Water, Sanitation and Hygiene Practices Associated with Intestinal Parasitic Infections, Diarrhoea, Undernutrition and Clinical Signs of Nutritional Deficiencies among Children in Surkhet, Dailekh and Achham districts, Nepal: a cross-sectional study

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Research article

Keywords: Drinking Water Quality, Sanitation and Hygiene, Child Health, Diarrhoea, Undernutrition, Intestinal Parasitic Infections, Nepal

Posted Date: October 2nd, 2019

DOI: https://doi.org/10.21203/rs.2.15462/v1

Version of Record: A version of this preprint was published on August 15th, 2020. See the published version at https://doi.org/10.1186/s12889-020-09302-3.

Abstract

Background: Providing universal access to safe water, sanitation and hygiene (WASH) in remote Nepal remains challenging. Efforts to improve WASH access in these areas are impeded by a dearth of information on the status of WASH conditions and its association with health and nutritional status of children in Nepal.

Methods: We investigated WASH practices, nutritional status, and their association with intestinal parasitic infections, diarrhoea, undernutrition and clinical signs of nutritional deficiencies (hereafter health outcomes) during March to May 2018. Data was collected through cross-sectional survey of 1427 households, including questionnaires, observations, stool analysis, anthropometry, water quality measurements and assessment of clinical signs of nutritional deficiencies.

Results: We found that 51.1% of children were suffering from intestinal parasitic infections and 55.5% had undernutrition; 52.2% had waterborne illnesses; and 63.9% had clinical signs of nutritional deficiencies. Multivariate mixed logistic regression analysis revealed significant associations between health outcomes and intermittent water supply (adjusted odds ratio (AOR)=2.72, 95% confidence intervals (CI)=1.18-6.31, P =0.02), washing hands when they look dirty (AOR=0.47, 95% CI=0.32-0.71, P =0.01), handwashing after going to toilet (AOR=0.37, 95% CI=0.13-1.02, P =0.06), cleanliness of the toilet (AOR=0.68, 95% CI=0.47-0.98, P =0.04), presence of earthen floor (AOR=2.29, 95% CI=1.20-4.37, P =0.01), caregivers who can read (AOR=4.07, 95% CI=1.00-16.55, P =0.05), no toilet (AOR=6.12, 95% CI=1.08-14.25, P =0.04), cleanliness of caregivers hand (AOR=0.61, 95% CI=0.41-0.89, P =0.01), regular deworming (AOR=0.44, 95% CI=0.20-0.94, P =0.03), own food production (AOR=0.67, 95% CI=0.46-0.97, P =0.03), animals inside the house overnight (AOR=1.71, 95% CI=1.17-2.51, P =0.01), source water quality (AOR=10.44, 95% CI=1.61-67.4, P =0.01), better socioeconomic status (AOR=0.43, 95% CI=0.25-0.75, P =0.01), and food supplements (AOR=0.57, 95% CI=0.38-0.84, P =0.01).

Conclusions: Findings suggest improvements in WASH services, along with household hygiene and nutritional interventions, may together reduce child morbidity and mortality in Nepal.

Background

Globally, an estimated 785 million people lack basic water services and at least 2 billion people use a water source contaminated with faeces [1]. In addition, 4.2 billion people lack safely managed sanitation and 673 million practice open defecation [1]. Only 28% of the people in low-income countries have access to soap and water for handwashing on their premises [1]. A total of 297,000 WASH attributable diarrhoea deaths occurred yearly among children under 5 years, representing 5.3% of all deaths in this age group [2]. Likewise, about 2.4 million deaths annually are due to diarrhoea, subsequent malnutrition, and their consequences [3]. Children in low-income settings are particularly vulnerable to WASH related diseases [4].

Insufficient WASH, inadequate nutrition, and subsequent infections, as well as growth and development impairments, are interrelated problems among children in low-income countries [5]. Globally, every fifth child under-five is stunted, one of 13 children under-five is wasted and every seventh child under-five is underweight. Nearly 90% of these cases occurred in South Asia and Sub-Saharan Africa over the past decade [6–8]. An association between improved WASH and better growth outcomes in children has been reported in various studies. For instance, a study from Peru conducted among children two years of age found that the surveyed children living under the worst WASH conditions were 1.0 cm shorter than their counterparts living under the best conditions [9]. Furthermore, a study conducted among children less than four years old in Bangladesh provided evidence that children living with better WASH conditions, including handwashing facilities, had a height-for-age score (HAZ) 0.54 greater than children living under worse WASH conditions [10].

Two billion people worldwide were infected with intestinal parasites, with the highest burden of disease among children and their caregivers living in resource-poor settings [11–13]. Studies have shown that infections with intestinal parasites among children were associated with stunting, physical weakness and low educational performance [12, 14, 15]. Nutrition is also closely interlinked with such multifactorial determinants [16, 17]. While malnutrition is directly associated with insufficient dietary intake, underlying contributing factors such as lack of access to safe water and sanitation result in recurrent infectious diseases, e.g. diarrhea and intestinal worms, which interfere with the digestive process by competing with the host for nutrients, inhibiting the absorption of nutrients and leading to compromised immunity. It is estimated that up to 45% of global malnutrition related child deaths annually could be prevented by improving WASH conditions and practices [8, 18, 19].

Nepal is a low-income country with a population of 28 million people, out of which 80% reside in rural areas [20, 21]. The Government of Nepal set a national target to provide basic levels of water services, as well as access to improved sanitation for all by 2017 [22]. Even though, 89% of the total population currently has access to at least basic water supply services and 62% to basic sanitation facilities, numerous challenges to sustain these achievements and to make WASH services available to the currently unserved people exist. In addition, various studies revealed that water quality at the point of distribution is frequently poor [23–25]. Even if the water is safe at the source, it is likely to be subject to recontamination due to inadequate hygiene during transportation and storage. Nevertheless, few households consistently practice water treatment [23, 26]. Also, open defecation remains prevalent and sanitation solutions mainly consist of simple pit latrines that pose a significant risk of faecal contamination in the household environment [8]. Risks related to poor hygiene are manifold; foods are unhygienically prepared, stored, and consumed in environments contaminated with flies [27]. Floors are mostly made of mud painted with cow dung. Kitchen wares and clothes are unhygienically handled and washing hands is rarely practiced [27]. Unsafe water is used for household chores and latrine surfaces are not frequently washed, increasing the presence of pathogens that may affect the health of the children directly or indirectly [28]. This results in an increased risk to different waterborne diseases, especially among children [22]. The Demographic and Health Survey (DHS) of 2016 showed that one out of 25 children in Nepal die before reaching the age of five and almost 3,500 die yearly from preventable causes [29, 30]. Diarrhoea is one of the most common illnesses among children and continues to be a major cause of childhood morbidity and mortality [29].

In a recent study, 31.5% of children in the Eastern region of Nepal were found to be infected with intestinal parasites. Not using soap after defecation, the habit of thumb sucking and not wearing sandals were found to be significantly associated with parasitic infections [31]. The DHS in 2016 revealed that 36.0% of children under-five in Nepal are stunted, 10% wasted and 27% underweight. Stunting was found to be more common in rural children (40%) and the poorest households (49.0%) [29]. Fifty three percent of children aged 6–59 months are anaemic, a condition which is more common (56.0%) among rural children [29]. Only one out of four children sees a health care provider for the treatment of illnesses [32]. The treatment costs of the WASH-associated disease burden and consequences therefrom may further increase the risks, by affecting households' budgets and thereby limiting the amount of food available, exacerbating the risks of insufficient nutrient intake and undernutrition among children [33].

The "Sustainable Development Goals (SDGs)" recognised unsafe water and inadequate sanitation and hygiene as a major cause of child morbidity and mortality, and SDG 6 was developed to address these challenges [34]. The data required to monitor the SDGs is lacking in many countries [1] and this is also the case in Nepal where there is a dearth of information on the status of WASH conditions in remote areas. Likewise, the health and nutritional status among children in remote hilly areas and their associations with WASH has not been investigated in this locale. As a result, efforts to combat health and nutritional problems among children in these settings do not effectively incorporate WASH interventions. The aim of this study, therefore, is to assess the influence of WASH practices on the health and nutritional status among children aged 6 months to 10 years of age in three districts in the rural hilly areas of Nepal. Findings from this study are crucial to support and inform efforts to deliver WASH, health and nutritional interventions, including hygiene behavioural change initiatives, in the study areas.

Methods

Study areas

The study areas were located in the Districts of Surkhet, Achham, Dailekh in the Karnali province of Nepal. Surkhet district covers an area of 2488 km^2, Achham 1692 km^2, and Dailekh 1502 km^2. Surkhet, Achham and Dailekh have a population of 350,804; 257,477 and 261,770 respectively in 2011. The majority of areas of Surkhet (64%) district is tropical; however of Achham (58%) and Dailekh (65%) districts are subtropical [35–37]. For our study, all areas in the selected districts were very remote, difficult to reach and lacked access to proper infrastructure, such as an electrical grid.

Study design, sample population, sample size and sampling methods

The study sites were located within the Helvetas Swiss Intercooperation Nepal, Water Resources Management Programme (WARM-P) sites. The sites were selected by the local teams of an organisation following a set of criteria: (a) extreme remote location (b) is an area with the availability of a piped water supply scheme, that has not yet received the WARM-P training intervention (c) not having access to products for household water treatment. The database of the households having children's aged 6 months up to 10 years in the targeted communities were prepared. We then conducted a cross-sectional study from March to May 2018 that involved 1427 households. A minimum of 345 households were randomly sampled from each of the districts (Surkhet A, Surkhet B, Dailekh and Achham) in the Karnali province of Nepal. If a household declined to participate, then the neighbouring household having children in the targeted age ranges were included. Sample size and statistical power were calculated using G*Power 3.1. A sample size of 300 households were required in each of the four areas to detect an effect in Cohen's f2 at one-tailed alpha of 0.05 and a statistical power of 90% with multiple logistic regression and 15 predictor variables adjusting for clustering [38, 39]. We therefore enrolled a minimum of 345 households from each of the three districts, for a total of 1427 households.

Questionnaire survey

A quantitative structured questionnaire was administered to the caregivers (male or female) in the households. The questionnaire contained mostly closed ended, multiple choices questions with Likert scale answer categories. The interviews that took around 15 minutes in on average were complemented by structured observations. The questionnaire was coded in "Open Data Kit (ODK)" software [40] on tablets (Samsung Galaxy note 10.1 N8010) and contained questions on the use of water sources, psychological factors concerning water handling and hygiene practices, observations of WASH infrastructure, information on WASH promotion activities received, and children's history of waterborne illnesses in the past seven days, including potential confounders, such as socio-demographic and economic factors. The questionnaire was developed using standardized questions in line with international guidelines, incorporating necessary amendments as per our study areas [41, 42]. The questionnaire was developed in English and translated into Nepali, with a back-translation. Interviewers were intensively trained for two days on data collection procedures. Pretesting was done in early March 2018 with households in an area with similar socioeconomic conditions as the study areas. Detailed interviews were conducted with caregivers during the pretesting to ascertain the reliability of the questions used in the final survey instrument [43]. Adaptations to the questionnaire were made after pretesting.

Child diet and household food security

Child dietary information was assessed following the guidelines of the Food and Agricultural Organisation (FAO) [42]. The caregivers were requested to recall whether or not the nine different food groups were consumed within the past seven days and, if consumed, the frequency of consumption. The survey methods were adapted by conducting detailed interviews during pre-testing to ascertain accuracy. In addition, supervisors re-interviewed a subset of surveyed households to assess reproducibility [43]. Household food security was assessed by questions relating to the adequacy and availability of food during the entire year.

Anthropometric measurements

Trained paramedics collected anthropometric measurements, adhering to the standard procedures [44]. Supine lengths were obtained for children younger than two years old (using a Seca BabyMat 210). For children aged more than 24 months to 10 years, a height measuring board and a digital scale (Seca 877; Hamburg, Germany) were used with a precision of 0.1 cm and 0.1 kg, respectively. Before each measurement, scales were calibrated with a standardized weight and the children were measured barefoot [43]. Anthropometric indices were calculated using the AnthroPlus (WHO; Geneva, Switzerland) in accordance with the World Health Organisation (WHO) [45, 46]. Age in total months was recorded for each child and confirmed with an inspection of the birth certificate. Three anthropometric indices: (a) weight-for-age (WAZ, underweight); (b) height-for-age (HAZ, stunting); and (c) body mass index-for-age (BMIZ, thinness) were expressed as z-scores (i.e. differences from the median in standard deviations) [8]. Z-scores of ≥ -2 were regarded as normal, those between < -2 and ≥ -3 as indicating moderate undernutrition and those below < -3 as severe undernutrition [44, 45]. Children were considered to be undernourished if at least one of the anthropometric indices indicated undernutrition.

Parasitological survey

On the day following the household survey visit, caregivers were requested to provide a fresh morning stool sample without urine contamination from the participating child. The samples were processed on the same day by two experienced laboratory technicians. Each stool sample was analysed using direct wet-mount and formalin-ether concentration techniques to detect intestinal protozoa and helminths following standard guidelines [47–49]. In addition, a duplicate Kato-Katz thick smear was prepared for the diagnosis of helminths [50]. The presence of infection by any worm species was defined by the detection of one or more eggs on either slide [13]. Children were considered positive if at least one of the diagnostic techniques revealed an infection.

The infection intensity of helminths was calculated based on criteria defined by the World Health Organisation (WHO) and multiplied by 24 to reach the total number of eggs per gram (EPG) of stool. Infection intensities were then classified as light, moderate and heavy as per the threshold set by WHO [51, 52].

Signs and symptoms of nutritional deficiencies

During the household survey, the children were screened for clinical signs and symptoms indicating nutritional deficiencies, such as wasted appearance (protein deficiency), loss of hair pigment and easy “pluckability” (protein deficiency), bitot’s spot (vitamin A deficiency), dry and infected cornea (vitamin A deficiency), oedema (thiamine deficiency), several types of dermatitis (niacin deficiency), spongy, bleeding gums (vitamin C deficiency), pale conjunctiva (iron-deficiency anaemia), red inflamed tongue (riboflavin deficiency), sub-dermal haemorrhage (vitamin C deficiency), bowed legs (vitamin D deficiency), and goitre (iodine deficiency) [53].

Drinking water quality examination

Water samples were collected from the household’s main drinking water source (point of collection) and from the container used for drinking water transport and storage (point of use). For the water quality examination at the point of use, the caregivers were requested to bring fresh drinking water in situ from the point of collection to the household in the same container they used to fetch their drinking water daily [54]. The sample at the source was taken after first, letting the water run for 60 seconds from the tap, and then filling a sterile Nasco Whirl-Pak bag. Back at the household, a second water sample was taken by pouring water from the transport container into another sterile Nasco Whirl-Pak bag. All water samples were stored inside cooler bags and immediately analysed at the field site using the membrane filtration technique, as follows: 100 ml water samples were passed through sterile 0.45 μm millipore cellulose membrane filters, using sterilized filtration equipment. The filter pads were plated on Nissui Compact Dry Coli-scan plates and incubated for 24 hours at 35 +/- 2°C. A solar energy based electrical power supply system was set-up to run a low-power incubator at the field-site. Colony forming units of total coliforms and *E. coli* were counted after 24 hours of incubation.

Data management and statistical analysis

Data cleaning was performed daily during the survey and if there was any missing value or inconsistency, the respective household was consulted the following day. Readings of intestinal parasites and nutritional deficiencies screening results were double entered into an Excel 2010 spread sheet (Microsoft; Redmond, USA) and cross-checked. Numerical variables were described by means and standard deviations if normally distributed and by medians and interquartile range, otherwise. Categorical variables were described by absolute and relative frequencies. We employed χ^2 statistics to assess the differences in distribution for categorical variables between the study areas. Household socioeconomic status was characterised by factor analysis, which included the reported household assets, such as the availability of electricity, radio, television, solar panel, mobile phone, bicycle, motorbike, fridge, watch, own house, and land ownership. Three factors reflecting three different socioeconomic domains were retained, and divided into three categories: (a) low, (b) medium and (c) high, using the k-means procedure [55]. The median of the score from factor analysis was categorised as poor, medium or better depending on whether the scores were below, at or above the medium. The same procedure was applied to create one variable for the hygiene of drinking water transport and water storage containers, latrine hygiene, the household environment, kitchen and the personal hygiene. Of these, three factors were retained and categorised, reflecting poor, moderate and better status.

We assessed four outcome variables: (a) intestinal parasitic infection, (b) diarrhoea, (c) undernutrition including stunting, thinness and underweight, and (d) clinical signs and symptoms of nutritional deficiencies. The associations between the outcome variables and risk factors were assessed first by conducting univariate mixed logistic regression analyses with random intercepts of the study areas. Since only a few undernutrition cases were of a severe nature, the cases were pooled into a binary variable of stunted/non-stunted, and underweight/non-underweight, for the subsequent analysis. Similarly, there was a low prevalence of parasites, such as *T. trichiura, E. vermicularis* and hookworm, so all reported intestinal parasitic infections were pooled into a binary variable of parasite infection/no infection to maximize statistical power. The clinical signs of nutritional deficiencies and diarrhoea outcomes were already coded into binary variables and were used as such for the subsequent comparative analysis.

We assessed associations between the binary outcome variables and hypothesized risk factors using a multivariate mixed logistic regression model with random study area intercepts and controlling for demographic variables, such as age, sex and socioeconomic status, as potential confounders. The variables with $P<0.2$ in univariate analysis (using likelihood ratio test) were included in the final multivariate model. Odds ratios were reported and the associations were considered as statistically significant if p-values were <0.05. The statistical analyses were done with STATA version 14 (STATA Corporation, College Station, TX, USA).

Results

Socio-demographic characteristics of the study participants

The details of the socio-demographic and socioeconomic characteristics of the interviewed households are provided in Table 1. Interviewees were roughly equally distributed across the four areas (Table 1). Among the 1427 interviewees interviewed, 25.0% were from Surkhet A, 25.1% from Surkhet B, 23.3% from Dailekh and 26.6% from Achham District. Caregivers aged 25–40 years of age constituted the largest group (57.9%), whereas those aged >40 years constituted the smallest group (13.9%). More than 80% of the caregivers could both read and write. More than half (64.5%) of the survey participants had 5–10 people residing within their household. Agriculture was the main (60.6%) occupation of the household heads. A total of 59.7% of the households kept animals inside the home overnight. A majority (84.1%) of the households had earthen floors. The majority of children (99.1%) included in the study were between 6 months and 5 years (<5 years) of age, while 0.9 % were age 6 to 10 years (>5 years). The number of children per household in the age range surveyed varied between one and six. Around 52.7% of the households across the study areas had access to electricity. The study areas significantly differed in terms of the distribution of sex, age, education, number of people residing in the household, animals kept inside the household, and the type of floor materials used in the household ($P = 0.01$).

Water handling, water quality, sanitation, hygiene and WASH promotion

Tables 2 and 3 describe water handling, water quality, sanitation and hygiene practices, WASH infrastructure, WASH promotion and WASH related psychological factors in the households stratified by the four study areas. 75.5% of the respondents depend on a communal village tap for drinking purposes, 20.7% have access to piped water in the house or yard, and the remaining respondents use open water sources (1.7%), unmanaged pipe systems (0.3%) and the river (0.3%). More than half (54.4%) of the respondents were quite confident about the safety of the available drinking water. Only 16.5% of the households reported treating their water at the point of use. One third (33.7%) of the respondents reported disliking the taste of treated water. Virtually all of the respondents (99.0%) cleaned their containers used for drinking water transport and storage at least every other day. Soap or ashes were used for cleaning these containers (42.2% *vs.* 47.4%, respectively) (Table 2).

Regarding water quality, we found that the vast majority of water samples from the point of collection and point of use were contaminated with *E. coli* (93.6% and 95.3%, respectively) and total coliform bacteria (99.4% and 98.8%, respectively). 5% of the water samples at the point of consumption confirmed with WHO's guidelines for microbial safety of drinking water (<1 CFU *E. coli*/100 mL), 16% were in the low risk category (1–10 CFU *E. coli*/100 mL), 51% in the intermediate risk category (10–100 CFU *E. coli*/100 mL) and 28% in the high or very high risk categories (>100 CFU *E. coli*/100 mL) [56]. Further details of the microbial water quality at the source and the point of use are presented in Table 2.

Concerning sanitation and hygiene, 6.3% of the households did not have latrines, and 93.7% of the households had traditional pit latrines. Almost half of the latrines (48.7%) were in a poor hygienic state (lowest category). 76.0% of the respondents reported having washed their hands with soap less than five times per day prior to the day of survey. The overall hygiene conditions were very low or low in 64.0% of the surveyed households. In addition, 42.8% of the caregivers and their children had a low personal hygiene score (Table 3).

Only 10.9% of the respondents reported having received information on water treatment and hygiene. Among those, 89.7% reported that this information changed their WASH behaviour, e.g. using soap more often for washing hands. About 52.2% of the respondents reported door to door visits as an effective means of hygiene literacy promotion (Table 3).

Child health, health-seeking behaviours and KAP survey

Table 4 shows the percentage distribution of child health records, health-seeking behaviours, and risk awareness of the causes of diarrhoea and of perceived vulnerability stratified by study areas. A total of 49.9% of the children from under age 6 months to five years were reported to be sick within seven days prior to the survey. Respiratory illnesses and fevers were most common (both 40.4%) followed by diarrhoea (16.5%). For respondents not seeking health care services, the main reason was a feeling of non-requirement (61.9%), followed by financial constraints (21.2%), preference of self-treatment (7.1%), and lack of accessibility (1.8%) (Table 4).

A majority (82.7%) of the respondents knew that contaminated water can cause diarrhoea and that children are particularly vulnerable (74.4%). However, a majority (78.9%) of the respondents had never heard about intestinal parasites. Similarly, awareness about how to prevent intestinal parasites was low. The frequency of caregivers being aware that the following behaviours might prevent intestinal parasites were: handwashing with soap 11.1%, wearing shoes 5%, drinking clean water 16.6%, and undergoing regular deworming treatment 11.1% (Table 4).

Prevalence of diarrhoea and associated risk factors

Tables 4 and 5 show the prevalence of diarrhoea and associated risk factors, respectively, in the study sample. A total of 16.5% <5 years children's suffered from diarrhoea within the seven days prior to the survey. The results from the multivariate regression analysis demonstrated that children above the age of five showed significantly lower odds of diarrhoea (adjusted odds ratio (AOR) = 0.39; 95% CI: 0.26–0.57; *P* = 0.01) compared to their younger counterparts. The children from the households experiencing a service interruption of more than one week of their main drinking water source at the time of visit had 2.87 higher odds of suffering from diarrhoea (AOR = 2.87; 95% CI: 1.24–6.61; *P* = 0.01) than children from households not experiencing an interruption. The children of caregivers who were aware of the need for handwashing during critical times, such as after using the latrine, were significantly protected against diarrhoea (AOR = 0.37; 95% CI: 0.14–1.10; *P* = 0.05) compared to children whose caregivers were unaware. Households with clean latrines were significantly protected against diarrhoea (AOR = 0.66; 95% CI: 0.45–0.95; *P* = 0.03) compared to households with dirty latrines. Similarly, the children with visually clean hands without spots of dirt were significantly protected against diarrhoea compared to children with dirty hands (AOR = 0.63; 95% CI: 0.41–0.98; *P* = 0.04). Children living in households with a floor made of "earth painted with cow dung" had 2.29 times higher odds of suffering from diarrhoea than children living in households with a cement floor (AOR = 2.29; 95% CI: 1.20–4.37; *P* = 0.01).

Prevalence of intestinal parasites and associated risk factors

A table 6 and 7 shows the prevalence of intestinal parasitic infections in the study population and the associated risk factors. The overall prevalence of intestinal parasitic infection is 51.1%.The prevalence of intestinal parasitic infections, stratified by sex, age group and study area, are summarised in Table 6. The predominant helminth species infecting the children was *Ascaris lumbricoides* (21.1%), followed by *Hymenolepsis nana* (4.6%), hookworm (3.2%), *Enterobius vermicularis* (2.7%), and *Trichuris trichiura* (0.7%). Polyparasitism and co-infection were not common. Significant differences across the study areas were observed for all recorded helminths except for *Trichiuris trichiura (P* = 0.23). Infections with all types of helminths were of light intensity. About 23.4% of the children were infected with *Giardia intestinalis* (Table 6).

Multivariate analysis showed that the odds of infection with intestinal parasites among children in households where the caregivers could only read were four times higher than the odds among children whose caregivers could both read and write (AOR = 4.07; 95% CI: 1.00–16.55; *P* = 0.05). Children in households relying on a simple pit latrine for defecation had six times higher odds of being infected with intestinal parasites than those in households with a pour flush pit latrine (AOR = 6.12; 95% CI:1.57–23.9; *P* = 0.01). Children with caregivers having clean hands were significantly protected from intestinal parasitic infection (AOR = 0.61; 95% CI: 0.41–0.89; *P* = 0.01) compared to children of caregivers with dirty hands (Table 7).

Child-feeding practices and household food security

Almost all caregivers (99.6%) reported having breastfed the participating child. Only 1.3% of the children were breastfed less than six months. About 97.0% of the children received weaning food at the age of five months for girls and at the age of six months for boys (during the traditional rice feeding ceremony in Nepal). About 43.3% of the children received food supplements in addition to regular meals. The dietary diversity scores were low with only 11.2% of the households having consumed all listed nine food groups in the past seven days (Table 8 and Additional file 1: Supplementary Table 1). The consumption of milk or milk products and eggs at least once per week was low (9.2% and5.3%, respectively) (Additional file 1: Supplementary Table 1). About 60% of the households never produced their own food and among the households that did produce their own food, 20.8% reported self-sufficiency throughout the entire year. All the analysed variables were significantly different across the study areas.

Prevalence of undernutrition and associated risk factors

Table 9 shows the percentage distribution of undernutrition in the study sample stratified by sex, age groups and study areas. The prevalence of undernutrition was high at 55.5%, while the prevalence of stunting was 44.5%, thinness 11.2%, and underweight 29.9%.

Table 10 provides an overview of the association between undernutrition and the caregiver's socioeconomic status, nutrition and health awareness, attitude and practices, intestinal parasitic infections, hygiene status, and water quality of the households obtained in univariate and multivariate regression analysis. Children living in a household of higher socioeconomic status showed lower odds of undernutrition (AOR = 0.43; 95% CI: 0.25–0.75; *P* = 0.00) compared with households with lower socioeconomic status. Children of caregivers with sound knowledge about the importance of regular deworming had lower odds of undernutrition (AOR = 0.44; 95% CI = 0.20–0.94; *P* = 0.03) compared to children whose caregivers had no such knowledge. Children receiving supplementary food were at significantly lower odds of being undernourished (AOR = 0.57; 95% CI: 0.38–0.84; *P* = 0.01) compared to the children without supplementary food. Similarly, households producing their own food were at significantly lower odds of being undernourished (AOR = 0.67; 95% CI: 0.46–0.97; *P* = 0.03) than were households without agricultural production.

Prevalence of nutritional deficiencies and associated risk factors

A total of 63.9% of the children in the study suffered from at least one sign of a nutritional deficiency. About one third (35.9%) of the children suffered from pale conjunctiva) a sign of iron deficiency and anaemia; followed by Bitot's spot (19.8%), a sign of vitamin A deficiency; red inflamed tongue (18.3%), a sign of riboflavin deficiency (Vitamin B2); spongy bleeding gums (16.3%), a sign of vitamin C deficiency; wasted appearance (13.8%), a sign of protein deficiency; dry and infected cornea (13.2%), a sign of vitamin A deficiency; loss of hair pigment (10.7%), a sign of protein deficiency; sub-dermal haemorrhage (4.6%), a sign of vitamin C deficiency; oedema (2.7%), a sign of thiamine deficiency (Vitamin B1); bowed legs (2.6%), a sign of vitamin D deficiency; and goitre (0.6%), a sign of iodine deficiency (Table 9).

The children >5 years had twice the odds of having nutritional deficiencies compared to their younger counterparts (AOR = 1.84; 95% CI: 1.30–2.62; $P = 0.01$). Children whose caregivers washed their hands after cleaning a baby's bottom were at lower odds of having nutritional deficiencies (AOR = 0.60; 95% CI = 0.40–0.92; $P = 0.02$) compared to children whose caregivers did not follow this practice. Children whose caregivers were aware of the benefit of wearing shoes were at lower odds of having nutritional deficiencies (AOR = 0.24; 95% CI: 0.09–0.62; $P = 0.01$) compared to those whose caregivers were unaware. Children from households producing their own food were significantly protected against nutritional deficiencies (AOR = 0.51; 95% CI: 0.35–0.76; $P = 0.01$) compared to children from households without their own food production. On the other hand, children from households in the higher category of latrine hygiene were at higher odds of nutritional deficiencies than latrines without any hygiene (AOR = 0.61; 95% CI: 0.41–0.91; $P = 0.01$). Children living in houses where animals were kept inside overnight had 1.71 times higher odds of having signs of nutritional deficiencies (AOR = 1.71; 95% CI = 1.17–2.51; $P = 0.01$) than children from households not keeping animals inside the home overnight. Being in the lower category of personal hygiene increased a child's odds for clinical signs of nutritional deficiencies by 1.84 (AOR = 1.90; 95% CI: 1.17–3.10; $P = 0.01$) compared to being in the higher category. Children from households having coliform bacteria in their drinking water sources had 10.4 times higher odds of having signs and symptoms of nutritional deficiencies (AOR = 10.4; 95% CI: 1.61–67.42; $P = 0.01$) than children from households with an uncontaminated water source (Table 11).

Discussion

Our findings highlight several important health and WASH issues in remote areas of rural Nepal. Household and personal hygiene, including adequate handwashing, appropriate sanitation and access to regular and safely managed drinking water supply in the surveyed area, were inadequate. These poor WASH conditions were associated with diarrhoea, parasitic infections and nutritional deficiencies, which were highly prevalent among the surveyed children. More than half of the children in the study area suffered from undernutrition. This alarming health outcome was mainly linked to the low socio-economic status of the household, poor nutrition, and to the lack of regular deworming activities, but undernutrition was not significantly associated with poor WASH conditions.

The high prevalence of intestinal parasitic infections among children (51.1%) found in our study is similar to or higher than the rate reported in studies conducted in other parts of Nepal [30, 31, 57]. The higher infection rates could be explained by the fact that our study areas were located in extremely remote rural and hilly areas where accessibility was difficult and there was a lack of infrastructure, which together result in a low level of access to basic health and WASH services [30, 31, 57]. Our analysis revealed that children from households without latrines developing a parasitic infection relative to those with latrines were four times likely to have infected with an intestinal parasites. This indicates that the poor hygienic status observed in the pit latrines used by more than 94% of the households and lack of water to flush the toilets is a major risk factor in the transmission of parasites.

The effect of inadequate sanitary conditions on intestinal parasitic infections was also documented in a systematic review and meta-analysis [58]. In our own study, we observed unsanitary practices that likely increased the presence of faecal pathogens in the household environment. For example, direct observation of toilets showed that many were stained with faecal matter. Additionally, the practice of keeping animals in or near the home, and sometimes bringing animals indoors overnight was observed in 59.7% of households. Such practices have been shown to increase exposure to faecal contamination in the household environment on other rural settings [26]. A majority of the houses (84.1%) were equipped with mud floors inside the dwellings. These floors are regularly painted with cow dung—a practice that may also lead to a significant increase of fecal pathogens in the household. Children playing on the floor inside the house or around the house are at a high risk of ingesting pathogens present in such settings [59, 60]. In addition, food and drinking water were frequently kept uncovered in the kitchen and handled unhygienically, as described by studies conducted elsewhere [61, 62].

The cleanliness of caregivers' hands was identified as a significant risk factor for children's parasitic infections, suggesting that caregivers' hands play a critical role in transferring parasites from the household environment to their children. There is strong evidence that a high load of pathogens in the household environment and inadequate handwashing cause an increased pathogen load on caregivers' hands [60]. We observed poor handwashing conditions, with 59.9% of households not having adequate infrastructure to wash hands and a limited presence of soap/water at the handwashing stations. Handwashing practices were largely insufficient, with 76% of the caregivers stating that they wash their hands with soap less than five times per day. The importance of clean hands to prevent parasitic infections is in agreement with previous studies conducted in eastern Nepal and Turkey where not using soap after defecation were significantly found to be associated with parasitic infection [31, 63]. The association between critical sanitation and hygiene factors and infections with intestinal parasites was also documented by studies conducted in other parts of Nepal [31, 64, 65].

Our study found that water quality at the point of consumption for the majority (78%) of households was in the intermediate or higher risk categories, according to WHO's guidelines for drinking water quality [56]. Even though most of all drinking water was collected from improved sources, high contamination levels were also measured at the source. This is similar to the findings of studies conducted elsewhere where improved sources were not necessarily safe [66] and contamination of the drinking water during transportation was reported [25, 67–70].

Surprisingly, despite the low quality of the water consumed, we did not find any association between drinking water quality and parasitic infections in the study households. We hypothesize that the transmission of pathogens through drinking water was minor compared to the high loads of pathogens existing in the household environment due to unhygienic sanitation, the practice of painting the earthen floors with cow dung and the presence of animal feces in and around the house. Contrary to this, two other recently conducted studies in Nepal identified the consumption of untreated water as a risk factor for infection with *Giardia* species [30, 65]. These studies, however, may have been conducted in a different, hygienically less challenging context.

We also examined the association between intestinal parasitic infections and different socio-demographic variables. Children belonging to households where caregivers could read but not write, or had not received any education, were at higher odds of intestinal parasitic infections compared to children whose caregivers could both read and write. These results are in line with those reported by Sah et. al (2013) which found higher prevalence of intestinal parasitic infection among children's belonging to the parents who have lower education in comparison to those of the children's with parents having higher education. [31].

The presence of livestock close to or inside the households, visible manure piles and the practice of spreading cow dung on the walls and floors of households likely pollute the household environment with faecal pathogens. This assumption is confirmed by several studies that associate the contamination of the floor with *E. coli* with the disposal of children's faeces and the presence of animals in close proximity to the households. Kwong et. al reported that 35% of the children put their hands in their mouths after touching soil particles, putting them at risk of contamination [70]. The studies conducted in India and Bangladesh [71–74] reported that faecal contamination in the domestic environment, including source and stored drinking water, hands and soil, was more prevalent from animals than from humans [75, 76]. We think that, similar to parasitic infections, a high load of pathogens in the household environments are due to unhygienic sanitation and inadequate hygiene practices, as well as the presence of animal faeces in and around the house, and that these were important risk factors for the diarrhoea burden in the study population [62, 73, 74, 76].

Interruptions of the water supply were associated with diarrhoea. Caregivers who reported more frequent interruptions to their drinking water systems that lasted more than a week, had 2.7 times higher odds of having children with diarrhoea. Underlying reasons could be the subsequent lack of water for hygienic practices or it could be that intermittent water services exhibit an increased risk of bacterial contamination in the system or it could be that the risk of pathogen infiltration is greater during such low pressure events in the piped network [77, 78]. Past research has reported that the households with the presence of *E.coli* in their drinking water were 3.6 times more likely to have children with diarrhoea than those that had water in compliance with WHO's guidelines for drinking water quality [56]. However, since only 5% of the households had water without any detectable *E.coli,* the association between diarrhoea and water quality was not significant in the multivariable regression model. Similar results were reported in other studies conducted in low- and middle-income countries, demonstrating that improvements in drinking water and sanitation are associated with decreased odds of diarrhoea [20, 79]. Specific improvements, such as the provision of high-quality piped water, sewer connections and the use of water filters, were associated with greater reductions in diarrhoea [79].

Our study found a high prevalence of undernutrition (55.5%) with stunting alone being at 44.5%. A reason for this could be that the study areas are located in food-scarce regions where agricultural activity has been affected by the impact of climate change, i.e. untimely heavy rainfall, droughts and hailstorms. Rural households in these areas are generally poor and their resilience and coping abilities to deal with reduced agricultural productivity is low. The vulnerability of low-income households towards increasing prices for food items has been demonstrated by Green et al [80]. In our multivariable mixed logistic regression analyses, undernutrition was significantly associated with a household's lower socioeconomic status, lower production of one's own food, lower provision of supplemental food to children and irregular deworming activities.

Although the relation between undernutrition and parasitic infections is not well understood, undernutrition may be caused by recurring infections in the gut, which limit the proper absorption of calories and nutrients [81, 82]. Our findings on the association between undernutrition and intestinal parasitic infection are in agreement with studies conducted elsewhere [82, 83]. However, contrary to findings from a study conducted in Bangladesh, our study did not identify recent diarrhoea infection as a risk factor for undernutrition [84]. As we collected data during a cross-sectional survey, we do not have any longitudinal information on the frequency and severity of diarrhoea cases occurring in the study population. We think that there is a high chance that chronic diarrhoea, as well as environmental enteropathy, are linked with undernutrition in our study site, but our data only refers to one point in time and, thus, cannot be confirmed [85–87]. WASH indicators were only significantly related with undernutrition in univariate analysis, but not in the multivariable logistic regression models. In univariate analysis, we found that low hygiene score in the kitchen, low personal hygiene of the caregiver and the child, and the presence of *E.coli* or total coliforms in the water source were associated with undernutrition.

Even though WHO recommends to start providing infants food in addition to breast milk from six months onwards [88], 97% of the children participating in the study received weaning food before this age. Multivariable mixed logistic regression analyses revealed considerably higher odds of undernutrition among children who were introduced with weaning food at an age of less than 6 months; however, the association was not significant. Nepal has a culture of starting to wean girls at five months, while boys usually receive weaning food at six months of age. The weaning practices before reaching six months of age may have caused some food borne infections and environmental enteropathy, resulting in nutritional deficiencies and undernutrition since the food provided to the infants was likely to be contaminated [82, 85]. We observed unhygienic handling and improper storage of food in the study areas—96% of the households did not have a refrigerator. Unsafe water was used to wash feeding and storage containers, unhygienic kitchen clothes were used to dry children's utensils and caregivers did not wash their hands with soap while preparing and feeding children. In addition, 76.8% of the households had flies indoors and in their surroundings. The recurrent food borne infections may have resulted in nutritional deficiency, environmental enteropathy, and consequently undernutrition [4, 82, 85, 89]. Similar observations of unsafe WASH and inadequate food hygiene were reported in a study conducted in other parts of Nepal [28]. A study from Mali showed that about 55% of complementary food samples used during weaning practices were infected with faecal coliform bacteria and might have been the main contributing factors to the poor nutritional status and infections among children under five years of age [90]. A study conducted in Kenya reported an association between the early introduction of complementary foods to children less than six months of age and stunting [91]. We found a significant protective association between children (six months to ten years) who received food supplements in addition to regular meals. This is in line with other studies that found a significant impact of nutrition on growth [92, 93]. However, surprisingly, we did not find a significant association between dietary diversity scores and undernutrition, which is in contrast to a study conducted in Indonesia that reported of higher dietary diversity scores associated with lower likelihood of child stunting [94]. We assume that several confounding factors, such as household environment could mediate the effect of dietary diversity on undernutrition status, indicating the need for more depth research in this study population.

The prevalence of having at least one clinical sign for a nutritional deficiency was high (63.9%). Because there is a dearth of studies conducted on children having clinical signs of nutritional deficiencies in Nepal and other similar countries in terms of geography, income level of its population, literacy level and life expectancies, our results cannot be compared with other studies. The most frequently encountered nutritional deficency, pale conjunctiva (Niacine deficiency), which was found in 36.0% of children, can be related to the lack of animal proteins in diets.

Contrary to our results regarding risk factors associated with undernutrition, clinical signs of nutritional deficiencies were significantly associated with WASH conditions. Our analysis identified a significant protective association with handwashing, improved latrine cleanliness and lower number of total coliforms in the drinking water source. In contrast, signs of nutritional deficiencies were positively associated with keeping animals inside the house and the low personal hygiene of caregivers and of the children. Further in-depth research is required to provide more insight into these issues.

Our study has several limitations. First, this study is a cross-sectional survey conducted during spring time. Hence, the results reflect only one point of time. Although the association between diarrhoea, environmental enteropathy and undernutrition is well established in literature [81, 85, 87], recent diarrhoea infection in our study population was not identified as a risk factor for undernutrition. To assess this association, we propose to implement a controlled longitudinal study design that involves the collection of data on recurring chronic diarrhoea and which would measure markers of environmental enteropathy. Second, we consider some of our outcome variables such as diarrhoea to be subject to a seasonal effect [8, 95, 96]. Third, the findings presented in our study cannot be generalised to other rural areas of Nepal, as the study was conducted in an extremely remote setting characterized by exceptionally low access to basic services. Third, an anthropometric survey has certain limitations related to the inaccuracy of children's dates of birth [95]. Although, we checked available birth certificates to validate the reported ages, these certificates were not always forthcoming. Fourth, only one stool sample per participating child was examined by a double Kato-Katz thick smear, which likely led to an underestimation of the true prevalence of parasitic infections due to the low sensitivity of the Kato-Katz technique. Fifth, the information we obtained during the interviews was self-reported by the caregivers and may be subject to recall and respondent bias [8, 97].

Conclusion

This study provides new insight into the burden of intestinal parasites, childhood waterborne illnesses (i.e. diarrhoea), undernutrition and nutritional deficiencies among children living in extremely remote hilly areas of Nepal. Our study shows that these health measures were all are highly prevalent in the study areas and that drinking water quality is poor. We found that all health outcome measures (intestinal parasitic infections, childhood waterborne illnesses, undernutrition and nutritional deficiencies) showed strong negative associations with household hygiene, such as appropriate sanitation, adequate handwashing, good personal hygiene, and access to safely manage drinking water supply, as well as the provision of adequate nutrition. In view of these findings, concerted efforts are needed to improve nutrition and household hygiene, e.g., by improving infrastructure, water quality and behaviour supporting appropriate sanitation, adequate handwashing, and good personal hygiene. We also suggest that greater attention should be given to children living in such hard-to-reach areas of Nepal. The surveyed children have serious unaddressed health and nutritional needs. A diet rich in energy and micronutrients needs to be complemented with adequate WASH infrastructure and, more importantly, with appropriate hygiene behaviour as well as household environment to reduce the health risks of intestinal parasites and childhood waterborne illnesses, including diarrhoea, nutritional deficiencies and undernutrition.

List Of Abbreviations

aOR - Adjusted Odds Ratio

BMIZ - Body Mass Index Z score

EPG - Eggs per gram

FAO - Food and Agricultural Organisations

HAZ - Height for age Z score

KAP - Knowledge, Attitude and Practices

SDC - Sustainable Development Goals

WAZ - Weight for age Z score

WASH - Water, sanitation and hygiene

WARM-P - Water Resource Management-Programme

WHO - World Health Organisations

Declarations

Ethical approval and consent to participate

The study protocol was approved from the “Stellungnahme der Kantonalen Ethikkommission, Zurich” in Switzerland (KEK, reference no. 2018–00089) and the “Nepal Health Research Council, Kathmandu” in Nepal (NHRC, reference no. 2956). Caregivers of the participating child were informed about an objectives and procedure of the study and written informed consent was obtained. Written informed consent for participation in the study was obtained where participants are children (under 16 years old) from their parents or guardian. For illiterate caregivers, a fingerprint was obtained in the presence of literate person from either the household or village. Voluntary participation was emphasized and informed to the caregivers that they could withdraw anytime without obligations. The unique identifying code was provided to each household. Results were communicated with the caregivers and when the child found positive with either intestinal parasites or nutritional deficiencies or malnutrition, were referred to the collaborated government health facilities where they get treatment free of charge.

Consent to publish

Not applicable

Availability of data and material

The dataset and the questionnaire supporting the conclusions are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no conflict of interest.

Funding

This work is supported by the Swiss Agency for Development and Cooperation and the REACH project. The donors had no role in either study design or data collection or analysis or the preparation of the manuscript or the decision to publish the manuscript.

Authors contribution

The following authors contributed to the study design: RM, AS and SM. RM, AS, JS, DD, RS and MB coordinated the field and laboratory work, and supervised the research assistants. AS, RM, JS, DD, SM performed the statistical analysis and drafted the manuscript. All authors contributed to the interpretation of the data, manuscript writing and revisions. All authors read and approved the final manuscript.

Acknowledgements

We would like to thank all caregivers in the households for their participation and their commitment. We would like to acknowledge Prof. Dr. Christian Schindler from the Swiss Tropical and Public Health Institute for checking the statistical analysis and providing input to the manuscript. We also would like to thank the team of the HelvetasSwiss Intercooperation Nepal for their support and technical assistance during the field work. Lastly, we would like to thank our field team for their efforts in data collection.

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Tables

Table 1 Characteristic of the study populations in the three regions of Nepal in March-May 2018 [N=1427]

Demographic and socioeconomic characterisitcs	[N(%)]	Surkhet A [n(%)] N=356	Surkhet B [n (%)] N=358	Dailekh [n (%)] N=333	Accham [n(%)] N=380	*p* value*
Caregivers sociodemographic characteristics (N=1427)						
Sex of the caregivers						
Female	1347 (94.4)	337 (96.8)	358 (98.1)	332 (93.3)	320 (89.4)	0.01
Male	80 (5.6)	11 (3.2)	7 (1.9)	24 (6.7)	38 (10.6)	
Age of the caregivers[a]						
15-25 years	402 (28.2)	105 (30.2)	120 (32.9)	105 (29.5)	72 (20.1)	0.01
25-40 years	827 (57.9)	193 (55.5)	215 (58.9)	207 (58.1)	212 (59.2)	
> 40 years	198 (13.9)	50 (14.4)	30 (8.2)	44 (12.4)	74 (20.7)	
Total people living in the household						
1-5 people	421 (29.5)	110 (31.6)	122 (33.4)	120 (33.7)	69 (19.3)	0.01
5-10 people	921 (64.5)	216 (62.1)	227 (62.2)	219 (61.5)	259 (72.3)	
10-15 people	78 (5.5)	20 (5.8)	14 (3.8)	15 (4.2)	29 (8.1)	
>15 people	7 (0.5)	2 (0.6)	2 (0.5)	2 (0.6)	1 (0.3)	
Age of the children included in the study						
< 5 years	1414 (99.1)	346 (99.4)	362 (99.2)	353 (99.2)	353 (98.6)	0.70
> 5 years	13 (0.9)	2 (0.6)	3 (0.8)	3 (0.84)	5 (1.40)	
Caregivers education characteristics						
Can neither read or write	235 (16.5)	32 (9.2)	12 (3.3)	41 (11.5)	150 (41.9)	0.01
Can read only	24 (1.7)	3 (0.9)	6 (1.6)	14 (3.9)	1 (0.3)	
Can both read or write	1168 (81.8)	313 (89.9)	347 (95.1)	301 (84.5)	207 (57.8)	
Highest education level the caregivers have completed						
Informal education	412 (28.9)	49 (14.1)	37 (10.1)	109 (30.6)	217 (60.6)	0.01
Primary	484 (33.9)	135 (38.8)	195 (54.4)	101 (28.4)	53 (14.8)	
Secondary	362 (25.4)	126 (36.2)	106 (29.0)	89 (25.0)	41 (11.4)	
College and higher	100 (7.0)	18 (5.2)	25 (6.8)	44 (12.4)	13 (3.6)	
None	69 (4.8)	20 (5.7)	2 (0.5)	13 (3.6)	34 (9.5)	
Occupation of the head of the household[b]						
Agriculture	865 (60.6)	159 (45.7)	188 (51.5)	250 (70.2)	268 (74.9)	0.01
Business	145 (10.2)	20 (5.7)	34 (9.3)	57 (16.0)	34 (9.5)	0.01
Daily laborer	517 (36.2)	118 (31.9)	127 (34.8)	100 (28.1)	172 (48.0)	0.01
Private employed	175 (12.3)	43 (12.4)	69 (18.9)	47 (13.2)	16 (4.5)	0.01
Government service	56 (3.9)	22 (6.3)	17 (4.7)	11 (3.1)	6 (1.7)	0.01
Other independent work	7 (0.5)	2 (0.6)	3 (0.8)	1 (0.3)	1 (0.3)	0.68
Retired with pension	5 (0.3)	2 (0.6)	1 (0.3)	2 (0.6)	0 (0.0)	0.55
None	12 (0.8)	0 (0.0)	4 (1.1)	3 (0.8)	5 (1.4)	0.21
Occupation of the spouse of the household head[b]						
Agriculture	1280 (89.7)	321 (92.2)	319 (87.4)	307 (86.2)	333 (93.0)	0.01
Service	45 (3.1)	10 (2.9)	13 (3.6)	15 (4.2)	7 (2.0)	0.35
Small business	106 (7.4)	12 (3.4)	24 (6.3)	46 (12.9)	24 (6.7)	0.01
Daily laborer	58 (4.1)	7 (2.0)	7 (1.9)	5 (1.4)	39 (10.9)	0.01
Other independent work	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)	0.39
None	12 (0.8)	0 (0.0)	10 (2.7)	2 (0.6)	0 (0.0)	0.01
Foreign employment	2 (0.1)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)	0.56
No spouse (single or widow)	10 (0.7)	1 (0.3)	2 (0.5)	4 (1.1)	3 (0.8)	0.58
Ethinicity						
Dalit	451 (31.6)	81 (23.3)	161 (44.1)	111 (31.2)	98 (27.4)	0.01
Janajati	266 (18.6)	161 (46.3)	103 (28.2)	1 (0.3)	1 (0.3)	
Brahmin, Chhetri, Thakuri	704 (49.3)	106 (30.5)	101 (28.7)	238 (66.8)	259 (72.3)	
Other	6 (0.4)	0 (0.0)	0 (0.0)	6 (1.7)	0 (0.0)	
Any member in a household holding a leadership position in the community	139 (9.7)	38 (10.9)	39 (10.7)	20 (5.6)	42 (11.7)	0.02
Caregivers socioeconomic status[c]						
Poorest	475 (33.3)	30 (8.6)	31 (8.5)	144 (40.5)	270 (75.4)	0.01
Average	474 (33.2)	134 (38.5)	131 (35.9)	123 (34.5)	86 (24.0)	
Above average	478 (33.5)	184 (52.9)	203 (55.6)	89 (25.0)	2 (0.6)	
Floor material of the household						
Earth	1200 (84.1)	255 (73.3)	272 (74.5)	321 (90.2)	352 (98.3)	0.01
Cement	227 (15.9)	93 (26.7)	85 (25.5)	35 (9.8)	6 (1.7)	
Animal in the household						
Yes	851 (59.7)	162 (46.5)	174 (47.8)	190 (53.4)	325 (90.8)	0.01
No	575 (40.3)	186 (53.4)	190 (52.2)	166 (46.6)	33 (9.2)	
Childrens demographic characteristics						
Sex						
Girls	790 (55.4)	198 (56.9)	196 (53.7)	210 (59.0)	186 (52.0)	0.23
Boys	637 (44.6)	150 (43.1)	169 (46.3)	146 (41.0)	172 (48.0)	
Age of children[d]						
6 months to 5 years	908 (63.6)	209 (60.1)	221 (60.5)	232 (65.2)	246 (68.7)	0.05

More than 5 years	519 (36.4)	139 (39.9)	144 (39.4)	124 (34.8)	112 (31.3)

[a] *Mean age of caregivers=30.2 (±8.9) years; minimum age=15 years and maximum age 70 years*

[b] *Multiple responses possible for the variable characterising occupation of the household head.*

[c] *Socio-economic status was derived from a factor analysis using principal component analysis of variables indicating the wealth index such as monthly expenditure, electricity connection at house, household ownership, rooms in the household, land ownership, and possession of household assets a electricity, radio, television, solar panel, mobile phone, bicycle, motorbike, car, fridge, watch. The score of the first factor was then divided into three categories using the k-means procedure.*

[d] *Mean age of the children in months=50.6 (30.1) months; minimum age in months=6 months and maximum 120 months*

**p-vaules were obtained by $\chi 2$ test*

Table 2 Key finding from water system related, water handing and water quality in four areas of Nepal, March-May 2018 [N=1427]

Variables	[n(%)]	Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accham [n(%)]	*p* value*
Household WASH[a] characteristics						
Household involved in water supply system in the community	1352 (94.7)	284 (81.6)	357 (97.8)	354 (99.4)	357 (99.7)	0.01
Main drinking water source						
Piped water in the house or yard	296 (20.7)	15 (4.3)	268 (73.4)	9 (2.5)	4 (1.1)	0.01
Piped water in the village	1077 (75.5)	292 (83.9)	97 (26.5)	340 (95.5)	348 (97.2)	
Open source[b]	25 (1.7)	20 (5.7)	0 (0.0)	5 (1.4)	0 (0.0)	
Protected source[c]	20 (1.4)	14 (4.0)	0 (0.0)	0 (0.0)	6 (1.7)	
Unmanaged piped system	4 (0.3)	2 (0.6)	0 (0.0)	2 (0.6)	0 (0.0)	
River, stream or canal	5 (0.3)	5 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	
Other water sources for drinking water [d]						
Piped water in the house or yard	113 (7.9)	3 (0.9)	106 (29.0)	4 (1.1)	0 (0.0)	0.01
Piped water in the village	320 (22.4)	105 (30.2)	23 (6.3)	65 (18.3)	127 (35.3)	0.01
Open source	32 (2.2)	30 (8.6)	2 (0.5)	0 (0.0)	0 (0.0)	0.01
Protected source	7 (0.5)	5 (1.4)	0 (0.0)	0 (0.0)	2 (0.6)	0.02
Unmanaged piped system	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0.38
River/Stream	14 (1.0)	14 (4.02)	0 (0.0)	0 (0.0)	0 (0.0)	0.01
Bottled water	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0.38
Time requied for fetching drinking water						
<5 minutes	57 (4.0)	18 (5.2)	34 (9.3)	1 (0.3)	4 (1.1)	0.01
5-15 minutes	882 (61.8)	185 (53.2)	308 (84.4)	165 (46.3)	224 (62.6)	
15 minutes to 60 minutes	453 (31.7)	141 (40.5)	23 (6.3)	169 (47.5)	120 (33.5)	
> 60 minutes	35 (2.4)	4 (1.1)	0 (0.0)	21 (5.9)	10 (2.8)	
Functioning of main drinking water source						
Functioning well	1,300 (91.1)	283 (81.3)	353 (96.7)	338 (94.9)	326 (91.1)	0.01
Functioning but not well	126 (8.8)	64 (18.4)	12 (3.3)	18 (5.1)	32 (8.9)	
Not functioning	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	
Caregivers perception on main drinking water getting fixed within one week						
Very confident	950 (66.6)	251 (72.1)	308 (84.4)	228 (64.0)	163 (45.5)	0.01
Somewhat confident	271 (19.0)	53 (15.2)	33 (9.0)	81 (22.7)	104 (29.0)	
Not confident at all	117 (8.2)	27 (7.8)	14 (3.8)	30 (8.4)	46 (12.8)	
Don`t know	89 (6.2)	17 (4.9)	10 (2.7)	17 (4.8)	45 (12.6)	
Main water source not functioning in the last 6 months						
Yes	47 (3.3)	25 (7.2)	21 (5.7)	0 (0.0)	1 (0.3)	0.01
No	1380 (96.7)	323 (92.8)	344 (94.2)	356 (100)	357 (99.7)	
Caregivers opinion on the safety of the main drinking water source						
Very safe	236 (16.5)	23 (6.6)	39 (10.7)	73 (20.59	101 (28.2)	0.01
Quite safe	541 (37.9)	114 (32.8)	140 (38.3)	151 (42.4)	136 (38.0)	
Neither safe nor risky	137 (9.6)	36 (10.3)	51 (14.0)	33 (9.3)	17 (4.7)	
A bit risky	464 (32.5)	154 (44.2)	116 (31.8)	99 (27.8)	95 (26.5)	
Very risky	49 (3.4)	21 (6.0)	19 (5.2)	0 (0.0)	9 (2.5)	
Caregivers opinion on factors that makes drinking water unsafe[e]						
Open unprotected source	1155 (80.9)	297 (85.3)	312 (85.5)	332 (93.3)	214 (59.8)	0.01
Unmanaged system	714 (50.0)	128 (36.8)	169 (46.3)	235 (66.0)	182 (50.8)	
Open defecation	835 (58.5)	231 (66.4)	229 (62.7)	266 (74.7)	109 (30.4)	
Settlement above source	324 (22.7)	56 (16.1)	80 (21.9)	112 (31.5)	76 (21.2)	
Deforestation	50 (3.5)	17 (4.9)	21 (5.7)	10 (2.8)	2 (0.6)	
Dont know	121 (8.5)	21 (6.0)	33 (9.0)	10 (2.8)	57 (15.9)	
Knowledge about water treatment method[e]						
Boiling	816 (57.2)	203 (58.3)	244 (66.8)	220 (61.8)	149 (41.6)	0.01
Filtration with a cloth	448 (31.4)	91 (26.1)	151 (41.4)	124 (34.8)	82 (22.9)	0.01
Flocculation and sedimentation	24 (1.7)	5 (1.4)	10 (2.7)	8 (2.2)	1 (0.3)	0.06
Chlorination	116 (8.1)	29 (8.3)	39 (10.7)	32 (9.0)	16 (4.5)	0.02
Sodis	94 (6.6)	35 (10.1)	33 (9.0)	16 (4.5)	10 (2.8)	0.01
Water filter	842 (59.0)	239 (68.7)	260 (71.2)	209 (58.7)	134 (37.4)	0.01
Other	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0.39
Do not know any way	460 (32.2)	82 (23.6)	73 (20.0)	111 (31.2)	194 (54.2)	0.01
Explanation of different methods of water treatment						
Good explanation of at least 4 methods	78 (8.1)	14 (5.3)	31 (10.6)	17 (6.9)	16 (9.8)	0.01
Good explanation of 3 methods	318 (32.9)	53 (19.9)	109 (37.3)	94 (38.4)	62 (37.8)	
Good explanation of 2 methods	299 (30.9)	99 (37.2)	67 (22.9)	83 (33.9)	50 (30.5)	
Satisfactory explanation of 1 method	208 (21.5)	86 (32.3)	53 (18.1)	40 (16.3)	29 (17.7)	
Cannot explain well	64 (6.6)	14 (5.3)	32 (11.0)	11 (4.5)	7 (4.3)	
Household drinking water treated prior to the consumption	193 (13.5)	73 (21.0)	60 (16.4)	55 (15.4)	5 (1.4)	0.01
Water treatment methods used [e]						
Boiling	58 (4.1)	22 (6.3)	31 (8.5)	3 (0.8)	2 (0.6)	0.01
Filtration with a cloth	34 (2.4)	10 (2.9)	24 (6.4)	0 (0.0)	0 (0.0)	0.01
Flocculation and sedimentation	3 (0.2)	3 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	0.03

Chlorination	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0.38
Sodis	2 (0.1)	1 (0.3)	1 (0.3)	0 (0.0)	0 (0.0)	0.57
Use of filter	137 (9.6)	50 (14.4)	31 (8.5)	52 (14.6)	4 (1.1)	0.01
Household member responsible for water treatment						
Wife	183 (12.8)	66 (19.0)	59 (16.2)	53 (14.9)	5 (1.4)	0.01
Husband	82 (5.7)	17 (4.9)	42 (11.5)	20 (5.6)	3 (0.8)	0.01
Daugher	23 (1.6)	5 (1.4)	15 (4.1)	3 (0.8)	0 (0.0)	0.01
Son	5 (0.3)	0 (0.0)	4 (1.1)	1 (0.3)	0 (0.0)	0.04
Opinion about treated water						
"I dislike it very much"	245 (17.2)	34 (9.8)	50 (13.7)	76 (21.3)	85 (23.7)	0.01
"I rather dislike it"	481 (33.7)	132 (37.9)	125 (34.2)	88 (24.7)	136 (38.0)	0.01
"Average"	370 (25.9)	93 (26.7)	79 (21.6)	107 (30.1)	91 (25.4)	0.01
"I rather like it"	212 (14.9)	66 (19.0)	66 (18.1)	45 (12.6)	35 (9.8)	0.01
"I like it very much"	119 (8.3)	23 (6.6)	45 (12.3)	40 (11.2)	11 (3.1)	0.01
Opinion on treating the drinking water worthwhile						
Never worthwhile	325 (22.8)	97 (27.9)	83 (22.7)	56 (15.7)	89 (24.9)	0.01
Rarely worthwhile	177 (12.4)	22 (6.3)	35 (9.6)	48 (13.5)	72 (20.1)	
Sometimes worthwhile	341 (23.9)	53 (15.2)	91 (24.9)	85 (23.9)	112 (31.3)	
Mostly worthwhile	378 (26.5)	131 (37.6)	82 (22.5)	115 (32.3)	50 (14.0)	
Always worthwhile	206 (14.4)	45 (12.9)	74 (20.3)	52 (14.6)	35 (9.8)	
Household drinking water transport container [e]						
Gagri brass	14 (1.0)	1 (0.3)	9 (2.5)	4 (1.1)	0 (0.0)	0.01
Gagri copper	562 (39.4)	192 (55.2)	102 (27.9)	87 (24.4)	181 (50.6)	0.01
Gagri plastic	133 (9.3)	4 (1.1)	17 (4.7)	94 (26.4)	18 (5.0)	0.01
Jerrycan plastic	778 (54.5)	117 (33.6)	217 (59.4)	230 (64.6)	214 (59.8)	0.01
Plastic bucket with large opening	218 (15.3)	2 (0.6)	24 (6.6)	88 (24.7)	104 (29.0)	0.01
Alu bucket with large opening	28 (2.0)	2 (0.6)	1 (0.3)	7 (2.0)	18 (5.0)	0.01
Claypot	8 (0.6)	0 (0.0)	3 (0.8)	5 (1.4)	0 (0.0)	0.03
Cleaning the household container for transport						
Yes	1416 (99.2)	347 (99.7)	363 (99.4)	355 (99.7)	351 (98.0)	0.03
No	11 (0.8)	1 (0.3)	2 (0.6)	1 (0.3)	351 (98.0)	
Cleaning household drinking water transport container						
Every day	1206 (85.2)	280 (80.7)	334 (92.0)	309 (87.0)	283 (80.6)	0.01
Every second day	177 (12.5)	53 (15.3)	21 (5.8)	40 (11.3)	63 (17.9)	
At least once per week	27 (1.9)	13 (3.7)	6 (1.6)	4 (1.1)	4 (1.1)	
Less than once per week	6 (0.4)	1 (0.3)	2 (0.5)	2 (0.6)	1 (0.3)	
Materials for household drinking water transport container						
Water/water and sand	390 (27.5)	120 (34.6)	104 (28.6)	37 (10.4)	129 (36.7)	0.01
Always with soap or ash	429 (30.3)	84 (24.2)	141 (38.8)	108 (30.4)	96 (27.3)	
Sometime with soap or ash	597 (42.2)	143 (41.2)	118 (32.5)	210 (59.1)	126 (35.9)	
Cleaning water storage container (n=79)						
Yes	78 (98.7)	67 (98.5)	7 (100.0)	4 (100.0)	0 (0.0)	0.92
No	1 (1.3)	1 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	
Frequency of cleaning household water storage container						
Every day	53 (67.9)	44 (65.7)	6 (85.7)	3 (75.0)	0 (0.0)	0.01
Every second day	18 (23.1)	18 (26.9)	0 (0.0)	0 (0.0)	0 (0.0)	
At least once per week	6 (7.7)	5 (7.5)	1 (14.3)	0 (0.0)	0 (0.0)	
Less than once per week	1 (1.3)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	
Cleaning household drinking water storage container						
Water/water and sand	24 (30.8)	23 (34.3)	1 (14.3)	0 (0.0)	0 (0.0)	0.01
Always with soap or ash	17 (21.8)	10 (14.9)	6 (85.7)	1 (25.0)	0 (0.0)	
Sometime with soap or ash	37 (47.4)	34 (50.7)	0 (0.0)	3 (75.0)	0 (0.0)	
Water quality of household point of collection[f] of drinking water						
Coliform bacteria (n=1136)						
0 CFU/100 mL	7 (0.6)	0 (0.0)	0 (0.0)	7 (2.0)	0 (0.0)	0.01
1-10 CFU[g]/100 mL	18 (1.6)	1 (0.5)	0 (0.0)	17 (4.9)	0 (0.0)	
10-100 CFU/100 mL	20 (1.8)	4 (2.1)	5 (1.6)	9 (2.6)	2 (0.7)	
100-1000 CFU/100 mL	884 (77.8)	101 (53.4)	274 (88.7)	258 (74.1)	251 (86.6)	
>1000 CFU/100 mL	207 (18.2)	83 (43.9)	30 (9.7)	57 (16.4)	37 (12.8)	
Escherichia coli						
0 CFU/100 mL	74 (6.5)	26 (13.7)	2 (0.6)	45 (13.0)	1 (0.3)	0.01
1-10 CFU[g]/100 mL	315 (27.8)	94 (49.5)	83 (27.0)	74 (21.3)	64 (22.1)	
10-100 CFU/100 mL	574 (50.6)	59 (31.1)	201 (65.3)	139 (40.1)	175 (60.3)	
100-1000 CFU/100 mL	153 (13.5)	6 (3.2)	20 (6.5)	84 (24.2)	43 (14.8)	
>1000 CFU/100 mL	19 (1.7)	5 (2.6)	2 (0.7)	5 (1.4)	7 (2.4)	
Water quality of household point of use[h] of drinking water						
Coliform bacteria (n=1257)						
0 CFU/100 mL	16 (1.3)	12 (4.0)	2 (0.9)	1 (0.3)	0 (0.0)	0.01
1-10 CFU[g]/100 mL	27 (2.2)	15 (5.1)	8 (2.5)	4 (1.2)	0 (0.0)	
10-100 CFU/100 mL	40 (3.2)	15 (5.1)	8 (2.5)	15 (4.3)	2 (0.7)	
100-1000 CFU/100 mL	743 (59.1)	100 (33.7)	223 (68.8)	218 (62.5)	202 (70.4)	
>1000 CFU/100 mL	431 (34.3)	155 (52.2)	82 (25.3)	111 (31.8)	83 (28.9)	
Escherichia coli (n=1260)						
0 CFU/100 mL	60 (4.8)	33 (11.0)	13 (4.0)	13 (3.7)	1 (0.4)	0.01

1-10 CFU[g]/100 mL	206 (16.4)	77 (25.7)	41 (12.7)	57 (16.3)	31 (10.8)	
10-100 CFU/100 mL	643 (51.0)	142 (47.3)	187 (57.7)	150 (43.0)	164 (57.1)	
100-1000 CFU/100 mL	292 (23.2)	32 (10.7)	71 (21.9)	115 (33.0)	74 (25.8)	
>1000 CFU/100 mL	59 (4.7)	16 (5.3)	12 (3.7)	14 (4.0)	17 (5.9)	
Hygiene condition of water transport container[i] (observation)						
Lower category	871 (61.0)	247 (71.0)	256 (70.1)	221 (62.1)	147 (41.1)	0.01
Middle category	214 (15.0)	33 (9.5)	34 (9.3)	42 (11.8)	105 (29.3)	
Higher category	342 (24.0)	68 (19.5)	75 (20.6)	93 (26.1)	106 (29.6)	
Hygiene condition of water storage containerk[j] (observation)						
Lower category	864 (60.5)	250 (71.8)	255 (69.9)	215 (60.4)	144 (40.2)	0.01
Middle category	212 (14.9)	28 (8.1)	35 (9.6)	44 (12.4)	105 (29.3)	
Higher category	351 (24.6)	70 (20.1)	75 (20.5)	97 (27.2)	109 (30.4)	

[a] *Water, sanitation and hygiene*

[b] *Open source referred to dug well, pond and springs.*

[c] *Protected source were referred to well and springs.*

[d] *Multiple responses were possible for other water sources of drinking water collection.*

[e] *Multiple responses were possible for the variables characterising the caregivers opinion on factors that makes drinking water unsafe, knowledge about water treatment methods and the treatment methods being used and household drinking water transport container.*

[f] *Point of collection referred to piped water in the household or community e.g. stand tap.*

[g] *Colony forming unit*

[h] *Point of use referred to the water from drinking water container such as gagri, jerrycan plastic, plastic bucket with large openings, alu bucket with large openings, claypot etc.*

[i] *A new variable for hygiene condition of drinking water transport container was created using factor analysis with three conceptually similar categorical variables of : (i) water transport container clean; (ii) water transport container have a lid; and (iii) water transport container broken. The hygiene condition of the drinking water transport container is then categorised into three categories with lower, middle and better hygiene categories.*

[j] *A new variable for hygiene condition of drinking water storage container was created using factor analysis with three conceptually similar categorical variables of : (i) water storage container clean; (ii) water storage container have a lid; and (iii) water storage container broken. The hygiene condition of the drinking water storage container is then categorised into three categories with lower, middle and better hygiene categories.*

**p-vaules were obtained by $\chi 2$ test*

Table 3 Questionnaire findings on hygiene and WASH promotion in the four areas of Nepal, March-May 2018 [N=1427]

Variables	[n(%)]	Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accham [n(%)]	*p* value*
Selected KAP[a] indicators on hygiene						
Handwashing times						
<5 times	408 (28.6)	102 (29.3)	64 (17.5)	101 (28.4)	141 (39.4)	0.01
5-10 times	935 (65.5)	225 (64.7)	251 (68.8)	251 (70.5)	208 (58.1)	
10-15 times	61 (4.3)	18 (5.2)	31 (8.5)	4 (1.1)	8 (2.2)	
> 15 times	23 (1.6)	3 (0.9)	19 (5.2)	0 (0.0)	1 (0.3)	
Handwashing with soap						
<5 times	1084 (76.0)	267 (76.7)	244 (66.8)	278 (78.1)	295 (82.4)	0.01
5-10 times	337 (23.6)	79 (22.7)	118 (32.3)	78 (21.9)	62 (17.3)	
10-15 times	5 (0.3)	2 (0.6)	2 (0.5)	0 (0.0)	1 (0.3)	
> 15 times	1 (0.1)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	
Handwashing[b]						
When they look dirty	862 (60.4)	224 (64.4)	254 (70.0)	172 (48.3)	212 (59.2)	0.01
After going toilet	1402 (98.2)	342 (98.3)	356 (97.5)	354 (99.4)	350 (97.8)	0.21
After cleaning babys bottom	834 (58.4)	170 (48.8)	225 (61.6)	236 (66.3)	203 (56.7)	0.01
Before eating	1039 (72.8)	259 (74.4)	298 (81.6)	295 (82.9)	187 (52.2)	0.01
Before cooking	572 (40.1)	170 (48.8)	146 (40.0)	142 (39.9)	114 (31.8)	0.01
There are not special occasions	2 (0.14)	0 (0.0)	1 (0.3)	0 (0.0)	1 (0.3)	0.58
Do not know	3 (0.21)	1 (0.3)	0 (0.0)	2 (0.6)	0 (0.0)	0.29
Types of latrines used						
Water pit latrine	1200 (84.1)	322 (92.5)	252 (69.0)	315 (88.5)	311 (86.9)	0.01
Simple pit latrine	137 (9.6)	12 (3.5)	93 (25.5)	22 (6.2)	10 (2.8)	
No latrine	90 (6.3)	14 (4.0)	20 (5.5)	19 (5.3)	37 (10.3)	
Animal[c] kept safe inside the household overnight	851 (59.7)	162 (46.5)	174 (47.8)	190 (53.4)	325 (90.8)	0.01
Overall hygiene[d] condition of households (questionnaire[e] n=1425)						
Very low hygiene	752 (52.7)	106 (30.5)	126 (34.5)	202 (56.7)	318 (88.8)	0.01
Low hygiene	162 (11.4)	50 (14.4)	33 (9.0)	65 (18.3)	14 (3.9)	
Middle hygiene	101 (7.1)	44 (12.6)	25 (6.8)	22 (6.2)	10 (2.8)	
Moderate hygiene	92 (6.4)	41 (11.8)	22 (6.0)	22 (6.2)	7 (2.0)	
Better hygiene	318 (22.3)	107 (30.7)	157 (43.0)	45 (12.6)	9 (2.5)	
Hygiene condition of latrine (observation)[f]						
Lower category	695 (48.7)	213 (61.2)	200 (54.8)	166 (46.6)	116 (32.4)	0.01
Middle category	390 (27.3)	86 (24.7)	54 (14.8)	130 (36.5)	120 (33.5)	
Better category	342 (24.0)	49 (14.1)	111 (30.4)	60 (16.9)	122 (34.1)	
Hygiene condition of handwashing facilities (observation)[g]						
Lower category	289 (50.5)	87 (39.9)	148 (67.0)	43 (43.9)	11 (31.4)	0.01
Middle category	97 (17.0)	45 (20.6)	25 (11.3)	22 (22.4)	5 (14.3)	
Better category	186 (32.5)	86 (39.5)	48 (21.7)	33 (33.7)	19 (54.3)	
Household environment condition (observation)[h]						
Lower category	289 (50.5)	87 (39.9)	148 (67.0)	43 (43.9)	11 (31.4)	0.01
Middle category	97 (17.0)	45 (20.6)	25 (11.3)	22 (22.4)	5 (14.3)	
Better category	186 (39.5)	86 (39.5)	48 (21.7)	33 (33.7)	19 (54.3)	
Household kitchen hygiene condition (observation)[i]						
Lower category	481 (33.7)	187 (53.7)	174 (47.7)	75 (21.1)	45 (12.6)	0.01
Middle category	637 (44.6)	128 (36.8)	120 (32.9)	206 (57.9)	183 (51.1)	
Better category	309 (21.6)	33 (9.5)	71 (19.4)	75 (21.1)	130 (36.3)	
Personal hygiene of participating child and their caregivers (observation)[j]						
Lower category	611 (42.8)	153 (44.0)	210 (57.5)	167 (46.9)	81 (22.6)	0.01

Middle category	424 (29.7)	92 (26.4)	72 (19.7)	130 (36.5)	130 (36.3)	
Better category	392 (27.5)	103 (29.6)	83 (22.7)	59 (16.6)	147 (41.1)	
Information on WASH[k] promotion						
Received any information on water treatement and hygiene[l]	155 (10.9)	105 (30.2)	13 (3.6)	19 (5.3)	18 (5.0)	0.01
Information on water treatment and hygiene changing behavior	139 (89.7)	95 (90.5)	10 (76.9)	17 (89.5)	17 (94.4)	0.42
Behaviors that changed after receiving information on water treatment and hygiene[m]						
"I purchased a product for water treatement"	16 (1.1)	5 (1.4)	0 (0.0)	9 (2.5)	2 (0.6)	0.01
"I am now regularly treating water"	32 (2.2)	20 (5.8)	2 (0.5)	9 (2.5)	1 (0.3)	0.01
"I am now sometimes treating water"	27 (1.9)	23 (6.6)	1 (0.3)	2 (0.6)	1 (0.3)	0.01
"I installed a handwashing station"	35 (2.4)	24 (6.9)	2 (0.8)	3 (0.8)	3 (0.8)	0.01
"I do wash my hands more often"	36 (2.5)	23 (6.6)	3 (0.8)	4 (1.1)	6 (1.7)	0.01
"I use soap to wash my hands more often"	90 (6.3)	63 (18.1)	6 (1.6)	15 (4.2)	6 (1.7)	0.01
"I wash my hands at the critical times"	65 (4.6)	51 (14.7)	6 (1.6)	6 (1.7)	2 (0.6)	0.01
" I regularly disinfect the water storage container with chlorine"	17 (1.2)	15 (4.3)	0 (0.0)	1 (0.3)	1 (0.3)	0.01
"I regularly wash the water storage container with soap"	21 (1.5)	18 (5.2)	0 (0.0)	3 (0.8)	0 (0.0)	0.01
"Other behavior changed"	2 (0.1)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)	0.56
Household attended hygine literacy class[n]	362 (25.4)	98 (28.2)	87 (23.8)	75 (21.1)	102 (28.5)	0.07
FCHVs[o] or other health workers visited household	537 (37.6)	131 (37.6)	115 (31.5)	123 (34.5)	168 (46.9)	0.01
Total times FCHVs/other health workers visited household						
Once	468 (87.1)	102 (77.9)	99 (86.1)	112 (91.1)	155 (92.3)	0.01
Twice	60 (11.2)	28 (21.4)	8 (7.0)	11 (8.9)	13 (7.7)	
Thrice	3 (0.6)	0 (0.0)	3 (2.6)	0 (0.0)	0 (0.0)	
Four times	1 (1.2)	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	
Don`t remember	5 (0.9)	1 (0.8)	4 (3.5)	0 (0.0)	0 (0.0)	
Effectiveness: HLC[p] or door to door visit						
Hygiene literacy class (HLC)	73 (23.0)	19 (25.0)	2 (2.5)	8 (11.9)	44 (45.8)	0.01
Door to door visit	166 (52.2)	48 (63.2)	45 (57.0)	53 (79.1)	20 (20.8)	
Both	79 (24.8)	9 (11.8)	32 (40.5)	6 (9.0)	32 (33.3)	

[a] *Knowledge, attitude and practice*

[b] *Multiple responses possible for the variables characterising the when did the handwashing was done*

[c] *Animals refers to any domestic animals such as chicken, goat, dog, cat, cow, ox etc.*

[d] *A new variable of hygiene from the questionaire data was created using with the handwashing times, handwashing with soap, when washing hand, kind of toilet used, animals inside the houshold.*

[e] *From questionnaire*

[f] *A new variable for observational condition of toilet was created using factor analysis with conceptually similar categorical variables of: (i) is the toilet clean; and (ii) are these materials available (sandals, drum with water, brush, none of these. The condition of toilet is then categorised into three categories with lower, middle and better hygiene categories.*

[g] *A new variable for observational condition of handwashing facility was created using factor analysis with four conceptually similar categorical variables of: (i) is handwashing facility in good condition; and (ii) are handwashing facilities clean (iii) is soap available (iv) is water available. The condition of handwashing facility is then categorised into three categories with lower, middle and better hygiene categories.*

[h] *A new variable for observational household environment condition was created using factor analysis with three conceptually similar categorical variables of: (i) can you see trash spread outside the house; (ii) does the household have a garbage pit to dispose garbage (iii) can you see trash spread inside the house? The condition of household environment is then categorised into three categories with lower, middle and better hygiene categories.*

[i] *A new variable for observational kitchen hygiene condition was created using factor analysis with four conceptually similar categorical variables of: (i) are clean dishes kept high; (ii) is the entirety of food covered (iii) is there dry rack to dry your utensils and dishes after washing and (iv) is there a significant number of flies in the kitchen (>10). The kitchen hygiene is then categorised into three categories with lower, middle and better hygiene categories.*

j *A new variable for observational persona hygiene of caregiver and participated child was created using factor analysis with four conceptually similar categorical variables of: (i) wearing shoe; (ii) hands clean (iii) any dry clothes piles lying. The personal hygiene is then categorised into three categories with lower, middle and better hygiene categories.*

[k] *Water, sanitation and hygiene*

[l] *Information from Helvetas (local INGO) or others*

[m] *Multiple responses possible*

[n] *Hygiene literacy class coducted by female community health volunteers or other health workers*

[0] *FCHVs: Female community health volunteers*

[p] *HLC: Hygiene literacy class*

Table 4 Key findings from the child health, health seeking behaviors and KAP survey in four regions of Nepal, March-May 2018 [N=1427]

Health variables	[N (%)]	Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accham [n(%)]	*p*-value*
Child health[a]						
Surveyed child sick within past 7 days	712 (49.9)	156 (44.8)	192 (52.6)	178 (50.0)	186 (52.0)	0.15
Child sufferred from illnessess in past 7 days[b]						
Fever	565 (39.6)	119 (34.2)	152 (41.6)	137 (38.5)	157 (43.8)	0.05
Cough	555 (38.9)	123 (35.3)	168 (46.0)	126 (35.4)	138 (38.5)	0.01
Respiratory difficulties	217 (15.2)	53 (15.2)	62 (17.0)	39 (11.0)	63 (17.6)	0.06
Diarrhoea[c]	235 (16.5)	36 (10.3)	59 (16.2)	69 (19.4)	71 (19.8)	0.01
Blood in stool	46 (3.2)	3 (0.9)	18 (4.9)	5 (1.4)	20 (5.6)	0.01
Mucus in stool	53 (3.7)	4 (1.1)	22 (6.0)	8 (2.2)	19 (5.3)	0.01
Blood in urine	9 (0.6)	0 (0.0)	6 (1.6)	0 (0.0)	3 (0.8)	0.01
Health seeking behavior						
Seeking medical advice for illness of surveyed child						
Yes	599 (84.0)	129 (82.7)	169 (87.6)	147 (82.6)	154 (82.8)	0.48
No	114 (16.0)	27 (17.3)	24 (12.4)	31 (17.4)	32 (17.2)	0.48
Seek medical advices/treatment from[d]						
Hospital	76 (5.3)	14 (4.0)	15 (4.1)	28 (7.9)	19 (5.3)	0.08
Health center/health post	285 (20.0)	48 (13.8)	77 (21.1)	69 (19.4)	91 (25.4)	0.01
Community health worker	27 (1.9)	0 (0.0)	0 (0.0)	6 (1.7)	21 (5.9)	0.01
Pharmacy	256 (17.9)	67 (19.2)	85 (23.3)	66 (18.5)	38 (10.6)	0.01
Self-treatment and traditional medicine	3 (0.2)	1 (0.3)	1 (0.3)	1 (0.3)	0 (0.0)	0.80
Other	5 (0.3)	5 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0.01
Reason for not seeking medical advices[e]						
"I do not have good access to a health facility"	2 (1.8)	2 (7.4)	0 (0.0)	0 (0.0)	0 (0.0)	0.01
"I do not have money to go to the health facility"	24 (21.2)	1 (3.7)	1 (4.3)	7 (22.6)	15 (46.9)	0.01
"I prefer self-treatment or traditional medicine"	8 (7.1)	0 (0.0)	5 (21.7)	0 (0.0)	3 (9.4)	0.01
" It was not necessary to go to the health facility"	70 (61.9)	17 (63.0)	17 (73.9)	22 (71.0)	14 (43.7)	0.01
Other	9 (8.0)	7 (25.9)	0 (0.0)	2 (6.4)	0 (0.0)	0.01
KAP survey[f]						
Causes of diarrhoeal diseases						
Some pathogens	71 (5.0)	22 (6.3)	13 (3.6)	34 (9.5)	2 (0.6)	0.01
Faecal pathogens	706 (49.5)	173 (49.7)	173 (47.4)	198 (55.6)	162 (45.3)	0.04
Dirty hands	706 (49.5)	173 (49.7)	173 (47.4)	198 (55.6)	162 (45.2)	0.04
Dirty food	1145 (80.2)	315 (90.5)	296 (81.1)	307 (86.2)	227 (63.4)	0.01
Dirty water	1180 (82.7)	298 (85.6)	295 (80.8)	319 (89.6)	268 (74.9)	0.01
Explanation does not corresponds with real cause	90 (6.3)	5 (1.4)	23 (6.3)	11 (3.1)	51 (14.2)	0.01
Chances of getting sick drinking untreated water						
Very low	3 (0.2)	2 (0.6)	1 (0.3)	0 (0.0)	0 (0.0)	0.01
Rather low	44 (3.1)	8 (2.3)	12 (3.3)	0 (0.0)	24 (6.7)	
Average	94 (6.6)	29 (8.3)	33 (9.0)	4 (1.1)	28 (7.8)	
Rather high	300 (21.0)	107 (30.8)	49 (13.4)	47 (13.2)	97 (27.1)	
Very high	986 (69.1)	202 (58.0)	270 (74.0)	305 (85.7)	209 (58.4)	
Impact of diarrhoea on life and development of child						
Not at all severe	4 (0.3)	3 (0.9)	1 (0.3)	0 (0.0)	0 (0.0)	0.01
Hardly severe	36 (2.5)	6 (1.7)	9 (2.5)	1 (0.3)	20 (5.6)	
Rather severe	120 (8.4)	61 (17.5)	29 (8.0)	4 (1.1)	26 (7.3)	
Severe	205 (14.4)	44 (12.6)	42 (11.5)	37 (10.4)	82 (22.9)	
Very severe	1062 (74.4)	234 (67.2)	284 (77.8)	314 (88.2)	230 (64.3)	
Heard of "intestinal parasite"						
Yes	301 (21.1)	109 (31.3)	66 (18.1)	84 (23.6)	42 (11.7)	0.01
No	1126 (78.9)	239 (68.7)	299 (81.9)	272 (76.4)	316 (88.3)	
Knowledge regarding habits against intestinal parasites[g]						
Wash hands with soap	158 (11.1)	70 (20.1)	23 (6.3)	53 (14.9)	12 (3.4)	0.01
Cut finger nails	76 (5.3)	21 (6.0)	14 (3.8)	33 (9.3)	8 (2.2)	0.01
Wear pants, trousers	49 (3.4)	26 (7.5)	6 (1.6)	12 (3.4)	5 (1.5)	0.01
Wash fruits and vegetables before consumption	26 (1.8)	1 (0.3)	9 (2.5)	13 (3.7)	3 (0.8)	0.01
Wear shoe	71 (5.0)	23 (6.6)	13 (3.6)	27 (7.6)	8 (2.2)	0.01
Drink clean water	237 (16.6)	86 (24.7)	54 (14.8)	77 (21.6)	20 (5.6)	0.01
Regular deworming	159 (11.1)	59 (17.0)	37 (10.1)	35 (9.8)	28 (7.8)	0.01

[a] *Health of the youngest surveyed child*

[b] *Multiple answers possible*

[c] *passage of liquid stool more than 3 times per day*

[d] *multiple responses possible for seeking medical advice or treatement*

[e] *multiple responses possible for reasons for not seeking medical advices*

[f] *KAP: knowledge attitude and practices survey*

[g] *Multiple responses possible for knowledge against intestinal parasites*

Table 5 Results from univariate and multivariate logistic regression with diarrhea as outcome

Risk factors [N (cases)=492]		Univariable logistic regression[a]			Multivariable logistic regression[b]		
		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
Age of the child	< 5 years	1.00			1.00		
	> 5 years	0.47	0.34-0.66	**0.00**	0.39	0.27-0.58	**0.01**
Sex of the child	Male	1.00			1.00		
	Female	1.08	0.82-1.44	0.58	1.14	0.82-1.58	0.43
Number of children in the household	< 5	1.00			1.00		
	> 5	2.18	0.66-0.18	0.20			
Caregivers can read/write	Can neither read or write	1.51	1.04-2.19	**0.03**	1.21	0.76-1.95	0.41
	Can read only	0.22	0.03-1.62	**0.14**	0.22	0.03-1.79	0.16
	Can both read and write	1.00			1.00		
Involvement in the water supply system in the community	"yes" *vs.* "no"	0.81	0.39-1.66	0.57			
Socioeconomic status	Poor	1.13	0.79-1.66	0.48	1.13	0.73-1.74	0.58
	Middle	0.88	0.57-1.38	0.59	1.09	0.65-1.86	0.74
	Better	1.00			1.00		
Main drinking water source	Piped water in the house	1.00					
	Piped water in the village	0.81	0.50-1.31	0.39			
	Open source	1.07	0.33-3.49	0.92			
	Protected source	0.91	0.24-3.45	0.90			
	Unmanaged piped system	1.57	0.15-16.17	0.71			
	River, stream or canal	1.60	0.17-15.38	0.68			
Time to fetch drinking water	< 5 minutes	1.00			1.00		
	5-15 minutes	10.45	2.19-50.05	**0.00**	0.77	0.34-1.73	0.52
	16-60 minutes	4.24	1.01-18.05	**0.05**	0.60	0.25-1.43	0.25
	> 60 minutes	3.13	0.73-13.44	**0.12**	0.26	0.05-1.44	0.12
Interruption of main drinking water source for more than a week	"yes" *vs.* "no"	2.92	1.49-5.71	**0.00**	2.72	1.18-6.31	**0.02**
Knowledge on factors that make water unsafe for drinking	Open unprotected source	2.39	1.71-3.33	**0.00**	0.66	0.37-1.17	0.16
	Open defecation	1.23	0.91-1.66	**0.17**	1.36	0.82-2.26	0.23
	Deforestation	1.05	0.48-2.29	0.90			
Method of drinking water treatment used	Boiling	0.94	0.45-1.97	0.87			
	Filtration with cloth	0.98	0.37-2.61	0.97			
	Use of filter ("yes" *vs.* "no")	0.63	0.36-1.15	**0.12**	0.81	0.41-1.60	0.54
Handwashing with soap	<5 times	2.49	0.45-13.89	0.30	5.52	0.49-61.63	0.16
	5-10 times	0.56	0.39-0.82	**0.00**	1.35	0.77-2.38	0.29
	>10 times	1.00			1.00		
Times of handwashing	When they look dirty	0.41	0.30-0.54	**0.00**	0.47	0.32-0.71	**0.01**
	After going to toilet	0.23	0.10-0.52	**0.00**	0.37	0.13-1.02	**0.06**
	After cleaning	0.64	0.48-	**0.00**	0.80	0.53-	0.27

	babys bottom		0.84			1.19	
	Before eating	0.57	0.42-0.78	**0.00**	0.78	0.51-1.17	0.23
	Before cooking	0.91	0.68-1.22	0.55			
Animals inside home overnight	"yes" *vs.* "no"	1.06	0.78-1.44	0.72			
Information received on WASH	"no" *vs.* "yes"	0.71	0.40-1.24	0.23			
Handwashing station installed	"no" *vs.* "yes"	0.57	0.17-1.89	0.35			
Wash hands during critical times	"yes" *vs.* "no"	0.91	0.41-2.01	0.83			
Attended hygiene literacy class	"no" *vs.* "yes"	0.47	0.32-0.68	**0.00**	0.76	0.46-1.25	0.29
Caregivers heard about intestinal parasites	"no" *vs.*"yes"	0.72	0.49-1.05	**0.09**	1.06	0.59-1.90	0.84
Awarness on measures against intestinal parasites	Wash hands with soap	0.99	0.62-1.58	0.95			
	Wear shoe	0.85	0.43-1.68	0.64			
	Drink clean water	0.81	0.53-1.22	0.30			
	Deworming	0.61	0.36-1.04	**0.07**	1.29	0.58-2.84	0.53
Type of toilet in the household	Water pit latrine	1.67	0.85-3.27	**0.14**	0.84	0.15-4.78	0.84
	Pit latrine	0.82	0.47-1.42	0.48	0.69	0.13-3.79	0.67
	No latrine	1.00			1.00		
Cleanliness of the toilet	"yes" *vs.* "no"	0.57	0.43-0.77	**0.00**	0.68	0.47-0.98	**0.04**
Materials available in toilet	Sandals/slippers	0.48	0.17-1.37	**0.17**	1.18	0.37-3.80	0.78
	Drum with water	0.77	0.54-1.08	**0.13**	1.35	0.28-6.69	0.71
	Brush	0.46	0.31-0.68	**0.00**	0.92	0.56-1.52	0.75
	None of these	1.41	0.93-2.13	**0.10**	0.86	0.16-4.48	0.86
Trash outside the house	"no" *vs.* "yes"	0.62	0.44-0.86	**0.01**	1.01	0.61-1.68	0.98
Trash spread inside the house	"yes" *vs.* "no"	1.33	0.98-1.81	**0.07**	1.30	0.81-2.10	0.27
Entirety of food covered	"yes" *vs.* "no"	0.59	0.48-0.80	**0.00**	1.26	0.81-1.96	0.30
Flies in the kitchen	"yes" *vs.* "no"	0.97	0.67-1.40	0.85			
Caregiver's hands clean	"yes" *vs.* "no"	0.53	0.38-0.73	**0.00**	0.84	0.51-1.38	0.50
Caregiver wearing shoe	"yes" *vs.* "no"	0.57	0.41-0.77	**0.00**	0.96	0.64-1.46	0.87
Child's hand clean	"yes" *vs.* "no"	0.45	0.34-0.61	**0.00**	0.62	0.40-0.96	**0.03**
Piles of dirty clothes in the house	"yes" *vs.* "no"	1.34	0.98-1.85	**0.07**	0.71	0.43-1.18	0.19
E. coli at point of use drinking water	"yes" *vs.* "no"	3.59	1.10-11.69	**0.03**	2.19	0.62-7.66	0.22
Total coliform at POU drinking water	"yes" *vs.* "no"	1.34	0.16-11.34	0.79			
Undernutrition	"yes" *vs.* "no"	1.12	0.83-1.51	0.47			
Presence of intestinal parasites	"yes" *vs.* "no"	1.19	0.84-1.70	0.33			
Floor	"mud" vs. "cement"	2.98	1.71-5.20	**0.01**	2.29	1.20-4.37	**0.01**

a *Odds ratios (OR) and p-values are based on the likelihood ratio test and the significant p-value from the univariable logistic regression model is indicated bold.*

b *Adjusted odds ratios (aOR) and p-vaules are based on likelihood ratio test of the mixed multivariable regression model. The model with random area intercepts included the categorical exposure variables age and sex of the* *participated child, socioeconomic domains and surveyed area. All the risk values that had p-values lower than 0.2 in the univariable analyses were included into the mixed multivariable regression analysis.*

Table 6 Prevalence and intensity of intestinal helminths and protozoa infections among children in four areas of Ne
2018 [N=962]

Parasite (No. of samples examined =962)	Prevalence of intestinal parasites [n (%)]	Sex		*p-value*	Age group		*p-value*	Area			
		Male	Female		<5 years	> 5years		Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accha [n(%)
Nematodes											
Trichuris trichiura[a]	7 (0.7)	4 (0.7)	3 (0.7)	0.99	1 (0.2)	6 (1.6)	0.01	2 (0.8)	0 (0.0)	3 (1.7)	2 (0.
Hookworm[a]	31 (3.2)	16 (2.9)	15 (3.6)	0.54	18 (3.0)	13 (3.6)	0.64	13 (5.0)	7 (2.5)	8 (4.5)	3 (1.
Enterobius vermicularis[a]	26 (2.7)	15 (2.7)	11 (2.7)	0.94	14 (2.4)	12 (3.3)	0.38	3 (1.2)	4 (1.4)	9 (5.1)	10 (4
Ascaris lumbricoides[a]	203 (21.1)	114(20.8)	89(21.5)	0.79	140(23.5)	63(17.3)	0.02	46(17.8)	68 (24.5)	68(38.4)	21 (8
Cestodes											
Hymenolepsis nana[a]	44 (4.6)	18 (3.3)	26 (6.3)	**0.03**	27 (4.5)	17 (4.7)	0.92	1 (0.4)	9 (3.2)	10 (5.7)	24 (9
Intestinal protozoa											
Giardia lamblia	225 (23.4)	144 (26.3)	81 (19.6)	**0.02**	145 (24.3)	80 (21.9)	0.40	67 (26.0)	12 (4.3)	33 (18.6)	11 (45.

[a] *The intensity of intestinal helminths in all participated child is light infection i.e. for Trichuris trichiura is 1-999; Enterobius vermicularis is 1-2999; Ascaris lumbricoides is 1-4999.*

[b] *Egg counts/ egg per gram of faeces describing intensity of parasitic infection*

Table 7 Results from univariate and multivariate logistic regression with overall parasitic infection as outcome

Overall parasitic infection	[N=962/ N (cases)=492]	Univariable logistic regression[a]			Multivariable logistic regression[b]		
		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
Age of the child	< 5 years	1.00			1.00		
	> 5 years	0.86	0.66-1.13	0.29	0.86	0.65-1.15	0.32
Sex of the child	Male	1.00			1.00		
	Female	0.90	0.69-1.17	0.43	0.88	0.66-1.16	0.35
Number of children in the household	< 5	1.00					
	> 5	2.01	0.49-8.11	0.34			
Caregivers can read/write	Can neither read or write	1.09	0.74-1.61	0.66	1.20	0.79-1.84	0.40
	Can read only	3.15	0.83-12.0	**0.09**	4.07	1.00-16.55	**0.05**
	Can both read and write	1.00			1.00		
Involvement in the water supply system in the community	"yes" *vs.* "no"	1.89	1.05-3.42	**0.03**	1.58	0.80-3.13	0.19
Socioeconomic status	Poor	1.00			1.00		
	Middle	0.85	0.61-1.78	0.33	0.85	0.59-1.22	0.39
	Better	0.86	0.56-1.32	0.49	0.90	0.57-1.45	0.66
Main drinking water source	Piped water in the house	1.00			1.00		
	Piped water in the village	1.39	0.87-2.21	**0.17**	1.11	0.66-1.86	0.71
	Open source	1.33	0.47-3.73	0.59	1.49	0.49-4.50	0.48
	Protected source	1.18	0.40-3.49	0.76	0.78	0.23-2.56	0.68
	River, stream or canal	6.79	0.72-64.33	**0.09**	5.37	0.51-56.21	0.16
Time to fetch drinking water	< 5 minutes	1.00					
	5-15 minutes	1.53	0.66-3.55	0.34			
	16-60 minutes	1.23	0.53-2.78	0.60			
	> 60 minutes	1.07	0.38-3.01	0.90			
Main drinking water source funtioning now	Functioning well	1.00					
	Functioning but not well	1.24	0.61-1.96	0.76			
Interruption of main drinking water source for more than a week	"no" *vs.* "yes"	1.76	0.91-3.41	**0.09**	1.33	0.65-2.70	0.44
Knowledge on factors that makes water unsafe for drinking	Open unprotected source	1.09	0.77-1.54	0.62			
	Open defecation	1.09	0.83-1.45	0.53			
	Deforestation	1.97	0.97-3.99	**0.06**	1.81	0.65-2.70	0.13
Method of drinking water treatment used	Boiling	0.96	0.50-1.86	0.91			
	Filtration with cloth	0.77	0.33-1.85	0.57			
	Use of filter ("yes" *vs.* "no")	1.55	1.00-2.41	**0.05**	1.25	0.76-2.05	0.39
Clean drinking water storage container	"no" *vs.* "yes"	1.88	1.04-3.41	**0.04**	1.66	0.86-3.19	0.13
Handwashing with soap	<5 times	1.00					
	5-10 times	1.08	0.79-1.47	0.64			
	>10 times	0.25	0.03-2.23	0.21			
Times of handwashing	When they look dirty	0.10	0.76-1.31	0.99			

	After going to toilet	0.58	0.23-1.49	0.26			
	After cleaning babys bottom	1.00	0.77-1.31	0.98			
	Before eating	1.07	0.79-1.46	0.65			
	Before cooking	1.14	0.87-1.48	0.35			
Animals inside home overnight	"yes" *vs.* "no"	1.13	0.84-1.51	0.41			
Information received on WASH	"no" *vs.* "yes"	1.90	1.21-3.00	**0.01**	1.09	0.44-2.71	0.85
Handwashing station installed	"no" *vs.* "yes"	2.66	1.05-6.73	**0.04**	1.64	0.51-5.12	0.39
Started using soap to wash hands	"yes" *vs.* "no"	1.69	0.96-2.99	**0.07**	1.27	0.50-3.21	0.61
Wash hands during critical times	"yes" *vs.* "no"	1.98	0.97-3.67	**0.06**	0.74	0.28-1.98	0.55
Sometimes treating water	"no" *vs.* "yes"	3.68	1.39-9.71	**0.01**	2.40	0.76-7.57	0.14
Attended hygiene literacy class	"no" *vs.* "yes"	1.47	1.08-1.99	**0.01**	1.36	0.96-1.92	0.08
Caregivers heard about intestinal parasites	"no" *vs.*"yes"	1.36	0.98-1.88	**0.06**	0.98	0.67-1.43	0.92
Kind of toilet in the household	Water pit latrine	1.00			1.00		
	Pit latrine	2.25	1.12-4.49	**0.02**	6.12	1.57-23.90	**0.01**
	No latrine	1.67	0.96-2.91	**0.07**	3.93	1.08-14.25	**0.04**
Cleanliness of the toilet	"yes" *vs.* "no"	0.89	0.69-1.16	0.40			
Materials availability in toilet	Sandals/slippers	0.86	0.45-1.65	0.66			
	Drum with water	1.36	0.96-1.91	**0.08**	0.46	0.14-1.48	0.19
	Brush	1.14	0.84-1.54	0.41			
	None of these	1.39	0.91-2.12	**0.12**	3.22	0.94-11.03	0.06
Soap available in handwashing facility	"yes" *vs.* "no"	0.87	0.55-1.37	0.55			
Trash outside the house	"yes" *vs.* "no"	1.38	1.03-1.86	**0.03**	1.30	0.89-1.90	0.18
Trash spread inside the house	"yes" *vs.* "no"	1.09	0.82-1.45	0.57			
Entirety of food covered	"yes" *vs.* "no"	1.06	0.78-1.43	0.72			
Flies in the kitchen	"yes" *vs.* "no"	1.05	0.76-1.44	0.78			
Caregiver's hands clean	"yes" *vs.* "no"	0.75	0.54-1.04	**0.09**	0.61	0.41-0.89	**0.01**
Caregiver is wearing shoe	"yes" *vs.* "no"	1.21	0.90-1.62	0.21			
Child's hand clean	"yes" *vs.* "no"	0.88	0.67-1.15	0.33			
Piles of dirty clothes in the house	"yes" *vs.* "no"	0.71	0.53-0.95	**0.02**	1.28	0.88-1.86	0.19
E. coli at point of use drinking water	"yes" *vs.* "no"	1.34	0.71-2.47	0.37			
E. coli at point of collection drinking water	"yes" *vs.* "no"	1.05	0.55-2.00	0.88			
Total coliforms at POC drinking water	"yes" *vs.* "no"	1.33	0.22-8.24	0.76			
Total coliforms at POU drinking water	"yes" *vs.* "no"	1.63	0.53-4.99	0.39			
Presence of undernutrition	"yes" *vs.* "no"	1.02	0.77-1.34	0.92			
Pesence of nutritional deficiencies	"yes" *vs.* "no"	1.14	0.85-1.51	0.38			
Presence of diarrhea	"yes" *vs.* "no"	1.16	0.81-	0.41			

	1.65	

[a] *Odds ratios (OR) and p-values are based on the likelihood ratio test and the significant p-value from the univariable logistic regression model is indicated bold.*

[b] *Adjusted odds ratios (aOR) and p-vaules are based on likelihood ratio test of the mixed multivariable regression model. The model with random area intercepts included the categorical exposure variables age and sex of the participated child, socioeconomic domains and surveyed area. All the risk values that had p-values lower than 0.2 in the univariable analyses were included into the mixed multivariable regression analysis.*

Table 8 Key finding on childrens nutrition and dietary behavior across four study areas in Nepal; March-May 2018 [N=1427]

Nutrition and dietary variables	[n (%)]	Sex		*p*-value*	Age		*p*-value*	Area				val
		Male (n=790)	Female (n=637)		<6 months (n=908)	> 6 months (n=519)		Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accham [n(%)]	
Child breastfed	1422 (99.6)	787 (99.6)	635 (99.7)	0.83	906 (99.8)	516 (99.4)	0.27	345 (99.1)	364 (99.7)	356 (100.0)	357 (99.7)	0.2
Total months of breastfeeding of child												
<6 months	19 (1.3)	9 (1.1)	10 (1.6)	0.30	14 (1.5)	5 (1.0)	**0.01**	9 (2.6)	6 (1.6)	4 (1.2)	0 (0.0)	**0.0**
6-12 months	773 (54.2)	416 (52.7)	357 (56.0)		552 (60.8)	221 (42.6)		175 (50.3)	181 (49.6)	208 (58.4)	209 (58.4)	
>12 months	635 (44.5)	365 (46.2)	270 (42.4)		342 (37.7)	293 (56.4)		164 (47.1)	178 (48.8)	144 (40.5)	149 (41.6)	
Weaning for the child started <6months												
Yes	1384 (97.0)	766 (97.0)	618 (97.0)	0.95	883 (97.3)	501 (96.5)	0.45	318 (91.4)	357 (97.8)	355 (99.7)	354 (98.9)	**0.0**
No	43 (3.0)	24 (3.0)	19 (3.0)		25 (2.7)	18 (3.5)		30 (8.6)	8 (2.2)	1 (0.3)	4 (1.1)	
Child's meal consumption per day												
< 2 meals	40 (2.8)	24 (3.0)	16 (2.5)	0.55	33 (3.6)	7 (1.4)	**0.01**	22 (3.2)	10 (2.7)	4 (1.1)	15 (4.2)	0.0
>3 meals	1387 (97.2)	766 (97.0)	621 (97.5)		875 (96.4)	512 (98.6)		337 (96.8)	355 (97.3)	352 (98.9)	343 (95.8)	
Child receiving food supplements in addition to regular meal												
Yes	618 (43.3)	351 (44.5)	267 (41.9)	0.33	403 (44.4)	215 (41.5)	0.29	166 (47.8)	179 (49.0)	159 (44.7)	114 (31.8)	**0.0**
No	808 (56.7)	438 (55.5)	370 (58.1)		505 (55.6)	303 (58.5)		181 (52.2)	186 (51.0)	197 (55.3)	244 (68.2)	
Dietary Diversity Scores (DDS)[a] based on food consumed in past one week												
1	158 (11.1)	95 (12.0)	63 (9.9)	0.23	102 (11.2)	56 (10.8)	0.58	63 (18.1)	16 (4.4)	65 (18.2)	14 (3.9)	**0.0**
2	147 (10.3)	85 (10.8)	62 (9.7)		88 (9.7)	59 (11.4)		78 (22.4)	29 (7.9)	28 (7.9)	12 (3.3)	
3	170 (11.9)	83 (10.5)	87 (13.7)		109 (12.0)	61 (11.8)		59 (16.9)	52 (14.2)	33 (9.3)	26 (7.3)	
4	154 (10.8)	79 (10.0)	75 (11.8)		92 (10.1)	62 (12.0)		48 (13.8)	35 (9.6)	31 (8.7)	40 (11.2)	
5	160 (11.2)	93 (11.8)	67 (10.5)		106 (11.7)	54 (10.4)		26 (7.5)	37 (10.1)	36 (10.1)	61 (17.0)	
6	162 (11.3)	80 (10.1)	82 (12.9)		101 (11.1)	61 (11.8)		25 (7.2)	62 (17.0)	39 (11.0)	36 (10.1)	
7	158 (11.1)	87 (11.0)	71 (11.2)		105 (11.6)	53 (10.2)		26 (7.5)	47 (12.9)	30 (8.4)	55 (15.4)	
8	158 (11.1)	94 (11.9)	64 (10.0)		94 (10.3)	64 (12.3)		11 (3.2)	44 (12.1)	42 (11.8)	61 (17.0)	
9	160 (11.2)	94 (11.9)	66 (10.4)		111 (12.2)	49 (9.4)		12 (3.4)	43 (11.8)	52 (14.6)	53 (14.8)	

[a] *the dietary diversity scores are based on the food consumed in the past week preceding the survey. The food wer categorized into nine food groups such as (i) starchy staples (ii) beans/peas/lentils, (iii) nuts (iv) dairy products (v meat/fish (vi) eggs (vii) leafy green vegetables; (viii) other vegetables and (ix) fruits. The detail of the food consumption can be found in the supplemental table.*

Table 9 Prevalence of undernutrition and signs of nutritional deficiencies obtained from physical examination of participated children in four areas of Nepal, March-May 2018

Malnutrition indicators, clinical outcomes and nutritional deficiency	[N (%)]	Sex		*p-value*	Age group		*p-value*	Area				*p-value*
		Male	Female		<5 years	> 5years		Surkhet A [n(%)]	Surkhet B [n (%)]	Dailekh [n (%)]	Accham [n(%)]	
Malnutrition indicators												
Stunting (n=1389)												
Severe[a]	248 (17.9)	146 (18.8)	102 (16.7)	0.51	158 (17.8)	90 (17.9)	0.81	29 (8.5)	49 (13.8)	87 (25.1)	83 (23.9)	**0.01**
Moderate[b]	370 (26.6)	209 (26.9)	161 (26.3)		241 (27.2)	129 (25.6)		73 (21.5)	83 (23.3)	104 (30.1)	110 (31.7)	
Normal[c]	771 (55.5)	422 (54.3)	349 (57.0)		487 (55.0)	284 (56.5)		238 (70.0)	224 (62.9)	155 (44.8)	154 (44.4)	
Thinness (n=1344)												
Severe[a]	55 (4.1)	25 (3.4)	30 (5.0)	0.31	36 (4.2)	19 (3.9)	0.83	12 (3.7)	14 (3.9)	16 (4.8)	13 (4.0)	0.31
Moderate[b]	96 (7.1)	54 (7.2)	42 (7.0)		63 (7.4)	33 (6.7)		19 (5.9)	22 (6.2)	34 (10.2)	21 (6.4)	
Normal[c]	1193 (88.8)	667 (89.4)	526 (88.0)		752 (88.4)	441 (89.4)		293 (90.4)	322 (89.9)	284 (85.0)	294 (89.6)	
Underweight (n=1360)												
Severe[a]	142 (10.4)	83 (11.0)	59 (9.8)	0.63	88 (10.2)	54 (10.9)	0.88	16 (4.9)	33 (9.2)	49 (14.4)	44 (13.3)	**0.01**
Moderate[b]	265 (19.5)	151 (20.0)	114 (18.9)		171 (19.8)	94 (19.0)		40 (21.1)	57 (15.8)	85 (25.1)	83 (25.1)	
Normal[c]	953 (70.1)	522 (69.0)	431 (71.3)		606 (70.1)	347 (70.1)		274 (83.0)	270 (75.0)	205 (60.5)	204 (61.6)	
Clinical outcomes and signs/symptoms of nutritional deficiency (n=1427)												
Wasted appearance	197 (13.8)	95 (12.0)	102 (16.0)	**0.03**	145 (16.0)	52 (10.0)	**0.01**	29 (8.3)	33 (9.0)	66 (18.5)	69 (19.3)	**0.01**
Bitots spot	283 (19.8)	168 (21.3)	115 (18.1)	0.13	147 (16.2)	136 (26.2)	**0.01**	27 (7.8)	65 (17.8)	89 (25.0)	102 (28.5)	**0.01**
Loss of hair pigment	153 (10.7)	80 (10.1)	73 (11.5)	0.42	114 (12.6)	39 (7.5)	**0.01**	12 (3.5)	46 (12.6)	56 (15.7)	39 (10.9)	**0.01**
Dry and infected cornea	189 (13.2)	108 (13.7)	81 (12.7)	0.60	114 (12.6)	75 (14.5)	0.31	25 (7.2)	26 (7.1)	49 (13.8)	89 (24.9)	**0.01**
Oedema	38 (2.7)	18 (2.3)	20 (3.14)	0.32	28 (3.1)	10 (1.9)	0.91	4 (1.2)	5 (1.4)	9 (2.5)	20 (5.6)	**0.01**
Pale conjunctiva	513 (35.9)	279 (35.3)	234 (36.7)	**0.01**	309 (34.0)	204 (39.3)	**0.05**	83 (23.9)	95 (26.0)	154 (43.3)	181 (50.6)	**0.01**
Bowed legs	37 (2.6)	25 (3.2)	12 (1.9)	0.13	23 (2.5)	14 (2.7)	0.85	7 (2.0)	3 (0.8)	9 (2.5)	18 (5.0)	**0.01**
Sponsy bleeding gums	232 (16.3)	131 (16.6)	101 (15.9)	0.71	104 (11.5)	128 (24.7)	**0.01**	37 (10.6)	68 (18.6)	70 (19.7)	57 (15.9)	**0.01**
Dermatitis	818 (57.3)	464 (58.7)	354 (55.8)	0.23	511 (56.3)	307 (59.2)	0.29	155 (44.5)	200 (54.8)	235 (66.0)	228 (63.7)	**0.01**
Red inflammed tongue	261 (18.3)	138 (17.5)	123 (19.3)	0.37	167 (18.4)	94 (18.1)	0.90	24 (6.9)	62 (17.0)	80 (22.5)	95 (26.5)	**0.01**
Subdermal haemorrhage	66 (4.6)	39 (4.9)	27 (4.2)	0.53	36 (4.0)	30 (5.8)	0.12	8 (2.3)	16 (4.4)	19 (5.3)	23 (6.4)	**0.06**
Goiter	9 (0.63)	7 (0.9)	2 (0.3)	0.18	7 (0.8)	2 (0.4)	0.38	1 (0.3)	3 (0.8)	1 (0.3)	4 (1.1)	0.41
Overall nutritional deficiency (n=1427)	1113 (78.0)	58 (72.5)	1055 (78.3)	0.22	697 (76.8)	416 (80.2)	0.14	216 (62.1)	269 (73.7)	306 (86.0)	322 (89.9)	**0.01**

[a] *z score of < -3*

[b] *z score of < -2 and ≥ -3*

[c] *z score ≥ -2*

p-values are calculated by χ2

test

Table 10 Results from univariate and multivariate logistic regression analysis with undernutrition* as outcome

Undernutrition [N (cases)=760]		Univariable logistic regression[a]			Multivariable logistic regression[b]		
		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
Age of the participated child	< 5 years	1.00			1.00		
	> 5 years	0.98	0.78-1.23	0.83	1.01	0.72-1.42	0.95
Sex of the participated child	Male	1.00			1.00		
	Female	1.01	0.81-1.27	0.89	0.95	0.68-1.33	0.77
Number of childrens in the household	< 5	1.00					
	> 5	1.05	0.32-3.42	0.93			
Socioeconomic status	Poor	1.00			1.00		
	Middle	0.73	0.54-0.99	**0.04**	0.70	0.43-1.11	0.13
	Better	0.57	0.41-0.80	**0.00**	0.43	0.25-0.75	**0.01**
Caregivers read/write	Can neither read or write	0.75	0.30-1.88	0.55			
	Can read only	1.10	0.80-1.52	0.56			
	Can both read and write	1.00					
Occupation of the household head	Agriculture	1.22	0.96-1.53	**0.10**	1.05	0.71-1.53	0.82
	Business	0.90	0.62-1.29	0.55			
	Daily laborer	1.11	0.88-1.40	0.37			
	Government service	0.50	0.28-0.92	**0.03**	0.54	0.21-1.38	0.20
	Other independent work	0.46	0.46-13.08	0.29			
	None	0.38	0.11-1.32	**0.13**	0.49	0.12-2.04	0.33
Household involved in the water system	"yes" *vs.* "no"	0.84	0.51-1.40	0.51			
Handwashing with soap	<5 times	1.00					
	5-10 times	0.93	0.72-1.20	0.57			
	>10 times	1.04	0.21-5.29	0.96			
Animals inside home overnight	"no" *vs.* "yes"	0.94	0.74-1.20	0.64			
Information received on WASH	"yes" *vs.* "no"	0.91	0.71-1.18	0.49			
Heard about intestinal parasites	"yes" *vs.* "no"	0.77	0.59-1.01	**0.06**	1.39	0.76-2.55	0.29
Awareness against intestinal parasites	Wash hands with soap	0.92	0.64-1.31	0.65			
	Drink clean water	0.84	0.63-1.13	0.26			
	Regular deworming	0.65	0.46-0.92	**0.02**	0.44	0.20-0.94	**0.03**
Weaning for the participated child started <6months	"yes" *vs.* "no"	0.64	0.33-1.23	**0.18**	1.95	0.60-6.36	0.27
Received additional meal (snacks) than usual meals	"yes" *vs.* "no"	0.65	0.51-0.83	**0.00**	0.57	0.38-0.84	**0.01**
DDS[c]	1	1.00			1.00		
	2	1.09	0.67-1.77	0.73	1.01	0.47-2.15	0.98
	3	1.41	0.89-2.25	**0.14**	0.85	0.41-1.74	0.66
	4	1.13	0.71-1.83	0.60	0.90	0.44-1.84	0.77
	5	1.35	0.84-2.18	0.22	0.84	0.40-1.75	0.63
	6	1.02	0.64-1.64	0.93	0.50	0.24-1.04	0.06
	7	1.85	1.13-3.03	**0.02**	1.69	0.77-3.73	0.19
	8	1.26	0.78-2.05	0.34	0.84	0.40-1.77	0.65
	9	1.61	0.99-2.61	**0.05**	1.76	0.80-3.90	0.16
Production of own food	"yes" *vs.* "no"	0.86	0.68-1.07	**0.18**	0.67	0.46-0.97	**0.03**
Giardia lamblia	"yes" *vs.* "no"	0.91	0.64-1.28	0.57			
Presence of intestinal helminths	"yes" *vs.* "no"	1.27	0.94-1.70	**0.12**	1.36	0.93-1.98	0.11
Ascaris lumbricoides	"yes" *vs.* "no"	1.15	0.82-1.62	0.41			
Trichuris trichiura	"yes" *vs.* "no"	1.68	0.31-9.19	0.55			
Hymenolepsis nana	"yes" *vs.* "no"	1.48	0.75-2.93	0.26			
Enterobius vermicularis	"yes" *vs.* "no"	2.19	0.85-5.62	**0.10**	2.01	0.70-5.79	0.19
Latrine hygiene	Lower category	1.00					
	Middle category	1.11	0.85-1.45	0.44			
	Better category	1.12	0.85-1.47	0.44			
Kitchen hygiene	Lower category	1.27	0.98-1.65	**0.08**	1.26	0.82-1.94	0.29
	Middle category	1.15	0.84-1.58	0.39	0.86	0.48-1.53	0.61
	Better category	1.00			1.00		
Personal hygiene of participating child and their caregivers	Lower category	1.32	1.01-1.73	**0.04**	1.43	0.92-2.22	0.11
	Middle category	1.04	0.79-1.37	0.77	0.83	0.51-1.35	0.46
	Better category	1.00			1.00		
E. coli at POU[d] drinking water	"yes" *vs.* "no"	1.48	0.84-2.59	**0.17**	0.87	0.34-2.24	0.77

E. coli at POC[e] drinking water	"yes" *vs.* "no"	1.63	0.96-2.76	**0.07**	1.27	0.59-2.71	0.25
Total coliform at POC drinking water	"yes" *vs.* "no"	5.31	1.01-27.9	**0.05**	3.81	0.32-45.49	0.29
Total coliform at POU drinking water	"yes" *vs.* "no"	2.32	0.72-7.48	**0.16**	1.47	0.18-12.04	0.72
Presence of diarrhea	"yes" *vs.* "no"	1.08	0.81-1.46	0.59			
Presence of nutritional deficiencies	"yes" *vs.* "no"	1.06	0.84-1.35	0.63			

[a] *Odds ratios (OR) and p-values are based on the likelihood ratio test and the significant p-value from the univariable logistic regression model is indicated bold.*

[b] *Adjusted odds ratios (aOR) and p-vaules are based on likelihood ratio test of the mixed multivariable regression model. The model with random area intercepts included the categorical exposure variables age and sex of the participated child, socioeconomic domains and surveyed area. All the risk values that had p-values lower than 0.2 in the univariable analyses were included into the mixed multivariable regression analysis.*

[c] Dietary diversity score

[d] Point of use

[e] Point of collection

** Undernutrition included the presence or absence of stunting, thinness and underweight.*

Table 11 Results from univariate and multivariate logistic regression with any signs of nutritional deficiency* as outcome

Nutritional deficiencies [N(cases)=912]		Univariable logistic regression[a]			Multivariable logistic regression[b]		
		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
Age of the participated child	< 5 years	1.00			1.00		
	> 5 years	1.59	1.25-2.02	**0.01**	1.84	1.30-2.62	**0.01**
Sex of the participated child	Male	1.00			1.00		
	Female	0.98	0.78-1.23	0.84	1.04	0.76-1.42	0.80
Number of children in the household	< 5	1.00			1.00		
	> 5	2.81	0.60-13.27	**0.19**	3.05	0.32-29.12	0.33
Socioeconomic status[c]	Poor	1.14	0.83-1.58	0.42	1.10	0.70-1.72	0.68
	Middle	1.20	0.84-1.71	0.30	1.37	0.81-2.32	0.23
	Better	1.00			1.00		
Occupation of the household head	Agriculture	0.96	0.76-1.21	0.73			
	Business	0.75	0.52-1.09	**0.13**	0.84	0.49-1.45	0.54
	Daily laborer	0.65	0.51-0.83	**0.01**	0.75	0.52-1.06	0.10
	Government service	1.04	0.59-1.83	0.88			
	Other independent work	0.25	0.04-1.36	**0.11**	0.51	0.07-3.67	0.50
	None	4.93	0.62-39.22	**0.13**	2.70	0.22-32.85	0.44
Handwashing with soap	<5 times	1.00			1.00		
	5-10 times	0.66	0.51-0.85	**0.01**	1.08	0.65-1.80	0.76
	>10 times	0.65	0.12-3.44	0.61	3.39	0.36-31.77	0.28
Times of handwashing	When they look dirty	0.56	0.44-0.71	**0.01**	0.74	0.50-1.08	0.12
	After going to toilet	0.39	0.14-1.09	**0.07**	0.13	0.01-1.10	0.06
	After cleaning babys bottom	0.40	0.32-0.52	**0.01**	0.60	0.40-0.92	**0.02**
	Before eating	1.02	0.78-1.33	**0.15**	0.75	0.49-1.15	0.19
	Before cooking	1.44	1.14-1.82	**0.01**	1.07	0.67-1.68	0.78
Animals inside home overnight	"yes" *vs.* "no"	1.67	1.32-2.13	**0.01**	1.71	1.17-2.51	**0.01**
Information received on WASH[d]	"yes" *vs.* "no"	0.65	0.45-0.95	**0.02**	1.03	0.56-1.89	0.93
Family members attended hygiene literacy class from health workers	"yes" *vs.* "no"	0.97	0.75-1.26	0.82			
Child sufferred from any illnessess:							
Fever	"yes" *vs.* "no"	0.98	0.78-1.24	0.89			
Cough	"yes" *vs.* "no"	1.09	0.86-1.37	0.47			
Respiratory difficulties	"yes" *vs.* "no"	1.97	1.40-2.78	**0.01**	1.32	0.79-2.18	0.29
Diarrhea[e]	"yes" *vs.* "no"	1.05	0.77-1.44	0.75			
Blood in stool	"yes" *vs.* "no"	2.87	1.25-6.60	**0.01**	1.72	0.50-5.90	0.39
Mucus in stool	"yes" *vs.* "no"	3.10	1.42-6.75	**0.01**	2.07	0.67-6.38	0.20
Blood in urine	"yes" *vs.* "no"	1.99	0.39-9.98	0.40			

Heard about intestinal parasites[f]	"yes" *vs.* "no"	0.53	0.40-0.70	**0.01**	1.12	0.46-2.69	0.80
Awareness against intestinal parasites	Washing hands with soap	0.39	0.27-0.57	**0.01**	0.56	0.26-1.24	0.15
	Cutting finger nails	0.22	0.13-0.37	**0.01**	0.83	0.32-2.15	0.71
	Wash fruits/vegetables before consumption	0.13	0.05-0.33	**0.01**	0.64	0.17-2.45	0.52
	Wear shoe	0.13	0.07-0.23	**0.01**	0.24	0.09-0.62	**0.01**
	Drink clean water	0.61	0.45-0.82	**0.01**	1.63	0.67-3.95	0.28
	Deworming regularly	0.85	0.60-1.21	0.38			
Child ever breastfed	"yes" *vs.* "no"	0.80	0.12-5.17	0.82			
Total months child breastfed	<6 months	2.82	1.07-7.42	**0.04**	3.99	0.86-18.50	0.08
	6-12 months	1.64	0.62-4.33	0.31	1.90	0.41-8.84	0.41
	>12 months	1.00			1.00		
Weaning for the participated child started <6months	"yes" *vs.* "no"	0.57	0.30-1.09	**0.09**	0.52	0.17-1.62	0.26
Floor material	"earth" vs. "cement"	1.01	0.74-1.37	0.95			
Dietary diversity scores[g]	1	1.00			1.00		
	2	1.07	0.66-1.74	0.77	0.75	0.36-1.54	0.44
	3	1.15	0.72-1.85	0.55	0.70	0.34-1.46	0.34
	4	2.06	1.23-3.44	**0.01**	1.12	0.52-2.44	0.76
	5	1.86	1.09-3.12	**0.02**	1.67	0.77-3.61	0.19
	6	1.28	0.78-2.10	0.32	0.89	0.43-1.84	0.75
	7	1.30	0.79-2.16	0.30	0.93	0.44-1.96	0.86
	8	0.83	0.51-1.37	0.48	0.84	0.41-1.74	0.65
	9	0.27	0.17-0.45	**0.01**	0.51	0.25-1.05	0.07
Production of own food	"yes" *vs.* "no"	0.52	0.41-0.67	**0.01**	0.51	0.35-0.76	**0.01**
Latrine hygiene[h]	Lower category	1.00			1.00		
	Middle category	1.38	1.02-1.86	**0.04**	1.43	0.93-2.20	0.10
	Better category	0.68	0.52-0.90	**0.01**	0.61	0.41-0.91	**0.01**
Kitchen hygiene[i]	Lower category	1.00			1.00		
	Middle category	1.33	1.01-1.74	**0.04**	0.89	0.58-1.34	0.57
	Better category	0.47	0.34-0.65	**0.01**	0.40	0.22-0.75	**0.01**
Personal hygiene of participating child and their caregivers[j]	Lower category	2.24	1.68-3.00	**0.01**	1.90	1.17-3.10	**0.01**
	Middle category	1.93	1.46-2.55	**0.01**	1.84	1.22-2.76	**0.01**
	Better category	1.00			1.00		
Hygiene status of water transport container[k]	Lower category	1.00			1.00		
	Middle category	0.97	0.68-1.38	**0.03**	0.60	0.23-1.58	0.30
	Better category	0.55	0.42-0.72	**0.01**	0.91	0.31-2.66	0.87
Hygiene status of water storage container[l]	Lower category	1.00			1.00		

	Middle category	1.10	0.77-1.59	0.59	1.84	0.69-4.87	0.22
	Better category	0.54	0.42-0.72	**0.01**	0.77	0.26-2.25	0.64
Presence of intestinal parasites	"yes" *vs.* "no"	0.88	0.66-1.17	0.37			
Presence of undernutrition	"yes" *vs.* "no"	1.07	0.84-1.35	0.59			
E. coli in POC[m] drinking water	"yes" *vs.* "no"	0.93	0.55-1.57	0.79			
Coliforms in POC[n] drinking water	"yes" *vs.* "no"	6.53	1.24-34.29	**0.03**	10.44	1.61-67.4	**0.01**
E. coli in POU drinking water	"yes" *vs.* "no"	1.08	0.63-1.85	0.78			
Coliforms in POU drinking water	"yes" *vs.* "no"	2.33	0.79-6.88	**0.13**	1.78	0.33-9.46	0.50

[a] *P-values and odds ratios are based on likelihood ratio test. The overall P-value <0.2 were indicated in bold letters in the univariable logistic regression model.*

[b] *P-value and adjusted odds ratios (aOR) based on the likelihood ratio test of the multivariable logistic regression model. The mixed multivariabel logistic regression model with radom area intercepts included the categorical exposure variables sex, age-group, socio-economic conditions and project area. The risk factors having a P-value <0.2 in the univarable analyses were included into the multivariable regression analysis (shown in table).*

[c] *Socio-economic status was derived from a factor analysis using principal component analysis of variables indicating the wealth index*

[d] *Water sanitation and hygiene*

[e] *Passage of loose stool three or more than three times per day*

[f] *Overall soil transmitted helminths and intestinal protozoa*

[g] *Diet diversity scores were created with conceptually similar categorical variables of nine food groups including (i) starchy staples, (ii) beans, peas or lentils (iii) nuts or seeds (iv) dairy products (v) meat or fish (vi) eggs (vii) leafy green vegetables (viii) other vegetables (ix) fruits. Childrens were classied into one of the nine categories of food groups consumption.*

[h] *Latrine hygiene includes the category of condition of latrine while observation, availability of sandals, drums, brush, kindl of handwashing facilities available, soap and water availabilty.*

[i] *Kitchen hygiene includes the category of if clean dishes kept high, entirety of food covered, if there is dry rack to dry the utensils and dishes after washing and flies availability in the kitchen*

[j] *personal hygiene includes the category of mother/father wearing shoes, hands clean, hands of child clean and dirty cloth piles lying*

[k] *hygine status of the water transport container includes the categories of if water transport container clean and have a lid, broken/not broken*

[l] *hygiene status of water storage container includes the categoires of if water storage container clean and have a lid, the water container storage broken or not*

[m] *Point of collection such as stand tap*

[n] *Point of use such as gagri, jerrican plastic*

* *Nutritional deficiency: presence of wasted appeareance, bitots spot, loss of hair pigment, dry and infected cornea, oedema, pale conjunctiva, bowed legs, sponsy bleeding gums, dermatitis, red inflammed tongue, subdermal haemorrhage and goiter*

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable1.docx