and health surveys
DW	Drinking Water
E. coli	*Escherichia Coli*
EAWAG	The Swiss Federal Institute of Aquatic Science and Technology
FCHV	Female community health volunteers
GGP	Good Governance Program
HELVETAS	HELVETAS Swiss Inter-cooperation
HH	Household
HI	Hygiene Index
ICC	Intraclass correlation coefficient
IWRMP	Integrated Water Resource Management program
KAP	Knowledge, Aptitude, Capacity
MAP	Multiple answers possible
MDG	Millennium Development Goals
NMIP	National management information project
ODF	Open-defecation-free
OR, aOR	Odds Ratio, adjusted Odds Ratio
PAF	Population attributable fraction
POC	Point-of-Collection (water)
POU	Point-of-Use (water)
PWS	Piped Water System
RANAS	Risk, attitudinal, normative, ability and self-regulation factor
SANDEC	Department for Sanitation, Water and Solid Waste for Development
SD	Standard deviation
SDG	Sustainable Development Goals
SES	Socio-economic status (=WI)
SODIS	Solar water disinfection
SWP	Safe water promotion group of SANDEC-EAWAG
TBSP	Trail Bridge Support Program
TTC	Total thermo-coliforms
WASH	Water, sanitation and hygiene
WI	Wealth index = SES

ABSTRACT

Background: People with limited access to safe drinking water, sanitation and hygiene (WASH) are more exposed to environmental pathogens. The main goals of the study were to investigate the risk factors for water contamination between point-of-collection (POC) and point-of-use (POU) as well as the relationship between environmental contamination and the development of diarrhoeal diseases.

Method: The study took place in Far- and Midwestern rural Nepal, between March and Mai 2018. Questionnaires assessing socio-demographic and economic status, WASH conditions, knowledge, aptitudes and practice as well as children health status were hold among 1427 households. Water samples were collected at POC and POU and analysed for faecal contamination by membrane filtration followed by incubation. Mixed-logistic regression models were used to determine risk factors associated with water contamination during transport and diarrhoea prevalence among children below 10 years old.

Results: 93.7% of POC and 95.4% of POU water samples were contaminated with *E. coli*. Re-contamination during transport occurred among 70% of the households. Multivariate analysis revealed that higher personal hygiene versus lower hygiene (aOR 0.54 [0.34-0.88], p=0.012), water treatment versus no treatment (aOR 0.56 [0.35-0.9], p=0.016) and affect for treated water versus disgust (aOR 0.5 [0.26-0.94]; p=0.033) were significantly associated with decreased risk of water contamination during transport. Diarrhoea prevalence in the week prior to the survey was of 16%. Children aged two and above were between 68% and 82% less likely to have diarrhoea compared to younger children. Flooring made from mud versus cement (aOR 1.97 [1.07-3.61]; p=0.030), higher personal hygiene versus lower hygiene (aOR 0.49 [0.3-0.8], p=0.004), and attendance of hygiene literacy class versus no attendance (aOR 0.52 [0.32-0.83]; p=0.007) were part of a longer list of risk and protective factors against diarrhoea.

Conclusion: The WASH situation in the area is critical. WASH facilities as well as hygiene education are urgently needed. Further studies should focus on the handling of animal excrements in the area.

CHAPTER 1. INTRODUCTION

Access to safe drinking water and sanitation are recognised as human rights and basic needs for good health [1]. In 2017, the Joint Monitoring Program (JMP) estimated that 844 million people lacked basic drinking water sources, 2.3 billion were deprived of sanitation facilities and 47% of world citizens had no handwashing facilities [2]. Poor water quality and lack of access to sanitation and hygiene are responsible for 7% of the global disease burden and a fifth of child mortality worldwide [3]–[5]. Children below 5 years of age are highly vulnerable to unsafe water consumption and at greater risk of contracting water-borne diseases such as diarrhoea, cholera and parasitic infections [6], [7]. Diarrhoeal diseases may be transmitted by several faecal-oral transmission routes summarized in the "F-diagram" by Wagner and Lanoix (Figure 1) [8]. Pathogens transmission may be direct via contamination by hand or indirect via contamination of drinking water, soil, tools, food and flies [8], [9].

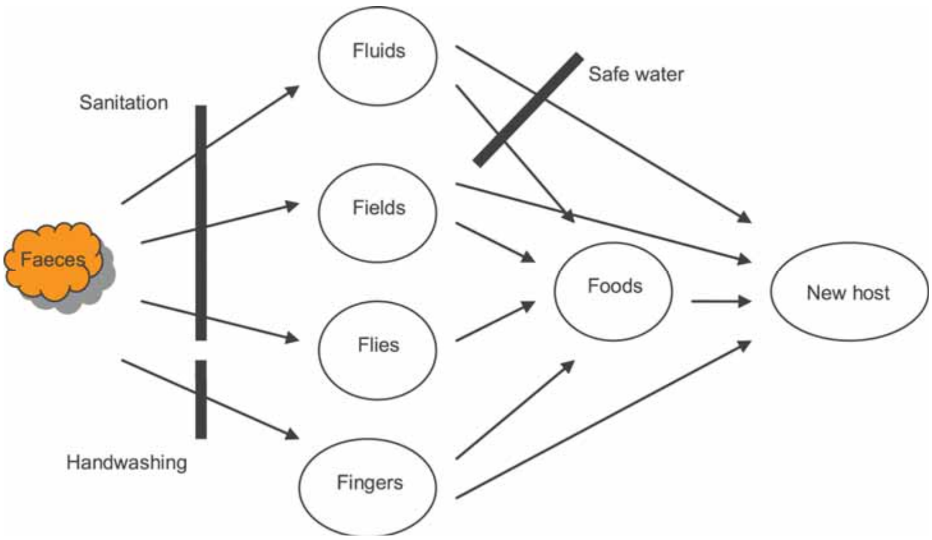


Figure 1 "F-diagram" showing faecal-oral transmission routes and barriers (sanitation, handwashing and safe water) to prevent pathogens transmission to host. Wagner and Lanoix (1958).

For decades, international global public health committees have gathered to find suitable solutions to prevent pathogen transmission and tackle water-borne diseases development by focusing on the WASH barriers: Safe water, Sanitation and Hygiene. In 2015, the Millennium development Goal (MDG) to halve the proportion of the population lacking sustainable access to basic sanitation and provide 2.6 billion people with "improved" drinking water source has been achieved. Nevertheless, MDG implementation lacked of sustainability in sanitary infrastructure and did not invest in the safety of the drinking water [10]. To fill this gap, Sustainable Development Goals (SDGs) set the objective to deliver "universal and equitable access to safe and affordable drinking water for all by 2030" (SDG 6.1) and "provide access to adequate and equitable sanitation and hygiene for all and end open defecation" (SDG 6.2).

1.1 WASH concept and WASH impact on health

Clean Water, Sanitation and Hygiene (WASH) interventions aim to prevent pathogen transmissions by providing communities with safe and accessible excreta disposal, supporting basic hygiene practices (e.g. handwashing), and assuring of a safe and reliable water supply [9]. Several studies investigated effects of WASH interventions on diarrhoeal reduction [11]. In 2014, Wolf and colleagues compared the effect of several WASH interventions on diarrhoea risk reductions and observed effects ranging from no reduction up to 85% reduction. Overall, they suggested that WASH interventions could lead to a reduction of diarrhoea by 35% (61 studies metanalysis) [12]. Recent results from a pooled analysis showed that WASH interventions could lead to diarrhoea risk reduction between 27% and 53% in children under 5, depending on the type of intervention [7]. As mentioned by Clasen and colleagues, assessing effectiveness of intervention in decreasing diarrhoeal risks is challenging because of the differences among the studies in methodologies, context, compliance, coverage, not-random allocation of intervention among cluster and lack of adjustment or reporting bias [13].

1.1.1 *Drinking water*

Providing rural communities with safe water supplies is challenging. Water is generally only available at community tap and requires transport of water from point-of-collection (POC) to point-of-use (POU). Deficient scheme pipes reaching POC might be contaminated by animals and open defecation. In addition, despite safe water at POC, water is likely to be (re)-contaminated[1] during transport through contact of water with dirty hands, dirty containers, inadequate water handling and low environmental hygiene (e.g. presence of animal or human faeces) [14]–[18]. In a prospective longitudinal cohort study looking at the relations between the level of contamination and the risk of diarrhoea among children, Luby and colleagues found that each 10-fold rise in faecal indicator counts (*E. coli)* in drinking water was associated with a 16% increase of diarrhoea [19].

In most studies conducted within the framework of the "MDGs", research on the effectiveness of improved water system is mentioned. In SGD, improved water service is categorised as "basic" when

[1] Water might be free of faecal coliforms POC and contaminated during transport, or water might already be contaminated at POC and re-contaminated because of a dirty container / inadequate treatment.

"drinking water comes from an improved source, with round trip no more than 30 minutes to fetch water" and as "safely managed" when "drinking water originates from an improved source that is located on premises, available when needed and free from faecal and priority chemical contamination" [20].

Several solutions against microbiological contamination of water exist at the scheme and household levels, such as chlorination, water filter, SODIS, etc. A report combining twelve studies suggested that treatment at POU should be favoured over POC because, on the one hand, it prevents contamination during transport and, on the other hand, it is more effective for prevention of diarrhoeal cases [21]. Another review evaluating several technologies at point-of-use reported that POU filtration could reduce diarrhoea by around half (RR 0.48, 95% CI 0.38 to 0.59), while POU chlorination could decrease diarrhoea by a quarter [21]. In 2018, Wolf and colleagues suggested that point-of-use filter intervention with safe storage could reduce diarrhoea risk by 61% [22]. The effectiveness of water treatment seems to be largely depending on "prevailing conditions such as pathogens circulating in the population, transmission dynamics and seasons" [23].

According to WHO, water contamination with faecal matter may be assessed by the quantification of some indicator organisms. The number of organisms can be directly associated with the level of contamination. *Escherichia coli* (*E. coli)* is the indicator organism selected by WHO for detecting recent faecal contamination in water. As stated in WHO standards, no *E. coli* should be present in a water sample (100mL) following filtration and incubation for 24 hours. Nevertheless, guidelines and national drinking-water quality standards should be adapted according to specific circumstances and risk and benefits to health. In addition, some researchers state that a sufficient amount of water for personal and environmental hygiene is more crucial for disease transmission prevention than the water quality itself [24], [25].

1.1.2 *Sanitation*

WHO defines improved sanitation as facilities and services aiming to maintain hygienic conditions. These facilities have the purpose of hygienically separating excreta from human contact by using wet sanitation technologies (flush and pour flush toilets connecting to sewers, septic tanks or pit latrines) and dry sanitation technologies (ventilated improved pit latrines, pit latrines with slabs or composting toilets) [2]. Benefits of improving sanitation include among other, "reducing of spread of intestinal worms, schistosomiasis and trachoma, reducing severity and impact of malnutrition, promoting dignity and boosting safety, particularly among women and girls". Indeed, in countries with frequent open defecation a higher risk of mortality under 5 years of age, poverty and malnutrition is notable [26]. Among the reviewed studies, almost no intervention study may be found where excreta disposal is investigated as a factor of reduction in diarrhoea morbidity *per se*. It is often combined with water and/or hygiene intervention. According to Baker and al, sanitation and hygiene interventions could lead to a reduction from 36% to 48% of diarrhoeal risk [27].

1.1.3 *Hygiene*

As stated by WHO, hygiene englobes "the conditions and practices that help maintain health and prevent spread of diseases" [28]. Hygiene practices include handwashing, menstrual hygiene and food hygiene. Absent of the MDG indicators, the hygiene concept has achieved recognition under Sustainable Development Goals (SDG, target 6.2). Handwashing with soap is now one of the top priorities in the WASH sector and is currently used as an indicator in WASH monitoring. The JMP ladder include three levels of handwashing, namely, "basic hygiene facilities" (handwashing with soap and water), "limited hygiene facilities" (handwashing facilities without soap and water) and "no facilities" [2], [28]. Handwashing at critical times such as after going to the toilet and cleaning baby bottom, before cooking and eating are protective against diffusion of diseases [29]. In 2014, a review by Freeman and colleagues stated that only 19% of the studied population was washing their hands with soap after having been in contacts with excreta. Their meta-regression of risk estimates suggested that the practice of handwashing, after adjustment for unblinded studies, could reduce the risk of diarrhoeal disease by 23% [30]. Other reviews estimated the risk reduction by 32% [31], [32].

1.1.4 *Diarrhoea: definition and burden*

Water-borne diseases are caused by the ingestion of water containing pathogens. Microorganisms (bacteria, viruses, protozoa and parasites) are later found in the intestinal tract of the human body and may lead to several conditions, such as diarrhoea. Enteric pathogens (virus, bacteria or parasites) are responsible for about 1.7 billion diarrhoea episodes per year among the group of less than 5 years old children [27], [33]–[38]. Diarrhoea is a major cause of morbidity and is known as the fourth leading cause of death in the under-five years old population segment (after preterm birth complications, neonatal encephalopathy and lower respiratory infections) [39]. In 2015, diarrhoeal diseases killed about 31 million people, of which 500'000 were children below 5 years of age, representing 8.6% of death in this age group [40]. Moderate to Severe diarrhoea is defined as having three loose or liquid stools in 24 hours during at least 7 days [41]. The burden of diarrhoea is very high as diarrhoea leads to secondary conditions by weakening the child's immune system. Additionally, repeated diarrhoeal events cause environmental enteropathy, a condition decreasing nutrients absorption and thus contributing to malnutrition and lowering the IQ score [42].

1.2 WASH interventions in Nepal and diarrhoeal burden

Nepal's WASH-related situation is critical [43]. As mentioned in the Nepal government WASH report (2014), increase in population along with poverty, traditional knowledge about real causes of diseases, poor WASH infrastructures and practices as well as illiteracy have increased the risk of waterborne diseases [44][45]. In South East Asia, 56% of diarrhoeal diseases were estimated to be linked with inadequate drinking water, sanitation and hygiene [15], [43]. In 2012, death rates owing to the lack of WASH services in southern Asia were 23/100'000 people, respectively compared to 12/100'000 people globally [46]. In 2012, although 92% of rural Nepalese households met the Millennium Development Goals (MDG) by having access to an improved drinking water source (WHO/ UNICEF JMP report), only 20% to 30% of the sources were free of faecal contamination and therefore safe for drinking [1]. In a study undertaken in Kathmandu valleys, total coliforms (TTC) and Escherichia coli (*E. coli*) bacteria were found in, respectively, 94% and 72% of the samples collected [47]. In another study 82% of the villagers with access to an "improved" drinking water source had presence of faecal coliform in water and only 14% had used treatment adequately [48]. In a more recent study by Shrestha and colleagues, assessing water quality sanitation in districts of Eastern Nepal, high levels of contamination in TTC was present at the source and at the point of consumption. In the same study they showed how the presence of domestic animals was significantly associated with drinking water contamination [49]. Another study in Eastern Nepal focusing on sanitary hygiene and practices showed that about 2% of villagers having soap and improved latrine were not using them [50]. The Government of Nepal has initiated a School Led Total Sanitation program in 2006, intending to empower teachers to educate their communities about changing hygienic behaviours and the importance of having a 100% toilet coverage and no more open defecation [51], [52]. The Demographic and Health Survey in Nepal estimated that due to this unsafe WASH environment, 3500 children die every year from waterborne-diseases, principally parasitic infection and diarrhoeal diseases [53], [54]. In a study undertaken in Kathmandu investigating the role of pathogens in development of diarrhoea, 8.8% of children had bacterial infections leading to acute diarrhoea because of poor hygiene [55]. Although several studies about WASH effects on health exist in Nepal, they focus mainly on the clinical level (e.g. maternity [56]) and consider less the community level. Close to none WASH-related studies conducted in rural Western Nepal can be found in literature.

1.2.1 *Study background*

This Master thesis aims to collect baseline information for the health impact study: "Evaluation of the impact of water quality and hygiene interventions on the health status of children in the project area of HELVETAS WARM-P Project in Nepal". This collaborative project between HELVETAS Swiss Inter-cooperation (HELVETAS) in Nepal and the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) wants to assess the impact of several WASH implementation strategies on child health status.

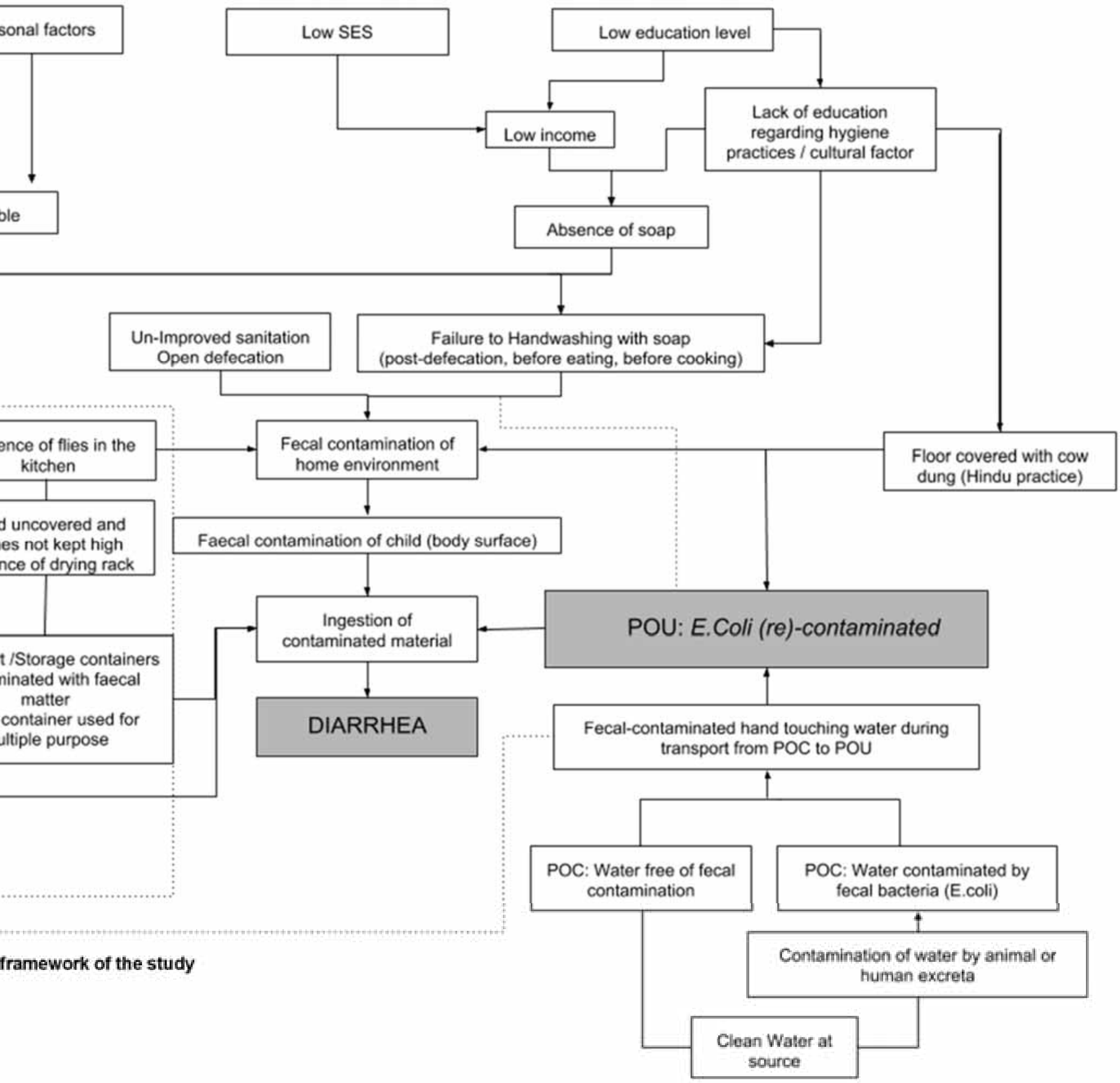
SANDEC group has been collaborating with HELVETAS in Nepal for a few years. Between 2014 and 2016, the Safe Water Promotion (SWP) group of SANDEC-EAWAG assessed the microbial water quality, household (HH) water management practices, and opportunities for market-based interventions in similar rural West- and Far-Western regions of Nepal. During this study, researchers analysed water quality between POC and POU and detected re-contamination during water transport or handling. After providing HH with water filters and education, an increase of use from 18% to 86% was observed [57]. In another study by SANDEC groups, they observed that only few participants practiced water purification even when being aware of its importance. Researchers suggested a campaign focusing on behaviour change through educating the local community on the risks of drinking unsafe water as well as interventions to improve access to sanitation products and adequate handwashing structures [58]. In 2017, another study by SANDEC demonstrated an improvement in water quality as a result of chlorination use, increase in use of soap from 43% to 63% and increase in use of handwashing station with a faucet from 65% to 83% after a WASH-improvement intervention [59].

With the present cross-sectional longitudinal study, the SWP group will provide currently lacking information on the role of a household level water treatment versus a scheme level water treatment that involves residual disinfection versus the impact of health education alone on children's health status, among Western rural Nepalese communities. The study will be conducted in four areas Mid- and Far-Western Nepal where no previous water treatment interventions have taken place. Four different types of water treatment/education interventions are planned, namely: (1) chlorination of water at scheme level with household hygiene education (HHE), (2) water filtration at household level with HHE, (3) no water treatment but HHE, (4) control area (no water treatment, no HHE). For the first time, the SWP group focuses on the impact of WASH intervention on the health status, including nutritional aspects. According to literature research and as confirmed by HELVETAS and municipalities representatives, the study sites have not yet received any complete WASH interventions.

1.2.2 *Research questions*

Results presented in this master thesis are findings of the baseline of the previously mentioned cluster randomized control trial. The master work has several aims:

1. Collect information on the WASH situation in rural areas of Mid- and Far- Western Nepal where no water treatment interventions have been previously conducted.
2. Answer the following two research questions:
   - Which environmental factors and/or practices are associated with faecal contamination of drinking water between point-of-collection and point-of-use?
   - Which risk factors are associated with presence of diarrhoea among children?
3. Provide the SWP group with relevant information for the implementation of interventions strategies and deliver good baseline data for the longitudinal study.



framework of the study

CHAPTER 2. MATERIAL AND METHODS

2.1 Study approach

The present work consisted of a cross-sectional study assessing WASH situation in the area, water quality at point-of-collection (POC) and point-of-use (POU) and associated risk factors for water contamination. It also assessed the prevalence of main WASH-related diseases (e.g. Diarrhoea) among children. Finally risk factors linked with drinking water contamination and diarrhoeal prevalence were investigated. Data were collected on a multilevel approach:

- One-to-one interviews and observations at the household level.
- Drinking water sampling at point-of-collection and point-of-use followed by onsite water quality analysis.
- Children anthropometric measurements and stool sample analysis (not included in this master work).

The study was carried out between the 19th March 2018 and the 15th May 2018, before the beginning of the rainy season.

2.2 Conceptual framework

The questionnaire as well as the list of structured observations were developed after having reviewed the DHS standard questionnaire and the WASH related literature. Figure 2 displays a conceptual framework developed on the basis of literature research, the questionnaire and personal observations. It presents identified factors associated with contamination of drinking water during transport and the ones associated with diarrhoea (inspired from Dangour et al [60]).

2.3 Study area and population

Nepal is part of Southern Asia and shares borders with Himalayas, India and China. Nepal is separated into three main ecological zones from south to north: the tropical flat area of Terai, the hilly area and the Himalayan mountainous area. In 2018, Nepali population reached over 29.5 million people

[61]. Even if Nepal experienced progress in life expectancy (total life expectancy of 70.2 years in 2018 [62]) and education in the past 30 years, Nepal is still poorly ranked in the 144th position out of 188 in the Human Development Index (HDI) [63]. According to 2016 estimates about 80% of the population lives in rural areas [64]. The majority of the population follows Hinduism (81.3%, 2011 estimates) [65]. A caste system ranks the Nepali community from lower to higher caste: Dalit (lower caste), Janajati (middle caste), Newari, Brahman and Chhetri (higher caste) [66].

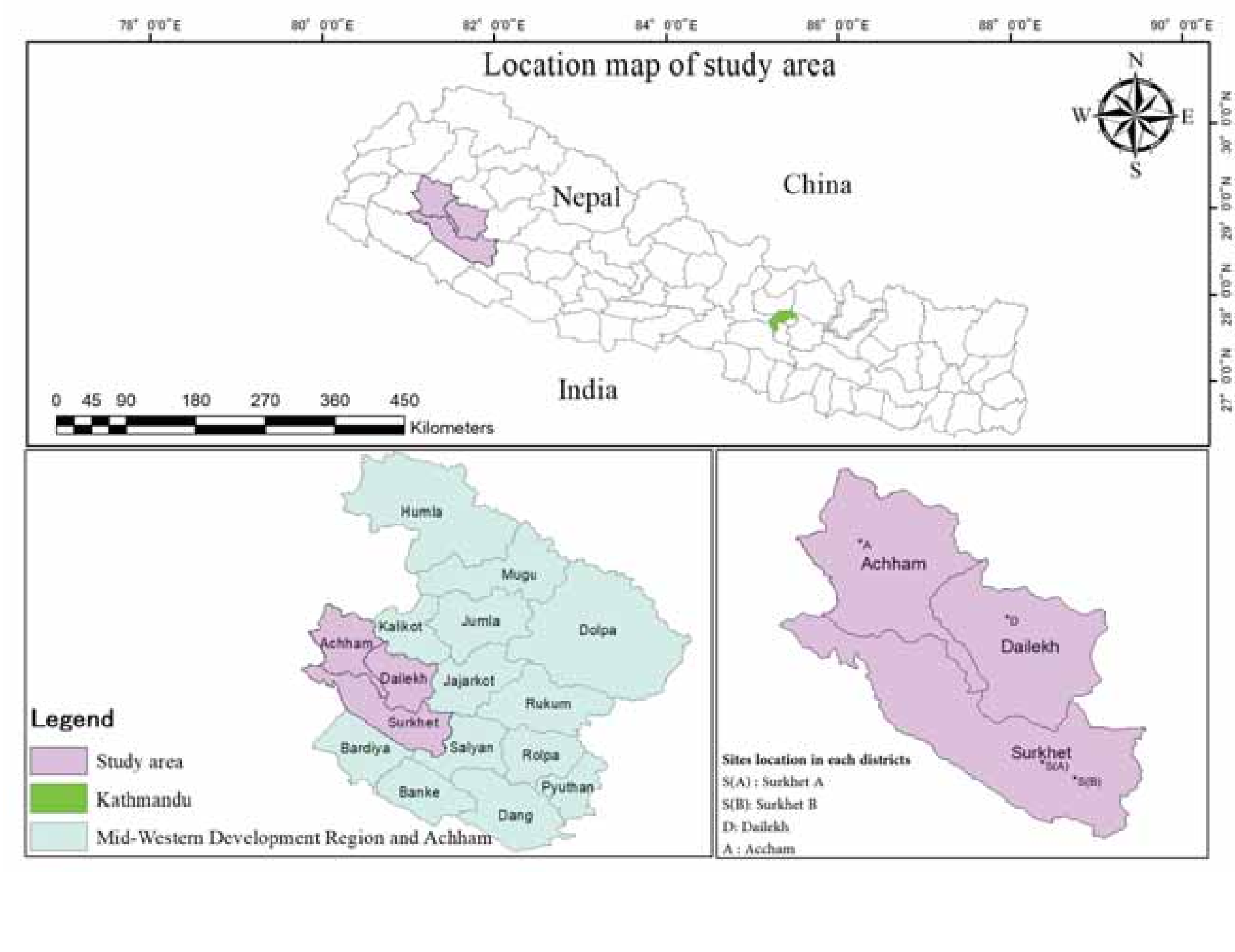


Figure 3 Study areas in the three districts of Far-and-Mid West Nepal[2]

The study was undertaken in Mid- and Far-Western Nepal in three different rural districts: Surkhet, Dailekh and Accham, approximately 580-980 km from the capital Kathmandu (Figure 3). Four study sites were selected by HELVETAS Nepal in prevision of future interventions: two sites in Surkhet district (Surkhet A and Surkhet B, Lekhabeshi municipality), one site in Dailekh (Dullu Municipality), one site in Accham district (Kamal Bazar). Sites selection criteria were as follows: at least 5 km distance between

[2] Study map designed by Midpoint Engineering Consultancy Pvt. Ltd, using GIS software

two sites, similarities between the sites, presence of piped water system (PWS) in the area, presence of children under 10 years of age and no previous total WASH program implemented. At the time of data collection, the following programs had been implemented by HELVETAS: In all districts, Integrated Water Resource Management Program (IWRMP) and Trail Bridge Support Programs for gender equality (TBSP) were running. In Dailekh and Accham districts, work with pregnant women (SUHARA NGO) and Good Governance Program (GGP) aiming for peace building, democracy and human rights were running [67]. Finally, in some areas of Dailekh district (but not in the areas selected for this study), food security and nutrition programs were implemented [68]. With regards to WASH situation, all working districts were declared as open-defecation-free (ODF) at the time of study. According to the National Management Information Project (NMIP), progress in sanitation coverage are seen in Mid-Western development regions [44][69]. In 2014, drinking water system coverage reached 82.52% in Surkhet, 71% in Dailekh, 87.68% in Accham [69]. The national program of female community health volunteers (FCHV) were active in the four areas [70]. Table 1 provides detailed information on the four study sites.

Table 1 Site by site information of the four study areas[3]

Characteristics	**Area Name**			
	Surkhet A	**Surkhet B**	**Dailekh**	**Accham**
Geographical situation (altitude)	Flat area /hilly	Flat area	Hilly area terrace cultivation	Hilly area terrace cultivation
Electricity connection (village level, some HH not connected)	Present	Present	Present	No electricity
Clustering / Spreading of the houses	Spread	Cluster	Spread	Spread
On-going road constructions during study in the villages themselves	Yes	Yes	No	No
Study timeline	19/03/2018-30/03/2018	08/04/2018-17/04/2018	23/04/2018.-01/05/2018	07/05/2018-15/05/2018
Weather during study [71]	Sunny Average 35°	Cloudy /Sunny Average 35°	Sunny / Windy 29.4 hailstorm Average 30°	Sunny 09.05 Hailstorm 12-14.05 : Wind and Rain Average 27°
Water supply at the scheme:	Tap open in the morning and evening	Tap open in the morning and afternoon or all day long	Dangling pipe. One in three schemes functioning well Sometimes request to open tap among authorities	Tap open early morning / afternoon; Dangling pipe Limited water system,
Open-defecation-free status (ODF)	ODF	ODF	ODF	ODF
Programs implemented by HELVETAS/other NGOs	IWRMP, TBSP, scheme chlorination projects	IWRMP, TBSP	IWRMP, TBSP, GGP, food security and nutrition program, SUHARA work with pregnant women	IWRMP, TBSP, GGP UNICEF and SUHARA work with pregnant women

[3] Source of information : personal observation, HELVETAS and municipality officers

2.4 Sample size and eligibility criteria

Household (HH) was the sampling unit of the study, defined by a group of people living under the same roof and sharing the same meal [72]. Sample size and power calculations using G*Power 3.1 revealed a sample size of 350 households in each group to detect a small effect between 4 groups with a correlation of 0.1 among repeated measures with 80% power and a one-tailed alpha of 0.05 [73]. A sample size of 300 households would be required to detect a small to medium effect in Cohen's f2 at one-tailed alpha of 0.05 and a statistical power of 95% with multiple linear regression and 15 predictor variables [74], [75]. 345 households would be sampled per study area, which would have the advantage to better balance potential design effects. The same sampling plan will be used during the follow up study in both beneficiary and control areas. In addition, a drop-out rate of 7% is being considered.

Families were eligible to participate if they reported using piped water system (PWS), had a child between 6 months to 10 years of age and a caregiver was present. When two children were available, the youngest child was examined because of its higher vulnerability to WASH-related diseases (e.g. diarrhoea) [75].

2.5 Data collection tools and Water quality analysis

2.5.1 *Household survey*

The questionnaire was composed of 102 questions categorised into seven sections: Household information (with GPS localisation of the household), wealth index (inspired by DHS[76]), water handling and hygiene (including RANAS questions as well as knowledge, attitude and practice concepts (KAP)), information on WASH promotion, child health, nutrition and observations through the interviewer. (HH survey material 1). The RANAS model developed by Mosler postulates that "for the formation of new habitual behaviour, five blocks of factors must be positive with regard to the new behaviour: Risk factors, Attitudinal factors, Normative factors, Ability factors, and Self-regulation factors"[77]. Understanding the behaviour awareness in the present context would help in implementing the best strategy. A 5-dot scale was used to quantify the RANAS questions (lowest to highest)(Figure 4). When asked about child sicknesses, caregivers had to report about the occurrence of diarrhoea in the past 7 days preceding the interview[4]. Data were collected using tablets (Samsung Galaxy Note A3; Seoul; Korea) and questions were pre-coded using open data kit software (ODK) (University of Washington, Seattle WA, USA). Every evening, questionnaires were downloaded from the tablets onto the computer and transformed into an

[4] When more than one child below 10 years old was present, the youngest child was selected because of his higher vulnerability.

Excel document including all questionnaires of the study. Automatic cross-checks were done at a daily basis to prevent repeated interviewers' errors and inconsistencies.

Left : Interviewer and interviewee during survey, use of the 5 dot-scale for RANAS questions,
Right : Inform consent form "signed" via fingerprint by an illiterate woman

Figure 4 Interviewer during survey

2.5.2 *Drinking water collection and water quality analysis*

Respondents were asked to walk together with the water quality specialist to the point-of-collection (POC) with an empty container to collect drinking water (Figure 5). After letting the water run for 30 seconds to wash out any deposited residues and ensure a representative water sample from the PWS, a 100mL water sample was taken at the POC and filled into a sterile Whirl-Pak bag (Nasco, Fort Atkinson, USA) containing sodium thiosulfate to inactivate any residual chlorine. Immediately after the sample collection, the empty water transport container was filled and carried to the HH by the respondent. After reaching the household, the respondent was asked to provide with 100mL of water in a similar way they would pour themselves a glass of drinking water. Also this sample was filled into a sterile Whirl-Pak bag. In absence of treatment at household level, water samples were directly collected from the container. Water samples were kept in cooler bags and immediately processed at the site of the household interview, using a modified filtration device (DelAgua, UK), sterile membrane (0.45μm) and Compact Dry EC plates (Nissui Pharmaceuticals, Tokyo, Japan). Sterile water was used to wet the Compact Dry EC plates. Each morning, water was boiled, poured into baby bottles and the set was boiled a second time. Water samples and plates were labelled with the same household ID (HHID) used in the questionnaire including: area of study, date, household number and respectively POC or POU. Every night, plates were placed in a solar-powered incubator (Eawag, Dübendorf) at 35 ± 2° for 24 hours (Appendix 1a) and 1b)). Special procedures were undertaken when the water tap was only available in the morning and/or evening. In this case, all HH using an identical POC were asked to join at the time of water availability with their empty water transport container. All containers were filled and the corresponding POC water sample to each HH was collected between each container filling. Filled containers were labelled with HHID. POU samples were collected later during the interview at the household. For each HH, information regarding date and time of water collection and processing as well as information on treatment were entered in a field booklet. Water physical characteristics in terms of colour, turbidity and odour were also recorded (HH survey material 2).

Left : Collection of water samples using Thio-Whirl Pack at Point-of-use
Right Onsite processing of water filtration

Figure 5 Collection and processing of water samples

2.5.3 *Bacteria counting and quality control*

After the incubation period (24h), *E. coli* and total coliform colony forming unit (CFU) per 100 mL water were counted on the Compact Dry EC following manufacturer's instructions (Figure 6). Counts were indicated directly on the plate using permanent markers before reporting them in the lab book. When the plates were too numerous to count (TNTC) or counts were equal to or higher than 2000, 2000 was indicated in records but the initial counts were also conserved. For the purpose of this work, *E. coli* was chosen as an indicator of water contamination as it is known to be the most suitable indicator of faecal contamination in DW and its presence is associated with higher risk of diarrhoeal disease and presence of other pathogens bacteria such as *Salmonella, Shigella* and *Campylobacter spp* [15], [24], [34].

Duplicates for every 10th HH were undertaken to control for the quality of water processing. Every night, negative controls (blanks) filtering boiled water were processed to control for the functionality of the funnel.

In red-pink : Total coliform In Blue : *E. coli.*
(Left picture) : “POC” has limited amount of *E. coli* while this amount greatly increases at POU.
(Right picture) : POU Sample treated at the household level with a ceramic filter showing less contamination than POC.

Figure 6 Bacterial growth after 24 hours incubation period of paired-samples (POC-POU) of the same Household.

2.5.4 *Chlorine testing*

Testing for residual chlorine was done only for POU water sample as no scheme level chlorination was present according to HELVETAS and municipality officers. Three-Chamber test kit and DPD-Tablets were used according to the manufacturer indications (Lovibond, Tintometer, Germany) (Appendix 1 (c)).

2.6 Organisation of the study

2.6.1 *Other measurements*

During the study, other measurements were also undertaken but the results are not presented in this master work. They included anthropometric measurement of children, clinical observations as well as stool sample analyses using Formal Ether Concentration, Kato-Katz and Wet Mount methods.

2.6.2 *Team training and pilot study*

The field group consisted of five teams, each composed of two people: an interviewer and a specialist for water and clinical data collection. In the base camp, two laboratory operators were responsible for stool sample analysis. Interviewers were speaking the local language. During a four-day training, individuals practiced their expertise (e.g. water treatment, questionnaire interviews and laboratory work) and a pilot study was undertaken in Surkhet A area.

2.6.3 *Pre-field visit and journal*

Before the study started, visits of the four study sites and meeting with health and municipal officers to obtain deeper information on the communities were done to assure that no WASH interventions had been implemented in these areas. Several observations were noted in a study journal during this visit as well as daily during the study.

2.6.4 *Electricity*

As not all sites were provided with electricity, solar panels, batteries and inverters were brought to the study sites to aliment incubator, tabloids and computers (Figure 7).

Figure 7 Incubator connected to solar-panel / battery system

2.7 Ethical considerations

This research project was conducted in accordance with the study protocol, the Declaration of Helsinki, the principles of Good Clinical Practice, the Human Research Act (HRA) and the Human Research Ordinance (HRO) as well as other locally relevant regulations and was accepted by the "Kantonale Ethikkommission Zürich" and the ethical commission of the Nepal Health Research Council. Study aims and procedures were explained to the caregivers and an informed consent forms were signed by each participant before each interview and measurements were undertaken (HH survey material 3). Fingerprints were used as proof of attestation among illiterate responders (Figure 4). Data were anonymized using an ID for each HH. Respondents younger than 16 years old were not allowed to participate in the study. HH were informed about their child's parasitological and the water quality of their house when requested. Measures for hygiene and water quality improvement will be provided to the communities in the studied areas by HELVETAS.

2.8 Statistical analysis

During field work, water quality data were daily doubled-entered, in paper format (study book records) and digitally using Excel 10 (Microsoft, Redmond; WA, USA). Data from field booklets and lab book were also entered in a digital format. After removal of inconsistencies and invalid results (e.g. mishandling during filtration processing) the verification of data was done by random cross-checking between the two formats.

Water quality, body measurements, parasites and survey datasets were linked by their identifications code (HHID), using Excel 10. Statistical analysis was carried out using IBM SPSS version 23 (IBM, New York, NY, USA) and Stata version 13 (Stata Corporation, College Station, TX, USA). Descriptive statistics including mean (if data were normally distributed), median (if data were not normally distributed), standard deviation and frequencies (absolute and relative) were generated. To examine the correlation between categorical variables, Pearson Chi-square (χ^2) was used, and for continuous variable Person correlation was used (r) [78].

2.8.1 *Factor score analysis: Wealth and Hygiene indexes*

I created new variables of wealth and hygiene indexes by factor analysis of selected indicator variables. Before running the factor analysis, categorical variables (2 or more categories) had to be relabelled so that the highest score represented better hygiene or higher wealth status. For example, the dummy variable "is there a significant number of flies in the kitchen" was originally labelled "many flies=1, few flies=0". This was recoded, with few flies=1, many flies=0. Factors yielding to an explanatory variance of at least 50% and all factors with an Eigenvalue above 1 were retained [78]. In addition, variables with low communality (less than 0.5) were removed from the analysis. In accordance with Vijaya 2010, I generated a Non-Standardized Index (NSI) (equation 1) and then normalized it (equation 2) [79].

Equation 1 Calculation of Non-standardized index

$$NSI = \left(\frac{variance\ explained\ by\ factor\ 1\ score}{total\ variance\ explained}\right) * (factor\ 1\ score) + \left(\frac{variance\ explained\ by\ factor\ 2\ score}{total\ variance\ explained}\right) * (factor\ 2\ score) + \cdots \left(\frac{variance\ explained\ by\ factor\ n\ score}{total\ variance\ explained}\right) * (factor\ n\ score)$$

Equation 2 Standardisation of NSI

$$SE(\mathbf{0}-\mathbf{1}) = \frac{value\ of\ factor\ score\ (NSI)}{(max - \min factor\ score)}$$

As recommended by DHS, I split the obtained index scores into five categories[80]. Nevertheless, the obtained categories were violating the rule of thumb "a category must not have less than 10% counts than the biggest category", I therefore divided the index categories into three levels: low, medium and better hygiene and wealth index, respectively.

Appendix 2 and 3 summarize the variables included / excluded, the number of factor score retained during factor analysis as well as the repartitions in three categories of different scores. Only one wealth index was calculated. I generated seven hygiene indexes using the same method. Six hygiene indexes were created in the following categories: personal hygiene, toilet hygiene, handwashing infrastructure, kitchen cleanliness, container and surrounding hygiene and one overall hygiene index reuniting variables included in all aforementioned hygiene categories.

2.8.2 *Univariate and multivariate logistic regression models*

Finally, I performed a risk analysis to observe which risk factors were related to the water contamination during transport / treatment (binary outcome variable 1) and to the presence of diarrhoea (binary outcome variable 2).

I first assessed predictor variables one-by-one using bivariate mixed logistic regression. ORs were determined, including 95% confidence intervals. Wald tests[5] were performed in order to evaluate their statistical significances and p-values were reported. Using backward stepwise elimination, non-predicting covariate having a *p-value* > 0.2 were excluded from the multivariate models [49]. Before running the multivariate mixed-effects logistic regression, I removed one of the variable having high correlation with another in order to prevent multi-collinearity (variable was removed when correlation factor higher than 0.8 and variance inflation factor (VIF) was higher than 10). The final model was selected among all models according to its Akaïke information criterion (AIC) value. The model with the lowest AIC value was favoured as it indicates the lowest loss of relative information during modelling [78]. In both bivariate and multivariate models, mixed logistic regression including a random intercept was used to adjust for all differences between the areas except the one already included in the model. In both final models, adjustments were made for potentials confounders. In the first model, socio-

[5] Wald-test was preferred to likelihood-ratio test, which does not take into account the part of variation of the outcome that is attributed to the random effect. [81]

economic status (SES) was controlled. In the second model (diarrhoea) I controlled for SES, sex and age of child. Predictors and outcome variables were significantly associated if p-values were <0.05. To assess the amplitude of the clustering within areas, the intra-class correlation coefficient (ICC) associated with them was reported. The ICC represents the proportion of the unexplained variability of the outcome by the model that can be attributed to the differences between the areas [81].

2.8.3 *Specification for water model*

During the analysis, I decided to focus on *E. coli* as water pollution indicator in both POC and POU water samples. For the multivariate model with diarrhoeal disease prevalence as outcome variable, the four risk levels of water contamination with *E. coli* at POU were used in accordance with WHO guideline for drinking water quality [24]. For the model with contamination between POC and POU, a new variable called "contamination between POC and POU" was created by calculating the delta of *E. coli* counts between POC and POU (Equation 3). For this calculation, the initial value of *E. coli* counts at POC and POU (and not the results round at 2000) were used:

Equation 3 Contamination of water between POC and POU

$$\Delta E.coli = Ecoli\ initial\ counts\ at\ POU - E.coli\ initial\ counts\ at\ POC \qquad (3)$$

Outcomes of this calculation were then categorised into four categories:

Δ*E. coli* values (supplementary colonies counts)	Level of (re) contamination during transport / treatment
0	None
1-10	Low
11-100	Middle
>101	High

In the process of analysing the water contamination model, I was forced to categorize the outcome variable (delta) into different categories as the data were not showing normal trend and could not be normalized because of the important number of null and negative values. Initially a model using ordinal (four categories) logistic regression was made but assumptions were violated. In a second attempt, using multinomial-logistic model (four categories), results showed no difference between the three levels of contamination categories (low, middle, high) compared to the reference "no contamination". Therefore, I opted for a logistic model using contamination of water as a dummy variable "contaminated vs not contaminated during transport / treatment". This choice was justified because more explanatory variables were significantly associated with binary logistic model and this model showed the lowest AIC value among all (ordinal, multinomial).

2.8.4 *Specification for diarrhoeal model*

Because of the collinearity between several hygiene indictor variables, only selected variables were included in the regression analysis for diarrhoea. The model with the lowest AIC value was selected as the final model for diarrhoea prevalence.

CHAPTER 3. RESULTS

Results are presented in six subcategories:

1. Study compliance, socio-demographic and wealth information
2. WASH status: infrastructure, knowledge and use
3. Microbiological and physicochemical water tests outcome
4. Health and diarrhoeal diseases prevalence
5. Risk factor analysis for contamination of water between Point-of-collection (POC) and Point-of-use (POU)
6. Risk factors for diarrhoeal diseases

3.1 Study compliance, demographics and wealth

3.1.1 *Study compliance and sample size*

A total of 1'427 interviews were conducted based on the four predefined areas. Interviewees generally agreed to participate. Occasionally, cultural context obliged us to insist on selecting mothers (if present) rather than fathers based on profound reasons[6]. As some caregivers had just returned from very remote POC, some of them appeared reluctant to accompany the water specialist to the source again. Others were unwilling to leave their children unattended. In some HH and especially in Surkhet A area, POC taps were sometimes unavailable due to constructions. While only limited data from the questionnaire were missing, not all POC and POU samples were collected or valid. For this reason, the final water contamination model included 1116 HH and the final model for diarrhoea included 1246 HH.

3.1.2 *Socio-demographics*

Table 2 summarizes socio-demographical information. The respondents were primarily women[6] with a mean age of 30.26 years (SD = ±8.890, range 15-70). One third of the interviewees belonged to the lower Dalit caste group. Every 5th respondent was unable to read and / or write. In this study setting, agriculture was the main occupation among women (about 90%) and men (60%), while about half of men worked as labourers or were otherwise employed as a first or secondary occupation.

[6] Women caregiver (mothers) were preferred over male as the survey included nutrition and breastfeeding related questions not presented in this master thesis.

Table 2 Socio-demographic characteristics including gender, age, ethnicity, literacy and employment of household.

Socio-Demographic characteristics (N=1427 if not specified)	Number (%)
Areas of study	
Surkhet A	348(24.4)
Surkhet B	365 (25.6)
Dailekh	356 (24.9)
Accham	358 (25.1)
Gender of respondent	
Female	1347 (94.4)
Male	80 (5.6)
Age of respondent (N=1424)	
15-25	498 (35)
26-35	645 (45.3)
36-45	196 (13.8)
46-55	54 (3.8)
> 56	31 (2.2)
Ethnicity	
Dalit	451 (31.6)
Janajati	266 (18.6)
Brahmin, Chhetri, Thakuri	704 (49.3)
Other	6 (0.4)
Literacy	
Can both read or write	1168 (81.9)
Can neither read or write	235 (16.5)
Can read only	24 (1.7)
Employment of spouse (MAP)°	
Agriculture	1280 (89.7)
Business	106 (7.4)
Labourer	58 (4.1)
Other (independent work, service, foreign country, unemployed, no spouse)	70 (4.9)
Employment of husband (MAP)°	
Agriculture	865 (60.6)
Labourer	517 (36.2)
Employed	175 (12.3)
Business	145 (10.2)
Other (Government service, unemployed, independent work, retired)	80 (5.6)
Number of children in the HH (N=1426)	
1	580 (40.6)
2	593 (41.6)
3	198 (13.9)
4	42 (2.9)
5	10 (0.7)
6	3 (0.2)
Number of children under 5 years of age (N=1426)	
No child under 5 years of age	412 (28.9)
1 child	770 (54)
2 or more children	244 (17.1)

°MAP = Multiple answers possible

3.1.3 *Socio-economic status (wealth index)*

All variables included in the Wealth index (WI) calculation are found in the Appendix 2. More than half of the respondents had no education or had only completed primary education. Seventy percent of respondents spent less than 15'000 Nepali Rupees per month[7]. While about half of the HH had electricity in the house, solar panels and a watch, more than 90% of caregivers had cell phones. Wood was the main source of fuel. Walls and floors were made from mud/stones in the majority of the HH (Figure 8). The size of the housing was measured by "people per room". The mean number of people per room was 1.99 (SD = ±1.93, range: 15-12). This variable included both information about number of people living in the house (mean =5.84 SD = ±2.1, range 2-21) and number of rooms in the house (mean= 3.85, SD = ±2.25, range 1-23[8]). On average, families had 1.82 (SD±0.844, range =1-6) children and about 70% of them were younger than 5 (Table 2). Figure 9 presents the socio-economic status (SES) and hygiene index (HI) of respondents in accordance with areas. Both wealth index and the overall hygiene index (presented in paragraph 3.2.4, page 36 and Figure 9) followed the same trend within the four different areas. HI and SES were positively correlated (r=0.232, p=0.000). Within the two field areas in Surkhet district, both SES and HI were significantly better than in Dailekh and Accham. Remoteness of of Dailkh and Accham may justify this phenomenon. Nevertheless, the two areas investigated in Surkhet district showed differences, namely Surkhet A having a larger percentage of people with higher overall HI. This could be explained by the fact that three different communities were visited during within the Surkhet A area and one of them was visibly more developed structurally and economically as compared to other communities visited in Surhket district.

Figure 8 A typical household of Nepal with floor made of mud, wall and roof made of stones, proximity of animals.

[7] 15'000 rupiah corresponded to about CHF 137 in April 2018 [128]
[8] Some house hosted more than one family but each HH (families) had separated kitchen.

Figure 9 Socio-economic status (SES) and HI (hygiene index) within the four areas

3.2 WASH infrastructure, knowledge and use

3.2.1 *Water system use and functionality*

Table 3 presents characteristics of the water system of all areas, water access information and perceived safety. As requested by the study criteria, the majority of the sites had a PWS (75.5% of HH had taps at the community level (Figure 10) and 20.7% had tap at the HH level). One third of the houses used a secondary source for water fetching. The median time for a round trip water collection was 10 minutes, (IQR 5-15, min-max: 1-90minutes). Because of PWS presence and as the collection time was not exceeding the "maximal 30 minutes per trip to collect water", this study area can be classified as having "basic drinking water service", and therefore the time variable was not included as risk factor in the regression models [20]. Ninety percent of HH claimed that their main drinking water source was functioning well and only 3.3% of HH had faced water interruption for more than one week in the past six months. Village maintenance workers (VMW) were present and supported less than half of the communities. Water was perceived as good or very good by 63% of respondents and quite safe or very safe by 54.4% of HH.

Figure 10 Community tap

racteristic and quality evaluation

	Overall N (%)
	296 (20.7)
	1077 (75.5)
ng)	25 (1.8)
	20 (1.4)
	4 (0.3)
	5 (0.4)
ing water (MAP)°	481 (33.7)
	113 (7.9)
	320 (22.4)
	32 (2.2)
	7 (0.5)
	1 (0.1)
	14 (1)
	1 (0.1)
of water	
	503 (35.2)
	417 (29.2)
	169 (11.8)
	132 (9.3)
	155 (10.9)
	15 (1.1)
	36 (2.5)
ning	
	1300 (91.1)
	126 (8.8)
	1 (0.1)

Variables (N=1427 if not specified)	Overall N (%)
Interruption in the last 6 months for more than one week	47 (3.3)
Level of confidence for the source to be fixed in a week	
Very confident	950 (66.6)
Somewhat confident	271 (19)
Not confident at all	117 (8.2)
Do not know / no answer	89 (6.2)
Village maintenance worker (VMW)	
Presence of VMW	774 (54.2)
Help is provided my VMW	
Yes	646 (45.3)
Maybe	177 (12.4)
No / No answer	604 (42,3)
Water is sufficient to daily need	1249 (87.5)
Quality of drinking water perception	
Very bad	0 (0)
Bad	28 (2)
Medium	500 (35)
Good	427 (29.9)
Very good	472 (33.1)
Safety of drinking water perception	
Very safe	236 (16.5)
Quite safe	541 (37.9)
Neither safe nor risky	137 (9.6)
A bit risky	464 (32.5)
Very risky	49 (3.4)

3.2.2 *General WASH knowledge and education*

Visit by Female community health volunteers (FCHV) or other health workers had reached slightly more than a third of HH (37.6%). A quarter of HH caregivers had participated in hygiene literacy classes. A majority of respondent pointed out that unprotected source (80.9%) and open defecation (58.5%) were responsible for water contamination (Table 4)

Table 4 General WASH knowledge and education

Variables N= 1427 if not specified	Overall N (%)
Female community health volunteer (FCHV)	
Any HH inhabitant attending hygiene literacy class conducted by FCHV	362 (25.4)
Visit of FCHV or other health workers at the household	537 (37.6)
Visit frequency (number of times in a year) of the FCHV or other health workers (N=537)	
Never	5 (0.9)
Once	468 (87.2)
Twice	60 (11.2)
Three time	3 (0.6)
Four times	1 (0.2)
General knowledge about contamination of water	
Reasons for water contamination (MAP)°	
Contamination due to unprotected source	1155 (80.9)
Contamination due to unmanaged system	714 (50)
Contamination due to open defecation	835 (58.5)
Contamination due to settlement above source	324 (22.7)
Contamination due to deforestation	50 (3.5)
Don't know about contamination source	121 (8.5)
Other causes	5 (0.4)

°MAP = Multiple answers possible

	Overall N (%)
MAP) °	
	842 (59)
	816 (57.2)
	448 (31.4)
	24 (1.7)
	116 (8.1)
	94 (6.6)
	1 (0.1)
ment	460 (32.2)
ethod of water	
	64 (6.6)
ethod	208 (21.5)
s	299 (30.9)
ds	318 (32.9)
methods	78 (8.1)
way (N=1427)	193 (13.5)
	137 (71)
	58 (30)
	3 (1.6)
N=193)	3 (1.6)
	1 (0.5)
	2 (1.0)
°	
	17 (1.2)
	33 (2.3)
	151 (10.6)
	1 (0.1)
	1228 (86.1)

Variables (N=1427 if not specified)	Overall N (%)
Water was treated every day in the past two weeks	177 (8.3)
Person responsible for water treatment (N=193, MAP°)	
Wife	183 (94.8)
Husband	82 (42.5)
Daughter	23 (12)
Son	5 (2.6)
Affect for treated water (N=1427)	
I dislike it very much	245 (17.2)
I rather dislike it	481 (33.7)
Average	370 (25.9)
I rather like it	212 (14.9)
I like it very much	119 (8.3)
Worth of treating water (N=1427)	
Never worthwhile	325 (22.8)
Rarely worthwhile	177 (12.4)
Sometimes worthwhile	341 (23.9)
Mostly worthwhile	378 (26.5)
Always worthwhile	206 (14.4)
Commitment: importance to treat the water (N=193)	
Not at all important	2 (1)
Little important	3 (1.6)
Rather important	15 (7.8)
Important	70 (36.3)
Very important	103 (53.4)

3.2.3 *Water treatment*

3.2.3.1 Knowledge, practice and outcomes

Respondents were asked about their knowledge of water treatment methods. Even though approximately two third of respondents (67.8%) knew about at least one water treatment method, only 13.5% had already used one to treat their water and as little as 8.3% of respondent purified their water daily (Table 5). The three most frequently used methods were water filter, boiling and filtration with a cloth. Half of the participants stating that they did not like the taste of treated water were currently not using any treatment methods (r =493.75, p=0.000). 86.1% of HH had no water treatment material available accordingly (water kettle, filters…). In addition, less than one in ten respondents knew about the chlorination method. Contrastingly, when they were asked about the benefits of treating their water, 40.9% of all the respondents (N=1427) claimed that treating their water was "mostly worthwhile" or "always worthwhile" and the majority of people currently treating their water (N=193) claimed that treatment was "important" or "very important" (89.7%).

3.2.4 *Hygiene and sanitation*

In this section, container, handwashing, toilet, kitchen, surrounding and personal hygiene and their corresponding hygiene index are described. Both interviewers' observation and collected data from the questionnaire were used for the analysis.

3.2.4.1 Container type and container hygiene

As described in Table 6 the majority of containers used for fetching water were Gagris made of copper (39.4%), jerrycans in plastic (54.5%) and Gagris made of aluminium (59.7%) (Figure 11). Almost all HH responded that they cleaned their container (N=1416), and 85.2% of them cleaned them daily. Cleaning methods were: the use of water only (27.5%), the occasional use of soap or ashes (42.2%) and 30.3% of respondents claimed using soap or ashes for each cleaning process. Observers reported that more than 60% of the transport containers were covered during transport and more than three quarters visibly looked clean[9]. The majority of HH used the same containers for transport and storage (94.5%)

[9] Potential observation bias with this recording of this variable: observer might have only look at the outside of container.

Table 6 Transport container : type and cleaning KAP, characteristic and HI

Transport container: type and cleaning KAP

Variables (N=1427 if not specified)	N (%)
Type of transport container (MAP) °	
Copper Gagri	562 (39.4)
Plastic Gagri	133 (9.3)
Aluminum Gagri	852 (59.7)
Brass Gagri	14 (1)
Plastic Jerrican	778 (54.5)
Plastic bucket	218 (15.3)
Aluminum Bucket	28 (2)
Clay pot	8 (0.6)
Other	1 (0.1)
Cleaning transport container	1416 (99.2)
Frequency of cleaning transport container (N=1416)	
Less often than once per week	6 (0.4)
At least once per week	27 (1.9)
Every second day	177 (12.5)
Every day	1206 (85.2)
Method for cleaning transport container (N=1416)	
Use of water only	390 (27.5)
Use of soap or ashes always	429 (30.3)
Use of soap or ashes sometimes	597 (42.2)
Using same container for transport and storage	1348 (94.5)

Container Hygiene characteristic included in HI

Variables (N=1427 if not specified)	N (%)
Transport container	
Clean (N=1426)	1098 (76.9)
Covered with a lid	935 (65.5)
HI: container hygiene (N=1426)	
Low hygiene	271 (19)
Medium hygiene	278 (19.5)
Higher hygiene	877 (64.5)

° MAP= Multiple answers possible

(Left) Men filling copper “Gagri” from dangling pipe. In proximity recycled containers are visible. In the back a women carrying filled Doko – (Accham area)
(Upper right) Child carrying water (Surkhet A)
(Lower right) Women transporting water from collection point to their home in Dailekh district

Figure 11 Container Types and transport

3.2.4.2 Handwashing and Toilet hygiene

A handwashing station was present in two houses out of five (either a bucket or a drum with a tap). Even though, handwashing stations were present, only 36.7% of the handwashing station had water, 27.2% of them had soap and 25.6% were clean. While nearly 80% of caregivers had clean hands, only half of all children hands were clean (Table 7 and Figure 13). When asked about the handwashing frequency the day before the visit, caregivers reported cleaning their hands on average 5.72 times (±2.34, range 1-30) from which 3.56 (SD ±1.35, range 1-15) times with soap. Despite that the majority of the population used improved sanitation (pour water flush latrine were used by 84.1% of HH), only half of the latrines were clean (no traces of faeces or dirt). While most of the HH had access to a water drum close to the latrine (80.6%), a toilet brush was yet present in about a quarter of them (Table 8 and Figure 12).

Table 7 Handwashing practices and corresponding HI

Handwashing practices

Variables (N=1427 if not specified)	N (%)
Number of times washing hands yesterday (N= 1422)	
1-2 times	16 (1.1)
3-4 times	392 (27.6)
5-6 times	660 (46.4)
> 7 times	354 (24.9)
Number of times washing hands with soap (N=1423)	
0-2 times	244 (17.1)
3-4 times	836 (58.7)
5-6 times	322 (22.6)
> 7 times	21 (1.5)
Reasons for handwashing (MAP)°	
When hand look dirty	862 (60.4)
After going to the toilet	1402 (98.2)
After clearing baby bottom	834 (58.4)
Before eating	1039 (72.8)
Before cooking	572 (40.1)
No special occasion	2 (0.1)
Do not know	3 (0.2)

Handwashing hygiene characteristic included in HI

Variables (N=1427 if not specified)	N (%)
Handwashing station	
Not present	855 (59.9)
Pouring out water from a bucket	255 (17.9)
Drum with a tap	317 (22.2)
Handwashing station conditions	
Clean	365 (25.6)
Presence of water	523 (36.7)
Presence of soap	388 (27.2)
HI: handwashing hygiene	
Low hygiene	940 (65.9)
Middle hygiene	110 (7.7)
Better hygiene	377 (26.4)

° MAP= Multiple answers possible

Table 8 Toilet hygiene index

Hygiene-related characteristics included in HI Variables (N=1427 if not specified)	**N (%)**
Toilet	
Type of toilet	
No latrine	90 (6.3)
Simple pit latrine	137 (9.6)
Pour water flush latrine	1200 (84.1)
Toilet conditions (MAP)°	
Toilet is clean	666 (46.7)
Brush present	375 (26.3)
Water drum	1150 (80.6)
No material present in the toilet	160 (11.2)
HI: Toilet hygiene	
Low hygiene	250 (17.5)
Middle hygiene	27 (1.9)
Better hygiene	1150 (80.6)

° MAP= Multiple answers possible

Left : Simple pit latrine
Right : Dirty pour- water flush latrine t

Figure 12 Toilet types and cleanness

3.2.4.3 Kitchen, surrounding and personal hygiene

In more than two third of the HH kitchens, a significant number of flies was visible. Dishes were kept high, food was covered and a drying rack was present in respectively 52.6%, 69.3% and 42.7% of households (Table 9 and Figure 13). Three HH out of five claimed keeping animal inside overnight. Trash inside and outside of the house were seen in respectively 54.7% and 76.9% of the households and only 6% of household had a garbage pit (Table 10). Frequently observed were animal and manure piles close by the houses and the practice of cow dung spreading, which is perceived as holy purifying in the Hindu culture (Figure 14). 80% of caregivers and 50% of children had no sign of dirt on their hands (Table 11).

Table 9 Kitchen Hygiene: observations and HI

Kitchen Hygiene characteristic included in HI.	
Variables (N=1427 if not specified)	N (%)
Kitchen	
Dishes are kept high	750 (52.6)
Food covered	989 (69.3)
Presence of a drying rack	609 (42.7)
Few flies present	331 (23.2)
HI: kitchen hygiene	
Low hygiene	617 (43.2)
Middle hygiene	263 (18.4)
Better hygiene	547 (38.3)

Left: handwashing station attendant to outside kitchen (gagri, handwashing bucket, drying rack)
Right : inside kitchen

Figure 13 Handwashing station and kitchen

Table 10 Surrounding Hygiene: observations and HI

Surrounding hygiene	
Variables (N=1427 if not specified)	N (%)
Surrounding hygiene characteristics not included in HI surrounding	
Animal sleeping outside at night (N=1426)*	575 (40.3)
Garbage pit	84 (5.9)
Surrounding hygiene characteristics included in HI.	
Surroundings	
Absence of trash outside of the house	473 (33.1)
Absence of trash inside the house	646 (45.3)
Absence of pile of cloth on the house floor	509 (35.7)
HI: surrounding hygiene	
Low hygiene	799 (56)
Middle hygiene	274 (19.2)
Better hygiene	354 (24.8)

Table 11 Personnal Hygiene: observations and HI

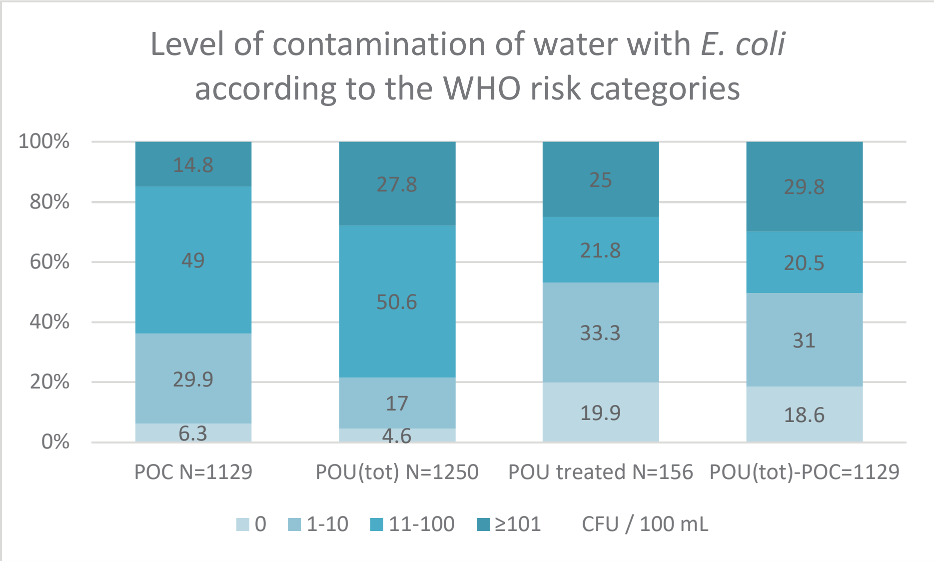
Personnal hygiene characteristics included in HI.	
Variables (N=1427 if not specified)	N (%)
Personal hygiene	
Hand of the caregiver clean	1131 (79.3)
Hand of child clean	726 (50.9)
HI: personal hygiene	
Low hygiene	271 (19)
Middle hygiene	455 (31.9)
Better hygiene	701 (49.1)

Left : Child playing with cow dung on the floor
Middle : cow-dung spreading preparation close to drinking water bucket
Right : Caregiver preparing manure for field, manure pile being close to the house

Figure 14 Proximity of caregivers and children with faecal material

3.3 Microbiological and physicochemical testing of water sample

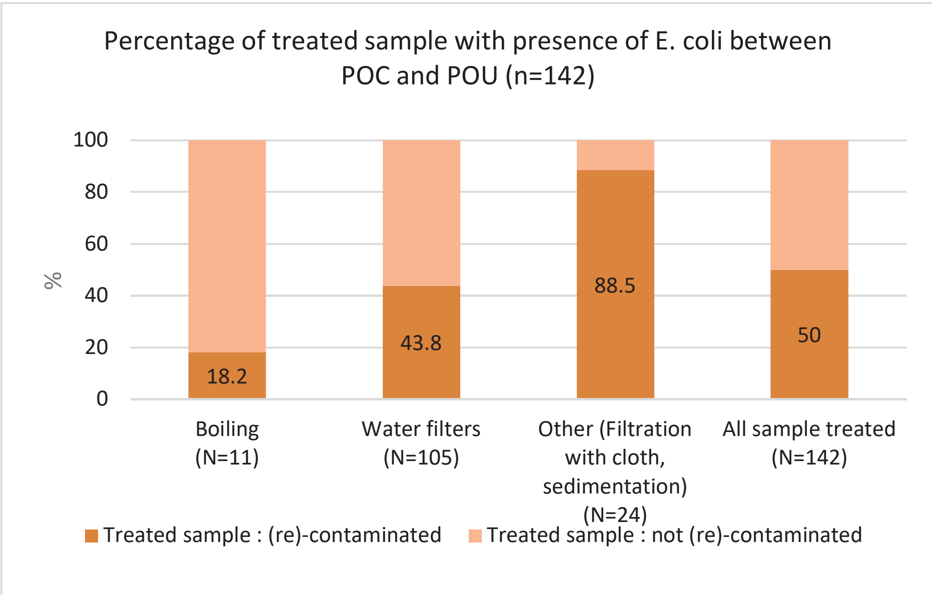
Water samples were generally non-odorant, transparent and non-turbid. Only 6 POC samples and 10 POU samples were turbid and 2 POC samples and 4 POU samples were coloured. Residual chlorine was not found in all samples. *E. coli* contamination was found in 93.7% of POC water samples (N=1129, median contamination 21 *E. coli* CFU / 100mL (IQR 5-51, min-max: 0-3450)) and in 95.4% of all POU water samples (N=1250, median contamination *E. coli* 40 CFU / 100mL (IQR 13-114 min-max= 0-4185)). As mentioned in the methods, I divided the number of *E. coli* colonies present at POC and POU into four risk categories: no risk, low, median and high risk. The percentage of HH water samples falling into each of these categories is presented in Figure 15. In the same figure, one can see the level of contamination between POC and POU (also separated into four categories). The categorisation of POU water samples for the group of individuals treating the water (N=156) is also presented in figure. As however the sample size was very small, POU total was kept for the calculation of the delta (POU (tot)).



Percentage of HH falling into four distinct contamination categories
WHO risk categories of *E. coli* contamination in water: 0 CFU / 100 mL: no risk, 1-10 CFU / 100mL : low risk, 11 -100 CFU / 100mL: median risk, ≥ 101 CFU /100 mL : high risk. POC= point-of-collection,
POU = point-of-use, CFU= colony forming units.
POU (tot) : including samples treated and not treated, used for the delta calculation of POU-POC
POU treated : only samples treated, due to the small sample size, POU treated was not analyzed independently

Figure 15 Contamination of drinking water at point-of-collection (POC) , point-of-use (POU) and between POC and POU.

After calculating the degree of *E. coli* contamination between POC and POU (Equation 3), it was discovered that in 70.2% of HH, *E. coli* counts in POU water samples was higher than in water sampled at POC. This indicates signs of contamination during transport and / or treatment. Among the 1129 HH included in the water quality analysis (univariate), 142 HH treated their water at POU. Even among half of those treating their water, (re)-contamination between POC and POU was present. Figure 16 shows the degree of failure of the used water treatment techniques. When filtration with a cloth or the sedimentation method were applied a (re)-contamination was very frequent. More than 40% of filter users had higher *E. coli* counts after filtration than at the POC.



POC= point-of-collection, POU= point-of-use

Figure 16 (Re)-contamination with *E. coli* between POC and POU among Households (HH) using treatment at POU.

3.4 Health and diarrhoeal diseases

Table 12 presents the health status related information. In total 637 girls and 790 boys (N=1427) with a mean age of 3.78 (SD ±2.55, range: 7months-10years) were included in the study. About one in two children was sick and one in six children had a diarrhoeal episode (N=225) in the week preceding interview. Among the children that were suffering from diarrhoea, 40% were aged between 0 to 2 years and 60% of them were younger than 4 years old (Figure 17). About 85% of caregivers having a child impaired with diarrhoea asked for help at community health facilities. Among all caregivers, half of them were aware that dirty hands may lead to diarrhoeal disease and only every fifth respondent knew about pathogens as cause of diarrhoea. The majority of respondent (88%) said that diarrhoea could have a severe and very severe impact on the children's health. Chances of developing diarrhoea because of the consumption of unsafe water was known by 82.7% of the respondent, whereas 80.2% of them linked it with dirty food and less than half of them mentioned that dirty hands may cause diarrhoea.

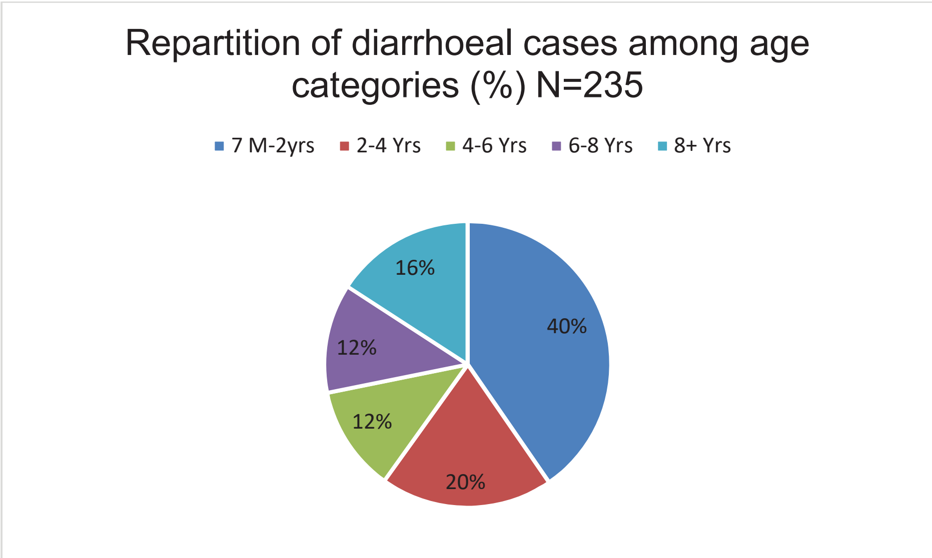


Figure 17 Repartition of diarrhoeal cases according to age of child

Table 12 Child health information

Variables (N=1427 if not specified)	Overall N (%)
Gender of child	
Female	637 (44.6)
Male	790 (55.4)
Age of child (categories)	
0 up to 2 years old	342 (24)
2 to 4 years old	428 (30)
4 to 6 years old	306 (21.4)
6 to 8 years old	211 (14.8)
older than 8	140 (9.8)
Child was sick during the past 7 days	712 (49.9)
Fever	565 (39.6)
Cough	555 (38.9)
Respiratory difficulties	217 (15.2)
Diarrhoea (passage of liquid stool more than 3 times per day)	235 (16.5)
Blood in stool	46 (3.2)
Mucus in stool	53 (3.7)
Blood in urine	9 (0.6)
Number of children sick with diarrhoea in each age categories	
0 up to 2 years old (N=342)	106 (31)
2 to 4 years old (N=428)	64 (15)
4 to 6 years old (N=306)	28 (9.2)
6 to 8 years old (N=211)	20 (9.5)
older than 8 (N=140)	17 (12.1)
Seek for medical advices for any diseases N=712	599 (84.12)
Seek for medical advices (for diarrhoea) N=235	190 (80.85)
Cause of diarrhoea (MAP)°	
Faecal pathogen	273 (19.1)
Some pathogen	71 (5)
Dirty hands	706 (49.5)
Dirty foods	1145 (80.2)
Dirty Water	1180 (82.7)
Explanation does not correspond to real cause	90 (6.3)
Impact of diarrhoea on child health (severity level)	
Not at all severe	4 (0.3)
Hardly severe	36 (2.5)
Rather severe	120 (8.4)
Severe	205 (14.4)
Very severe	1062 (74.4)
Chances of contracting a disease if the child drinks unclean water (vulnerability)	
Very low	3 (0.2)
Rather low	44 (3.1)
Average	94 (6.6)
Rather high	300 (21)
Very high	986 (69.1)

°MAP = Multiple answers possible

3.5 Univariate and multivariate logistic regression models: Risk factors for water contamination between POC and POU

The logistic regression models presented in Table 13 aimed to answer my first research question i.e. what are the WASH-related risk factors associated with the outcome variable "difference of *E. coli* contamination between POC and POU"? This "delta" variable was calculated using "POU (tot)", a variable including POU samples treated and not treated. Considering the small sample size of people treating their water at POU (N=142), it could not be evaluated independently. I therefore controlled for treatment in the model. Table 13 presents the significant factors (p<0.2) associated with the occurrence of contamination with *E. coli* during transport from the univariate analysis. Source type, area and wealth index are also presented in the table, even though no significant association was found between these variables and faecal contamination of water during the transport. People that received a visit from a FCHV had 27% lower odds of (re)-contaminating of their water (OR: 0.73; 95%CI: [0.56-0.95]; p=0.02). Respondents who mentioned "liking treated water" were less likely to have higher concentration of *E. coli* at POU compared to POC compared to individuals not liking treated water at all. People liking treated water very much had 68% lower odds for (re)-contamination compared to individuals disliking treated water very much (OR:0.32; 95%CI: [0.19-0.54]; p<0.001). Similarly, people treating their water with any technology were 64% less likely to have higher *E. coli* counts compared to people not treating it. Boiling was the most effective treatment against water contamination in this study context (OR: 0.09; 95%CI: [0.02-0.43]; p<0.0001) followed by water filters (OR: 0.29; 95%CI: [0.19-0.44]; p<0.0001). When individuals were cleaning their transport container using soap or ashes sometimes, they had 32% lower odds of (re)-contamination source water compared to individuals cleaning their container with water only (OR: 0.68; 95%CI: [0.49-0.95]; p=0.02). Containers covered during transport were less likely to be (re)-contaminated than the ones not being covered (OR: 0.6; 95%CI: [0.45-0.79]; p<0.0001). Families having the highest personal hygiene (caregiver and children having clean hands) had 53% less chance of the re-contaminating of their water between POC and POU, compared to families with lower personal hygiene (95%CI: [0.32-0.7]; p<0.0001). HH keeping their animal outside of their home at night were less likely to have contamination with *E. coli* compared to individual letting their animal sleep inside (OR: 0.73; 95%CI: [0.56-0.95]; p=0.02).

From factors identified as significant risk factors for the presence or absence of (re)-contamination during the univariate analysis, only three risk factors remained significant in the multivariate mixed-model (Wald-chi^2= 52.56, p=0.000). These were: people "liking treated water very much" versus "disliking very much" (aOR: 0.5; 95%CI: [0.26-0.94]; p=0.033), parents and children having visibly clean hands (aOR: 0.54; 95%CI: [0.34-0.88]; p=0.012) and water sample treated versus untreated (aOR: 0.56; 95%CI: [0.35-0.9]; p=0.016). Socio-economic status was not significantly associated with this outcome variable. Even though, the use of uncovered containers to transport water was identified as a risk factor in the univariate regression, no strong statistical evidence confirmed this relationship in the adjusted model. Similarly, the variables “presence of FCHV at home”, “animal sleeping outside at night” lost their statistical significant association with the protection against water contamination.

Table 13 Univariate and multivariate logistic regression model for water contamination between POC and POU

Risk factors for water contamination	N (%) (N=1129 if not specified)	Univariate analysis (N=1129)[10] OR (95% CI)	Univariate analysis *P-value*	Multivariate analysis (N=1116)[10] aOR (95% CI)	Multivariate analysis *P-value*
Areas of study					
Surkhet A	182 (16.2)	1			
Surkhet B	304 (26.93)	1.15 (0.77-1.71)	0.5		
Dailekh	347 (30.74)	0.97 (0.66-1.42)	0.87		
Accham	296 (26.22)	1.30 (0.87-1.96)	0.19		
SES (N=1121)					
Low SES	398 (35.5)	1		1	
Medium SES	369 (32.92)	1.08 (0.82-1.43)	0.59	1.19 (0.88-1.62)	0.247
Higher SES	354 (31.58)	0.91 (0.61-1.35)	0.63	0.97 (0.64-1.49)	0.893
Main source of drinking water [11]					
Piped water in the house or yard	250 (22.14)	1			
Piped water in the village	852 (75.47)	1.05 (0.74-1.5)	0.77		
Open source	16 (1.42)	**6.92 (0.88-54.55)**	**0.07**		
Protected source	4 (0.35)	1.31 (0.13-12.92)	0.82		
Visit of FCHV <yes vs no>	427 (37.82)	**0.73 (0.56-0.95)**	**0.02**	0.78 (0.58-1.05)	0.106
Feeling about treated water					
I dislike it very much	207 (18.33)	1		1	
I rather dislike it	360 (31.89)	0.8 (0.53-1.2)	0.28	**0.66 (0.42-1.04)**	**0.07**
Average	292 (25.86)	**0.53 (0.35-0.81)**	**<0.0001**	**0.5 (0.32-0.79)**	**0.003**
I rather like it	167 (14.79)	**0.52 (0.33-0.83)**	**0.01**	**0.54 (0.33-0.9)**	**0.018**
I like it very much	103 (9.12)	**0.32 (0.19-0.54)**	**<0.001**	**0.5 (0.26-0.94)**	**0.033**
Method for cleaning transport container					
Use of water only	275 (24.55)	1		1	
Use of soap or ashes always	341 (30.45)	0.7 (0.49-1.01)	0.06	1.02 (0.67-1.57)	0.915
Use of soap or ashes sometimes	504 (45)	**0.68 (0.49-0.95)**	**0.02**	1.08 (0.72-1.62)	0.709
Sample treated [12]<yes vs no> N=1128	142 (12.5)	**0.36 (0.25-0.52)**	**<0.0001**	**0.56 (0.35-0.9)**	**0.016**
Boiling <yes vs no>	11 (0.97)	**0.09 (0.02-0.43)**	**<0.0001**		
Use of water filter	105 (9.3)	**0.29 (0.19-0.44)**	**<0.0001**		
Hygiene indexes					
Container hygiene (N=1128)	N=1128				
Low hygiene	223 (19.8)	1			
Medium hygiene	212 (18.8)	0.82 (0.53-1.28)	0.39		
Higher hygiene	693 (61.4)	**0.53 (0.37-0.76)**	**<0.0001**		
Transport container <lid vs no lid>	732 (64.84)	**0.6 (0.45-0.79)**	**<0.0001**	0.9 (0.64-1.27)	0.568
Handwashing hygiene					
Low hygiene	768 (68)	1			
Medium hygiene	80 (7.1)	0.64 (0.4-1.05)	0.08		
Higher hygiene	281 (24.9)	**0.64 (0.48-0.87)**	**<0.0001**		
Kitchen hygiene					
Low hygiene	520 (46.1)	1			
Medium hygiene	206 (18.2)	1.03 (0.72-1.48)	0.85		
Higher hygiene	403 (35.7)	0.86 (0.65-1.14)	0.3		
Personal hygiene					
Low hygiene	206 (18.2)	1		1	
Medium hygiene	386 (34.2)	**0.51 (0.34-0.77)**	**<0.0001**	0.63 (0.39-1.02)	0.059
Higher hygiene	537 (47.6)	**0.47 (0.32-0.7)**	**<0.0001**	**0.54 (0.34-0.88)**	**0.012**
Surrounding hygiene					
Low hygiene	658 (58.3)	1			
Medium hygiene	194 (17.2)	0.76 (0.54-1.07)	0.12		
Higher hygiene	277 (24.5)	**0.73 (0.54-0.98)**	**0.04**		
Animal shelter at night <out vs in>	446 (39.5)	**0.73 (0.56-0.95)**	**0.02**	0.83 (0.62-1.12)	0.229
Hygiene indexes (continues)					
Toilet hygiene					
Low hygiene	200 (17.7)	1			
Medium hygiene	20 (1.8)	0.4 (0.16-1.01)	0.05		
Higher hygiene	909 (80.5)	**0.73 (0.52-1.04)**	**0.08**		

[10]For the dummy variable, reference category is 1

[11] Opensource (dug well. pond. spring. protected source (well. spring)

[12] Including boiling, filter (ceramic and silver), filtration with a cloth, sedimentation and SODIS

Multivariate model precisions:
Mixed model with with "area of study" at intercept to control for the random effect of the area : N=1125
Wald chi2 (14) = 52,56 p=0,0000
Chibar2 (01) = 0
ICC: 6,02e^{-17}, 96 CI 6,02 6,02e^{-17} -6,02e^{-17}
Risk factors significantly (p<0.05) associated with water contamination during transport / treatment in the univariate and multivariate model are marked bold

3.6 Univariate and multivariate logistic regression models: Risk factors for diarrhoea among children

The logistic regression models presented in Table 14 aimed at answering my second research question, i.e. what are risk factors associated with diarrhoea prevalence in this study context.

Because of the long list of variables significantly associated with the outcome variable in the univariate analysis, I will present only risk factors for diarrhoea that were significant in the univariate model and included in the multivariate analysis (Wald chi2 = 121.94, p=0.0000). Because of the collinearity between several variables and notably between the different hygiene indexes, I could not include all significant variable in the model. Additionally, the model with the most satisfactory AIC did not include all variables. As a first point, I would like to emphasise on that unlike the precedent model, the risk of having a child sick with diarrhoea in Accham was 2.14-fold higher compared to Surkhet A. (OR: 2.14; 95%CI: [1.39-3.3]; p<0.001). The need for a random-effect control in the multivariate model is therefore highly justified.

The models revealed that caregivers that attended hygiene literacy classes had lower odds of having a child sick with diarrhoea compared to the ones that did not attend them (univariate (OR: 0.47; 95%CI: [0.32-0.68]; p=<0.001)), (multivariate (aOR 0.52; 95%CI: [0.32-0.83]; p=0.007)). When dishes were kept in adequate height versus on the kitchen floor, children had 59% lower odds of having diarrhoea (OR 0.41, 95%CI: [0.3-0.55]; p=<0.001) (aOR 0.68; 95%CI: [0.46-0.99]; p=0.042).

Children from households with POU samples >11 CFU *E. coli* / 100mL had 3-fold increased risk of having diarrhoea compared to household where no *E. coli* was found in POU sample (for HH "11-100 CFU *E. coli* / 100mL in POU sample compared to *E. coli* free POU": OR 3.76; 95%CI: [1.15-12.37]; p=0.029), (for HH with ">101 CFU *E. coli* / 100mL in POU sample compared to *E. coli* free POU" OR 3.39; 95%CI: [1.01-11.39]; p=0.048). In the multivariate model the presence of *E. coli* at POU was not significantly associated with children's diarrhoea incidence independently of contamination level.

With regard to handwashing behaviour, individuals washing their hands with soap more than twice per day were gradually less at risk of having a child sick with diarrhoea compared to individuals washing their hands from 0 to 2 times per day (handwashing with soap 3-4 times per day versus 0-2 times per day OR 0.52; 95%CI: [0.37-0.74]; p=<0.001, aOR 0-65; 95%CI: [0.42-1]; p=0.049) (handwashing with soap more than five times per day versus 0-2 times per day OR 0.36; 95%CI: [0.23-0.56]; p=<0.001, not significant in multivariate model for more than five times per day). In households where individuals washed their hands after going to the toilet, child was significantly less likely to have diarrhoea compared to households where this practice was not common. (OR 0.23; 95%CI: [0.1-0.52]; p=<0.001), (aOR 0.27; 95%CI: [0.1-0.73]; p=0.01) When hands of both parents and child were clean, children were 51% less likely to have diarrhoea compared to families where the hands of the family members were dirty. (OR 0.37; 95%CI: [0.25-0.53]; p<0.001); (aOR 0.49; 95%CI: [0.3-0.8]; p=0.004). Improved sanitation infrastructure also played a protective role as children were 60% less likely to have diarrhoea if pour-water flushed latrine was present in the HH compared to HH having a simple pit latrine or no latrine at all (OR 0.6; 95%CI: [0.42-0.86]; p=0.005), (aOR 0.64; 95%CI: [0.42-0.98]; p=0.042). A floor made of mud was a statistically significant risk factor as children living in houses with a floor made of mud were three times more likely (univariate) and two times more likely (multivariate) to have diarrhoea compared to children living in concrete houses. (OR 2.98; 95%CI: [1.71-5.2]; p=<0.001) (aOR 1.97; 95%CI: [1.07-3.61]; p=0.03).

When caregivers were able to associate diarrhoea as a consequence of ingestion of dirty water, children were 54% less likely to have diarrhoea (OR 0.46; 95%CI: [0.33-0.64]; p=<0.001). Knowledge about dirty food and dirty hands being risk factors for diarrhoea were also significantly associated with the outcome variable in the univariate model. Finally, when asked about the severity and vulnerability of a child in case of diarrhoea, individuals stating that diarrhoea would impact their child in a "not very severe" way were up to 2.68 times more likely to have a child sick with diarrhoeal diseases compared to one considering it as "very severe" (OR 2.68 (1.89-3.81), p<0.001). Similar trends were seen for vulnerability of contracting a disease due to unclean water. The multivariate was adjusted for age and sex of the children. While gender was not a significant risk factor for diarrhoea, analysis revealed that children of younger age were more likely to have diarrhoea (e.g. children 6 to 8 years old versus 0 to 2 years old: aOR 0.18 (0.1-0.33), P<0.0001). ICC value of the random effect revealed that the differences between the areas did not significantly impact the multivariate model.

e mixed logistic regression model for diarrhoea prevalence

ea prevalence	N (%) N=1427 if not specified	Univariate analysis (N=1427)[10]		Multivariate analysis (N=1246)[10]	
		OR (95% CI)	*P-value*	aOR (95% CI)	*P-value*
	348(24.4)	1			
	365 (25.6)	1.67 (1.07-2.6)	0.02		
	356 (24.9)	**2.08 (1.35-3.21)**	**<0.001**		
	358 (25.1)	**2.14 (1.39-3.3)**	**<0.001**		
	451 (31.6)	1			
	266 (18.6)	0.65 (0.39-1.09)	0.11		
	704 (49.3)	1.02 (0.74-1.4)	0.9		
TION					
ucted by female community	362 (25.4)	**0.47 (0.32-0.68)**	**<0.001**	**0.52 (0.32-0.83)**	**0.007**
at the household	537 (37.6)	0.8 (0.59-1.07)	0.13		
D WATER QUALITY					
nultiple answer possible)					
	816 (57.2)	**0.57 (0.43-0.76)**	**<0.001**		
	448 (31.4)	**0.63 (0.45-0.87)**	**0.01**		
	24 (1.7)	2.18 (0.89-5.36)	0.09		
	842 (59)	**0.55 (0.41-0.73)**	**<0.001**		
t	460 (32.2)	**1.98 (1.47-2.66)**	**<0.001**		
193 (13.5%))					
ter filter, sodis, filtration with	188 (13.2)	0.74 (0.46-1.18)	0.212		
	137 (71)	0.63 (0.36-1.11)	0.11		
	58 (30)	1.06 (0.51-2.23)	0.87		
1250)					
	58 (4.6)	1		1	
	213 (17)	3.34 (0.98-11.35)	0.053	2.31 (0.63-8.41)	0.204
/ 100mL)	632 (50.6)	**3.76 (1.15-12.37)**	**0.029**	2.33 (0.66-8.18)	0.188
100mL)	347 (27.8)	**3.39 (1.01-11.39)**	**0.048**	1.71 (0.48-6.14)	0.412

e)	N (%) N=1427 if not specified	OR (95% CI)	*P-value*	aOR (95% CI)	*P-value*
7) MAP°					
	562 (39.4)	0.89 (0.66-1.2)	0.44		
	852 (59.7)	**0.69 (0.51-0.93)**	**0.01**		
ontainer					
	1416 (99.2)	**0.48 (0.34-0.68)**	**<0.001**		
ainer (N=1416)					
	390 (27.5)	1			
	429 (30.3)	**0.57 (0.39-0.83)**	**<0.001**		
	597 (42.2)	**0.61 (0.43-0.87)**	**0.01**		
	271 (19)	1			
	278 (19.5)	**0.56 (0.36-0.87)**	**0.01**		
	877 (64.5)	**0.57 (0.4-0.8)**	**<0.001**		
ith soap (N=1427)					
	248 (17.38)	1		1	
	836 (58.7)	**0.52 (0.37-0.74)**	**<0.001**	**0.65 (0.42-1)**	**0.049**
	343 (24.04)	**0.36 (0.23-0.56)**	**<0.001**	0.7 (0.39-1.26)	0.239
), MAP°					
	862 (60.4)	**0.41 (0.3-0.54)**	**<0.001**		
	1402 (98.2)	**0.23 (0.1-0.52)**	**<0.001**	**0.27 (0.1-0.73)**	**0.010**
o>	834 (58.4)	**0.64 (0.48-0.85)**	**<0.001**		
	1039 (72.8)	**0.57 (0.42-0.78)**	**<0.001**		
	572 (40.1)	0.91 (0.68-1.22)	0.55		
	3 (0.2)	1.1 (0.95-122.02)	0.06		
	855 (59.9)	1			
	255 (17.9)	**0.55 (0.36-0.84)**	**0.01**		
	317 (22.2)	**0.5 (0.33-0.75)**	**<0.001**		
	940 (65.9)	1			
	110 (7.7)	0.64 (0.35-1.17)	0.15		
	377 (26.4)	**0.48 (0.32-0.71)**	**<0.001**		

e)	N (%) N=1427 if not specified	OR (95% CI)	*P-value*	aOR (95% CI)	*P-value*
		1.19 (0.69-2.06)	0.52		
		2.01 (1.29-3.12)	**0.002**		
		0.6 (0.42-0.86)	**0.005**	**0.64 (0.42-0.98)**	**0.042**
	250 (17.5)	1			
	27 (1.9)	0.7 (0.23-2.12)	0.53		
	1150 (80.6)	0.74 (0.52-1.06)	0.1		
	637 (44.6)	1		1	
	790 (55.4)	0.92 (0.7-1.22)	0.58	0.93 (0.67-1.28)	0.651
	342 (24)	1		1	
	428 (30)	**0.4 (0.28-0.56)**	**<0.001**	**0.32 (0.21-0.47)**	**<0.0001**
	306 (21.4)	**0.23 (0.14-0.35)**	**<0.001**	**0.18 (0.11-0.3)**	**<0.0001**
	211 (14.8)	**0.24 (0.14-0.4)**	**<0.001**	**0.18 (0.1-0.33)**	**<0.0001**
	140 (9.8)	**0.32 (0.18-0.56)**	**<0.001**	**0.27 (0.14-0.51)**	**<0.0001**
	235 (16.5)				
	273 (19.1)	0.75 (0.51-1.09)	0.14		
	71 (5)	0.74 (0.36-1.52)	0.41		
	706 (49.5)	**0.64 (0.48-0.85)**	**<0.001**		
	1145 (80.2)	**0.63 (0.45-0.88)**	**0.01**		
	1180 (82.7)	**0.46 (0.33-0.64)**	**<0.001**		
real cause <yes vs no>	90 (6.3)	**2.76 (1.72-4.43)**	**<0.001**		
(severity level) N=1423 [13]					
	4 (0.3)	na			
	36 (2.5)	2.21 (1.02-4.81)	0.05		
	120 (8.4)	2.02 (1.28-3.2)	<0.001		
	205 (14.4)	**2.68 (1.89-3.81)**	**<0.001**		
	1062 (74.4)	1	0		

nto the multivariate model as rule of thumb for categorisation was violated.

e)	N (%) N=1427 if not specified	OR (95% CI)	*P-value*	aOR (95% CI)	*P-value*
f the child drinks unclean water (vulnerability)					
	3 (0.2)	na			
	44 (3.1)	2.12 (1.05-4.29)	0.04		
	94 (6.6)	**2.84 (1.77-4.56)**	**<0.001**		
	300 (21)	**1.62 (1.16-2.27)**	**0.01**		
	986 (69.1)	1			
	1200 (84.1)	**2.98 (1.71-5.2)**	**<0.001**	**1.97 (1.07-3.61)**	**0.030**
26) <yes vs no>	575 (40.3)	0.94 (0.69-1.29)	0.72		
	443 (31.1)	1		1	
	765 (53.8)	1.16 (0.82-1.64)	0.4	1.22 (0.84-1.78)	0.303
	241 (15.05)	1.47 (0.92-2.35)	0.11	1.51 (0.89-2.54)	0.125
	271 (19)	1		1	
	455 (31.9)	0.69 (0.48-1)	0.05	0.76 (0.49-1.19)	0.234
	701 (49.1)	**0.37 (0.25-0.53)**	**<0.001**	**0.49 (0.3-0.8)**	**0.004**
	799 (56)	1			
	274 (19.2)	0.72 (0.48-1.08)	0.11		
	354 (24.8)	**0.61 (0.42-0.9)**	**0.01**		
	617 (43.24)	1			
	263 (18.43)	**0.61 (0.42-0.9)**	**0.01**		
	547 (38.33)	**0.38 (0.27-0.53)**	**<0.001**		
	750 (52.56)	**0.41 (0.3-0.55)**	**<0.001**	**0.68 (0.46-0.99)**	**0.042**

ept to control for the random effect of the area : N=1246

beginning area on the model)
14)
ciated with diarrhoea in the univariate and multivariate model are marked bold

luded in the Wealth index, including or excluding it from the final model was not impacting general model

CHAPTER 4. DISCUSSION AND CONCLUSIONS

The main results are discussed in the following three subsections:

1. General WASH context
2. The water quality in the study area and the risk factors for contamination
3. The risk factors associated with diarrhoea

Within the four investigated areas of Far and Mid-Western Nepal, evidence of unsafe water consumption and inadequate WASH practices and infrastructure was apparent. Inhabitants of the areas are facing several challenges regarding water access, infrastructure and quality, sanitary and household maintenance as well as in hygiene facilities, commodities and knowledge that will be further discussed.

4.1 WASH situation in the study areas

4.1.1 *Water situation in the study areas*

Most of the PWS in the studied areas did not deliver high drinking water quality. In fact, among all water samples collected at POC, 93.7% were contaminated with *E. coli* and almost two thirds had more than 11 CFU *E. coli* per 100 mL (63.8%), indicating that the water was unsafe for drinking. Similarly, in a study researching the water quality in a mountainous district of Nepal, between 67.4% and 81.0% of samples collected were polluted with *E. coli* [82]. There are numerous causes of drinking water contamination at the collection points such as: the presence of animal and / or human faecal pollution at the source, cross-contamination at leakage points in old pipes, back siphoning or open defecation practices as similarly reported in other studies conducted in rural Nepal [49], [53]. Especially in Dailekh and Accham study sites, not all houses had access to taps connected to well established water supply schemes and fixed in concrete. Instead of underground pipes, dangling pipes were crossing roads and fields, probably easing contamination of water at POC. Concerning POU water samples, an even larger number of samples (96.4%) was contaminated and bacterial counts were alarming: 50.0% of samples collected at POU had contamination levels between 11-100 CFU *E. coli* / 100 mL and 27.8% of them had > 100 *E. coli* CFU / 100mL, requiring urgent water treatment according to WHO recommendations [24]. A similar decline in microbiological quality of water among paired-collected water samples between POC and POU was observed in most of the studies included in a review by Wright et al. and a meta-analysis by Schields et al. [83][84]. A surprising and worrisome finding is that most of the HH were trusting their water system. Indeed, most households stated that the water they consumed was safe or very safe (54.4% of caregivers) and good or very good (63.0% of caregivers). At the same time, reasons for water contamination were known by several respondents: open source (80.9%) and open defecation

(58.5%). The improvement of the water system from “Muhan” (open source) to a piped water system might have biased villager’s perception of water safety. In fact, the visibly “good looking”, non-turbid water coming from the tap might erroneously encourage consumers to trust in their water system. This misconception of water safety was also perceived in a study undertaken in rural Southern India by Francis and al.[85]

4.1.2 *Sanitation in the study areas*

All four areas were registered as open-defecation-free. This was confirmed, as only 6.3% of the HH had no latrine and 84.1% of HH used an improved pour-water flush latrine. The adaptation of the population to ODF and the use of the sanitary facilities is promising. Nevertheless, hygiene materials such as filled water drums or toilet brushes were often absent and education is still needed in terms of cleanness as more than half of respondents had traces of dirt or faeces in their toilets. Additionally, as the question about defecation practices was generally formulated in the questionnaire, no specific information was gained about child faeces handling. Several times, the children were seen urinating on the house front floor and some human faeces were observable around the houses (e.g. Accham district). With regard to the disposal of animal faeces, warm-blooded animals and manure piles were found in proximity of the houses. Investigation about handling of child and animal faeces should be undertaken in this area.

4.1.3 *Hygiene and education*

Principal challenges in the studied areas are the weak hygiene scores, in terms of facility management and personal hygiene. The majority of respondents had lower to middle WI and HI. Even if some households had better socio-economic status or better hygiene index compared to others houses within the areas, there is still a huge gap in comparison with western standards. Hygiene conditions among the inhabitants were far from ideal. Indeed, houses were often overcrowded, and the cleanness of the kitchen and the surrounding areas was critical (56% of the respondents had the lowest “surrounding hygiene” score possible). Even when knowledge about hygiene practices was present, it was not always put into practice. Cultural mind-sets and agricultural setting influence the life of inhabitants. Mothers supervise several tasks, such as child caregiving, water fetching and cooking. Women were frequently seen working in the fields bare-feet or filling with bare hands their “Doko” (basket) with buffalo faeces mixed with leaves to be used as manure. Because mothers were busy in their occupation, children were often observed to be unattended, with lice in their hair, running noses, not wearing underwear, playing directly on the floor or ingesting some dirt particles or roots. In this men-led society, higher education is usually reserved to men rather than women and therefore hygiene education might not be brought to the individuals in constant contact with environmental contamination and children. All those interconnected factors are part of the vicious cycle of contamination, from environment / animals to humans, from hands to mouth, water and food, and from children to caregivers and from caregivers to children, without relevant hygienic behaviour or hygiene education in place to counteract it.

4.2 Risk factors for water contamination between Point-of-collection and Point-of-use

The univariate models revealed that several factors are significantly associated with decreased risk for water contamination between POC and POU: visits of female community health volunteers at the HH levels, treatment of drinking water, appreciation for treated water, washing of container with ashes and soap occasionally compared to washing it with water only, covering the container, having the highest level of surrounding hygiene (absence of trash or flies in close proximity), handwashing hygiene (having a handwashing station in a good condition with water and soap), toilet hygiene (with presence of commodities and clean toilets) compared to the lowest hygiene; having middle or highest hand hygiene (caregiver and children) compared to lowest hand hygiene and keeping the animals away from the house at night. In the multivariate model, the following factors remained significantly associated with lower odds of water contamination between POC and POU: treatment of drinking water, highest appreciation for treated water versus lowest appreciation and highest personal (hand) hygiene versus lower personal (hand) hygiene.

Water collection and container hygiene

The communal taps (POC) were used for several purposes, namely collecting drinking water, showering, washing of cloth and cleaning of vegetables. Taps were particularly scarce in Dailekh district and people were waiting for their turn in line, placing their containers on the floor or letting children play with it. Due to high water demand, taps were constantly open, and villagers were filling their vessels without interruption, leaving limited or no time for container cleaning. Some people were observed cleaning their hands above the water collector while it was being filled. Regarding the type of containers used, recycling of old jerrycans, paint buckets, candy containers or oil buckets were frequent. Although types of containers generally used for water transport were registered in the survey, it omitted the question about potential use of the water containers for multiple purposes (e.g. toilet water drum, food collection, cow dung collection, water bowl for animal, etc…). This information could help in understanding the causes of container contamination. Regarding cleaning of the container, individuals were often seen meticulously cleaning the visible dirt on the outside of the container rather than the inside. It is evident that fetching water in a clean container would prevent water contamination from the container itself, nevertheless, in the multivariate model, the significant association between container washing and its protective role against water contamination was lost probably because of a recall bias between respondents' perception of good washing practices and their actions (e.g. washing of the outside part of the container rather than the inside part). Thorough cleaning of the internal part of the container might have been prevented because of the narrow openings and because dirt was not as visible as on the outside part. Simultaneously, containers with large opening are easing access to water by hands and are associated with both contaminated water and subsequent diseases [86]. Designing a better lid system for Gagris with large opening could solve both issues.

Water treatment

Multivariate models showed that respondents treating their water had 44% lower odds to have recontamination between POC and POU. Several studies confirmed the efficacy of different treatment methods for removing bacteria from the water [21], [22], [87]. Even if water treatment is of key importance in achieving a better drinking water quality at the point-of-use, in light of critical hygiene conditions in the area, the impact of water treatment was smaller than expected. Among several hygienic factors, hand dirtiness and mishandling of water treatment method might have reduced treatment effect as similarly observed in the study by Rufener et al [14]. There is some evidence that inappropriate use of water treatment can lead to increased levels of microbiological contaminants of consumed water [88][89]. In the present study, it was not investigated whether the contamination occurred during water collection, during transport (by hand and container dirtiness) or at the household level by the misuse of the treatment method. Sampling and analysing a POU sample before and after treatment could have helped to determine contamination origins.

Education and Water treatment perception

Even if only significant in the univariate model, visits of the HH by Female community health volunteer (FCHV) were associated with lower odds of water contamination during transport compared to individuals who did not receive the visits. During their visits, individuals should have been informed about the risky WASH behaviour and given tools to adopt an adequate hygiene behaviour. Informed individuals are therefore more likely to be compliant with new technologies. Information is a key factor for implementation, and in the present context, only 23.0% of respondents mentioned "rather liking treated water" or "very much liking treated water" (above average), showing a lack of awareness about benefits of treated water. Among all respondents, the ones liking treated water "very much" were half as likely to have higher *E. coli* CFU at POU compared to POC versus the one "disliking treated water very much "(aOR 0.5). In addition, the survey recalled that 14.4% of the respondents mentioned that treating their water was always worthwhile and 26.5% claimed it was mostly worthwhile. According to these figures, there is a risk for low compliance in the use of water treatment method that will be implemented in the areas. Indeed, a behavioural study suggested that perception of the benefits of a new and affordable treatment method is a driver for better adoption of new treatment methods. Nevertheless, the same study also declared that providing new treatment tools to communities without treatment habits is more effective than changing existing treatment routines. In the present context, only 15% of respondent treated their water which gives hope for an effective upcoming intervention.[90]

Personal hygiene

Children and caregivers who had clean hands during household interviews were less likely to contaminate their water during transport. This significant association confirms that when the water fetchers (e.g. mother and children) handle, clean, fill and carry the container with clean hands they have 46% lower odds to (re)-contaminate the source water. In the study agricultural context, water fetchers were frequently at risk of touching faecal-contaminated materials. An Indian study revealed that presence of *E. coli* on people's hands was significantly associated with *E. coli* presence in the stored drinking water ($P<0.001$) [91]. Several studies suggest that solutions to prevent dirty hand contact with water container (handwashing with soap, lid protection) are associated with reduced levels of faecal contamination [86], [92], [93].

Wealth status and animal presence in the house

Interestingly, wealth status of individuals was not significantly associated with water contamination. Education about contamination should therefore be done among all population classes. Contrary to findings from a study by Shrestha et al., presence of animals in the house overnight was not significantly associated with higher (re)contamination of water during transport. Animal presence in the house at night can increase pathogen load in the home environment, including dishes and containers. Still, animals were observed in or near the house during interviews. Shelters were sometimes in the same construction as the house. Instead of examining the overnight presence of animals, one should have asked if animals were in or around the house at any time of the day, similarly as done in the Shrestha study [49].

There are limitations in the model investigating presence of faecal contamination between POC and POU. A total of 337 samples fell into the contamination category "not (re)-contaminated during transport". Among them, 35 samples had a delta value of "0", 71 samples were adequately treated, 91 had a delta value of -1 to -5 (very close to zero). The delta value of the remaining 140 (not treated) was more negative, indicating that *E. coli* at POU was lower than POC even in absence of treatment. Several factors could explain this phenomenon, one being the important fluctuation of the water quality at POC. In some communities, as all the participants used the same tap, several water samples from the same POC were collected at different time of the day (approximately every hour). Remarkable differences in water quality was observed between the samples from the same tap, processed by the same person, using the same funnel. Therefore, it cannot be neglected that water running at tap was contaminated with a lower amount of *E. coli* during the transport container filling and higher amount during the POC water sampling. Moreover, there might be a limitation of the implementation of the research strategy as the time gap between POC and POU samples collection varied according to water availability (see end of paragraph 2.5.2, special procedures). Another reason could be the self-disinfection of the water through solar disinfection, pasteurization effect or natural die-off of bacteria.

As a summary, water treatment is of key importance to achieve a better drinking water quality at the point-of-use. In order to implement successfully treatment methods in the area, first, the population should be aware of and accept the upcoming treatment method. To prevent these issues, one should insist on the education of the villagers currently unaware of benefits of treated water. Special work should be done among households receiving chlorination intervention to prevent use of a secondary non-chlorinated source because of disgust of treated water taste. In addition, repeated reminders about adequate use of treatment methods should be held in the community (e.g. increasing visit frequencies of the FCHV at the HH level). Finally, personal hygiene and particularly handwashing practices should be promoted to increase the effects of the upcoming interventions

4.3 Health situation in the area and risk factors for diarrhoea

The health status of children in the study area was alarming, as half of them were sick at the time of the interview. In total, 16% of the children aged between 7 months and 10 years and 22% of children below the age of four had diarrhoeal events in the week before the visit. This rate was higher than the prevalence reported in Nepali DHS of 8% of children below five being sick with diarrhoea two weeks before survey [94].

Health facilities were visibly rudimentary, and their location often required caregivers and children to walk for hours. However, most caregivers with a sick child sought help among their communities or within the health post. Reaching traditional doctors is also a common practice among rural communities in Nepal [95]. Most caregivers were aware of the impact of diarrhoea on child health. 88.8% of respondents said it had a “severe or very severe impact on their child’s health” and 90.1% of them mentioned that the chances of contracting a disease because of drinking polluted water were “rather high” or “very high”. These results might be biased as the stated high awareness of the population about the threat of polluted water may have been influenced by the simultaneous collection of water samples during the interview [19]. Nevertheless, even if people were aware of the risk, they did not seem to take actions to protect their children against it (e.g. boiling water). This could be caused by the fact that individuals blindly trusted their defective piped water system, as previously mentioned.

A large number of factors was significantly linked with diarrhoea in the univariate model, namely: districts (children living in Accham and Dailekh being more at risk for diarrhoea compared to Surkhet A), attendance versus non-attendance to hygiene literacy class, knowledge about treatment method versus no knowledge, high CFU counts (>10 CFU *E. coli* / 100 mL) in the consumed water versus *E. coli* free water. A good container hygiene was also protective as children of individuals cleaning the container daily with soap rather than with water only were less at risk of having diarrhoea. Hand hygiene was also important, as presence of a handwashing station (versus no station), washing hands more than twice per day with soap, washing hands at critical times: after going to the toilet, cleaning baby bottom, before eating, when hands look dirty and having visible clean hand were all protective factor against diarrhoea. Presence of toilet and of improved toilet facilities rather than using the bushes and having the highest surrounding hygiene and kitchen hygiene (e.g. keeping dishes high) were all associated with lower risk of diarrhoea. Younger children (aged 7 months to 2 years) were significantly more at risk of having diarrhoea compared to older children. Finally, caregiver having knowledge about health consequences of diarrhoea on the child, linking vulnerability of child after consumption of unclean water and knowledge about causes of diarrhoea (dirty hands, dirty good, dirty water) were more likely to protect their children against diarrhoea. Because of collinearity, not all previously listed variables were included in the final multivariate models. Among the remaining variables included in the mixed-effects model calculation, the following were statistically significant protective factors against diarrhoea: attendance of hygiene literacy class, washing hands more than twice a day, washing hands after going to the toilet, owning an improved pour-water flush latrine, having high personal hygiene and keeping the dishes high. On the contrary, being less than 2 years old and having a floor made of mud were risk factors associated with diarrhoea occurrence.

Weaning age and food contamination

While gender was not significantly associated with diarrhoea, age below 2 years was a significant risk factor for contracting diarrhoea (40% of all the diarrhoea cases were found in this age class). At this age, children are more vulnerable and at risk of infection as they have an immature digestive system, lose the immune-protection given by the mother's milk and have their first contact with potentially contaminated complementary food and fluids [96], [97]. As reported in DHS Nepal, the prevalence of diarrhoea among children in weaning age increased from 6% among infants up to 6 months to 15% among infants aged 6-11 months [98]. Moreover, in developing countries food seems to contain higher bacterial counts than drinking water, probably because of the multiplication of the microorganism in the food itself [97]. Finally, in a study in Indonesia, inadequate food hygiene practices were significantly associated with diarrhoea prevalence among children less than 2 years old [99]. In the current survey it was recorded that only a limited amount of people had appropriate kitchen hygiene behaviour (43.2% of respondents fell in the lowest kitchen hygiene category). In the rural areas, the food might have been contaminated at several levels: harvests collected with dirty hands, washing of vegetables with contaminated hands and/or water, crops drying on the front floor of the house near children and chicken, food contamination during cooking by dirty hands and dirty containers, unsafe storage of non-eaten food easing flies access and ingestion of non-reheated food pre-exposed to contaminants. In a study in Bangladesh, presence of animal faeces were associated with the contamination of soil and the contamination of complementary foods.[100] In another study in Bangladesh it was observed that caregivers did not properly wash their hands between handling of cow dung cake and feeding children or processing food [101]. To prevent multicollinearity with other hygiene indexes, rather than including kitchen hygiene index, "keeping dishes high" was included as a single variable in the multivariate model and the variable remained significantly associated with diarrhoea risk reduction in the multivariate model (aOR=0.68). Keeping the dishes in height might have prevented several contamination sources such as dust, animal and children presence. A study in Vietnam showed that not cooking on the floor had a potential prevention impact on children diarrhoea (aOR 2.85; 95CI [1.11-7,28]) [102]. Promoting hygiene practices while cooking and keeping the food and the containers away from contaminants would simultaneously improve the nutrient content and decrease the food contamination with hazardous micro-organisms [97], [103]–[105].

Water quality

In the univariate model, children drinking water with >11 CFU *E. coli* / 100mL had more than 3-fold higher chance of having diarrhoea compared to children drinking a *E. coli* free water ("11-100 CFU *E. coli* / 100 mL versus *E. coli* free POU" *aOR* = 3.76 [1.15-12.37]; p=0.029). The association between contaminated water and diarrhoea has been extensively investigated. For example in a study in Cambodia, HH with concentration of *E. coli* of 11-100 in 100 mL water sample reported diarrhoeal increase (LPR = 1.2, 95% CI 1.1-1.3) [106]. In a study in India, *E. coli* presence was positively associated with diarrhoeal symptoms (OR 1.42, p<0.05) [91]. Nevertheless, even if this variable was significant in the univariate model, loss of statistical significance occurred in the multivariate model. This could be explained by the fact that the pathogen transmission pathways for diarrhoea are numerous, and as the pathogen load in the HH environment was extremely high, levels of contamination in the water might have only played a secondary role in this present context [107]. In a different context with higher hygiene factors (kitchen, personal hygiene, etc…) water contamination would have possibly remained significant in the multifactorial model. In addition, as stressed by Jensen et al, exposure assessment on the association between water quality and diarrhoea might be difficult as people might not use the same source all the time [108]. In fact, in the present context, more than 30% of the population mentioned using a secondary source of drinking water. This could be a limitation of the coming intervention as children might drink directly from the tap instead of filtered water or from open water instead of from the chlorinated scheme. Therefore by not drinking constantly from safe source, the effect of water treatment in decreasing diarrhoeal prevalence might grade below expectations in the baseline.

Soil

Presence of soil made of mud was the variable significantly associated with higher odds of diarrhoea in both univariate (OR 2.98) and multivariate (aOR 1.97) models. Even if the study did not include soil samples analysis, by the presence of livestock close to the house, the visible manure piles and the practice of cow dung spreading on walls and floor (Figure 14), it is highly likely that the soil was polluted with faecal contaminants such as *E. coli*. This assumption is confirmed by several studies associating the contamination of soil with *E. coli* with inadequate behaviour, such as inadequate animal and child faeces disposal and presence of animals around the house. Kwong et al mentioned that 35% of children placed their mouth or put their hands in their mouth after touching soil particles putting children at risk of further contamination [109]. In Bangladesh and in India studies reported that faecal contamination from animals is more prevalent than human contamination in the domestic environment, including source and stored drinking water, hands and soil [41], [100], [110], [111]. Other studies mentioned that presence of animal faeces in the compound has been associated with visible dirtiness of caregivers' and children's hands and faces [100], [112], [113]. Compared with the negative association between presence of pour-water flush latrine and prevalence of diarrhoea (aOR=0.64 [0.42-0.98], p= 0.042), presence of mud on the floor showed a higher association with diarrhoea prevalence (aOR= 1.97 [1.07-3.61], p=0.03). This finding gives the information that hygiene intervention should not only focus on human faeces management but also on dangers of contamination from children by constant contact with soil and manure.

Nevertheless, not all studies agree on the effects of animal presence and its impact on child diarrhoea and growth. In a study in India, the presence of flies in the kitchen and animals close to the house did not have a significant impact on diarrhoea and growth. The body adaptation to the constantly contaminated environment could explain these results [114].

Education

Education plays an important protective role against diarrhoea, which was observed in our study among caregivers attending the hygiene literacy class (aOR=0.52 [0.32-0.83], p=0.007). Ghimire et al, showed that within their community-based intervention, training of the community health volunteers reduced the burden of acute diarrhoea across the country [115]. Nevertheless, knowledge about a threat is not sufficient and should be completed with access to facilities and training. In the present study, causes of diarrhoea such as contaminated food, hands, and water were mentioned by many respondents but the percentage of them putting their knowledge in practice was limited. Similarly as in a study done in Colombia, even if the majority of caregivers had knowledge about diarrhoea, preventive behaviour for diarrhoea was poor [116].

Handwashing

Several variables in the multivariate analysis englobing adequate handwashing practices and improved facilities were significantly associated with lower risk of diarrhoea. Hands are the first transmission pathway of pathogens between caregivers and children. Assuring the cleanliness of both children and caregivers' hands is of utmost importance in case of diarrhoea events to prevent contamination between the sick child (loose stool and dirty hands) other children and caregivers, especially in HH where overcrowding is present. Similarly a review by Curtis et al mentioned that handwashing after cleaning up children and before handling food were scarce, as only 58.4% of the respondents mentioned cleaning their hands after cleaning baby bottom, 73.8% before eating and 40.1% before cooking [117]. Several studies have investigated the protective role of hand cleanliness towards diarrhoea. A review stated that handwashing with soap could reduce diarrhoea risk from 42% to 47% [118]. Even if handwashing reporting with soap was high, soap was present in only 27.3% of the handwashing stations and handwashing stations were present among less than 50% of the respondents' households. This discrepancy between reporting and observations shows that respondents were probably aware of good hygiene practices but did not put them into practice. Promotion of handwashing is necessary and tools are given by another qualitative study in Nepal suggesting that hand hygiene habit formation is done by easing access to facilities and by reinforcing the key emotional drivers of hygiene behaviour change: perceived threat, disgust, comfort, and shame [119]. Also, use of soap not only for bathing or washing clothes should be encouraged, as soap is cheap and can be found everywhere [118].

Socio-economic status and reporting bias

In the present context, unlike among other researches on diarrhoea, living with less socio-economic resources was not significantly associated with more diarrhoeal events compared to higher SES. Several reasons might explain this phenomenon. First, even if some individuals graded a higher socio-economic status, the hygienic conditions among these individuals was also critical. Second, less educated caregivers might not see diarrhoea as a disease *per se* and might have omitted to report it, whereas higher educated people are more aware of diarrhoeal presence and dangers and might therefor report it more precisely. A research undertaken in Brazil estimated that “parental reporting is unreliable to estimate the incidence of diarrhoea” as often diarrhoeal cases are omitted by caregivers [120]. This responder bias was also mentioned in several studies collecting self-reported diarrhoea data [121]. To prevent this recall bias, the model could be improved by the use of another proxy marker for diarrhoea such as weight-for-age z-score stunting. Checkley et al reported how higher cumulative burden of diarrhoea increases the risk of stunting [122]. Although the complexity of diarrhoeal diseases dynamics and its link with malnutrition would require more research, it is today accepted that a lower absorption of nutrients because of diarrhoeal events could lead to stunting and malnutrition, especially when occurring during the first 2 years of life [122].

As a conclusion, an important number of environmental and personal hygiene factors and facilities as well as knowledge were associated with diarrhoea. Regarding the upcoming implementation, there is an urgent need for better hygiene knowledge and practices among caregivers and children in the areas of faeces management, facilities maintenance (e.g. cleaning toilet), kitchen hygiene and upmost in the handwashing sector independently of the socio-economic status of the family. Even more intensive awareness about food hygiene should be raised among families with children below the age of 2. Cheap and cost-effective interventions such as construction of dry rack and promotion of soap use should complement the water treatment intervention. Compliance to these hygiene practices could increase the effect of the water quality intervention and give hope to a decrease of diarrhoeal prevalence in the area.

CHAPTER 5. LIMITATIONS, CONCLUSION AND RECOMMENDATIONS

This study has limitations at different levels. First, the findings presented are only representative of the studied areas and cannot be generalised for entire Nepal. Second, some respondents were less educated than others, and the concept of time (time to reach tap) was sometimes only approximately estimated as only half of the respondents were in possession of a watch. Third, in Accham, the language spoken was a dialect of Nepali and Hindi and comprehension of questions and answers was sometimes difficult for respondents and interviewers.

In spite of an intensive training of interviewers, corrections for potential errors as well as emphasizing the relevance of accuracy, interviewer bias cannot be excluded. Observations bias of the indicator variables included in the hygiene indexes are also to mention (e.g. dirtiness perception). Information on developing diarrhoea in the week preceding interviewer visit was self-reported and recalled by respondents. As mentioned in Manesh et al, diarrhoea prevalence recall among households with a higher socio-economic status might be more precise than among poorer families [107][123]. Other more objective diarrhoeal indicators such as such as weight, mortality or growth could help in preventing reporting bias [124]. Similarly, handwashing practices, especially handwashing with soap (the day prior to the survey) might have been over-reported. As mentioned in a study by Mosler and colleagues, over-reporting of handwashing can be associated with three factors : socially desirable responding, encoding and recall of information, and dissonance processes [125].

Concerning water collection practices and water quality, an unrepresentative behaviour might have been pictured. Sometimes I observed “excessive container cleaning” or encountered respondents wanting to provide the water from a different tap than their main one (“because it is colder”). In these cases, it was explained to the respondent to act as in their daily routine. I respectfully accepted the offered water but asked for a sample of the main source as well. A further limitation is that the water at each household was only sampled once and during the period of time preceding the rainy season, thus the observed results might not be representative of the water quality over the entire year.

Despite these limitations, this present observational study was able to picture an alarming WASH status in the area and to highlight several important issues. Regarding the water treatment component, even if the population was aware of purification methods, only a very small part of respondents was using purification method in an appropriate way. In the coming implementation phase, one should insist on a complete, careful and repeated teaching of water treatment in order to obtain significant improvement in water quality at POU. In areas where filters will be implemented, a special warning should be brought to caregivers in order to prevent their children from drinking water directly at the untreated tap. Also, the present pipe water system should be controlled for leakages and education about adequate handwashing and container cleaning should be given to the population.

Concerning diarrhoea, the impact of animal excrement mishandling on health should be further investigated. As recommended by Freeman and colleagues, WASH-intervention specialists should consider integrating measures to control human exposure not only to human faeces but also to animal faeces in order to prevent both water and food, as well as home floor contamination and maximize intervention effects [126]. In addition, education about safer cooking practices and food storage should take place, such as construction of dry rack, covering food and storing it in height in order to prevent food contamination and consequent diarrhoea. Finally, experts should focus on the importance of hand hygiene as protective factor against both water contamination during transport and against diarrhoeal diseases. A very similar implementation study reported promising results demonstrating a diarrhoeal prevalence decrease from 5.7% to 3.9% after handwashing promotion, and a drop of diarrhoeal prevalence to 3.5% after combining similar to planned intervention cornerstones, namely water, sanitation and handwashing intervention [127]. These promising results should encourage professionals in promoting hygiene education, as recommended by the SDG.

CHAPTER 6. REFERENCES

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CHAPTER 7. APPENDIXES

Appendix 1 . Protocol for water collection and testing for microbiological quality of water processing using membrane filtration method and chlorine kit (adapted from study research Manual Water quality processing)

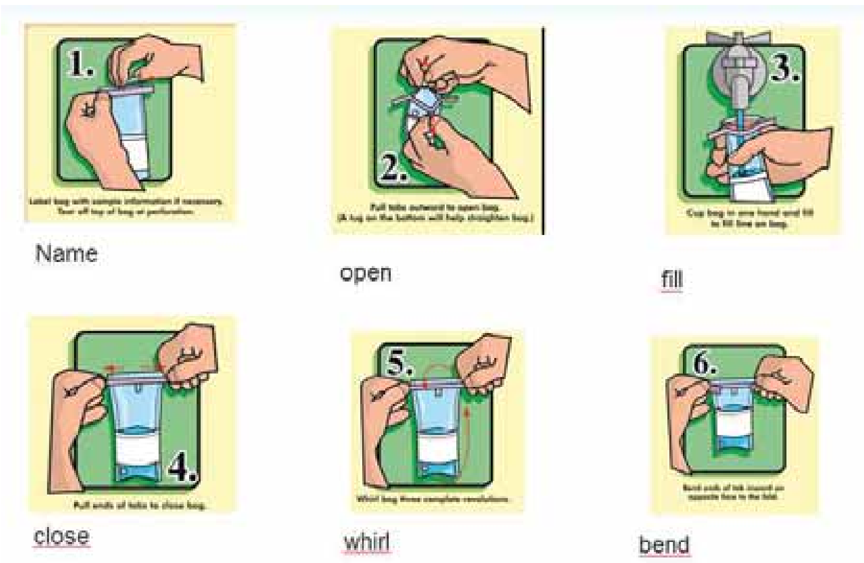
a) Water Collection

Collection of the water at:

- Point-of-collection (house/ community tap) (from where the household usually collects the drinking water)
- Point-of-use (house) (ask the household to pour a water sample as if they would pour a glass of drinking)

Procedure:

- Before collecting water samples, disinfect your hands with the hand sanitizer!
- For the sampling of the source water: if tap - open the tap and let the water run for 2 seconds. Then pour water from the tap into the whirl pack / if other source – collect water in the whirl pack without touching the opening
- For the sampling of the drinking water: ask the household to pour water into the whirl pack as if they would normally prepare and fill in water for drinking – either from the safe storage bucket, thermos, ceramic filter, etc.
- Be careful not to touch the top of the bag! Your hand may be minimally dirty
- Close sample bag tightly – if the bag is too full, dump a bit of water without touching the opening
- Note the household number, date & time of sampling, type of source (source water or household water) and sample ID number on the bag
- Place the sample into the cooler bag and **keep it cool!** Carry it back to the place of analysis immediately after completing data collection with this household. Analysis should be conducted within 4 hours.



b) Water filtration procedure

A) Sterilize the filtration unit by pouring about 2mL of Methanol into the lower cup. Burn methanol and wait for some seconds.

B) Note: The plastic collar has 3 adjustment positions:
1 Completely free - the apparatus can be dismantled when in this position.
2 Loose but not free - all interior surfaces are exposed to the atmosphere. This is the position used when sterilising the apparatus.
3 Fully tightened - the funnel forms a tight seal between the membrane support and the membrane filter. This is the position for filtration.

C) Assure that the filtration head is in loose but not free position.
Allow the methanol to burn for several seconds and, when almost completely burned up (ie. as the flames are dying down), place it over the sample cup and push firmLy into place to form a good seal.

D) Wait for 10 Minutes to let disinfection take place!
After 10 Minutes, remove filter funnel from the lower cup and place it up. Remove the sterile sample cup from the filtration apparatus. Push the filtration apparatus firmLy onto the vacuum cup (if this is difficult, lubricate the black rubber O-ring with silicone grease). Unscrew the plastic collar and filtration funnel in order that these may be easily removed. Do not place these on any surface other than the filtration base.

E) Sterilize tweezers by placing a drop of methanol on them and burn them.

F) Open a package of sterilized filter and pick up a sterilized membrane filter with sterilized tweezers.
Hold the membrane only by the edge and do not let the membrane filter touch anything while it is being transferred to the filtration apparatus.
G) Open the filter funnel with one hand and place the filter paper onto the filter support with the other hand. Screw the filter funnel tightly!

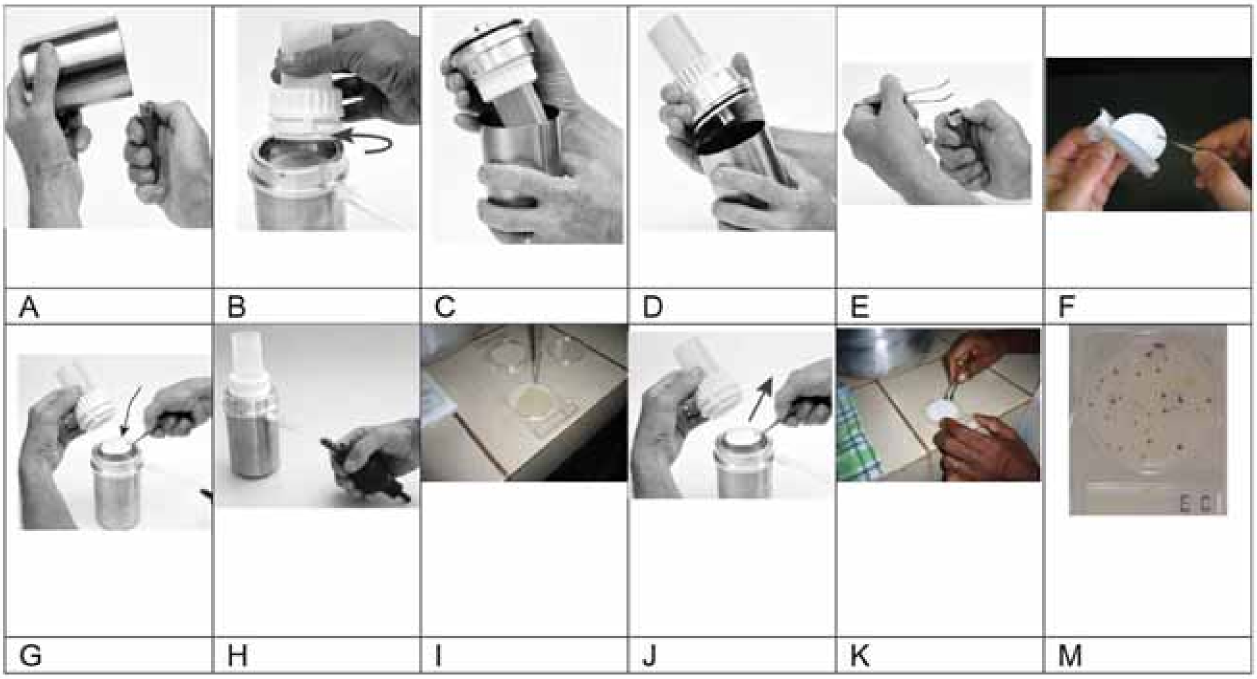
H) Pour 100mL of the water sample from the Whirl-pack (or directly from the ceramic filter tap) into the filter funnel. Filter the 100mL through the funnel by creating a vacuum with the pump in the lower cup.

I) Prepare compact dry plates:
Label the compact dry plate with the HHID as in the example: group, study site, full date, household. “1A220318HH1”. Remove the lid of the compact dry plate and place it face up on a clean surface. Do not touch the inside of the lid with anything. Pour about 3 drops on the compact dry plate to make it moist.
Detach the funnel and take the membrane filter out with sterilized tweezers.

J) Place the filter paper carefully on the *E. coli* plate. Avoid air pockets between the nutrient path and the filter paper
K) Place the plate cover on top of the plate and close tightly
Write on the plate with the permanent marker the same HHID code as indicated in the water sample as well as filter number and data and time of analysis

L) Turn over the plate and put it in an incubator for incubation at 35°C for 24 hours.
Keep a thermometer in the incubator and control for temperature.
After 24 hours of incubation count colonies on plate: Blue colonies are *E. coli*, Red colonies are Total coliforms

M) Old compact dry plates are bio-hazard and have to be disinfected before disposal!!
In this study, the plates were burnt at Helvetas.



c) Chlorination test procedure

1. Assure that the pool tester is clean and no color deposits are visible in the tube. If the tube is not clean, use the brush to clean it with test water

2. Ask the household for to provide a sample of drinking water as if they would normally prepare it. Fill/empty the test tube 3x with drinking water

3. Add the DPD Nr1 tablet in the sampling tube without touching it with your hands.

4. Shake and wait for 30 Seconds

5. After 30 Seconds, compare the colour of the sample with the printed scale

6. Report the analysis in the booklet

7. After reading and noting the result, rinse the test tube with chlorine free water. Use brush if necessary.

Appendix 2 Variables and coding for wealth index calculation

Variable included in WI (N=1427 if not mentioned)	Number (%)	Factor analysis Coded as
Level of education		
None/ do not know	69 (4.8)	0
Informal education	412 (28.9)	1
Primary	484 (33.9)	2
Secondary	362 (25.4)	3
College or higher	100 (7)	4
Expenditure levels (categorization in rupees[15])		
<=15000	982 (68.8)	0
15000-30000	410 (28.7)	1
30000-45000	29 (2)	2
>=45000	6 (0.4)	3
Electricity in the house <present vs absent>	675 (47.3)	(0=absent, 1=present)
TV <present vs absent>	675 (47.3)	(0=absent, 1=present)
Solar Panel <present vs absent>	743 (52.1)	(0=absent, 1=present)
Mobile Phone <present vs absent>	116 (8.1)	(0=absent, 1=present)
Motor Bike <present vs absent>	81 (5.7)	(0=absent, 1=present)
Fridge <present vs absent>	62 (4.3)	(0=absent, 1=present)
Watch <present vs absent>	607 (42.5)	(0=absent, 1=present)
Type of fuel (MAP)°		
wood	1112 (77.9)	0
gas	298 (20.9)	1
electricity	17 (1.2)	2
Landownership in Ropani Erreur ! Signet non défini.[16]**(N=1422)**		
<=15	1339 (93.8)	0
15-30	72 (5)	1
>=45	11 (0.8)	2
Type of wall of the household		
stone with mud	1116 (78.2)	0
stone with cement	219 (15.3)	1
wood planks	21 (1.5)	2
brick with cement	71 (5)	3
Type of roof of the household		
Mud	23 (1.6)	0
Straw	137 (9.6)	1
Roof tiles	671 (47)	2
CGI sheet (Corrugated Galvanised iron)	483 (33.8)	3
RCC (Roller compacted concrete)	113 (7.9)	4
Type of floor of the household		
Earth	1200 (84.1)	0
Cement	227 (15.9)	1
Number of people per room		
up to one person per room	184 (12.9)	4
1 to 2 people per room	662 (46.4)	3
2 to 3 people per room	319 (22.4)	2
3 to 4 people per room	110 (7.7)	1
4 and more people per room	152 (10.7)	0
Wealth Index in 3 categories (N=1422)		
Lowest wealth index (poorest)	442 (31)	
Middle wealth index	765 (53.6)	
Higher wealth index (richest)	214 (15)	
Variable excluded from Wealth index calculation : [17]		
Bicycle <present vs absent>	58 (4.1)	(0=absent, 1= present)
Radio < present vs absent>	325 (22.8)	(0=absent, 1= present)
Ownership <own vs rent>	1934 (97.7)	(0=rent, 1= own)

°MAP : multiple answer possible

[15] Rupees transaction in May 2018

[16] Ropani conversion 15 ropanis = 1.88 acres [129]

[17] Excluded because of their low communality or because the variable had a value <0.5 in the anti-image matrix (house ownership)

Appendix 3 Variables and coding for Hygiene index calculation

Hygiene-related characteristics included in HI (N=1427 if not specified)	N (%)	Factor anylsis : coded as
Transport container		
Clean (N=1426)	1098 (76.9)	(0=dirty. 1=clean)
Covered with a lid	935 (65.5)	(0=uncovered, 1=covered)
Toilet		
Type of toilet		
No latrine	90 (6.3)	0
Simple pit	137 (9.6)	1
Water flush	1200 (84.1)	2
Toilet conditions (MAP)		
Toilet is clean	666 (46.7)	(0=dirty, 1=clean)
Brush	375 (26.3)	(0=absent. 1=present)
Waterdrum	1150 (80.6)	(0=absent. 1=present)
No material present in the toilet	160 (11.2)	(0=no material present . 1=material present)
Handwashing station		
Not present	855 (59.9)	0
Pouring out water from a bucket	255 (17.9)	1
Drum with a tap	317 (22.2)	2
Handwashing station conditions		
Clean	365 (25.6)	(0=dirty, 1=clean)
Presence of water	523 (36.7)	(0=absent, 1=present)
Presence of soap	388 (27.2)	(0=absent, 1=present)
Personal hygiene		
Hand of the caregiver clean	1131 (79.3)	(0=dirty, 1=clean)
Hand of child clean	726 (50.9)	(0=dirty, 1=clean)
Kitchen		
Dishes kept high	750 (52.6)	(0=low, 1=high)
Food covered	989 (69.3)	(0=uncovered, 1=covered)
Presence of a drying rack	609 (42.7)	(0=absent, 1=present)
Few flies present	331 (23.2)	(0=many flies, 1=few flies)
Surroundings		
Absence of trash outside of the house	473 (33.1)	(0=present, 1=absent)
Absence of trash inside the house	646 (45.3)	(0=present, 1=absent)
Absence of pile of cloth on the house floor	509 (35.7)	(0=present, 1=absent)
Animal sleeping outside at night (N=1426)*[18]	575 (40.3)	(0=inside, 1=outside
Hygiene index (3 categories) (N=1425)		
Low hygiene index	914 (64.1)	
Middle hygiene index	193 (13.5)	
Higher hygiene index	318 (22.3)	
Excluded from HI calculation [19]		
Sandals in toilet	53 (7.7)	(0=absent, 1=present)
Garbage pit	84 (5.9)	(0=absent, 1=present)
Transport container not broken	1389 (97.3)	(0=broken, 1=not broken)

[18] Included in the common hygiene index calculation but excluded from Hygiene index surroundings

[19] Excluded because of their low communality. Also storage containers were most of the time similar as the transport containers they were not included in this analysis.

CHAPTER 8. HOUSEHOLD SURVEY MATERIAL

HH survey material 1 : Questionnaire

HH survey material 2: Booklet

HH survey material 3 : Informed consent sheet

quality and hygiene interventions on the
RM-P Project in Mid- and Far Westerm

e disclosed anywhere. The results will be treated
ake part if you don't want to. You don't have to
at any time. If you decide not to participate there

elvetas. The phone number of the Helvetas office

ed to questionnaire

the water directly into the whirlpack as if a glass

glass of drinking water (for example from drinking

Select the municipality/VDC

____

Select the ward number

____

Select the name of the area

- ◯ area A
- ◯ area B
- ◯ area C
- ◯ area D

A - Household Information

A-Household information

Name of person interviewed

____

What is the gender of the repondent?

Please indicate without notifying the respondent

- ◯ Male
- ◯ Female

What is the age of the respondent?

Enter number / if unknown: approximate the age: ."60-70"

____

What is your mobile phone number?

Enter mobile phone number / Enter 999 if no mobile phone

____

How many people in TOTAL, including you, live in your household?

Including respondent

____

How many children are 0 to 10 years in this household?

Enter number

____

What is the occupation of the spouse of the household head?
Do not read out - select one answer given by respondent

- ☐ Agriculture
- ☐ Service
- ☐ Small business
- ☐ Daily laborer
- ☐ Other independent work
- ☐ Retired with pension
- ☐ None
- ☐ Foreign employment
- ☐ No spouse (=single or widow)

What is the ethnicity of this household?
Do not read out - select one answer given by respondent

- ◯ Dalit
- ◯ Janajati
- ◯ Bramihin, Chhetr, Thakuri
- ◯ Other

Specify other ethnicity

Is anyone in this household involved in the water supply system in this community ?

- ◯ Yes
- ◯ No

Does anyone in this household hold a leadership position in this community?

- ◯ Yes
- ◯ No

ILLAGE?

r expenses (regular expenses = food, transport,

Does the household have an electricity connection?

- ◯ Yes
- ◯ No

What kind of fuel do you use mainly for cooking?
Do not read out - select all answers given by respondent

- ☐ Wood
- ☐ Charcoal
- ☐ Kerosene
- ☐ Gas
- ☐ Electricity

Are you the owner of your house?

- ◯ Own house
- ◯ Rent house

How many rooms does your house have?

____

How much land does your family own?
Enter area owned by the household in Ropanis
If no area is owned enter "0"
If don't know enter "999"

____

C - Water handling and hygiene

C-Water handling and hygiene

Which water source do you currently use as MAIN drinking water source?
Do not read out

- ◯ Piped water in the house or yard
- ◯ Piped water in the village
- ◯ Rainwater harvesting
- ◯ Open source (dug well, pond, spring)
- ◯ Protected source (well, spring)
- ◯ Unmanaged piped system
- ◯ River, Stream or Canal
- ◯ Lake
- ◯ Bottled Water

t the water system?

ource take, including time required to queue

If main drinking water source needed repairs, how confident are you that the problem could be fixed within 1 week?

- ◯ Very confident
- ◯ Somewhat confident
- ◯ Not confident at all
- ◯ Don't know/ no answer

Is there a village maintenance worker (VMW) to look after your main drinking water source?

- ◯ Yes
- ◯ No

Can you get help from the VMW to repair main drinking water source when you need it?

- ◯ Yes
- ◯ Maybe
- ◯ No
- ◯ Don't know/no answer

In the last 6 months, were there any times when water from main drinking water source was not available for more than one week?

- ◉ Yes
- ◯ No

How many days did the interruption last?

____

Do you think the main drinking water source will be functional one year from now?

- ◯ Yes
- ◯ No

Instructions: Think about the home, animals or furniture that you own or co-own with someone, and the experiences and feelings associated with the statement 'THIS IS MY (OUR) HOUSE!' The next 10 questions deal with the 'sense of ownership' that you feel for the water system in your village. How true are the following statements for you? (to be adapted after pretest)

How much do you agree with the following statement? This is MY water system.
Use five dots scale

- ◯ Not at all true
- ◯ Hardly true
- ◯ Rather true
- ◯ Mostly true
- ◯ Very true

COMMUNITY'S water system.

me to think about this water system as MINE.

nking water source right now?

ng?

What do you think could make your water unsafe for drinking?

Do not read out - select answer that match with categories

- [ ] Open unprotected source
- [ ] Unmanaged system/fittings chamber pipe
- [ ] Open defecation
- [ ] Settlement above source
- [ ] Deforestation
- [ ] Don't know
- [ ] Other...

Please specify other:

Which methods for water treatment do you know?

Do not read out

- [ ] Boiling
- [ ] Filtration with a cloth
- [ ] Flocculation and sedimentation
- [ ] Chlorination
- [ ] Sodis
- [ ] Use of Filter
- [ ] Other (specify)
- [ ] Do not know any

Please specify other:

Can you explain to me the procedures of the different methods (the ones the interviewee knows) for water treatment?

Let the person explain the different methods for water treatment

- ( ) Good explaination of at least 4 methods
- ( ) Good explaination of 3 methods
- ( ) Good explaination of 2 methods
- ( ) satisfactory explanation of 1 method
- ( ) Cannot explain well
- ( ) Don't know any

treatment in the last 2 weeks?

How much do you like or dislike drinking treated water?
Use 5 dots scale

- ◯ I dislike it very much
- ◯ I rather dislike it
- ◯ Average
- ◯ I rather like it
- ◯ I like it very much

Do you think that treating your drinking water is worthwhile?
Use 5 dots scale

- ◯ Never worthwile
- ◯ Rarely worthwile
- ◯ Sometimes worthwile
- ◯ Mostly worthwile
- ◯ Always worthwile

How much would people who are important to you approve or disapprove if you treated your drinking water?
Use 5 dots scale

- ◯ They would disapprove very much
- ◯ They would rather disapprove
- ◯ Neither approve nor disapprove
- ◯ They would rather approve
- ◯ They would approve very much

How many people who are important to you (your family, friends etc.) treat their water before drinking?
Use 5 dots scale / do not read out the %, it is just a help for you to visualise the number of people

- ◯ (Almost) nobody (0%)
- ◯ Some of them (25%)
- ◯ Half of them (50%)
- ◯ Most of them (75%)
- ◯ (Almost) all (100%)

How sure are you that you can always treat your water before drinking, even if this may be difficult sometimes?
Use 5 dots scale

- ◯ Not at all sure
- ◯ Hardly sure
- ◯ Rather sure
- ◯ Mostly sure
- ◯ Very sure

r treatment (e.g. when you run out of chlorine,

drink water, but you forgot to treat it in time?

ing?

water is something... I do automatically.

Collection and Transport containers

What kind of containers do you use to collect & transport water from the source?

- [ ] Gagri silver
- [ ] Gagri brass
- [ ] Gagri copper
- [ ] Gagri plastic
- [ ] Jerrycan plastic
- [ ] Plastic bucket with large opening
- [ ] Alu bucket with large opening
- [ ] Claypot
- [ ] Other

Please specify other:

Do you clean your container for transport?

- (●) Yes
- ( ) No

How often do you clean the container used for transport of water?

- ( ) Every day
- ( ) Every second day
- ( ) At least once per week
- ( ) Less often than once per week

How do you clean the container used for transport of water?

- ( ) I use water or water and sand
- ( ) I use Chlorine to disinfect it almost always
- ( ) I use Chlorine to disinfect it sometimes
- ( ) I wash it almost always with soap or ash
- ( ) I wash it sometimes with soap or ash

Do you use the same container for water transport and water storage?

- ( ) Yes
- (●) No

Storage containers

s?

o or ash?

During which times did you wash your hands yesterday?
Do not read out, multiple answer possible

- ☐ When they look dirty
- ☐ After going to toilet
- ☐ After cleaning baby's bottom
- ☐ Before eating
- ☐ Before cooking
- ☐ There are no special occasions
- ☐ Never
- ☐ Do not know

Where do members of your family usually go for defaecation?
Do not read out, if answer unclear give options

- ○ They use the bushes
- ○ A shared simple pit latrine
- ○ A shared water sealed toilet
- ○ Household's own simple pit latrine
- ○ Household's own water sealed toilet

Do you keep the animal safe inside your house over night ?

- ◉ Yes
- ○ No

D - Information on WASH Promotion

D - Information on WASH Promotion

Have you received any information on water treatment and hygiene from Helvetas or others in the last 2 months?

- ◉ Yes
- ○ No

Did the information on water, hygiene and sanitation change your behavior?

- ◉ Yes
- ○ No

water treatment and hygiene?

conducted by FCHV or other health workers ?

s visited your household in total?

e effective?

What are the causes for diarrheal diseases?

Let the respondent explain the cause, tick the selection which matches the explanation best

- ☐ Some pathogens
- ☐ Faecal pathogens
- ☐ Dirty hands
- ☐ Dirty food
- ☐ Dirty water
- ☐ Explanation does not correspond with real cause

How high or low are the chances that you or your children get sick if you drink untreated water?

Use 5 dots scale

- ○ Very low
- ○ Rather low
- ○ Average
- ○ Rather high
- ○ Very high

Imagine your child below 5 years has diarrhea, how severe would be the impact on his life and development?

Only read options if answer unclear. Use 5 dots scale

- ○ Not at all severe
- ○ Hardly severe
- ○ Rather severe
- ○ Severe
- ○ Very severe

» Children's illnesses

Note the ID Code of child

____

How old is child?

Enter number of year

____

Enter number of months

____

What is the gender of child ?

- ○ female
- ○ male

days?

No

○
○
○
○
○
○
○

Have you ever heard of 'intestinal parasites'?

- (●) Yes
- ( ) No

What can be done against intestinal parasites
Do not promt

- [ ] Wash hands with soap
- [ ] Cut finger nails
- [ ] Wear pants, trousers
- [ ] Wash fruits and vegetables before consumption
- [ ] Wear shoes
- [ ] Drink clean water
- [ ] Take medication
- [ ] Other

F - Nutrition

F - Nutrition

Did you breastfeed your child?

- (●) Yes
- ( ) No

How many months did you breastfeed your child?

____

Did you feed your child any other liquids or foods during the first six months in addition to mother breastfeeding?

- (●) Yes
- ( ) No

After how many months of age did you start to provide additional weaning food to your child?

____

Usually how many meals do your children eat per day?

____

Do you give your child other things to eat, for example sweets or snacks in addition to the usual meals?

- (●) Yes
- ( ) No

m pitho) in addition to the usual meals?

y of these foods?

Nuts or seeds

- three times per day
- twice per day
- once per day
- every second day
- two times per week
- once per week
- less than once per week
- Sometimes
- not at all

Dairy products (for example milk, yoghurt)

- three times per day
- twice per day
- once per day
- every second day
- two times per week
- once per week
- less than once per week
- Sometimes
- not at all

Meat or fish

- three times per day
- twice per day
- once per day
- every second day
- two times per week
- once per week
- less than once per week
- Sometimes
- not at all

Fruits

- ◯ three times per day
- ◯ twice per day
- ◯ once per day
- ◯ every second day
- ◯ two times per week
- ◯ once per week
- ◯ less than once per week
- ◯ Sometimes
- ◯ not at all

Do you produce your own food?

- ◉ Yes
- ◯ No

Is your harvest enough for meeting your household's food needs all year long?

- ◯ Yes
- ◯ No

For how many months do you have to buy extra food (not sufficient production from own agricultural activities)?

- ◯ Up to 3 months
- ◯ 3 to 6 months
- ◯ More than 6 months
- ◯ Do not need to buy any food

G - Observation through the interviewer (your own observation)

G - Observation through the interviewer (your own observation)

What type of walls does the main house have?

- ◯ Stone with mud
- ◯ Stone with cement
- ◯ Brick with cement
- ◯ Wood planks
- ◯ Corrugated iron
- ◯ Cement

Is the water storage container clean?

- ◯ Yes
- ◯ No

Does the water storage container have a lid?

- ◯ Yes
- ◯ No

Is the water storage container broken?

- ◯ Yes
- ◯ No

What kind of toilet does the HH have on the compound?

- ◯ No latrine
- ◯ Pit latrine
- ◯ Ventilated improved latrine
- ◯ Water-sealed latrine

» Condition of the toilet

In which condition is the toilet?

Take a picture of the toilet.

Click here to upload file. (< 5MB)

Is the toilet clean?

There are no traces of faeces and dirt in the toilet

- ◯ Yes
- ◯ No

Are these material available?

- ☐ Sandals/slippers
- ☐ Drum with water
- ☐ Brush
- ☐ None of these

What kind of handwashing facilities does the HH have?

- ◯ None
- ◯ A drum with a tap
- ◯ They pour out water from a bucket

» Condition of handwashing facilities

Is the entirety of food covered ?

- ◯ Yes
- ◯ No

Is there dry rack to dry your utensils and dishes after washing?

- ◯ Yes
- ◯ No

Is there a significant number of flies in the kitchen (more than 10)?
if more than 10, type yes

- ◯ Yes
- ◯ No

» Personal hygiene

Personal hygiene

Is the Mother/Father wearing shoes?
Look at respondant feet

- ◯ Yes
- ◯ No

Are the Mother/Father's hands clean?
Look at respondant hand

- ◯ Yes
- ◯ No

Are the hands of child clean?
No traces of dirt visible

- ◯ Yes
- ◯ No

Can you see any dirty cloth piles lying?
No traces of dirt visible

- ◯ Yes
- ◯ No

****Please record any additional information here or in your notebook**

____

t to switch it off afterward!

Map data ©2018

Specify the treatment at the household level

- [ ] Chlorine
- [ ] Screening/filtration with Cloth
- [ ] Ceramic filter
- [ ] Silver coated filter
- [ ] Coagulation/settlement
- [ ] UV/SODIS
- [ ] Boiling
- [ ] Other (specify)
- [ ] Don't know / no answer

Specify other household treatment

Thank you for answering these questions!
This is the end of the interview.

booklet

Water sampling and health measurements

पानीको नमूना सङ्कलन र स्वास्थ्यको मापन

Nepal

नेपाल

2018

दुई हजार अठार साल

समूह ....

साक्षात्कारको लागि उत्तरदायी :

सुरु :

पानीको नमूना सङ्कलन / स्वास्थ्य परीक्षण को लागि उत्तरदायी:

सुरु :

क्षेत्र :

H1)

:   कोद:

ो गुणस्तर परीक्षण – संग्रहको बिन्दु	
n° :	Duplicate नक्कल YES (हो) ☐ NO (होइन) ☐
O ☐	Odour (गन्ध): YES ☐ NO ☐
coliforms (pink ाणना गर्नुहोस्	Count Total coliforms: कुल कोलिफर्म गणना गर्नुहोस्।

ानीको गुणस्तर परीक्षण – खपतको बिन्दु	
n° :	Duplicate नक्कल YES (हो) ☐ NO (होइन) ☐
O ☐	Odour (गन्ध): YES ☐ NO ☐
coliforms (pink c.) : ाणना गर्नुहोस्	Count Total coliforms: कुल कोलिफर्म गणना गर्नुहोस्।
: mg/l	

Child Health measurements बाल स्वास्थ्य मापन			
Child ID: बच्चा को आईडी :			
Height उचाइ	Cm सी. एम.	Middle-Upper arm circumference मध्य-माथिल्लो हातको गोलाई	Cm सी. एम.
Weight वजन	Kg के. जी.	Wrist circumference नादीको गोलाई	Cm सी. एम.
Limb length हातको लम्बाइ	Cm सी. एम.	Head circumference टाउकोको गोलाई	Cm सी. एम.
Limb circumference हातको गोलाई	Cm सी. एम.	Waste circumference कम्मरको गोलाई	Cm सी. एम.
Shoulder breadth कुमको चौडाई	Cm सी. एम.		
Wasted appearance सुकेनाश	YES ☐ NO ☐	Bitots spot बिटोट स्पोट	YES ☐ NO ☐
Loss of hair pigment and easy pluckability कपाल झर्नु वा सजिलै निक्लिनु	YES ☐ NO ☐	Dry and infected cornea सुक्खा र संक्रामक	YES ☐ NO ☐
Oedema सुन्निनु	YES ☐ NO ☐	Pale conjunctiva पहेलो कोन्जुन्क्तिवा	YES ☐ NO ☐
Enlargement of liver कलेजो सुन्निनु	YES ☐ NO ☐	Spongy, bleeding gums ब्लिडिंग गम्स	YES ☐ NO ☐
Dermatitis छाला रोगहरू	YES ☐ NO ☐	Red inflamed tongue रातो संक्रामक जिब्रो	YES ☐ NO ☐
Spontaneous bruising स्पोन्तणेओूस ब्रुइसिङ	YES ☐ NO ☐	Swelling of the thyroid gland in the neck (goiter) थाइरोइड ग्रंथि सुन्निनु	YES ☐ NO ☐
Tiny subdermal hemorrhages (petechiae) सबडरल हेमोर्रेज	YES ☐ NO ☐	Angular stomatitis अँगुलर् स्तोमतितिस	YES ☐ NO ☐

med consent form

ी पढ्नुहोस्।
हँसँग कुनै प्रश्न छ भने।

/ARM-P परियोजना व्यवस्थापन
ट पानीको गुणस्तर तथा स्वच्छता
कार्यान्वयनले बच्चाहरूको स्वास्थ्य
भावको मूल्यांकन

strasse 133
र्फर्फ
ाण्ड
स स्विस इनटरकोपरेशन नेपाल, एकिकृत
यवस्थापन कार्यक्रम, विरेन्द्रनगर सुर्खेत

ाल

होफर, स्विट्जरल्याण्ड
Meierhofer, Switzerland)

श्रेष्ठ, नेपाल

ठ

____
____
☐ पुरुष
____
____

ा यस अध्ययनको उद्देश्यको बारेमा र
गरी, प्रभाव, फाईदा र सीमाको साथ साथै

ाफ दिइयो। म प्रोजेक्ट / संस्करण बाट
चित सहमति फारमको एक साइन
दान गरिएको सामग्री स्वीकार गर्दछु।

- म स्वैच्छिक रूपमा यस अध्ययनमा भाग लिन चाहन्छु। अध्ययनमा मेरो सहभागिता हटाउन कुनै पनि कारणबिना कुनै पनि समयमा फिर्ता लिन सकिन्छ। अध्ययनबाट हटाउनको लागि कुनै नकारात्मक नतीजाहरू छैनन्।
- मलाई सूचित गरिएको थियो कि यदि मेरो बच्चा परजीवी संक्रमणबाट ग्रस्त छन् भने उसलाई स्थानिय अवस्थित स्वास्थ्य चौकी सँग समन्वय गरेर उपचार प्रदान गरिनेछ।
- मलाई सूचित गरिएको थियो कि म अध्ययनको नतिजाबारे जानकारी पाउनेछु ।
- मेरो निर्णयको बारेमा सोच्न पर्याप्त समय थियो।
- मलाई सूचित गरिएको छ कि यदि मेरो बच्चामा कुनै स्वास्थ्य समस्या पत्ता लागेमा मलाई सूचित गरिनेछ।
- मलाई थाहा छ कि सबै व्यक्तिगत तथ्यांक गोप्य राखिनेछ र हाम्रो सर्वेक्षण टोलीका सदस्यहरू भन्दा अरुसँग साझेदारी गरिनेछैन । म सहमत छु कि शोधकर्ताहरूले यो अध्ययन, र नेपालमा र स्विट्जरल्याण्डमा नैतिक समीक्षा बोर्डका सदस्यहरू गोप्य राख्दा मूल डेटा पहुँच गर्न सक्दछन्।
- म सहमत छु कि एस अध्ययनमा संलग्न भयका सोध्कर्ताहरु तथा नेपाल र स्विट्जरल्याण्डका नैतीक समिक्षा बोर्डका (ethical board) सदस्यहरूलाई मैले उपलब्ध गरायका तथ्यंकहरु पहुच हुनेछ।

बालबालिकाको कानूनी प्रतिनिधिको हस्ताक्षर

स्थान, मिति	नाम र उपनाम बच्चासंगको नाता (आमा / बुबा आदि) कानूनी प्रतिनिधित्वको हस्ताक्षर (आमा / बुबा आदि) ______________________________ यदि व्यक्ति अनपढ हो भने, प्रतिवादीको फिंगरप्रिन्ट

अध्ययनमा संलग्न कर्मचारीको पुष्टिकरण: यसबाहेक, म पुष्टि गर्छु कि मैले अध्ययनमा संलग्न उत्तरदातालाई अध्ययनको उद्देश्य तथा प्रकृयाको बारेमा व्याख्या गरेको छु। म अध्ययन जानकारी पत्रमा उल्लिखित सबै दायित्वहरूको पालन गर्दछु।

स्थान, मिति	परियोजना कर्मचारीको हस्ताक्षर

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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