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Diarrhoea, malnutrition, and dehydration associated with school water, sanitation, and hygiene in Metro Manila, Philippines: A cross-sectional study

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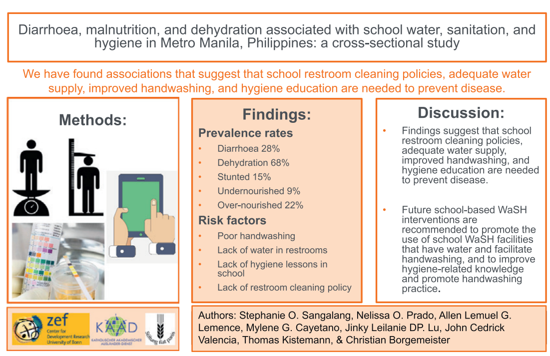
HIGHLIGHTS

- Addressing school water, sanitation, and hygiene requires a mixed-methods approach.
- Dehydration is a useful indicator of water insecurity and can be measured in urine.
- Children who had no hygiene lessons in school were more likely to be stunted.
- Proper handwashing and hygiene education should be promoted in schools and homes.

GRAPHICAL ABSTRACT



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ABSTRACT

Introduction: Diarrhoea, malnutrition, and dehydration threaten the lives of millions of children globally due to inadequate water, sanitation, and hygiene (WaSH). Our study aimed to identify environmental and behavioural risk factors of these health outcomes among schoolchildren in Metro Manila, Philippines.
Materials and methods: We analysed data from a multistage cluster sample of schoolchildren in grades 5, 6, 7, 9, and 10 (ages ~10–15 years old) to investigate WaSH facilities and hygiene practices. Outcomes were: self-reported diarrhoea, measured via questionnaire; observed malnutrition (stunting, undernutrition [underweight/thin and wasted/severely thin], over-nutrition [overweight and obese]), measured via anthropometry; dehydration, measured via urine specific gravity/urine test strips. We used multiple logistic regression to explore correlates.
Results: We included 1558 students from 15 schools in three cities. Over 28% (421) of students had diarrhoea and 68% (956) were dehydrated. Over 15% (227) of students were stunted, ~9% (127) were undernourished, and >21% (321) were over-nourished. Diarrhoea was associated with poor handwashing, while dehydration was associated with the lack of water in school restrooms. Stunting was linked with not using the school restroom, the lack of water in school restrooms, and the lack of hygiene lessons in school. Undernutrition was associated with the lack of a school restroom cleaning policy. Risks of diarrhoea, stunting, and undernutrition decreased as the number of school restrooms

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increased. Risks of stunting and overnutrition decreased as the numbers of school toilets increased. Having more than seven handwashing basins was associated with decreased risk of dehydration.

Discussion: Findings from our cross-sectional study cannot describe causation. We have found associations that suggest that school restroom cleaning policies, adequate water supply, improved handwashing, and hygiene education are needed to prevent disease. School-based WaSH interventions are recommended to provide water in school WaSH facilities, promote handwashing, and improve hygiene-related knowledge.

1. Introduction

Diarrhoea affects 2.39 billion people globally and caused 1,655,944 deaths in 2016 (Troeger et al., 2018). In the same year, about 60% of diarrhoea deaths (829,000) were attributed to inadequate water, sanitation, and hygiene (WaSH) (Prüss-Ustün et al., 2019). Nearly 90% of deaths occurred in South Asia and sub-Saharan Africa (Naghavi et al., 2017). People of low socioeconomic status (SES) are disproportionately affected due to their high exposure to risk factors like inadequate WaSH facilities and food insecurity. In 2016, diarrhoea resulted in 74.4 million disability-adjusted life-years (DALYs) (Troeger et al., 2018). Diarrhoea has been associated with high annual costs, ranging from United States Dollar (USD) $1.3–$1.7 million in Rwanda (Ngabo et al., 2016) to USD $926.4 million in China (Jin et al., 2011).

Malnutrition affects about one out of three people globally (World Health Organization [WHO], 2017a). In 2017, stunting affected 22.2% (150.8 million) of all children <5. In 2017, while 5.6% (38.3 million) of children were overweight, 7.5% (50.5 million) were wasted or thin (Development Initiatives, 2018). Undernutrition, especially in low- and middle-income countries (LMICs), caused 45% of deaths in children <5 (Black et al., 2013). Overweight and obesity caused ~7% of deaths (4 million) and 120 million DALYs (Naghavi et al., 2017). Malnutrition, in all its forms, costs society ~USD $3.5 trillion, or 5% of the global gross domestic product, annually (Food and Agriculture Organization of the United Nations, 2013). Preventing children's malnutrition involves preventing infectious diseases that precipitate imbalanced protein and/or energy intake. Risk of infectious diseases, in turn, can be decreased by improving WaSH (Ashraf et al., 2020; Trinies et al., 2016). Examples of WaSH improvements include interrupting routes of faecal-oral disease transmission through proper handwashing, safe handling of food and disposal of faeces, and providing access to clean water. In 2016, 6000 deaths due to malnutrition could have been prevented by improving WaSH (Prüss-Ustün et al., 2019).

The purpose of this study was to assess risk factors of diarrhoea, malnutrition, and dehydration in Metro Manila, Philippines. We collected data on students' health history, hydration, nutrition, hygiene practices, and WaSH-related perceptions, as well as schools' WaSH facilities and policies, in order to find out if certain child- or school-level factors increased children's risks for diseases. We collected data from a subsample of children's households, assessing demographic information, families' handwashing practice, food security, and home WaSH facilities.

2. Materials and methods

2.1. Study area

The Philippines has a tropical monsoon climate, with dry (December–May) and wet (June–November) seasons. The National Capital Region, known as Metro Manila, is a megacity that had ~13.5 million inhabitants in 2020 (Philippine Statistics Authority, 2021), comprising 12.4% of the country's population. In 2016, 14,800 deaths, including ~4113 from diarrhoea, were attributed to inadequate WaSH in the Philippines (Prüss-Ustün et al., 2019). Diarrhoea is the sixth leading cause of disease in Metro Manila and among the top 10 causes of disease nationally (Philippines Department of Health, 2018). In 2018, the prevalence rates of school-age (6–10 years old) children's stunting, underweight, wasting/thinness (low weight-for-height), and overweight-for-height were: 24.5%, 25%, 7.6%, and 11.7%, respectively (Vargas, 2019). Over 29,000 annual deaths of children <5 in the Philippines were attributed to undernutrition (United Nations International Children's Emergency Fund [UNICEF], 2018). While undernutrition alone costs the Philippines USD $4.4 million annually (UNICEF, 2018), the overall cost of hunger was USD $6.5 billion in 2013 (Save the Children Philippines, 2016).

The Philippines Department of Education operates 54,602 public schools nationally and hosted >22.6 million children during school year 2018–2019 (Philippines Department of Education, 2019a). While public schools receive government funding, they are often severely understaffed, have a shortage of classrooms, and are frequently overcrowded. The country's poorest children attend public schools.

2.2. Study design, sampling, and sample estimation

We conducted a school-based survey on a multistage cluster sample of primary and secondary school students from 15 public schools in Metro Manila, where prevalence rates of diarrhoea and malnutrition are high but access to environmental health and hygiene education is low. This paper describes a cross-sectional study that took place during the dry season and the beginning of the wet season (February–June 2017), was observational, and part of a larger research project, “WaSH in Metro Manila Schools”, which involved developing and evaluating a comprehensive, school-based WaSH intervention package. We focused on two cities in Metro Manila, Navotas and Quezon City (Fig. 1), because they are considered geographically and socio-demographically representative of the 14 other cities that constitute Metro Manila. Our sampling frame (Fig. 2) was the total number of public schools in Navotas and Quezon City, which consisted of 164 schools in 160 “barangays” (the smallest government units in the Philippines) in eight legislative districts.

During the first stage of sampling, we obtained annual school enrolment data for school year 2015–2016 from the Philippines Department of Education (2019a), identified all public primary schools in Navotas and Quezon City, and sorted them by enrolment size, from largest to smallest. We selected 25 schools from the top of the sorted list to invite to participate in our study. After applying our inclusion criteria (i.e., accessibility of classrooms during school-day hours and availability of WaSH facilities), we identified 15 schools to visit and ask permission from school principals to conduct our survey. One of the 15 schools had served as the location of our previous pilot study wherein we tested our survey instruments. A 16th school, located in the city of Manila, asked us directly to participate in the study. Before we finished our recruitment of study participants, one of the schools we invited to join refused to participate in the study. Thus, our final study sample came from 15 out of 16 originally contacted schools in three cities (participation rate: 93.8%). During the second stage of sampling we asked school principals, or representatives who were familiar with students' schedules, to select the class section(s) that we would survey based on scheduling availability to help us comply with the Philippines Department of Education's “no disruption of class” policy. Applying our inclusion criteria, of recruiting students in grade five or six (ages ~10–11 years old) from primary schools and students in grade seven, nine, or 10 (ages ~12–15 years old) from secondary schools, school principals/representatives selected the class section(s). Based on the school's enrolment size, one to three class sections per school were selected in order to obtain a target sample of ~100 students per school. All students belonging to the selected class section(s) were invited to participate in our study if they met our inclusion criteria: able to 1) read, comprehend, and answer our questionnaire; 2) operate an electronic tablet independently or with

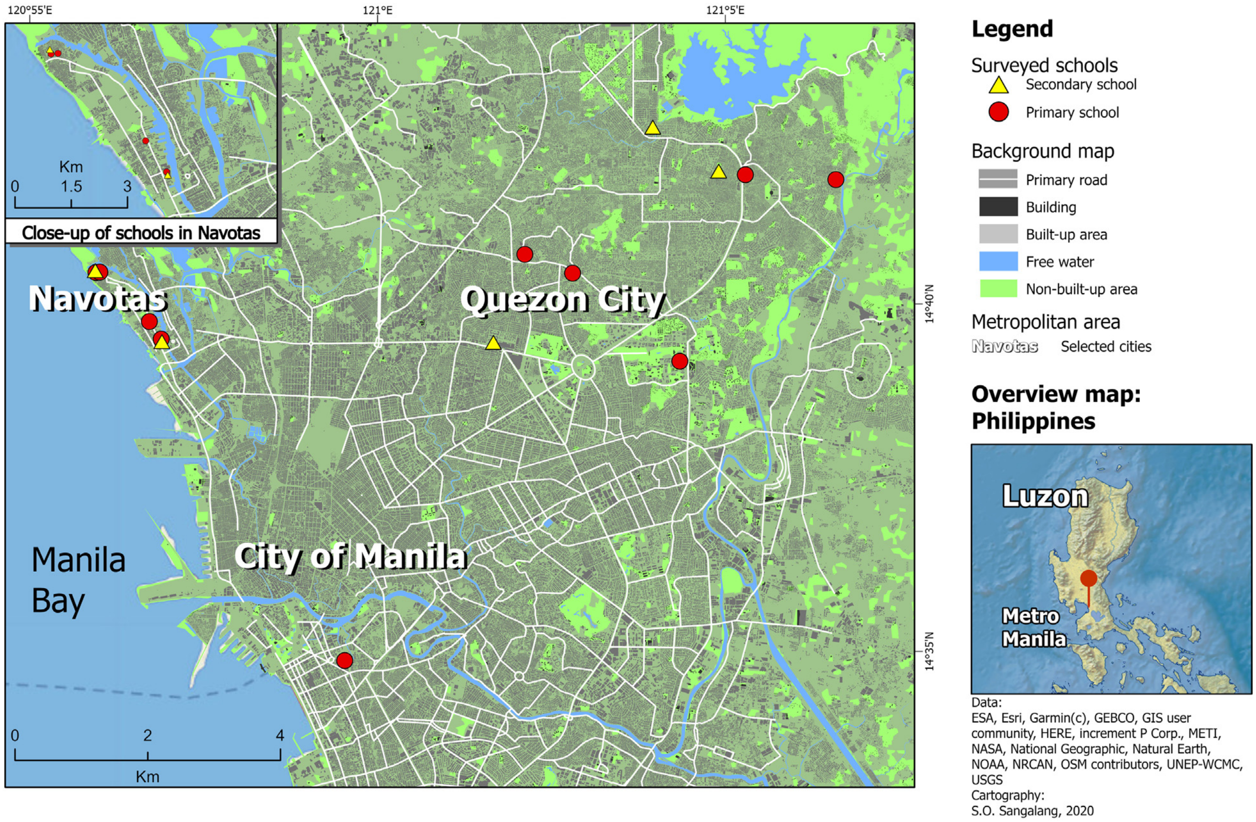

Fig. 1. Map of study area. The map shows the study area in the Philippines' National Capital Region, known as Metro Manila. Points mark the location of study schools. In the lower right inset map, the red pushpin marker indicates where the location of the study area is within the Philippines, specifically in the northern most island group of Luzon.

minimal assistance; 3) provide a urine specimen; and 4) be measured for height and weight.

Prior to starting field research, we estimated the sample size. Our target population was all the public school children in Metro Manila. There was a total of 2,059,447 public school children (1,373,852 elementary and 685,595 secondary school children) in Metro Manila in school year 2014–2015 (Philippines Department of Education, 2019a). For this baseline survey, in order to estimate proportion parameters in schoolchildren, the precision of a 95% CI should be five percentage points. As the prevalence is not known (assumed to be 50%), the sample size was estimated as N = 399 under a finite population size of ~2.1 million (based on the Philippines Department of Education data for school year 2014–2015). The sample size was calculated via PASS (NCSS) software (2006 version). We inflated the sample by 30% to account for nonresponse and 45% for refusal. To account for differences in schools' enrolment sizes and the possible effects of the study design, we inflated the sample by another 45% and 20%, respectively. Our target sample size was N = 1309, and 1558 students enrolled in the study. We received complete responses to questions about outcomes and exposures of interest from 1296 students (response rate: 83.2%). We conducted household surveys on a subsample of students and their parents/guardians as described below.

2.3. Data collection

We developed a self-administered questionnaire (Appendix 1) in English for students and then translated it into Tagalog (Filipino language). We developed structured interview scripts for school principals and parents, school and home restroom inspection checklists, and student health examination data entry forms. We pilot tested these electronic survey instruments at one school, and then refined them to improve understandability. Except for the students' health examination data entry forms, which we preserved as Microsoft Excel© files, the final versions of all survey instruments were administered using the QuickTapSurvey© app installed on password-protected electronic tablets.

Research assistants received hands-on training from the research supervisor during a one-day workshop prior to conducting field research. To begin the school survey, we went to schools, and research assistants gave a simple explanation in Tagalog about the study to the students, who were assigned a study identification number, which students were instructed to input into questionnaires instead of their names to ensure anonymity and confidentiality. Research assistants measured students' height (without shoes), using a standard tape measure attached to the classroom or hallway wall, and weight (without shoes or items inside their pockets), using a standard digital weighing scale [EKS Asia Ltd., Hong Kong, People's Republic of China]. Research assistants performed point-of-care urine analysis on students' urine specimens, using urine test strips [Insight Urinalysis Reagent Strips, Acon Laboratories Inc., San Diego, California, U.S.A.]. Research assistants completed the school restroom inspection checklist and took digital photos of WaSH facilities (toilets, urinals, handwashing basins); they also interviewed school principals/representatives about school WaSH policies. The research supervisor verified adherence to research protocols via direct observation. We obtained other school data, e.g., annual budget for maintenance and other operating expenses, from the Philippines Department of Education (2019a, 2019b, 2019c).

2.4. Dependent variables

We measured diarrhoea prevalence via students' self-report assessed by a questionnaire. The rationale for using self-report were: reliability, validity, convenience, and the ability to quickly, affordably, and accurately assess prevalence in a large sample of children. In our study, diarrhoea was defined as a numeric answer greater than zero to one question in the questionnaire ("How many times have you had diarrhoea in the last month?"). We used the WHO's definition of diarrhoea, i.e., having ≥three loose/

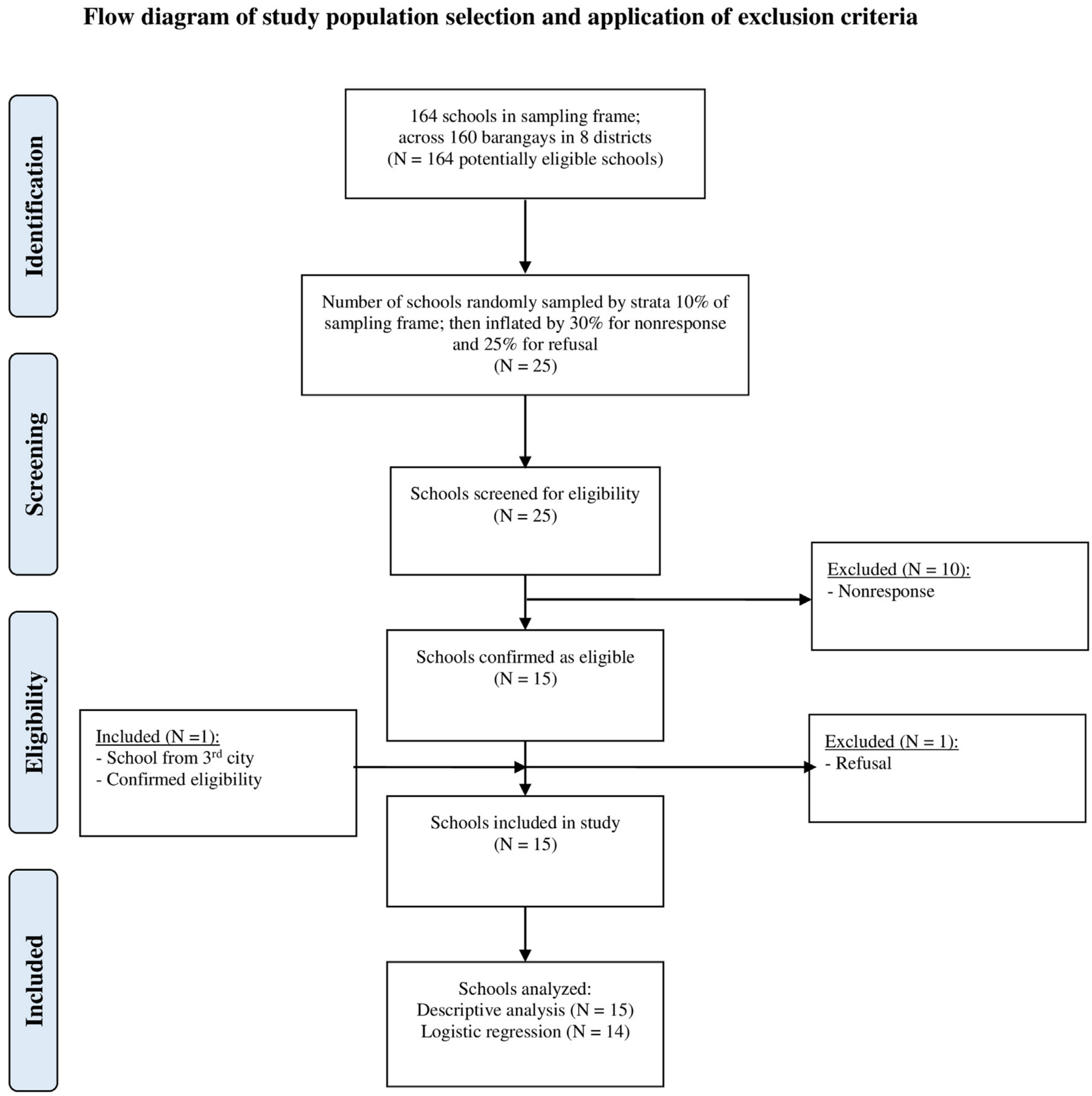

Fig. 2. Flow diagram of recruitment of public schools showing school selection, inclusion, and analysis.

liquid bowel movements (i.e., passing stools or faeces) in one day (WHO, 2017b).

We measured stunting, undernutrition, and over-nutrition as follows: 1) We used anthropometry to measure children's height and weight; 2) we used the WHO AnthroPlus software (WHO, Geneva, Switzerland) to calculate z-scores; 3) we used the WHO 2007 Growth Reference for children 5–19 years old (de Onis et al., 2007) and WHO's cut-off points for z-scores to classify children's nutrition status (WHO, 2007a, 2007b). “Stunting” was defined as having a height-for-age z-score (HAZ) < -2 (Appendix 2). We considered “undernourished” to be a composite variable, i.e., comprised of two variables. First, we considered “underweight” (or “thin”), which is based on body mass index (BMI)-for-age z-score (BAZ). BMI is calculated with the formula: weight (kg) / [height (m)]^2. The cut-off points for z-scores for “underweight” are $-3 < \text{BAZ} < -2$. Second, we defined “wasted” (or “severely thin”) as $\text{BAZ} < -3$. We considered “over-nourished” to be a composite variable, i.e., comprised of two variables. First, we defined “overweight” as $1 < \text{BAZ} < 2$. Second, we defined “obese” as $\text{BAZ} > 2$.

Dehydration was defined as having highly concentrated urine, i.e., urine specific gravity (U_{sg}) $\geq$ 1.020 (Pagana et al., 2015), measured using urine test strips (Insight Urinalysis Reagent Strips, Acon Laboratories Inc., San Diego, California, U.S.A.). We used the cut-off point of U_{sg} 1.020 because it corresponds to a urine osmolality (U_{osm}), which is considered to be the gold standard of urine-based measures of dehydration (Armstrong et al., 1994), of 800 mOsm/kg H_2O. This is the cut-off point used in previous studies involving dehydrated children (Bar-David et al., 2005). We defined mild, moderate, and severe dehydration as U_{sg} of 1.020, 1.025, and 1.030, respectively.

2.5. Independent variables

We assessed risk factors at the individual- and school-levels. We defined children as individuals <13 years old and teenagers as individuals ≥13 years old. We asked students about handwashing, use of and perceptions about school WaSH facilities, their health history and nutrition, and if hygiene lessons were taught in school. We asked school principals about WaSH-related school policies. We counted the number and assessed the quality of school WaSH facilities, noting characteristics of improved versus unimproved sanitation (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). We estimated student-to-toilet and student-to-handwashing basin ratios based on the Philippines Department of Health (1998) guidelines, which do not include specific or fixed ratios (Appendix 2). Rather they recommend a range of numbers for WaSH facilities that are sex-specific. We decided not to base our estimations on the WHO guidelines (WHO et al., 2009) (Appendix 2) because public schools in many parts of the Philippines, similar to other LMICs, currently have limited capacity to effectively address the over-crowding of students on school campuses. We provide operational definitions in Appendix 2.

We conducted a survey with a subsample of students' households to assess risk factors, e.g., food security, access to drinking water, at the home level. If a student provided a functioning telephone number during the questionnaire portion of the school survey, then his/her parent/guardian was contacted by a research assistant to be recruited for the household survey. Our main interest was to estimate the children's parameters with certain precision (±5%) but not the parameters of their background (e.g. family, household environment), as this was beyond the scope of our study. Therefore, this limitation to 20% of the background information was determined by the feasibility of the overall study only. We aimed to sample ~10–12 parents/guardians per school and to inflate the sample by 10% to account for nonresponse or refusal. The target sample was N = 225 parents/guardians. We collected samples for tests of water quality, specifically faecal contamination, from study schools and a separate sample of households (located in the school neighbourhood) in April 2018. We report our water quality indicators in Appendix 3. We assessed water samples according to the 2017 Philippine National Standards for Drinking Water (Philippines Department of Health, 2017).

2.6. Statistical analysis

We downloaded data from the QuickTapSurvey© app as Microsoft Excel© files. We used key matching data (students' self-reported date of birth and telephone number) to link data from students' questionnaires and health examinations to home restroom inspections and parents'/guardians' interviews. We used Stata, version 15 (StataCorp, College Station, Texas, U.S.A.), to prepare data for analysis.

To describe exposure to inadequate WaSH, we measured frequencies and interquartile ranges (IQRs) relevant to schools' and homes' WaSH facilities. Data from school inspections were summarized at the school-level by measuring the mean scores of individual facility inspections. To describe outcomes of diarrhoea and malnutrition, we measured prevalence rates of diseases using contingency tables with estimates of standard error (SE) and 95% confidence intervals (CI).

To identify statistically significant factors associated with diarrhoea, malnutrition, and dehydration, we used multiple logistic regression (Appendix 4), which produces adjusted odds ratios (aORs). In contrast to unadjusted ORs, aORs allowed us to control for confounding. We considered the following potential confounders: children's sex, age group, self-reported food intake and health status, hygiene behaviours, and WaSH-related perceptions, and schools' WaSH facilities (quantity, quality) and related policies and budget. We considered p-values < 0.05 to be statistically significant.

For all multiple logistic regression models, clustering was controlled for by using the “cluster” option in Stata. It is important to account for clustering because of the potential for within-group (“intragroup”) correlation among children from the same school and to adjust the SE of estimates. The “cluster” option in Stata enabled us to indicate that the observations were clustered into schools (based on school identification number) and that the observations may be correlated within schools, but would be independent between schools.

We analysed the main study sample with multiple logistic regression models, including variables such as: student does not wash hands in school, school restroom lacks water, and school lacks policy for cleaning restrooms daily. We analysed the subsample with multiple logistic regression models, including variables such as: the home restroom is not clean, it has signs of mould, and the number of adults in the home.

2.7. Ethics

Ethical approval for this study was granted by the Ethics Committees of the University of Bonn, Germany (approval date: 28 September 2016; reference number: 216/16), and the University of the Philippines Manila (approval date: 23 February 2017; reference number: 2017-0113). We obtained written approval from the Philippines Department of Education through division superintendents. As per local procedure, we obtained written informed consent from school principals “in loco parentis”, i.e., in the place of a parent. In Tagalog, we described to the children the study procedures and stated that participation in our study was voluntary and that anyone could decide to stop participating in the study anytime.

3. Results

3.1. Description of study population and WaSH characteristics

We measured diarrhoea, malnutrition, and dehydration prevalence in 1558 students from 15 schools in three cities (Appendix 5). Students were 9–19 years old; 66.7% (1039) were <13 years old and 73.1% (1085) considered themselves to be “healthy” (Table 1). Over 16% (239) of students said they avoided the school restroom and, while >91% of students (1359) said they washed their hands at school, only 53% (554) said they washed their hands with soap and water at school.

During our assessment of associated risk factors of diseases, we excluded 266 students (17.1%): 167 because of nonresponse on outcomes or logistic regression model covariates and 99 (6.4%) because they attended a school where the school principal declined our request to inspect the school restrooms during the baseline study.

We found handwashing basins in ~86% of schools (12); ~33% (26) of handwashing basins lacked water and >82% (65) lacked soap (Table 2). Over 33% (4) of schools had water that was contaminated by coliform bacteria, while 24% (3) had water that was contaminated by *Escherichia coli* (*E. coli*) (Appendix 3).

3.1.1. Subsample

From our main study sample, we found $N = 211$ students whose parent/guardian was willing to participate in our household survey. The subsample of students was 66% (134) female and ~73% of students were <13 years old (Table 2). Households had a median of six people (interquartile range [IQR] 4, 8) and the median duration of residence in the home was 13 years (IQR 5, 25). We report results of water quality testing in homes in Appendix 3.

3.2. Measurement of health outcomes

Over 28% (421) of students reported having diarrhoea in the last month. Over 15% (227) of students were stunted, ~9% (127) were undernourished, and >21% (321) were over-nourished. Sixty-eight percent (68%) of students (956) had highly concentrated urine ($U_{sg} \geq 1.020$), indicative of dehydration. A greater proportion of males (68.7%, 432) compared to females (67.5%, 524), and a greater proportion of teenagers (72.1%, 354) compared to children (65.9%, 602), were dehydrated (Appendix 6).

3.3. Associations between diarrhoea, dehydration, and school WaSH

Students' not washing their hands in school was significantly associated with increased odds of diarrhoea (aOR 1.77, 95% CI = 1.18 to 2.65) (Table 3). Diarrhoea risk decreased as the number of school restrooms increased (Table 3) and when schools had the maximum maintenance and other operating expenses budget (aOR 0.42, 95% CI = 0.31 to 0.57). The lack of water in school restrooms was associated with mild (aOR 1.84, 95% CI = 1.63 to 2.08) and moderate dehydration (aOR 2.21, 95% CI = 1.71 to 2.87). Risk of mild dehydration decreased as the number of school handwashing basins increased, while the risk of moderate dehydration decreased as the number of school toilets increased (Table 3).

3.4. Associations between malnutrition and school WaSH

Decreased risk of stunting and undernutrition was associated with schools >50 years old and a maximum maintenance and other operating expenses budget (Table 4). Risk factors of stunting were not using the school restroom (aOR 2.26, 95% CI = 1.22 to 4.20), lack of water in school restrooms (aOR 1.52, 95% CI = 1.21 to 1.90), and lack of hygiene lessons (aOR 1.91, 95% CI = 1.12 to 3.26) (Table 4). Risk of stunting decreased as the number of school restrooms increased (Table 4).

Flies in school restrooms were associated with under- and over-nutrition (Table 4). The maximum numbers of school toilets and handwashing basins were associated with decreased risks for under- and over-nutrition (Table 4). Undernutrition was associated with school restrooms that lacked water (aOR 2.18, 95% CI = 1.54 to 3.09), while overnutrition was associated with school restrooms that were not accessible for person(s) with disabilities (PWDs) (aOR 1.43, 95% CI = 1.06 to 1.93).

3.5. Impacts of home-level factors on diarrhoea and malnutrition

Diarrhoea was associated with not eating three times per day (aOR 5, 95% CI = 1.05 to 24.00), while mild dehydration was associated with

Table 1
Characteristics of main sample of students (N = 1558) and schools (N = 15).

	n	% (95% CI)
Student factors (*N* = 1588)		
Sex (self-reported)		
Female (self-reported)	861	55.3 (52.8, 57.7)
School attendance (self-reported)		
Attended school in the last 6 months	1391	93.5 (92.2, 94.7)
Missed class last year due to health problem or illness	610	41(38.5, 43.5)
Grade group (observed)		
Primary (grades 5–6; ~ages 10–11 years old)	1012	65 (62.6, 67.3)
Age (self-reported)		
Median (IQR)		12 (11,13)
Age group (self-reported)		
Child (age < 13 years)	1039	66.7 (64.3, 69.0)
Adolescent (age ≥ 13 years)	518	33.2 (30.9, 35.6)
Health-related knowledge, perceptions, and hygiene practices (self-reported)		
Does not wash hands at school	129	8.67 (7.2, 10.1)
Does not use soap when washing hands at school	491	47 (44.0, 50.0)
Does not use school restroom	107	7.19 (5.9, 8.5)
Avoids school restroom	239	16.1 (14.2, 18)
Does not know if he/she had helminth infection	318	21.4 (19.4, 23.5)
Considers oneself to be “not healthy”	399	26.9 (24.6, 29.1)
No provision of hygiene lessons at school	135	9.1 (7.6, 10.6)
Infectious disease (self-reported)		
Had diarrhoea (in the last month)	421	28.5 (26.2, 30.9)
Had helminth infection (ever)	647	43.6 (41.1, 46.2)
Malnutrition[a] (observed)		
Stunted	227	15.2 (13.4, 17.1)
Undernutrition	127	8.6 (7.2, 10.1)
Wasted (“severely thin”)	28	1.9 (1.3, 2.7)
Underweight (“thin”)	99	6.7 (5.5, 8.1)
Overnutrition	321	21.7 (19.6, 23.9)
Overweight	226	15.3 (13.5, 17.2)
Obese	95	6.4 (5.2, 7.8)
Sign of acute dehydration (observed)		
Highly concentrated urine, U_{sg} ≥ 1.020	956	68.0 (65.5, 70.5)
School factors		
Number of schools with unimproved[b] sanitation present	1	7.1 (0.2–33.9)
Number of schools without handwashing basin	1	14.3 (1.8, 42.8)
Type of toilet, latrine (e.g. dry, non-flush)	1	1.3 (0.03, 6.9)
Type of toilet, pour-flush	56	74.7 (59.6, 80.6)
Type of toilet, flush	16	24.1 (12.0, 30.8)
Number of toilet bowls, median (IQR)		17 (5.9, 26.5)
Number of handwashing basins, median (IQR)		5 (4, 12.5)
Number of schools that exceeded guidelines for student-to-toilet ratio[c]	13	92.9 (66.2, 99.8)
Number of schools that exceeded guidelines for student-to- handwashing unit ratio[c,d]	13	92.9 (66.2, 99.9)
Student-to-toilet ratio, median (IQR)		302.3 (219, 418)
Student-to- handwashing basin ratio, median (IQR)		562 (380.3, 935.1)
Number of toilets that had no nearby handwashing basin	24	30.4 (20.5, 41.8)
Number of handwashing basins not near toilet	61	49.2 (40.1, 58.3)
Provision of no separate toilet for females	8	3.6 (1.5, 6.8)
No water available	26	32.9 (22.7, 44.4)
No soap available	65	82.3 (72.1, 90.0)

Note. CI, confidence interval; IQR, interquartile range; U_{sg}, urine specific gravity; WaSH, water, sanitation, and hygiene.; WHO, World Health Organization. When estimating some proportions the denominator was not always N = 1558 due to missing data.

[a] Malnutrition indices are defined in Appendix 2 and were estimated using WHO AnthroPlus software. We classified malnutrition status according to WHO guidelines (de Onis et al., 2007; WHO, 2007a, 2007b).

[b] Unimproved sanitation does not hygenically separate human faeces from human contact (WHO/UNICEF. [2010]. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. Progress on Sanitation and Drinking-water: 2010 Update).

[c] We referred to the national guidelines (Philippines Department of Health, 1998). We estimated student-to-toilet and student-to-handwashing unit ratios by using school enrolment data from school year 2016–2017 (Philippines Department of Education, 2019a). Then we divided the number of students by two to take into account schools' use of a “double shift”. We divided the number of students by the total number of toilets, taking into account that some toilets were coed toilets (i.e. used by both males and females). We report sex-specific ratios in the Supplementary Data.

[d] We included in the analysis one school which had no functioning handwashing stations or basins (i.e. sinks); rather, a hose connected to water was provided for children to wash their hands.

Table 2
Characteristics of subsample of students, households, and homes ($N = 211$).

Factors	n	% (95% CI)
Student level		
Female	134	63.5 (56.6, 70.0)
Age < 13 years old	153	72.5 (66.0, 78.4)
Home level		
Household demographics		
Number of people in home, median (IQR)		6 (4, 8)
Number of adults in home, median (IQR)		3 (2, 5)
Number of kids in home, median (IQR)		3 (2, 4)
Duration (years) of residence in home, median (IQR)		13 (5, 25)
Household WaSH		
Has no restroom inside home	20	10.4 (5.9, 14.3)
Has no toilet	3	1.4 (0.3, 4.5)
Has no handwashing basin	66	34.4 (27.7, 41.6)
Home restroom has no water available	8	4.2 (1.8, 8.0)
Home restroom has no soap available	25	13.0 (8.6, 18.6)
Home restroom has no hand towels	129	67.2 (60.1, 73.8)
Home restroom has no toilet paper	187	97.4 (94.0, 99.1)
Home restroom not clean	76	39.6 (32.6, 46.9)
Home restroom has signs of mould	98	51.0 (43.7, 58.3)
Home restroom has signs of damage	139	72.4 (65.5, 78.6)
Home restroom is not well-lit	83	43.2 (36.1, 50.6)
Home restroom has wet floor	145	75.5 (68.8, 81.4)
Home restroom door has no lock	85	44.3 (37.1, 51.6)
Home restroom has unimproved[a] sanitation	39	20.3 (14.9, 26.7)
Home restroom toilet cannot be flushed	140	72.9 (66.0, 79.1)
Home restroom has septic tank	57	29.7 (23.3, 36.7)
Household food insecurity		
Insufficient amount of food at home	14	6.6 (3.7, 10.9)
No place nearby to buy food	6	2.8 (1.1, 6.1)
Food prices are not affordable	16	7.6 (4.34, 12.0)
Not able to buy food	113	53.6 (46.6, 60.4)
Has experienced asking/begging someone for food	165	78.2 (72.0, 83.6)
Does not eat a variety[b] of food	13	6.2 (3.3, 10.3)
Cooks food less often than buys prepared food	20	9.5 (5.9, 14.3)
No access to drinking water	4	1.9 (0.5, 4.8)

Note. CI, confidence interval; IQR, interquartile range; WaSH, water, sanitation, and hygiene. When estimating some proportions the denominator was not always N = 211 due to missing data.
[a] Unimproved sanitation does not hygienically separate human excreta from human contact (WHO/UNICEF. [2010]. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. Progress on Sanitation and Drinking-water: Update 2010).
[b] Variety of food refers to e.g. fruits, vegetables, meat, and fish.

having no handwashing basin at home (aOR 2.45, 95% CI = 1.08 to 5.56) and moderate dehydration was associated with five or more adults living at home (aOR 5.42, 95% CI = 1.59 to 18.40) (Table 5).

Home restrooms' having signs of mould (aOR 9.12, 95% CI = 1.89 to 44.00) and having no handwashing basin (aOR 14.00, 95% CI = 4.30 to 46.20) were associated with increased odds of stunting only (Table 6), as was the presence of five or more children at home (aOR 15.70, 95% CI = 1.79 to 138). A lack of food variety was associated with decreased risk of stunting (aOR 0.10, 95% CI = 0.01 to 0.90) and increased risk of undernutrition (aOR 5.56, 95% CI = 1.45 to 21.35).

4. Discussion

4.1. Key findings and interpretation

The overall school WaSH situation in our study schools was characterized by deficiencies in supply, access, and functionality. Such deficiencies in school WaSH were consistent with findings from previous studies conducted in the Philippines (Ellis et al., 2016; Katsuno et al., 2019). Our findings suggest that inadequate school WaSH increases the risk of children self-reporting diarrhoea and increases risks of observed dehydration and malnutrition. We highlight four deficiencies that had negative effects on children's health and hygiene behaviour. First was the lack of water in school restrooms, which increased children's risks for dehydration and stunting. This may be explained by the fact that children, without having water to wash their hands or flush the toilet, may have been more exposed to faeces. Consequences of faecal exposure include diarrhoea, which can cause dehydration, and helminth infection, which can stunt growth if experienced repeatedly. Tap water in the Philippines is not safe for drinking. A lack of drinking water dispensers in many of our study schools likely explained the high prevalence of dehydration. Another possible reason is voluntary dehydration wherein children, in order to avoid using school toilets which they perceived to be unclean, purposefully did not drink water. When no water was available to flush faeces down the toilet, children could have found the situation disgusting or scary. Thus, they would do whatever possible (including not drinking water) in order to avoid using the toilet. A similar thing happens when adults knowingly avoid drinking fluids during long flights or car rides because they want to avoid using (what they perceived to be) unclean public restrooms.

Second was the improper maintenance of school restrooms as evidenced by the presence of flies, which was associated with under- and over-nutrition. Children may have avoided or not used the school restroom because they perceived them as negative, i.e., unclean, foul-smelling, dark, lacking privacy. Such negative perceptions were in line with findings from a survey of secondary school students and school restrooms in France. In that study, adolescents perceived restrooms negatively, avoided using the toilet, and complained of abdominal pain and urinary disorders (Hoarau et al., 2014). In our study, over half of students were not satisfied with school restrooms, with ~67% of students reporting that restrooms were not clean and more than half of students reporting that restrooms lacked privacy. Yet almost all students still used the restrooms. Thus, more investments are needed to improve and maintain the conditions of school restrooms in order to promote their use by children. We found that not using the school restroom was associated with stunting. This may be explained by the fact that children who did not use the toilet could become constipated. Consequences of chronic constipation include decreased appetite and stunted growth (Chao et al., 2008), which could explain the increased risk of undernutrition. Another possible explanation is that recurring enteric infections could alter the gastrointestinal tract, resulting in decreased nutrient absorption and stunted growth (Guerrant et al., 1983). Changes in the gastrointestinal tract that are relevant for stunted growth include: increased intestinal permeability, gut inflammation, bacterial translocation, and nutrient malabsorption (Owino et al., 2016). Another possible explanation is environmental enteric dysfunction, characterized by abnormalities in the small intestine that have been caused by chronic exposure to toxins found in unhygienic living conditions (Keusch et al., 2013). An unexpected result was the association between not using school restrooms and over-nutrition. One possible explanation is that this association was a proxy for family income and/or parental education, attention, and/or involvement. For example, the over-nourished children may have had parents with higher income or more education or involvement. As a result, these parents not only provided their children more food, but also more instructions about proper hygiene. Also they may have advised their children not to use the school's "dirty" restrooms for fear of catching an infection.

Third was the lack of hygiene lessons, which was associated with stunting. Children may have had inadequate knowledge about preventing the spread of germs and, as a result, were not able or willing to practice health-promoting behaviours like handwashing and washing fruits and vegetables before consuming. A consequence of poor handwashing is infectious disease, which could result in malnutrition and impaired growth. While a study by Riiser et al. (2020) showed how handwashing knowledge was linked to handwashing practices, a review by de Buck et al. (2017) showed that there was no one clear handwashing promotion strategy that effectively increased handwashing practice.

Fourth was poor handwashing, which was associated with diarrhoea. Besides individual factors, poor handwashing may be attributed to the insufficient number of handwashing basins and the lack of water and soap in schools. Diarrhoea prevalence rates from our study were higher compared to those from previous studies in LMICs (Chard et al., 2019; Davis

Table 3
Adjusted logistic regression models of self-reported diarrhoea and observed mild and moderate dehydration among students and risk factors at public schools in Metro Manila, Philippines (N = 1478).

Factor	Diarrhoea (N = 421)			Mild dehydration (N = 214)			Moderate dehydration (N = 457)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Student level									
Demographics (self-reported)									
Sex									
Male	201 (30.6)	Ref.		103 (16.4)	Ref.		193 (30.7)	Ref.	
Female	220 (26.8)	0.94 (0.71, 1.26)	0.69	111 (14.3)	0.80 (0.54, 1.19)	0.28	264 (34)	1.18 (0.89, 1.56)	0.25
Age group: early teenager (13–14 years old)									
Yes	90 (27.7)	1.30 (0.94, 1.79)	0.11	48 (14.7)	0.75 (0.49, 1.13)	0.16	87 (26.6)	0.95 (0.63, 1.44)	0.83
No	331 (28.7)	Ref.		166 (15.4)	Ref.		370 (34.3)	Ref.	
Health & nutrition (self-reported)									
Does not eat three times per day									
Yes	36 (41.4)	1.49 (0.96, 2.32)	0.08	6 (7.8)	0.53 (0.24, 1.15)	0.11	30 (39)	1.58 (0.80, 3.13)	0.19
No	385 (27.8)	Ref.		196 (15.6)	Ref.		400 (31.9)	Ref.	
Is not "healthy"									
Yes	139 (35)	1.43 (1.03, 2)	0.03	53 (14.6)	0.93 (0.71, 1.22)	0.60	107 (29.4)	0.82 (0.65, 1.03)	0.08
No	282 (26.2)	Ref.		150 (15.5)	Ref.		325 (33.5)	Ref.	
Had helminth infection									
Yes	207 (32.1)	1.20 (0.98, 1.48)	0.08	86 (15.1)	1.05 (0.91, 1.21)	0.50	186 (32.8)	1.03 (0.81, 1.32)	0.81
No	212 (25.6)	Ref.		116 (15.2)	Ref.		244 (32)	Ref.	
Hygiene-related perception and practices (self-reported)									
Student does not wash hands at school									
Yes	45 (34.9)	1.77 (1.18, 2.65)	0.01	11 (8.9)	0.49 (0.21, 1.16)	0.11	46 (37.1)	1.05 (0.61, 1.80)	0.86
No	376 (27.9)	Ref.		192 (15.8)	Ref.		386 (31.9)	Ref.	
Student is not satisfied with school restroom									
Yes	213 (27.8)	0.89 (0.64, 1.22)	0.46	103 (14.7)	1.05 (0.81, 1.37)	0.71	238 (34)	1.13 (0.82, 1.56)	0.46
No	208 (29.3)	Ref.		100 (15.8)	Ref.		194 (30.6)	Ref.	
Student avoids using school restroom									
Yes	80 (33.9)	1.44 (0.97, 2.14)	0.07	22 (12.1)	0.87 (0.52, 1.43)	0.58	65 (35.7)	1.11 (0.70, 1.77)	0.65
No	341 (27.5)	Ref.		181 (15.7)	Ref.		366 (31.8)	Ref.	
Student does not use school restroom									
Yes	24 (23.1)	0.64 (0.38, 1.09)	0.10	4 (6.2)	0.50 (0.24, 1.05)	0.07	20 (30.8)	0.88 (0.47, 1.63)	0.68
No	397 (28.9)	Ref.		199 (15.7)	Ref.		412 (32.4)	Ref.	
Facilities (observed)									
Number of restrooms									
1–3	190 (32.8)	Ref.		71 (11.6)	Ref.		182 (29.6)	Ref.	
4–8	124 (25.1)	0.38 (0.25, 0.56)	*p* < 0.01	74 (17.1)	1.21 (1.01, 1.45)	0.03	149 (34.3)	4.98 (3.63, 6.84)	p < 0.01
9–15	76 (24.8)	0.34 (0.17, 0.65)	p < 0.01	60 (19.8)	5.61 (3.44, 9.15)	p < 0.01	108 (35.6)	49.7 (29.9, 82.5)	p < 0.01
Number of toilet bowls									
3–5	134 (33.8)	Ref.		52 (12.1)	Ref.		154 (35.9)	Ref.	
6–18	141 (29.1)	1.63 (1.19, 2.23)	p < 0.01	83 (16.5)	4.48 (3.51, 5.71)	p < 0.01	126 (25.1)	0.11 (0.08, 0.16)	p < 0.01
19–30	115 (23)	2 (1.15, 3.48)	0.01	70 (16.7)	2.20 (1.68, 2.90)	p < 0.01	159 (38)	0.02 (0.01, 0.03)	p < 0.01
Number of handwashing basins									
0–7	230 (29)	Ref.		107 (12.6)	Ref.		270 (31.8)	Ref.	
8–15	80 (27.1)	1.85 (1.33, 2.58)	p < 0.01	53 (17.7)	0.42 (0.33, 0.54)	p < 0.01	97 (32.3)	0.22 (0.17, 0.30)	p < 0.01
16–28	80 (27.2)	1.78 (1.20, 2.63)	p < 0.01	45 (22.2)	0.38 (0.24, 0.60)	p < 0.01	72 (35.5)	0.55 (0.33, 0.93)	0.03
Restroom lacks water									
Yes	278 (27.6)	1.18 (0.90, 1.54)	0.24	174 (16.5)	1.84 (1.63, 2.08)	p < 0.01	388 (36.7)	2.21 (1.71, 2.87)	p < 0.01
No	112 (30)	Ref.		31 (10.6)	Ref.		51 (17.4)	Ref.	
Restroom lacks cleanliness[a]									
Yes	279 (30.4)	1.24 (0.95, 1.63)	0.11	125 (14.9)	0.91 (0.66, 1.27)	0.59	290 (34.4)	1.25 (0.96, 1.63)	0.11
No	142 (25.4)	Ref.		78 (15.8)	Ref.		142 (28.7)	Ref.	
Restroom has flies									
Yes	78 (26)	0.81 (0.63, 1.04)	0.10	36 (11.7)	0.45 (0.38, 0.54)	p < 0.01	120 (38.3)	9.17 (7.19, 11.7)	p < 0.01
No	312 (28.9)	Ref.		169 (16.2)	Ref.		319 (30.6)	Ref.	
Restroom not accessible for person(s) with disability[a]									
Yes	225 (29)	1.05 (0.72, 1.52)	0.80	114 (15.5)	1.16 (0.88, 1.54)	0.30	238 (32.4)	0.87 (0.62, 1.22)	0.41
No	196 (27.9)	Ref.		89 (14.8)	Ref.		194 (32.3)	Ref.	
Long line to use restroom[a]									
Yes	116 (33.2)	1.22 (0.93, 1.61)	0.15	44 (14)	0.88 (0.62, 1.24)	0.47	114 (36.2)	1.30 (0.91, 1.86)	0.15
No	304 (27)	Ref.		159 (15.6)	Ref.		318 (31.2)	Ref.	
Administration (self-reported)									
Lack of policy for cleaning restroom daily									
Yes	29 (27.4)	0.57 (0.41, 0.78)	*p* < 0.01	19 (19)	0.24 (0.18, 0.30)	*p* < 0.01	39 (39)	2.03 (1.61, 2.56)	*p* < 0.01
No	392 (28.6)	Ref.		195 (14.9)	Ref.		418 (32)	Ref.	
Hygiene lessons are not taught in school									
Yes	37 (27.8)	0.84 (0.60, 1.17)	0.31	14 (12.4)	1.12 (0.57, 2.20)	0.74	37 (32.7)	0.74 (0.48, 1.13)	0.16
No	384 (28.7)	Ref.		189 (15.5)	Ref.		392 (32.2)	Ref.	
Age of school >50 years									
Yes	193 (33.3)	1.78 (1.37, 2.30)	*p* < 0.01	100 (16.7)	2.99 (2.39, 3.74)	*p* < 0.01	194 (32.4)	0.70 (0.55, 0.89)	*p* < 0.01
No	228 (25.4)	Ref.		114 (14.1)	Ref.		263 (32.6)	Ref.	

Table 3 (*continued*)

Factor	Diarrhoea (N = 421)			Mild dehydration (N = 214)			Moderate dehydration (N = 457)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Maximum maintenance and other operating expenses budget ≥ $350,000 USD[b]									
Yes	40 (21.7)	0.42 (0.31, 0.57)	$p < 0.01$	33 (17.5)	0.62 (0.48, 0.81)	$p < 0.01$	52 (27.5)	3.07 (2.28, 4.13)	$p < 0.01$
No	381 (29.4)	Ref.		181 (14.9)	Ref.		405 (33.3)	Ref.	

Note. aOR, adjusted odds ratio; CI, confidence interval; Ref., reference group; USD, United States Dollar.
aORs were estimated by multiple logistic regression models. Variables of exposure included in models were: female, early-teenager (age 13–14 years old), does not eat three times per day, does not consider self to be "healthy", had helminth infection, does not wash hands in school, is not satisfied with school restroom, avoids school restroom, does not use school restroom, number of school restrooms, number of school toilets, number of school handwashing basins, school restroom lacks water, school restroom is not clean, school restroom has flies, school restroom is not accessible for persons with disability, long lines to use school restroom, lack of policy to clean school restroom daily, hygiene lessons are not taught in school, age of school >50 years, and maximum maintenance and other operating expenses budget.

[a] Self-reported by students.

[b] Data source: Philippines Department of Education (2019c).

et al., 2014; Worrell et al., 2016). Children who did not wash their hands with soap and water after using the toilet were likely more exposed to faecal matter that causes gastrointestinal diseases like diarrhoea and HI. Besides malnutrition, weight loss, and stunted growth, consequences of infection include school absence and increased risk of school dropout. These findings demonstrate the need to better promote hygiene education and handwashing, which decreases prevalence rates of diarrhoea by up to 47%, if done with soap (Curtis and Cairncross, 2003).

Where could these disease-causing WaSH deficiencies have come from? Besides the school environment and children's socioeconomic status, which was outside the scope of this study, we can examine health policy. Nearly all school principals reported that WaSH management policies were in place, yet the "poor" conditions of school restrooms begged the question of whether or not the policies were being effectively enforced. These findings may point to possible gaps in resource utilization, incident reporting, or factors outside of schools. We found that the maximum maintenance and other operating expenses budget was associated with decreased risks for diarrhoea, dehydration, and stunting. This demonstrates the need for further investments in schools in order to better protect children's health and prevent diseases.

4.2. Limitations

Our cross-sectional, observational study is limited by confounding and the inability to describe causality. Selection bias likely occurred when we allowed: one school to join our study after school personnel asked us directly if her school could participate; school personnel to select which class section(s) would be surveyed; one school to join our study where we conducted pilot testing of our survey instruments. A possible impact of allowing the pre-tested school to join our study was that some children may have been aware of our survey, leading some to provide biased answers on the questionnaire that they perceived to be "desirable". Allowing school personnel to select the class sections to be surveyed likely resulted in an over-sampling of top-academically-performing children and an under-representation of poor-academically-performing children, who may have also belonged to families of the lowest SES and who had greater exposures to inadequate WaSH and other disease risk factors.

Self-report is prone to bias, e.g., recall bias, which may have occurred when we used self-reported outcome measures for diarrhoea without corroborating with medical records. Self-report may be influenced by children's perceptions about what is "desirable" and "undesirable" according to social/cultural norms, feelings of shame, and fears about being punished.

A disadvantage of using U_{sg} is that measurements depend on the number and size of particles contained in the urine (Baron et al., 2015). Evidence about the reliability of urine test strips, compared with refractometry, to measure U_{sg} is mixed (de Buys Roessingh et al., 2001; Gounden and Newall, 1983). A disadvantage of using urine test strips is that the accuracy of measurements may decrease as urine alkalinity increases (pH > 7) (Adams, 1983). We did not triangulate dehydration measurements with physical symptoms of dehydration or children's report of thirst.

There was a one-year time lag between our measurement of children's health outcomes and water quality testing, and we measured water quality only once, so, we could not assess seasonality/temporal variability. Another risk of bias was the large number of children excluded from data analysis due to missing responses. After examining missing data, however, we found no statistically significant difference between children who were missing data and children who were not missing data for key outcomes. Therefore, we concluded that data were missing at random (MAR), though not missing completely at random (MCAR).

We assessed a large number of risk factors, some of which may be unrelated to each other; it is possible that associations have arisen by chance. We also simultaneously assessed multiple outcomes, so, there could have been a possible multiple comparisons effect (Lindquist and Mejia, 2015).

4.3. Strengths

Our study provided new information about using children's dehydration, measured via U_{sg}, as an indicator of schools' water insecurity, which we confirmed with children's self-report and researchers' observations. These data are helpful for interpreting study findings about children's dehydration, which could negatively impact children's cognitive performance, e.g., by decreasing short-term memory (Bar-David et al., 2005). Previous studies (Edmonds and Jeffes, 2009) have examined dehydration's negative impact on children's cognitive performance but few have used biospecimens to measure dehydration. Findings from our study address this data gap.

4.4. Generalizability

The generalizability, or external validity, of our study was supported by: multistage cluster sampling of students in grades five, six, seven, nine, and 10 (ages ~10–15 years old) from 15 public schools in three cities of Metro Manila; high participation rate from a large study sample; analyses of risk factors for diarrhoea, malnutrition, and dehydration while taking into account variance in prevalence rates across different schools. Adherence to study protocols, rigorous investigation, and standardized data collection and reporting increase our confidence that our study findings may be generalizable to other urban poor populations living in areas with comparable weather and school WaSH conditions. However, due to our study's cross-sectional, observational design and limited capacity to control for confounding and describe cause and effect, our study findings may be applicable only to specific locations in terms of disease prevalence and environmental risk factors. Our findings need to be verified by longitudinal studies with larger samples before attempting to generalize them to diverse populations or settings in other LMICs.

Table 4
Adjusted logistic regression models of observed malnutrition among students and risk factors at public schools in Metro Manila, Philippines (N = 1478).

Factor	Stunted only (N = 186)			Undernutrition only (N = 87)			Overnutrition only (N = 306)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Student level (self-reported)									
Student characteristics									
Sex									
Male	80 (12.1)	Ref.		51 (7.7)	Ref.		154 (23.4)	Ref.	
Female	106 (12.9)	1.18 (0.77, 1.81)	0.46	36 (4.4)	0.65 (0.36, 1.17)	0.15	152 (18.6)	0.67 (0.44, 1.01)	0.06
Age group: early teenager (13–14 years old)									
Yes	37 (11)	1.42 (0.76, 2.64)	0.27	17 (5.1)	0.65 (0.38, 1.11)	0.11	53 (15.8)	0.85 (0.53, 1.36)	0.49
No	149 (13.1)	Ref.		70 (6.1)	Ref.		253 (22.2)	Ref.	
Health & nutrition (self-reported)									
Does not eat three times per day									
Yes	14 (17.7)	1.02 (0.56, 1.88)	0.94	4 (5.1)	0.80 (0.33, 1.92)	0.62	14 (17.7)	1.24 (0.63, 2.46)	0.53
No	158 (11.9)	Ref.		77 (5.8)	Ref.		278 (21)	Ref.	
Is not "healthy"									
Yes	55 (14.2)	1.28 (0.73, 2.24)	0.38	33 (8.5)	1.82 (1.24, 2.67)	$p < 0.01$	42 (10.9)	0.37 (0.23, 0.59)	$p < 0.01$
No	117 (11.5)	Ref.		49 (4.8)	Ref.		250 (24.5)	Ref.	
Had diarrhoea									
Yes	62 (15.3)	1.45 (1.10, 1.93)	0.01	23 (5.7)	1 (0.64, 1.56)	1	86 (21.2)	1.14 (0.90, 1.45)	0.26
No	110 (11)	Ref.		57 (5.7)	Ref.		207 (20.7)	Ref.	
Was dehydrated									
Yes	113 (11.8)	0.81 (0.59, 1.11)	0.20	62 (6.5)	1.75 (1.09, 2.81)	0.02	201 (21)	1.22 (0.94, 1.58)	0.13
No	62 (13.8)	Ref.		21 (4.7)	Ref.		88 (19.6)	Ref.	
Had helminth infection									
Yes	106 (17.4)	1.65 (1.13, 2.43)	0.01	45 (7.4)	1.56 (1.08, 2.24)	0.02	101 (16.6)	0.68 (0.51, 0.90)	0.01
No	66 (8.3)	Ref.		37 (4.7)	Ref.		192 (24.2)	Ref.	
Hygiene-related perception and practices (self-reported)									
Does not wash hands in school									
Yes	15 (11.8)	1.06 (0.45, 2.53)	0.89	7 (5.5)	0.77 (0.32, 1.83)	0.55	23 (18.1)	1 (0.70, 1.44)	1
No	158 (12.3)	Ref.		75 (5.9)	Ref.		270 (21.1)	Ref.	
Is not satisfied with school restroom									
Yes	73 (9.8)	0.63 (0.44, 0.90)	0.01	44 (5.9)	0.84 (0.45, 1.59)	0.59	161 (21.7)	1.06 (0.75, 1.51)	0.73
No	100 (15.1)	Ref.		38 (5.7)	Ref.		131 (19.7)	Ref.	
Avoids using school restroom									
Yes	26 (13.1)	0.71 (0.43, 1.16)	0.17	16 (8.1)	1.58 (0.55, 4.52)	0.39	40 (20.2)	0.93 (0.64, 1.34)	0.70
No	147 (12.2)	Ref.		66 (5.5)	Ref.		253 (20.9)	Ref.	
Does not use school restroom									
Yes	14 (20)	2.26 (1.22, 4.20)	0.01	5 (7.1)	0.96 (0.25, 3.66)	0.95	13 (18.6)	1.09 (0.59, 2)	0.78
No	159 (11.9)	Ref.		77 (5.8)	Ref.		280 (20.9)	Ref.	
School level									
Facilities (observed)									
Number of restrooms									
1–3	109 (17.6)	Ref.		38 (6.1)	Ref.		122 (19.7)	Ref.	
4–8	37 (8.2)	0.34 (0.24, 0.47)	$p < 0.01$	24 (5.3)	0.75 (0.45, 1.25)	0.27	103 (22.8)	3.28 (2.60, 4.13)	$p < 0.01$
9–15	20 (6.5)	0.08 (0.04, 0.14)	$p < 0.01$	21 (6.8)	5.59 (2.96, 10.6)	$p < 0.01$	65 (21)	15.7 (10.2, 24.3)	$p < 0.01$
Number of toilet bowls									
3–5	90 (20.8)	Ref.		29 (6.7)	Ref.		83 (19.2)	Ref.	
6–18	48 (9.5)	0.42 (0.27, 0.67)	$p < 0.01$	24 (4.7)	0.81 (0.44, 1.46)	0.48	109 (21.5)	1.12 (0.84, 1.50)	0.44
19–30	28 (6.3)	0.51 (0.27, 0.94)	0.03	30 (6.8)	0.44 (0.20, 0.94)	0.03	98 (22.2)	0.60 (0.41, 0.88)	0.01
Number of handwashing basins									
0–7	125 (14.7)	Ref.		52 (6.1)	Ref.		169 (19.8)	Ref.	
8–15	22 (7.3)	5.93 (4.49, 7.83)	$p < 0.01$	17 (5.7)	1.04 (0.70, 1.53)	0.85	68 (22.6)	0.26 (0.20, 0.33)	$p < 0.01$
16 or more	19 (8.4)	8.17 (5.61, 11.9)	$p < 0.01$	14 (6.2)	0.23 (0.14, 0.39)	$p < 0.01$	53 (23.5)	0.32 (0.21, 0.50)	$p < 0.01$
Restroom has no water available									
Yes	130 (12.2)	1.52 (1.21, 1.90)	$p < 0.01$	69 (6.5)	2.18 (1.54, 3.09)	$p < 0.01$	214 (20)	0.49 (0.43, 0.56)	$p < 0.01$
No	36 (11.5)	Ref.		14 (4.5)	Ref.		76 (24.4)	Ref.	
Restroom is not clean									
Yes	98 (11.1)	0.67 (0.48, 0.94)	0.02	49 (5.5)	0.94 (0.55, 1.60)	0.81	204 (23)	1.28 (0.92, 1.80)	0.15
No	75 (14.4)	Ref.		33 (6.3)	Ref.		89 (17.1)	Ref.	
Restroom has flies									
Yes	25 (8.1)	0.90 (0.65, 1.25)	0.53	16 (5.2)	1.61 (1.03, 2.52)	0.04	86 (27.8)	1.70 (1.27, 2.29)	$p < 0.01$
No	141 (13.2)	Ref.		67 (6.3)	Ref.		204 (19.1)	Ref.	
Restroom not accessible for person(s) with disability[a]									
Yes	86 (11.2)	0.85 (0.57, 1.29)	0.45	48 (6.2)	1.21 (0.72, 2.02)	0.47	176 (22.9)	1.43 (1.06, 1.93)	0.02
No	87 (13.6)	Ref.		34 (5.3)	Ref.		117 (18.3)	Ref.	
Long line to use restroom[a]									
Yes	46 (13.8)	1.12 (0.75, 1.66)	0.59	16 (4.8)	0.82 (0.48, 1.41)	0.48	52 (15.6)	0.62 (0.45, 0.86)	$p < 0.01$
No	127 (11.8)	Ref.		66 (6.2)	Ref.		241 (22.4)	Ref.	
Administration and policies (self-reported)									
No policy to clean school restroom daily									
Yes	7 (6.6)	0.98 (0.70, 1.38)	0.91	4 (3.8)	1.65 (0.98, 2.80)	0.06	26 (24.5)	0.46 (0.34, 0.61)	$p < 0.01$
No	179 (13.1)	Ref.		83 (6.1)	Ref.		280 (20.4)	Ref.	

Table 4 (*continued*)

Factor	Stunted only (N = 186)			Undernutrition only (N = 87)			Overnutrition only (N = 306)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Hygiene lessons are not taught in school									
Yes	23 (19.3)	1.91 (1.12, 3.26)	0.02	7 (5.9)	0.87 (0.15, 5.20)	0.88	19 (16)	1.05 (0.52, 2.11)	0.89
No	148 (11.5)	Ref.		74 (5.8)	Ref.		274 (21.3)	Ref.	
Age of school >50 years									
Yes	82 (13.5)	0.64 (0.46, 0.90)	0.01	24 (4)	0.39 (0.25, 0.61)	$p < 0.01$	147 (24.2)	2.60 (1.99, 3.42)	$p < 0.01$
No	104 (11.9)	Ref.		63 (7.2)	Ref.		159 (18.3)	Ref.	
Maximum maintenance and other operating expenses; budget ≥ $350,000 USD[b]									
Yes	8 (4.2)	0.34 (0.21, 0.54)	$p < 0.01$	12 (6.3)	0.57 (0.34, 0.95)	0.03	35 (18.4)	1.08 (0.79, 1.47)	0.63
No	178 (13.8)	Ref.		75 (5.8)	Ref.		271 (21)	Ref.	

Note. aOR, adjusted odds ratio; CI, confidence interval; Ref., reference group; USD, United States Dollar.
aORs were estimated by multiple logistic regression models. Variables of exposure included in models were: female, early-teenager (age 13–14 years old), does not eat three times per day, does not consider self to be "healthy", had diarrhoea, is dehydrated (urine specific gravity ≥ 1.020), had helminth infection, does not wash hands in school, is not satisfied with school restroom, avoids school restroom, does not use school restroom, number of school restrooms, number of school toilets, number of school handwashing basins, school restroom lacks water, school restroom is not clean, school restroom has flies, school restroom is not accessible for persons with disability, long lines to use school restroom, lack of policy to clean school restroom daily, hygiene lessons are not taught in school, age of school >50 years, and maximum maintenance and other operating expenses budget.

[a] Self-reported by students.

[b] Data source: Philippines Department of Education (2019c).

4.5. Implications for policy, practice, and future research

Before we make any recommendations, we acknowledge that our cross-sectional study neither measured changes in diarrhoea episodes and contributing factors over time, nor did it measure changes during different seasons. Thus, readers should consider that these study results provide no evidence in terms of causality, and that our below recommendations were based on suggested, rather than causal, associations.

Due to the complexity of school WaSH management, a comprehensive, context-specific school WaSH strategy is recommended instead of a one-size-fits-all approach. Possible solutions could be interventions that facilitate the implementation and enforcement of school WaSH policies. For example, a school administrator may be designated to lead a small team of "super-users" (school personnel) to ensure restrooms are being cleaned and maintained, provide hygiene lessons, and promote group handwashing among students. Also, a group of student volunteers may be named as "restroom monitors" in each school to ensure that WaSH facilities are properly used and kept clean, and to remind their fellow students to wash their hands after using the toilet/urinal and before eating. Funding should be used to increase the number of clean and functional WaSH facilities, maintain them, and promote their proper use by schoolchildren.

Future research should explore other methods of assessing diarrhoea, although our findings indicate that self-report should not necessarily be dismissed. We identified an association between diarrhoea and stunting, which is consistent with previous studies (Schilling et al., 2017). Future studies should explore school WaSH facilities and students' diarrhoea prevalence in other LMICs or upper-middle-income countries located in the tropics, e.g., Vietnam and Thailand, where temperatures and rainfall are as high as in the Philippines, but the rates of diarrhoea-related mortality are lower.

Research is needed to test WaSH interventions aimed at improving children's nutrition status by preventing diarrhoea. This could be achieved by reducing children's exposure to enteropathogens in schools' WaSH facilities and increasing children's health literacy and promoting handwashing. Greater emphasis should be placed on improving water quality in settings where faecal water contamination is prevalent and causing disease. Evidence about the effectiveness of WaSH interventions in decreasing risks of infectious diseases is mixed (Ashraf et al., 2020; Chard et al., 2019; Pickering et al., 2019; Trinies et al., 2016). Research is needed to clarify the relationship between WaSH and infectious diseases.

5. Conclusions

By linking schools' WaSH facilities and students' handwashing and dissatisfaction with and avoidance of school restrooms with disease prevalence, we point to an urgent need for comprehensive school-based WaSH interventions, especially those that promote proper handwashing. However, the associations we found between school WaSH and children's health may be explained more by school location than school WaSH. Due to the cross-sectional design of our study, we were not able to assess causation. This should be considered when interpreting our study results. Future studies that use, for example, a cluster-randomised controlled design, are needed to assess causation between exposure to inadequate school WaSH and children's health outcomes. More research is needed to understand the complex relationship between schools' WaSH facilities and children's hygiene practices and diarrhoea, malnutrition, and dehydration in the Philippines. Elsewhere in the Global South, where the COVID-19 pandemic has forced schools to close and has increased food and water insecurity, new WaSH strategies are needed. Our study findings could help promote school WaSH to protect children from faecal-contaminated water that drives disease risks, while ensuring that children have access to the benefits of water security: good health, hygiene, and hydration.

Availability of data and additional materials

Datasets will be made available on the Data Portal of the Center for Development Research (ZEF), University of Bonn: [https://daten.zef.de/geonetwork/srv/eng/catalog.search#/home]. Additional materials may be found in Appendix A.

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CRediT authorship contribution statement

Stephanie O. Sangalang: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Nelissa O. Prado:** Software, Validation, Formal analysis, Investigation, Data curation, Writing – review & editing, Visualization. **Allen Lemuel G. Lemence:** Software, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Mylene**

Table 5
Adjusted logistic regression models of self-reported diarrhoea and observed dehydration among subsample of students and risk factors at public schools in Metro Manila, Philippines (N = 211).

Factor	Diarrhoea (N = 56)			Mild dehydration (N = 30)			Moderate dehydration (N = 63)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Student level (self-reported)									
Student characteristics									
Sex									
Male	19 (24.7)	Ref.		11 (14.3)	Ref.		20 (26)	Ref.	
Female	37 (27.6)	1.45 (0.82, 2.56)	0.20	19 (14.3)	1.05 (0.28, 3.95)	0.95	43 (32.3)	1.35 (0.63, 2.90)	0.44
Age group: early teenager (13–14 years old)									
Yes	12 (29.3)	1.12 (0.38, 3.33)	0.83	6 (14.6)	1.25 (0.47, 3.31)	0.65	8 (19.5)	0.39 (0.18, 0.84)	0.02
No	44 (25.9)	Ref.		24 (14.2)	Ref.		55 (32.5)	Ref.	
Health & nutrition (self-reported)									
Does not eat three times per day									
Yes	5 (62.5)	5 (1.05, 24)	0.04	0	n/a		4 (50)	1.60 (0.25, 10.2)	0.62
No	51 (25.1)	Ref.		30 (14.9)			59 (29.2)	Ref.	
Is not "healthy"									
Yes	20 (37)	1.79 (0.91, 3.53)	0.09	9 (16.7)	1.55 (0.55, 4.33)	0.41	15 (27.8)	0.90 (0.33, 2.47)	0.83
No	36 (22.9)	Ref.		21 (13.5)	Ref.		48 (30.8)	Ref.	
Had helminth infection									
Yes	26 (33.8)	2.25 (0.90, 5.61)	0.08	11 (14.5)	1.61 (0.57, 4.49)	0.37	23 (30.3)	0.71 (0.32, 1.55)	0.39
No	19 (21.4)	Ref.		11 (12.4)	Ref.		28 (31.5)	Ref.	
Hygiene-related perception and practices (self-reported)									
Does not wash hands in school									
Yes	9 (40.9)	2.08 (0.96, 4.52)	0.06	3 (13.6)	0.23 (0.06, 0.93)	0.04	5 (22.7)	0.84 (0.24, 2.91)	0.78
No	47 (24.9)	Ref.		27 (14.4)	Ref.		58 (30.9)	Ref.	
Does not use school restroom									
Yes	2 (22.2)	0.13 (0.01, 1.46)	0.10	2 (22.2)	3.79 (0.20, 70.9)	0.37	2 (22.2)	0.55 (0.07, 4.53)	0.58
No	54 (26.7)	Ref.		28 (13.9)	Ref.		61 (30.4)	Ref.	
Hygiene lessons are not taught in school									
Yes	4 (21.1)	0.72 (0.14, 3.58)	0.68	1 (5.3)	0.44 (0.04, 4.77)	0.50	5 (26.3)	1 (0.21, 4.73)	1
No	52 (27.1)	Ref.		29 (15.2)	Ref.		58 (30.4)	Ref.	
Household level									
Number of adults									
1–2	26 (27.1)	Ref.		14 (14.6)	Ref.		21 (21.9)	Ref.	
3–4	14 (22.6)	1.03 (0.50, 2.11)	0.94	9 (14.5)	1.10 (0.46, 2.66)	0.83	18 (29)	1.57 (0.61, 4.04)	0.35
≥5	16 (30.2)	1.10 (0.45, 2.69)	0.83	7 (13.5)	0.55 (0.12, 2.61)	0.45	24 (46.2)	5.42 (1.59, 18.4)	0.01
Number of children									
1–2	20 (20.8)	Ref.		15 (15.6)	Ref.		32 (33.3)	Ref.	
3–4	31 (34.4)	2.31 (0.85, 6.31)	0.10	8 (9)	0.58 (0.21, 1.65)	0.31	21 (23.6)	0.76 (0.29, 2.02)	0.59
≥5	5 (20.8)	0.54 (0.10, 2.91)	0.47	6 (25)	3.72 (0.64, 21.7)	0.15	10 (41.7)	0.92 (0.29, 2.85)	0.88
Duration (years) of residence in home									
0–4	13 (28.9)	Ref.		6 (13.3)	Ref.		17 (37.8)	Ref.	
5–19	22 (25)	1.34 (0.50, 2.59)	0.76	14 (15.9)	0.97 (0.22, 4.19)	0.96	26 (29.6)	0.53 (0.20, 1.46)	0.22
≥20	21 (26.9)	1.05 (0.53, 2.09)	0.89	10 (13)	0.61 (0.23, 1.63)	0.33	20 (26)	0.48 (0.19, 1.25)	0.13
Does not eat a variety of food (self-reported)									
Yes	3 (23.1)	1.51 (0.49, 4.61)	0.47	3 (23.1)	1.36 (0.32, 5.72)	0.68	4 (30.8)	1.63 (0.42, 6.31)	0.48
No	53 (26.8)	Ref.		27 (13.7)	Ref.		59 (30)	Ref.	
WaSH									
No restroom inside home									
Yes	4 (20)	0.70 (0.17, 2.88)	0.62	2 (10)	0.53 (0.12, 2.26)	0.39	6 (30)	0.83 (0.18, 3.84)	0.81
No	48 (27.9)	Ref.		26 (15.2)	Ref.		47 (27.5)	Ref.	
Restroom is not clean									
Yes	23 (30.3)	1.39 (0.68, 2.85)	0.37	9 (11.8)	1.17 (0.53, 2.59)	0.71	27 (35.5)	2.03 (0.76, 5.40)	0.16
No	29 (25)	Ref.		19 (16.5)	Ref.		26 (22.6)	Ref.	
Restroom has no water									
Yes	3 (37.5)	2.24 (0.16, 32.4)	0.55	0	n/a		2 (25)	0.26 (0.02, 2.80)	0.27
No	49 (26.6)	Ref.		28 (15.3)			51 (27.9)	Ref.	
Restroom has no handwashing basin									
Yes	14 (23.3)	0.97 (0.31, 3.03)	0.96	10 (16.7)	2.45 (1.08, 5.56)	0.03	15 (25)	0.76 (0.24, 2.44)	0.64
No	38 (29)	Ref.		18 (13.9)	Ref.		37 (28.5)	Ref.	
Restroom is not well-lit									
Yes	23 (27.7)	1.03 (0.39, 2.70)	0.96	12 (14.5)	1.14 (0.50, 2.61)	0.75	24 (28.9)	0.83 (0.25, 2.74)	0.76
No	29 (27.4)	Ref.		15 (14.3)	Ref.		28 (26.7)	Ref.	
Restroom has no door lock									
Yes	22 (25.9)	0.61 (0.20, 1.85)	0.39	10 (11.8)	0.43 (0.21, 0.88)	0.02	26 (30.6)	1.69 (0.66, 4.33)	0.27
No	30 (28.3)	Ref.		18 (17.1)	Ref.		26 (24.8)	Ref.	
Restroom has signs of mould									
Yes	31 (31.6)	1.63 (0.67, 4)	0.28	14 (14.3)	0.95 (0.34, 2.63)	0.91	21 (21.4)	0.39 (0.18, 0.83)	0.02
No	21 (22.3)	Ref.		14 (15.1)	Ref.		32 (34.4)	Ref.	
No garbage bin in or near restroom									
Yes	27 (23.7)	0.82 (0.50, 2.11)	0.94	14 (12.3)	0.45 (0.21, 0.96)	0.04	33 (29)	1.44 (0.80, 2.59)	0.23
No	25 (32.1)	Ref.		14 (18.2)	Ref.		20 (26)	Ref.	

Table 6
Adjusted logistic regression models of observed malnutrition among subsample of students and risk factors at public schools in Metro Manila, Philippines (N = 211).

Factor	Stunting only (N = 28)			Undernutrition only (N = 13)			Overnutrition (N = 46)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Student level									
Student characteristics									
Sex									
Male	7 (9.1)	Ref.		6 (7.8)	Ref.		22 (28.6)	Ref.	
Female	21 (15.7)	2.46 (0.40, 15.2)	0.33	7 (5.2)	0.55 (0.11, 2.63)	0.45	24 (17.9)	0.33 (0.18, 0.61)	$p < 0.01$
Age group: early teenager (13–14 years old)									
Yes	5 (12.2)	0.26 (0.04, 1.83)	0.18	1 (2.4)	0.10 (0.01, 0.72)	0.02	6 (14.6)	0.18 (0.05, 0.57)	$p < 0.01$
No	23 (13.5)	Ref.		12 (7.1)	Ref.		40 (23.5)	Ref.	
Health & nutrition (self-reported)									
Does not eat three times per day									
Yes	1 (12.5)	0.19 (0.03, 1.21)	0.08	0	n/a		3 (37.5)	0.58 (0.11, 3.09)	0.52
No	27 (13.3)	Ref.		13 (6.4)			43 (21.2)	Ref.	
Is not "healthy"									
Yes	12 (22.2)	2.55 (0.48, 13.6)	0.28	3 (5.6)	2.82 (0.52, 15.2)	0.23	9 (16.7)	0.42 (0.14, 1.27)	0.13
No	16 (10.2)	Ref.		10 (6.4)	Ref.		37 (23.6)	Ref.	
Diarrhoea									
Yes	8 (14.3)	2.16 (0.79, 5.94)	0.13	1 (1.8)	0.08 (0.01, 0.70)	0.02	13 (23.2)	1.58 (0.81, 3.09)	0.18
No	20 (12.9)	Ref.		12 (7.7)	Ref.		33 (21.3)	Ref.	
Dehydration									
Yes	14 (10.1)	0.49 (0.17, 1.36)	0.17	11 (7.9)	4.29 (0.53, 34.4)	0.17	32 (23)	1.50 (0.54, 4.19)	0.43
No	14 (19.7)	Ref.		2 (2.8)	Ref.		14 (19.7)	Ref.	
Had helminth infection									
Yes	17 (22.1)	2.92 (0.80, 10.7)	0.11	6 (7.8)	1.56 (0.50, 4.81)	0.44	15 (19.5)	2.38 (1, 5.70)	0.05
No	7 (7.9)	Ref.		6 (6.7)	Ref.		18 (20.2)	Ref.	
Hygiene-related perception and practices (self-reported)									
Does not wash hands in school									
Yes	5 (22.7)	2.31 (0.64, 8.30)	0.20	1 (4.6)	0.56 (0.23, 1.37)	0.21	4 (18.2)	0.63 (0.16, 2.47)	0.51
No	23 (12.2)	Ref.		12 (6.4)	Ref.		42 (22.2)	Ref.	
Does not use school restroom									
Yes	4 (44.4)	62.9 (2.62, 1508)	0.01	1 (11.1)	6.47 (0.40, 105)	0.19	2 (22.2)	0.43 (0.08, 2.39)	0.33
No	24 (11.9)	Ref.		12 (5.9)	Ref.		44 (21.8)	Ref.	
Hygiene lessons are not taught in school									
Yes	5 (26.3)	3.36 (0.61, 18.5)	0.16	2 (10.5)	6.22 (0.77, 49.9)	0.09	5 (26.3)	3.58 (0.92, 13.9)	0.07
No	23 (12)	Ref.		11 (5.7)	Ref.		41 (21.4)	Ref.	
Household level (self-reported)									
Number of adults									
1–2	13 (13.5)	Ref.		4 (4.2)	Ref.		22 (22.9)	Ref.	
3–4	7 (11.3)	0.69 (0.20, 2.38)	0.56	5 (8.1)	4.92 (0.91, 26.8)	0.07	15 (24.2)	0.46 (0.14, 1.51)	0.20
≥5	8 (15.1)	0.75 (0.16, 3.48)	0.71	4 (7.6)	3.12 (0.41, 23.4)	0.27	9 (17)	0.29 (0.06, 1.44)	0.13
Number of children									
1–2	6 (6.3)	Ref.		5 (5.2)	Ref.		26 (27.1)	Ref.	
3–4	11 (12.2)	0.96 (0.19, 4.82)	0.96	8 (8.9)	2.92 (0.49, 17.2)	0.24	15 (16.7)	0.37 (0.16, 0.87)	0.02
≥5	11 (45.8)	15.7 (1.79, 138)	0.01	0	n/a		4 (16.7)	0.15 (0.03, 0.80)	0.03
Duration (years) of residence in home									
0–4	7 (15.6)	Ref		3 (6.7)	Ref.		8 (17.8)	Ref.	
5–19	7 (8)	0.52 (0.07, 3.98)	0.53	4 (4.6)	0.41 (0.03, 6.18)	0.52	19 (21.6)	1.52 (0.57, 4.08)	0.40
≥20	14 (18)	1.41 (0.28, 7.22)	0.68	6 (7.7)	1.04 (0.22, 4.81)	0.97	19 (24.4)	4.21 (1.07, 16.7)	0.04
Does not eat a variety of food									
Yes	1 (7.7)	0.10 (0.01, 0.90)	0.04	2 (15.4)	5.56 (1.45, 21.4)	0.01	4 (30.8)	0.42 (0.06, 2.76)	0.37
No	27 (13.6)	Ref.		11 (5.6)	Ref.		42 (21.2)	Ref.	
Home WaSH (observed)									
No restroom inside home									
Yes	7 (35)	4.44 (0.73, 27.1)	0.11	2 (10)	6.31 (0.87, 45.9)	0.07	3 (15)	0.82 (0.26, 2.65)	0.74
No	20 (11.6)	Ref.		11 (6.4)	Ref.		35 (20.4)	Ref.	
Restroom is not clean									
Yes	15 (19.7)	0.71 (0.18, 2.86)	0.63	8 (10.5)	2 (0.24, 17)	0.53	9 (11.8)	0.46 (0.20, 1.07)	0.07
No	12 (10.3)	Ref.		5 (4.3)	Ref.		29 (25)	Ref.	
Restroom has no water									
Yes	3 (37.5)	1.09 (0.17, 7)	0.92	1 (12.5)	0.34 (0.01, 12.3)	0.56	0	n/a	
No	24 (13)	Ref.		12 (6.5)	Ref.		38 (20.7)		

(continued on next page)

Notes to Table 5:
Note. aOR, adjusted odds ratio; CI, confidence interval; Ref., reference group; WaSH, water, sanitation, and hygiene.
aORs were estimated by multiple logistic regression models. Variables of exposure included in models were: female, early-teenager (age 13–14 years old), does not eat three times per day, does not consider self to be "healthy", had helminth infection, does not wash hands in school, does not use school restroom, hygiene lessons are not taught in school, number of adults living in home, number of children living in home, duration (years) of residence in home, does not eat a variety of food at home, home has no indoor restroom, home restroom is not clean, home restroom has no water, home restroom has no handwashing basin, home restroom is not well-lit, home restroom has no door lock, home restroom has signs of mould, and no garbage can inside or nearby home restroom.

Table 6 (*continued*)

Factor	Stunting only (N = 28)			Undernutrition only (N = 13)			Overnutrition (N = 46)		
	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value	n (%)	aOR (95% CI)	*p*-Value
Restroom has no handwashing basin									
Yes	15 (25)	14 (4.30, 46.2)	$p < 0.01$	4 (6.7)	1.80 (0.27, 12.2)	0.55	12 (20)	2.40 (0.94, 6.16)	0.07
No	11 (8.4)	Ref.		9 (6.9)	Ref.		26 (19.9)	Ref.	
Restroom is not well-lit									
Yes	12 (14.5)	0.15 (0.01, 1.51)	0.11	9 (10.8)	6.99 (1.20, 40.7)	0.03	14 (16.9)	1.51 (0.49, 4.64)	0.47
No	14 (13.2)	Ref.		4 (3.8)	Ref.		24 (22.6)	Ref.	
Restroom has no door lock									
Yes	15 (17.7)	1.73 (0.20, 15.2)	0.62	7 (8.2)	0.29 (0.06, 1.34)	0.11	12 (14.1)	0.43 (0.11, 1.70)	0.23
No	11 (10.4)	Ref.		6 (5.7)	Ref.		26 (24.5)	Ref.	
Restroom has signs of mould									
Yes	19 (19.4)	9.12 (1.89, 44)	0.01	7 (7.1)	2.18 (0.57, 8.42)	0.26	13 (13.3)	0.45 (0.28, 0.73)	$p < 0.01$
No	8 (8.5)	Ref.		6 (6.4)	Ref.		25 (26.6)	Ref.	
No garbage bin in or near restroom									
Yes	21 (18.4)	1.71 (0.34, 8.49)	0.51	8 (7)	0.51 (0.12, 2.28)	0.38	25 (21.9)	1.36 (0.60, 3.08)	0.47
No	6 (7.7)	Ref.		5 (6.4)	Ref.		13 (16.7)		

Note. aOR, adjusted odds ratio; CI, confidence interval; Ref., reference group; WaSH, water, sanitation, and hygiene.
aORs were estimated by multiple logistic regression models. Variables of exposure included in models were: female, early-teenager (age 13–14 years old), does not eat three times per day, does not consider self to be "healthy", had diarrhoea, is dehydrated (urine specific gravity ≥ 1.020), had helminth infection, does not wash hands in school, does not use school restroom, hygiene lessons are not taught in school, number of adults living in home, number of children living in home, duration (years) of residence in home, does not eat a variety of food at home, home has no indoor restroom, home restroom is not clean, home restroom has no water, home restroom has no handwashing basin, home restroom is not well-lit, home restroom has no door lock, home restroom has signs of mould, and no garbage can inside or nearby home restroom.

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Declaration of competing interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

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References

Adams, L.J., 1983. Evaluation of Ames Multistix-SG for urine specific gravity versus refractometer specific gravity. Am. J. Clin. Pathol. 80 (6), 871–873. https://doi.org/10.1093/ajcp/80.6.871.

Armstrong, L.E., Maresh, C.M., Castellani, J.W., Bergeron, M.F., Kenefick, R.W., LaGasse, K.E., Riebe, D., 1994. Urinary indices of hydration status. Int. J. Sport Nutr. 4 (3), 265–279. https://doi.org/10.1123/ijsn.4.3.265.

Ashraf, S., Islam, M., Unicomb, L., Rahman, M., Winch, P.J., Arnold, B.F., Benjamin-Chung, J., Ram, P.K., Colford, J.M., Luby, S.P., 2020. Effect of improved water quality, sanitation, hygiene and nutrition interventions on respiratory illness in young children in rural Bangladesh: a multi-arm cluster-randomized controlled trial. Am. J. Trop. Med. Hyg. 102 (5), 1124–1130. https://doi.org/10.4269/ajtmh.19-0769.

Bar-David, Y., Urkin, J., Kozminsky, E., 2005. The effect of voluntary dehydration on cognitive functions of elementary school children. Acta Paediatr. 94 (11), 1667–1673. https://doi.org/10.1080/08035250500254670 (Oslo, Norway: 1992).

Baron, S., Courbebaisse, M., Lepicard, E.M., Friedlander, G., 2015. Assessment of hydration status in a large population. Br. J. Nutr. 113 (1), 147–158. https://doi.org/10.1017/S0007114514003213.

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., Uauy, R., 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 382 (9890), 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X.

Chao, H.-C., Chen, S.-Y., Chen, C.-C., Chang, K.-W., Kong, M.-S., Lai, M.-W., Chiu, C.-H., 2008. The impact of constipation on growth in children. Pediatr. Res. 64 (3), 308–311. https://doi.org/10.1203/PDR.0b013e31817995aa.

Chard, A.N., Garn, J.V., Chang, H.H., Clasen, T., Freeman, M.C., 2019. Impact of a school-based water, sanitation, and hygiene intervention on school absence, diarrhoea, respiratory infection, and soil-transmitted helminths: results from the WASH HELPS cluster-randomized trial. J. Glob. Health 9 (2), 020402. https://doi.org/10.7189/jogh.09.020402.

Curtis, V., Cairncross, S., 2003. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. Lancet Infect. Dis. 3 (5), 275–281. https://doi.org/10.1016/S1473-3099(03)00606-6.

Davis, S.M., Worrell, C.M., Wiegand, R.E., Odero, K.O., Suchdev, P.S., Ruth, L.J., Lopez, G., Cosmas, L., Neatherlin, J., Njenga, S.M., Montgomery, J.M., Fox, L.M., 2014. Soil-transmitted helminths in pre-school-aged and school-aged children in an urban slum: a cross-sectional study of prevalence, distribution, and associated exposures. Am. J. Trop. Med. Hyg. 91 (5), 1002–1010. https://doi.org/10.4269/ajtmh.14-0060.

de Buck, E., Van Remoortel, H., Hannes, K., Govender, T., Naidoo, S., Avau, B., Vande Veegaete, A., Musekiwa, A., Lutje, V., 2017. Promoting handwashing and sanitation behaviour change in low- and middle-income countries: a mixed-method systematic review. 3ie Systematic Review Summary 10. International Initiative for Impact Evaluation (3ie), London Retrieved on April 22, 2022 from https://www.3ieimpact.org/evidence-hub/publications/systematic-reviews/promoting-handwashing-and-sanitation-behaviour-change.

de Buys Roessingh, A.S., Drukker, A., Guignard, J.P., 2001. Dipstick measurements of urine specific gravity are unreliable. Arch. Dis. Child. 85 (2), 155–157. https://doi.org/10.1136/adc.85.2.155.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C., Siekmann, J., 2007. Development of a WHO growth reference for school-aged children and adolescents. Bull. World Health Organ. 85 (9), 660–667. https://doi.org/10.2471/blt.07.043497.

Development Initiatives, 2018. 2018 Global Nutrition Report: Shining a light to spur action on nutrition. https://globalnutritionreport.org/reports/global-nutrition-report-2018/. (Accessed 26 January 2022).

Edmonds, C.J., Jeffes, B., 2009. Does having a drink help you think? 6–7-year-old children show improvements in cognitive performance from baseline to test after having a drink of water. Appetite 53 (3), 469–472. https://doi.org/10.1016/j.appet.2009.10.002.

Ellis, A., Haver, J., Villasenor, J., Parawan, A., Venkatesh, M., Freeman, M.C., Caruso, B.A., 2016. WASH challenges to girls' menstrual hygiene management in Metro Manila, Masbate, and South Central Mindanao,Philippines. Waterlines 35 (3), 306–323. https://doi.org/10.3362/1756-3488.2016.022.

Food and Agriculture Organization of the United Nations, 2013. The state of food and agriculture. 2013Food Systems for Better Nutrition. 99. Food and Agriculture Organization of the United Nations, Rome http://www.fao.org/3/i3300e/i3300e00.pdf. Accessed 26 January 2022.

Gounden, D., Newall, R.G., 1983. Urine specific gravity measurements: comparison of a new reagent strip method with existing methodologies, as applied to the water concentration/dilution tests. Curr. Med. Res. Opin. 8 (6), 375–381. https://doi.org/10.1185/03007998309111742.

Guerrant, R.L., Kirchhoff, L.V., Shields, D.S., Nations, M.K., Leslie, J., de Sousa, M.A., Araujo, J.G., Correia, L.L., Sauer, K.T., McClelland, K.E., 1983. Prospective study of diarrheal illnesses in northeastern Brazil: patterns of disease, nutritional impact, etiologies, and risk factors. J. Infect. Dis. 148 (6), 986–997. https://doi.org/10.1093/infdis/148.6.986.

Hoarau, B., Vercherin, P., Bois, C., 2014. School Bathrooms: Children's Perceptions And Prevalence of Gastrointestinal And Urinary Disorders, A Survey in 3 Secondary Schools Near Saint-Etienne. 26(4). Sante Publique (Vandoeuvre-les-Nancy,France), pp. 421–431.

Jin, H., Wang, B., Fang, Z., Duan, Z., Gao, Q., Liu, N., Zhang, L., Qian, Y., Gong, S., Zhu, Q., Shen, X., Wu, Q., 2011. Hospital-based study of the economic burden associated with rotavirus diarrhoea in eastern China. Vaccine 29 (44), 7801–7806. https://doi.org/10.1016/j.vaccine.2011.07.104.

Katsuno, C., Gregorio, E.R., Lomboy, M.F.T.C., Nonaka, D., Hernandez, P.M.R., Estrada, C.A.M., Pimentel, J.M.T., Bernadas, R.M.G.C., Kobayashi, J., 2019. Quality of public school toilets and the frequency of changing sanitary napkins among students in public secondary schools in the City of Manila,Philippines. Trop. Med. Health 47 (1), 5. https://doi.org/10.1186/s41182-018-0131-8.

Keusch, G.T., Rosenberg, I.H., Denno, D.M., Duggan, C., Guerrant, R.L., Lavery, J.V., Tarr, P.I., Ward, H.D., Black, R.E., Nataro, J.P., Ryan, E.T., Bhutta, Z.A., Coovadia, H., Lima, A., Ramakrishna, B., Zaidi, A.K., Burgess, D.C., Brewer, T., 2013. Implications of acquired environmental enteric dysfunction for growth and stunting in infants and children living in low- and middle-income countries. Food Nutr. Bull. 34 (3), 357–364. https://doi.org/10.1177/156482651303400308.

Lindquist, M.A., Mejia, A., 2015. Zen and the art of multiple comparisons. Psychosom. Med. 77 (2), 114–125. https://doi.org/10.1097/PSY.0000000000000148.

Naghavi, M., et al., 2017. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016—The Lancet. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(17)32152-9/fulltext.

Ngabo, F., Mvundura, M., Gazley, L., Gatera, M., Rugambwa, C., Kayonga, E., Tuyishime, Y., Niyibaho, J., Mwenda, J.M., Donnen, P., Lepage, P., Binagwaho, A., Atherly, D., 2016. The economic burden attributable to a child's inpatient admission for diarrhoeal disease in Rwanda. PLOS ONE 11 (2), e0149805. https://doi.org/10.1371/journal.pone.0149805.

Owino, V., Ahmed, T., Freemark, M., Kelly, P., Loy, A., Manary, M., Loechl, C., 2016. Environmental enteric dysfunction and growth failure/stunting in global child health. Pediatrics 138 (6), e20160641. https://doi.org/10.1542/peds.2016-0641.

Pagana, K.D., Pagana, T.J., Pagana, T.N., 2015. Mosby's Diagnostic And Laboratory Test Reference, 12th ed. 952. Elsevier, Inc, St. Louis, MO, USA, pp. 671–672.

Philippines Department of Education, 2019a. Elementary And Junior And Senior High School Enrolment, School Years 2014-2019. [Data set].

Philippines Department of Education, 2019b. Number of Public Classroom in Elementary And Junior High School, Enrolment School Year 2018-2019. [Data set].

Philippines Department of Education, 2019c. Public Schools MOOE Allocation, Fiscal Years (FYs) 2015-2019. [Data set].

Philippines Department of Health, 1998. Implementing rules of and regulations on chapter VI, "School sanitation and health services", of the code on sanitation of the Philippines (P.D. 856). https://www.doh.gov.ph/sites/default/files/publications/Chapter_6_School_Sanitation_and_Health_Services.pdf. (Accessed 7 July 2021).

Philippines Department of Health, 2017. Philippine National Standards for Drinking Water of 2017. Administrative Order 2017-0010. https://dmas.doh.gov.ph:8083/Rest/GetFile?id=337128. (Accessed 26 January 2022).

Philippines Department of Health, 2018. Field Health Services Information System Annual Report 2018. https://doh.gov.ph/sites/default/files/publications/FHSIS_Annual_2018_Final.pdf. (Accessed 26 January 2022).

Philippine Statistics Authority, 2021. 2021 Philippines in figures. https://psa.gov.ph/sites/default/files/2021_pif_final%20%281%29.pdf. (Accessed 3 October 2022).

Pickering, A.J., Null, C., Winch, P.J., Mangwadu, G., Arnold, B.F., Prendergast, A.J., Njenga, S.M., Rahman, M., Ntozini, R., Benjamin-Chung, J., Stewart, C.P., Huda, T., Moulton, L.H., Colford Jr., J.M., Luby, S.P., Humphrey, J.H., 2019. The WASH Benefits and SHINE trials: interpretation of WASH intervention effects on linear growth and diarrhoea. Lancet Glob. Health 7 (8), e1139–e1146. https://doi.org/10.1016/S2214-109X(19)30268-2.

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M.C., Gordon, B., Hunter, P.R., Medlicott, K., Johnston, R., 2019. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low- and middle-income countries. Int. J. Hyg. Environ. Health 222 (5), 765–777. https://doi.org/10.1016/j.ijheh.2019.05.004.

Riiser, K., Helseth, S., Haraldstad, K., Torbjørnsen, A., Richardsen, K.R., 2020. Adolescents' health literacy, health protective measures, and health-related quality of life during the COVID-19 pandemic. PLOS ONE 15 (8), e0238161. https://doi.org/10.1371/journal.pone.0238161.

Save the Children Philippines, 2016. Cost of Hunger: Philippines. The economic impact of child undernutrition on education and productivity in the Philippines. https://resourcecentre.savethechildren.net/node/12557/pdf/save-the-children-cost-of-hunger-philippines-2016.pdf. (Accessed 26 January 2022).

Schilling, K.A., Omore, R., Derado, G., Ayers, T., Ochieng, J.B., Farag, T.H., Nasrin, D., Panchalingam, S., Nataro, J.P., Kotloff, K.L., Levine, M.M., Oundo, J., Parsons, M.B., Bopp, C., Laserson, K., Stauber, C.E., Rothenberg, R., Breiman, R.F., O'Reilly, C.E., Mintz, E.D., 2017. Factors associated with the duration of moderate-to-severe diarrhoea among children in rural Western Kenya enrolled in the Global Enteric Multicenter Study, 2008–2012. Am. J. Trop. Med. Hyg. 97 (1), 248–258. https://doi.org/10.4269/ajtmh.16-0898.

Trinies, V., Garn, J.V., Chang, H.H., Freeman, M.C., 2016. The impact of a school-based water, sanitation, and hygiene program on absenteeism, diarrhea, and respiratory infection: a matched-control trial in Mali. Am. J. Trop. Med. Hyg. 94 (6), 1418–1425. https://doi.org/10.4269/ajtmh.15-0757.

Troeger, C., Blacker, B.F., Khalil, I.A., Rao, P.C., Cao, S., Zimsen, S.R., Albertson, S.B., Stanaway, J.D., Deshpande, A., Abebe, Z., Alvis-Guzman, N., Amare, A.T., Asgedom, S.W., Anteneh, Z.A., Antonio, C.A.T., Aremu, O., Asfaw, E.T., Atey, T.M., Atique, S., Reiner, R.C., 2018. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: A systematic analysis for the Global Burden of Disease Study 2016. Lancet Infect. Dis. 18 (11), 1211–1228. https://doi.org/10.1016/S1473-3099(18)30362-1.

United Nations International Children's Emergency Fund (UNICEF), 2018. The economic consequences of undernutrition in the Philippines: a damage assessment report (DAR). https://childrightsnetwork.ph/download/the-economic-consequences-of-undernutrition-in-the-philippines-pdf/. (Accessed 7 June 2021).

Vargas, M., 2019. Nutritional Status of Filipino School Children (6-10 years old), 2018 Expanded National Nutrition Survey (ENNS). Department of Science and Technology Food & Nutrition Research Institute (DOST-FNRI). [Electronic source] Presented in 2019 National Nutrition Summit. https://www.fnri.dost.gov.ph/images//sources/eNNS2018/Pre-school_and_School-Children.pdf. (Accessed 15 June 2020).

WHO, 2017b. Diarrhoeal disease. https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease. (Accessed 26 January 2022).

WHO, 2007a. Growth reference 5-19 years—BMI-for-age (5-19 years). https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age. (Accessed 26 January 2022).

WHO, 2007b. Growth reference 5-19 years—height-for-age (5-19 years). https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/height-for-age. (Accessed 26 January 2022).

WHO, 2017a. The double burden of malnutrition. Policy Brief. https://apps.who.int/iris/bitstream/handle/10665/255413/WHO-NMH-NHD-17.3-eng.pdf?ua=1. (Accessed 26 January 2022).

WHO, Adams, J., Bartram, J., Chartier, Y., Sims, J., 2009. Water, sanitation and hygiene standards for schools in low-cost settings. https://www.who.int/water_sanitation_health/publications/wash_standards_school.pdf?ua=1. (Accessed 26 January 2022).

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010. Progress on sanitation and drinking-water: 2010 update. World Health Organization. https://apps.who.int/iris/handle/10665/44272. (Accessed 26 January 2022).

Worrell, C.M., Wiegand, R.E., Davis, S.M., Odero, K.O., Blackstock, A., Cuéllar, V.M., Njenga, S.M., Montgomery, J.M., Roy, S.L., Fox, L.M., 2016. A cross-sectional study of water, sanitation, and hygiene-related risk factors for soil-transmitted helminth infection in urban school- and preschool-aged children in Kibera,Nairobi. PLOS ONE 11 (3), e0150744. https://doi.org/10.1371/journal.pone.0150744.