RESEARCH ARTICLE

REVISED The association of socio-demographic and environmental factors on childhood diarrhea in Cambodia [version 3; peer review: 1 approved with reservations]

Vong Pisey[1,2], Pannee Banchonhattakit[3], Wongsa Laohasiriwong[3]

[1]Doctor of Public Health Program, Faculty of Public Health, Khon Kaen University, Khon Kaen, 40002, Thailand
[2]Office of Rural Health Care, Pursat Provincial Department of Rural Development, Ministry of Rural Development, Cambodia
[3]Faculty of Public Health, Khon Kaen University, Khon Kaen, 40002, Thailand

v3 **First published:** 28 Apr 2020, **9**:303
https://doi.org/10.12688/f1000research.23246.1
Second version: 03 Jul 2020, **9**:303
https://doi.org/10.12688/f1000research.23246.2
Third version: 12 Apr 2021, **9**:303
https://doi.org/10.12688/f1000research.23246.3
Fourth version: 04 Aug 2021, **9**:303
https://doi.org/10.12688/f1000research.23246.4
Latest published: 23 Sep 2021, **9**:303
https://doi.org/10.12688/f1000research.23246.5

Abstract

Background: Diarrhea is still the leading cause of childhood death worldwide, as well as a major cause for concern in developing countries. This study was conducted to investigate the factors related to childhood diarrhea in Cambodia.

Methods: A cross-sectional study of the secondary data from the Cambodia Demographic and Health Survey 2014 was conducted using the combination of household data and children's data. A generalized linear mixed model was used to analyze the determinant factors of childhood diarrhea.

Results: The surveys included 2,828 children, aged 12 to 35 months. The prevalence of diarrhea in the last 2 weeks was 16.44% (95% CI: 14.72%-18.31%). Factors with statistically significant associations with childhood diarrhea in Cambodia were: maternal unemployment, compared with being in employment (AOR = 1.43; 95% CI: 1.14-1.78); the child being male (AOR = 1.25; 95%CI: 1.02-1.53); the presence of unimproved toilet facilities (AOR = 1.17; 95%CI: 1.05-1.31) compared with improved toilet facilities; and unhygienic disposal of children's stools (AOR = 1.32; 95%CI: 1.06-1.64) compared with hygienic disposal of children's stools when controlling for other covariates. Both maternal age (one year older; AOR = 0.85; 95%CI: 0.78– 0.93) and child age (one month older; AOR = 0.86; 95%CI: 0.78-0.94) had significant negative associations with the occurrence of childhood diarrhea.

Conclusion: Childhood diarrhea remains a public health concern in Cambodia. The probability of diarrhea occurring is shown to be

Open Peer Review

Reviewer Status ? ?

	Invited Reviewers	
	1	**2**
version 5 (revision) 23 Sep 2021		
version 4 (revision) 04 Aug 2021	? report	? report
version 3 (revision) 12 Apr 2021		
version 2 (revision) 03 Jul 2020		
version 1 28 Apr 2020	? report	

1. **Siyan Yi**, National University of Singapore, Singapore, Singapore
KHANA Center for Population Health Research, Phnom Penh, Cambodia
Touro University California, Vallejo, USA

increased by maternal unemployment, the sex of the child being male, lack of provision of improved toilet facilities, and the unhygienic disposal of children's stools; whereas increasing maternal age and child's age were associated with a reduced chance of diarrhea occurring. On the basis of these results, we recommend provision of programs focusing on reducing diarrhea through the construction of improved toilet facilities and the promotion of behavior to improve hygiene, specifically targeting younger mothers.

Keywords
Socio-demographic, environmental, childhood diarrhea, generalized linear mixed model, Cambodia

2. **Okechukwu S. Chukwudeh**, North-West University, Mahikeng, South Africa

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Pannee Banchonhattakit (panban@kku.ac.th)

Author roles: Pisey V: Conceptualization, Data Curation, Investigation, Writing – Original Draft Preparation, Writing – Review & Editing; **Banchonhattakit P**: Conceptualization, Methodology, Supervision, Validation; **Laohasiriwong W**: Conceptualization, Methodology, Supervision, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

How to cite this article: Pisey V, Banchonhattakit P and Laohasiriwong W. **The association of socio-demographic and environmental factors on childhood diarrhea in Cambodia [version 3; peer review: 1 approved with reservations]** F1000Research 2021, **9**:303 https://doi.org/10.12688/f1000research.23246.3

First published: 28 Apr 2020, **9**:303 https://doi.org/10.12688/f1000research.23246.1

REVISED **Amendments from Version 2**

We have updated the authorship of article by adding Wonga Laohasiriwong as last author

Any further responses from the reviewers can be found at the end of the article

Introduction

Diarrhea is defined as the passage of loose or watery stools, three or more times each day, or more frequent passage than is normal for an individual[1]. Diarrhea remains a leading cause of child mortality and morbidity in the world, with an estimated 1.7 billion cases of childhood diarrhea and 525,000 deaths of children under five caused by diarrhea each year[1,2]. Diarrhea is the second leading cause of death in children under the age of five years[1,2]. Globally, 88% of diarrhea cases are attributable to poor water, poor sanitation or poor hygiene[3]. There is not just the one single factor associated with childhood diarrhea but multiple factors, including unimproved drinking water sources[4–7], untreated water[8–10], unimproved toilet facilities[6,8,9,11], unhygienic disposal of children's stools[12–14], lack of hand washing facilities[15,16], type and location of residence[11,16], the child's age[4,13,16], the child's sex (male)[13], maternal illiteracy[12,13,17], the mother's occupation[9,12], maternal age[14,18], wealth index[4,19], and whether or not the child is breastfed[10,15].

In 2014, Cambodia still had one of the highest prevalence levels of diarrhea among children under the age of five amongst countries in South-East Asia, at 12.8%[20]. By comparison, Myanmar had a prevalence of 10.4% in 2015–16[21], Malaysia 4.4% in 2016[7], Laos 6.5% in 2017[22], Philippines 6.1% in 2017[23], and Indonesia 14.1% in 2017[24]. According to 2016 data from UNICEF, Cambodia had 5,947 total neonatal deaths, of which 20 were due to diarrhea; 5,248 post-neonatal deaths, of which 672 were due to diarrhea (13%); and 692 deaths of children under five due to diarrhea (6%)[25]. High rates of diarrhea alone account for one fifth of the deaths of children under the age of five in Cambodia, and an estimated 10,000 deaths overall each year[26]. This demonstrates that diarrhea is the most common cause of death in Cambodian children. According to the Cambodia Demographic and Health Survey (CDHS) 2014, the prevalence of diarrhea among children aged 12 to 35 months was high, which is known to affect for child development and growth[20].

It is of great importance to understand the factors related to the prevalence of diarrhea among children aged 12 to 35 months. There are no existing studies on the association in this age group, and no national studies on the associated factors with childhood diarrhea in Cambodia have yet been published.

Methods

Ethical statement

This research project received approval from the Khon Kean University Ethics Committee in Human Research (HE632097). This study uses existing CDHS data and re-analysis was done under the original consent provided by the participants.

CDHS 2014

The CDHS 2014 collected data nationally across the country, which is subdivided into 19 province domains. Its sampling frame consisted of 28,455 eligible enumeration areas (EAs), which comprised the 2008 Cambodian General Population Census (GPC). The sample was allocated into urban and rural in each domain with a power allocation preventing oversample urban, and can represent Cambodia is mainly rural. The stratified sample was selected in two stages. In the first stage, a fixed number of EAs were chosen using probabilities weighted proportional to the size of the EA. In the second stage, 24 and 28 households were picked up from every urban cluster and rural cluster, respectively, through a systematic sampling process with equal probability weighting. 15,825 households, 17,578 women, and 5,190 men were interviewed between the 2nd June and the 12th December 2014; further details can be found in the CDHS 2014 report[20]. The final sample size comprised 2,828 children aged 12 to 35 months, providing a suitable degree of power (0.9627, 0.9682).

Data use

Two raw CDHS 2014 datasets, comprising household data and children's data were combined for use in this study. All entries and variables in these datasets were included in this study.

Dependent variable

The prevalence of diarrhea is the dependent variable considered in this study. This is referred to the questionnaire thus: "Has (NAME) had diarrhea in the last 2 weeks?" The dichotomous variable *childhood diarrhea* can take values "1" representing a response of "yes" or "0" representing "no" and "don't know" responses.

Independent variables

Socio-demographic characteristics take the form of continuous variables such as maternal age, child's age, and number of household members and categorical variables such as maternal education (no education/primary/secondary/higher), maternal occupation (employed/unemployed), mother's knowledge of oral rehydration salts (ORS) (good/poor)[27], exposure to media (yes/no)[28], sex of the child, breastfeeding (ever/never), deworming (yes/no)[27], vaccination (ever/never), residence (urban/rural) and wealth index (poorest/poorer/middle/richer/richest)[27]. CDHS data were organized in 19 province domains, which we regrouped into four regions: Central Plain; Tonle Sap; Coastal and Sea; and Plateau and Mountains[29]. Environmental characteristics were also treated as categorical variables, including drinking water source (improved/unimproved)[30], whether or not the same source of drinking water was used during wet and dry seasons (same/different), whether or not water was treated before drinking (always/no), type of toilet facility (improved/unimproved)[30], hygiene (adequate/inadequate)[30], and disposal of children's stools (sanitary/unsanitary)[31]. World Health Organization (WHO) guidelines on water, sanitation and hygiene

(WASH) were used to classify WASH as either improved or unimproved, and sanitary or unsanitary according to the WHO/UNICEF Joint Monitoring Programme (Table 1 and Table 2)[30,31].

Statistical analysis

Statistical data analyses were performed using STATA/SE 14.0[32] as follows.

Categorical variables were analyzed to provide frequency and percentage. Continuous variables were calculated as means, standard deviations, and ranges. A weighting variable was used in the form of the woman's individual sample weighting. Cross-tabulations were run with the appropriate sample weights to provide nationally representative results[19]. The *svyset* command was used to test for complex survey sampling methods used in the original surveys, in order to adjust for differences in the probabilities of sample selection and to avoid using over-sampled strata within the survey data[27].

The prevalence of diarrhea was estimated as a percentage. The numerator was the number of living children aged 12 to 35 months with an occurrence of diarrhea during the two weeks preceding the interview (i.e. an answer "yes" to, "Has (NAME) had diarrhea in the last 2 weeks?") and the denominator was the number of living children aged 12 to 35 months.

A bivariate analysis with simple logistic regression was performed using the *svyset* (*svy* command). A linearity test was conducted between the continuous variable and dependent variable. Any independent variables significant at $p<0.25$ were entered into the initial model[33,34]. Multicollinearity assessment was performed with the independent variables-variance inflation factor (VIF)[35]. Finally, a multivariate analysis was performed using a generalized mixed linear model with four regions picked as 'random effects' corresponding to the various clusters in the sampling design[36]. The backward stepwise procedure was applied as the model fitting strategy. Statistical significance was considered at a threshold of $p<0.05$ and the adjusted odds ratio (AOR) with 95% confidence intervals (CI) was considered as the magnitude of the effect.

Results

A total of 2,828 children were included in the study. The majority of the children (84.12%) lived in rural areas. Nearly half (44.03%) lived in Central Plain and one third (33.32%) lived in Tonle Sap. The mean of maternal age was 28.27±5.89 years old. More than half the mothers (51.08%) attended primary school. Three quarters (75.10%) of the mothers were employed and the average number of household members was five. More than half (51.18%) of the children were male and the mean age was 23.33±6.79 months. Almost all (96.17%) children had been breastfed; 59.60% had received deworming treatment. Out of 2,828 households, more than half (54.07%) always had treated water to drink; 57.97% had an unimproved toilet facility; while 68.01% used adequate hygiene; and 70.25% used sanitary disposal of children's stool (Table 3).

Bivariate analysis of factors associated with childhood diarrhea in Cambodia

Factors with a significant association with childhood diarrhea ($p<0.05$) were maternal age, maternal occupation, the child's age, available toilet facilities, and the method of stool disposal

Table 1. Joint Monitoring Programme classification of improved and unimproved water, sanitation and hygiene (WASH)[30].

Service	Improved	Unimproved
Drinking water	Piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water, and provided collection time is not more than 30 minutes for a round trip, including queuing	Unprotected dug well, unprotected spring, surface water (river, reservoirs, lakes, ponds, streams, canals, and irrigation channels).
Sanitation	Flush and pour flush connected to piped sewer, septic tanks or pit latrines; ventilated improved pit (VIP) latrine, composting toilets or pit latrines with slabs, and that are not shared with other households	Flush and pour flush not to sewer/septic tank/pit latrine, pit latrine without slab/open pit, bucket, hanging toilet/hanging latrine, no facility/bush/field
Hygiene	Availability of a handwashing facility on premises with soap and water	No handwashing facility on premises

Table 2. Joint Monitoring Programme classification of sanitary and unsanitary disposal of children stool[31].

Sanitary	Unsanitary
Child used toilet or latrine Put or rinsed in the toilet or latrine Buried	Put or rinsed into drain or ditch Throw into the garbage Left in the open or not disposed of Other

Table 3. Socio-demographic and environmental characteristics of households in Cambodia, 2014 (n=2,828).

Variables	Frequency	Percentage
Maternal characteristics		
Age (years)		
16–24	397	14.04
25–34	1591	56.26
35–49	840	29.70
Mean±SD	28.27±5.89	
Range	16 to 49	
Education		
No education	366	12.96
Primary	1445	51.08
Secondary	921	32.58
Higher	96	3.38
Occupation		
Employed	2124	75.10
Unemployed	704	24.90
Knowledge of oral rehydration salts		
Good	2717	96.05
Poor	111	3.95
Exposure to media		
Yes	1808	63.92
No	1020	36.08
Children's characteristics		
Age (months)		
12–23	1460	51.64
24–35	1368	48.36
Mean±SD	23.33±6.79	
Range	12 to 35	
Sex		
Male	1448	51.18
Female	1381	48.82
Breastfeeding status		
Ever	2720	96.17
Never	108	3.83
Deworming		
Yes	1686	59.60
No	1142	40.40
Household characteristics		
Residence		
Urban	449	15.88
Rural	2379	84.12
Region		
Coastal and Sea	169	5.98
Tonle Sap	942	33.32
Central Plain	1245	44.03
Plateau and Mountains	472	16.67
Number of household members		
1–4	969	34.28
>4	1859	65.72
Mean±SD	5.73±2.31	
Range	1 to 22	
Wealth index		
Poorest	672	23.76
Poorer	523	18.49
Middle	550	19.44
Richer	493	17.45
Richest	590	20.86
Environmental characteristics		
Drinking water during dry season		
Improved	1745	61.71
Unimproved	1083	38.29
Drinking water during wet season		
Improved	2320	82.02
Unimproved	508	17.98
Same source of drinking water during wet and dry season		
Same	1955	69.11
Different	873	30.89
Treating water to drink		
Yes, always	1529	54.07
No	1299	45.93
Toilet facility		
Improved	1189	42.03
Unimproved	1640	57.97
Hygiene		
Adequate	1923	68.01
Inadequate	905	31.99
Disposal of children's stool		
Sanitary	1987	70.25
Unsanitary	841	29.75

SD, standard deviation.

(Table 4). Further, the factors of the child's sex, the number of household members, wealth index, source of drinking water during dry season, whether or not the same source of drinking water is used during wet and dry seasons, and the treatment/non-treatment of drinking water did not reach significance but did meet the pre-determined threshold of p<0.25 for inclusion in the initial model. Finally, region (p<0.25) also met the criteria for inclusion in the initial model and was used as a random effect. As such, the multivariate analysis was conducted using a generalized mixed linear model with each of the four regions of Cambodia treated as random effects.

Multivariate analysis of factors associated with childhood diarrhea in Cambodia

The multivariate analysis (Table 5) showed that as maternal age increased by a year, the odds of the child suffering from diarrhea decreased 15% (AOR = 0.85; 95%CI: 0.78– 0.93; p=0.001). The odds of suffering from diarrhea was 43% higher (AOR = 1.43; 95% CI: 1.14-1.78; p=0.002) in children whose mother was unemployed compared to employed. As the child's age increased by a month, the odds of the child suffering from diarrhea decreased 14% (AOR = 0.86; 95%CI: 0.78-0.94; p=0.001). The odds of suffering from diarrhea was 25% higher (AOR = 1.25;

Table 4. Bivariate analysis of factors associated with childhood diarrhea in Cambodia, 2014 (n=2,828).

Variables	Number	Diarrhea %	COR	95% CI	p-value
Overall	2828	16.44		14.72-18.31	
Maternal age (years)	2828	N/A	0.82	0.73-0.92	<0.001
Maternal education					0.681
Literate	2462	16.29	1		
Illiterate	366	17.46	1.09	0.73-1.62	
Maternal occupation					0.007
Employed	2124	15.00	1		
Unemployed	704	20.78	1.49	1.11-1.98	
Mother's knowledge of oral rehydration salts					0.481
Good	2717	16.61	1		
Poor	111	12.21	0.69	0.25-1.90	
Mother's exposure to media					0.502
Yes	1808	15.99	1		
No	1020	17.23	1.09	0.84-1.42	
Child's age (months)	2828	N/A	0.83	0.75-0.92	<0.001
Child's sex					0.075
Female	1381	14.86	1		
Male	1448	17.94	1.25	0.97-1.61	
Breastfeeding status					0.268
Ever	2720	16.64	1		
Never	108	11.42	0.64	0.29-1.40	
Deworming					0.504
Yes	1686	16.91	1		
No	1142	15.75	0.91	0.71-1.17	
Residence					0.561
Urban	449	15.39	1		
Rural	2379	16.64	1.10	0.80-1.50	

Variables	Number	Diarrhea %	COR	95% CI	p-value
Region					0.203
Coastal and Sea	169	12.36	1		
Tonle Sap	942	15.55	1.31	0.82-2.07	
Central Plain	1245	16.92	1.44	0.92-2.25	
Plateau and Mountains	472	18.40	1.60	1.02-2.51	
Number of household members					0.095
>4	1859	15.38	1		
1–4	969	18.47	1.25	0.96- 1.62	
Wealth index					0.128
Richest	590	14.44	1		
Richer	493	17.40	1.25	0.82-1.90	
Middle	550	14.65	1.02	0.67-1.55	
Poorer	523	14.50	1.00	0.67-1.50	
Poorest	672	20.46	1.52	1.03-2.26	
Drinking water during dry season					0.065
Improved	1745	15.12	1		
Unimproved	1083	18.56	1.28	0.98-1.66	
Drinking water during wet season					0.676
Improved	2320	16.27	1		
Unimproved	508	17.22	1.07	0.78-1.48	
Same source of drinking water during wet and dry season					0.161
Same	1955	15.56	1		
Different	873	18.40	1.22	0.92-1.62	
Treating water to drink					0.139
Yes, always	1529	15.28	1		
No	1299	17.81	1.20	0.94-1.53	
Toilet facility					0.013
Improved	1189	13.61	1		
Unimproved	1640	18.49	1.20	1.04-1.39	
Hygiene					0.995
Adequate	1923	16.44	1		
Inadequate	905	16.43	0.99	0.74-1.34	
Disposal of children's stool					0.020
Sanitary	1987	14.99	1		
Unsanitary	841	19.85	1.40	1.05-1.87	

COR, crude odds ratio; CI, confidence interval.

Table 5. Multivariate analysis of factors associated with childhood diarrhea in Cambodia, 2014 using generalized mixed linear model (n=2,828).

Variables	Number	Diarrhea %	AOR	95% CI	p-value
Maternal age (years)	2828	N/A	0.85	0.78-0.93	0.001
Maternal occupation					0.002
Employed	2124	15.00	1		
Unemployed	704	20.78	1.43	1.14-1.78	
Child's age (months)	2828	N/A	0.86	0.78-0.94	0.001
Child's sex					0.031
Female	1381	14.86	1		
Male	1448	17.94	1.25	1.02-1.53	
Toilet facility					0.004
Improved	1189	13.61	1		
Unimproved	1640	18.49	1.17	1.05-1.31	
Disposal of children's stool					0.011
Sanitary	1987	14.99	1		
Unsanitary	841	19.85	1.32	1.06-1.64	

AOR, adjusted odds ratio; CI, confidence interval.

95%CI: 1.02-1.53; p=0.031) in males compared to females. The odds of suffering from diarrhea was 17% higher (AOR = 1.17; 95%CI: 1.05-1.31; p=0.004) in children living in a household with unimproved toilet facilities compared with those with improved toilet facilities. The odds of suffering from diarrhea was 32% higher (AOR = 1.32; 95%CI: 1.06-1.64; p=0.011) in children whose stools were disposed of unhygienically compared to children whose stools were disposed of hygienically.

Discussion

This is the first study to report factors associated with diarrhea in children aged 12 to 35 months at the national level in Cambodia. Younger maternal age, maternal unemployment, younger child age, being male, lack of unimprovement to toilet facilities, and unhygienic disposal of children's stools were found to be associated with childhood diarrhea.

Socio-demographic characteristics such as maternal age were significantly associated with reduced incidence of diarrhea, in line with studies conducted in Brazil and Tanzania[14,18], and perhaps due to the mother having more experience in child-care and feeding. The association of maternal unemployment with the incidence of diarrhea is consistent with a study in Senegal[9]. The child's age had a significant, negative association with incidence of diarrhea, in line with many studies in Ethiopia and Tanzania[4,14,16], and potentially due to the development of the immune system throughout childhood. Males were more likely to suffer from diarrhea than females, which may simply reflect a natural predisposition of males to develop diarrhea more frequently than females[37], but is also supported by a previous study conducted in India[13].

Environmental characteristics such as the lack of improvements to toilet facilities were significantly associated with the incidence of diarrhea, consistent with many studies including a systematic review[4,6,8,11]. Finally, disposal of children's stools was significantly associated with the incidence of diarrhea, consistent with previous studies in Ethiopia, India, and Tanzania[12–14]. These findings demonstrate that the quality of sanitation facilities strongly influences the prevalence of childhood diarrhea in Cambodia.

A limitation of this research study was that it used a cross-sectional design with just one outcome measure (diarrhea prevalence) taken as a snapshot at a given point in time. Future longitudinal studies may improve on this. The CDHS 2014 was not fully comprehensive in that it did not cover the WASH factors of hand washing before preparing meals and after defecating. The inclusion of these questions in the survey would give a more comprehensive analysis of hygiene practices in the population. Moreover, self-reporting measures and recall bias could happened and considered in the study. Further, the CDHS 2014 captured data by household, rather than by individual person, which may introduce a confound in that it has a tendency to under-estimate the quality of both drinking water source and sanitation facility available.

Conclusion

Diarrhea still remains a public health concern among children in Cambodia. The probability of developing diarrhea is strongly associated with maternal unemployment, being male, not having access to improved toilet facilities, or practicing hygienic disposal of children's stools. Conversely, increasing maternal and child age is associated with a reduction in the probability of developing diarrhea.

Recommendations

"Based on this finding, the authors provide the following recommendations.

National: The WASH program should focus on younger mothers, mothers of younger children and unemployed mothers. Guidance should include sanitary methods of stool disposal, water treatment, sanitation, and health. Intervention programs should focus on the construction of improved toilet facilities and promoting hygienic behaviors.

Local: Younger mothers should be encouraged to enroll in health education. Additional community sanitation facilities should be constructed and existing facilities should be improved/maintained.

Future study: Longitudinal studies are needed to measure the impact of these interventions.

Data availability

Our study used raw children's and household data from DHS, Cambodia 2014. Data are free to access for research purposes and can be obtained through the DHS Program after registering and obtaining an approval letter from the Inner City Fund (ICF) (https://dhsprogram.com/data/Access-Instructions.cfm).

Acknowledgements

The authors would like to express sincere thanks and appreciation to:

Dr. Kavin Thinkhamrop, Health and Epidemiology Geoinformatics Research (HEGER), Faculty of Public Health, Khon Kaen University; Dr. Wilaiphorn Thinkhamrop, Data Management and Statistical Analysis Center (DAMASAC), Faculty of Public Health, Khon Kaen University for their statistical support; and Rebecca S Dewey, University of Nottingham for language editing.

References

1. World Health Organization: **Diarrhoeal disease**. 2017.
Reference Source
2. Liu L, Johnson HL, Cousens S, *et al.*: **Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000.** *Lancet.* 2012; **379**(9832): 2151–61.
PubMed Abstract | Publisher Full Text
3. Prüss-Üstün A, Bos R, Gore F, *et al.*: **Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health**. World Health Organization, Geneva, 2008. 2008.
Reference Source
4. Azage M, Kumie A, Worku A, *et al.*: **Childhood diarrhea in high and low hotspot districts of Amhara Region, northwest Ethiopia: a multilevel modeling.** *J Health Popul Nutr.* 2016; **35**: 13.
PubMed Abstract | Publisher Full Text | Free Full Text
5. Kapwata T, Mathee A, Le Roux WJ, *et al.*: **Diarrhoeal Disease in Relation to Possible Household Risk Factors in South African Villages.** *Int J Environ Res Public Health.* 2018; **15**(8): E1665.
PubMed Abstract | Publisher Full Text | Free Full Text
6. Yaya S, Hudani A, Udenigwe O, *et al.*: **Improving Water, Sanitation and Hygiene Practices, and Housing Quality to Prevent Diarrhea among Under-Five Children in Nigeria.** *Trop Med Infect Dis.* 2018; **3**(2): E41.
PubMed Abstract | Publisher Full Text | Free Full Text
7. Aziz FAA, Ahmad NA, Razak MAA, *et al.*: **Prevalence of and factors associated with diarrhoeal diseases among children under five in Malaysia: a cross-sectional study 2016.** *BMC Public Health.* 2018; **18**(1): 1363.
PubMed Abstract | Publisher Full Text | Free Full Text
8. Godana W, Mengistie B: **Determinants of acute diarrhoea among children under five years of age in Derashe District, Southern Ethiopia.** *Rural Remote Health.* 2013; **13**(3): 2329.
PubMed Abstract
9. Thiam S, Diène AN, Fuhrimann S, *et al.*: **Prevalence of diarrhoea and risk factors among children under five years old in Mbour, Senegal: a cross-sectional study.** *Infect Dis Poverty.* 2017; **6**(1): 109.
PubMed Abstract | Publisher Full Text | Free Full Text
10. Acharya D, Singh JK, Adhikari M, *et al.*: **Association of water handling and child feeding practice with childhood diarrhoea in rural community of Southern Nepal.** *J Infect Public Health.* 2018; **11**(1): 69–74.
PubMed Abstract | Publisher Full Text
11. Alebel A, Tesema C, Temesgen B, *et al.*: **Prevalence and determinants of diarrhea among under-five children in Ethiopia: A systematic review and meta-analysis.** *PLoS One.* 2018; **13**(6): e0199684.
PubMed Abstract | Publisher Full Text | Free Full Text
12. Sinmegn Mihrete T, Asres Alemie G, Shimeka Teferra A: **Determinants of childhood diarrhea among underfive children in Benishangul Gumuz Regional State, North West Ethiopia.** *BMC Pediatr.* 2014; **14**(1): 102.
PubMed Abstract | Publisher Full Text | Free Full Text
13. Bawankule R, Singh A, Kumar K, *et al.*: **Disposal of children's stools and its association with childhood diarrhea in India.** *BMC Public Health.* 2017; **17**(1): 12.
PubMed Abstract | Publisher Full Text | Free Full Text
14. Edwin P, Azage M: **Geographical Variations and Factors Associated with Childhood Diarrhea in Tanzania: A National Population Based Survey 2015–16.** *Ethiop J Health Sci.* 2019; **29**(4): 513–24.
PubMed Abstract | Publisher Full Text | Free Full Text
15. Dagnew AB, Tewabe T, Miskir Y, *et al.*: **Prevalence of diarrhea and associated factors among under-five children in Bahir Dar city, Northwest Ethiopia, 2016: a cross-sectional study.** *BMC Infect Dis.* 2019; **19**(1): 417.
PubMed Abstract | Publisher Full Text | Free Full Text
16. Mengistie B, Berhane Y, Worku A: **Prevalence of diarrhea and associated risk factors among children under-five years of age in Eastern Ethiopia: A cross-sectional study.** *Open J Prev Med.* 2013; **03**(07): 446–53.
Publisher Full Text
17. Gebru T, Taha M, Kassahun W: **Risk factors of diarrhoeal disease in under-five children among health extension model and non-model families in Sheko district rural community, Southwest Ethiopia: comparative cross-sectional study.** *BMC Public Health.* 2014; **14**(1): 395.
PubMed Abstract | Publisher Full Text | Free Full Text
18. Vasconcelos MJOB, Rissin A, Figueiroa JN, *et al.*: **Factors associated with diarrhea in children under five years old in the state of Pernambuco, according to surveys conducted in 1997 and 2006.** *Rev Saude Publica.* 2018; **52**: 48.
PubMed Abstract | Publisher Full Text | Free Full Text
19. Rutstein SO, Staveteig S, Winter R, *et al.*: **Urban Child Poverty, Health, and Survival in Low- and Middle-Income Countries.** DHS Comparative Reports No. 40. Rockville, Maryland, USA; 2016.
Reference Source

20. Kosal S, Satia C, Kheam T, *et al.*: **Cambodia Demographic and Health Survey 2014.** Phnom Penh: National Institute of Statistics, Directorate General for Health, and ICF International. 2015.
Reference Source

21. Ministry of Health and Sports (MoHS) and ICF: **Myanmar Demographic Household Survey 2015–16.** Nay Pyi Taw, Myanmar, and Rockville, Maryland USA; 2017.
Reference Source

22. Lao Statistics Bureau: **Lao Social Indicator Survey II 2017, Survey Findings Report.** Vientiane, Lao PDR; 2018.
Reference Source

23. Philippine Statistics Authority (PSA), ICF: **Philippines National Demographic and Health Survey 2017.** Quezon City, Philippines, and Rockville, Maryland, USA; 2018.
Reference Source

24. National Population and Family Planning Board (BKKBN), Statistics Indonesia (BPS), Ministry of Health (Kemenkes), ICF: **Indonesia Demographic and Health Survey 2017.** Jakarta, Indonesia; 2018.
Reference Source

25. United Nations Children's Fund: **Diarrhoeal disease | Diarrhoea as a cause of death in children under 5.** Unicef, 2018.
Reference Source

26. United Nations Children's Fund (UNICEF): **Water, sanitation, and hygiene.** Unicef, 2014.
Reference Source

27. Croft TN, Marshall AMJ, Allen CK: **Guide to DHS Statistics.** Rockville, Maryland, USA ICF, 2018; 22–51.
Reference Source

28. Westoff CF, Bankole A: **Mass media and reproductive behaviour in Africa.** DHS Analytical Reports no. 2, 1997.
Reference Source

29. Ministry of Planning: **General Population Census of the Kingdom of Cambodia 2019.** 2019.
Reference Source

30. United Nations Children's Fund (UNICEF), World Health Organization: **Core questions on drinking water, sanitation and hygiene for household surveys: 2018 update.** New York; 2018.
Reference Source

31. United Nations Children's Fund (UNICEF), World Health Organization: **Core questions on drinking-water and sanitation for household surveys.** World Health Organization. 2006.
Reference Source

32. StataCorp: **Stata Statistical Software Release 14.** College Station, TX: StataCorp LP. 2015.
Reference Source

33. Hosmer DW, Lemeshow S: **Applied Logistic Regression.** Hoboken, New Jersey: Wiley. 2000; 1–369 ISBN: 978-0-470-58247-3.
Publisher Full Text

34. Hosmer DW, Lemeshow S, Sturdivant RX: **Applied Logistic Regression Analysis.** The Statistician. New York, United States: John Wiley & Sons Inc; 2013; 528.
Publisher Full Text

35. Jr JFH, Black WC, Babin BJ, *et al.*: **Multivariate Data Analysis (7th Edition).** 7th edition. Pearson Education Limited. Harlow, United Kingdom: Pearson Education Limited; 2014; 740.
Reference Source

36. Hox JJ, Moerbeek M, van de Schoot R: **Multilevel analysis: Techniques and applications.** New York, NY 10017 and Oxon, OX14 4RN: Routledge; 2018.
Reference Source

37. World Health Organization: **Addressing sex and gender in epidemic-prone infectious diseases.** 2007; 1–46.
Reference Source

Open Peer Review

Current Peer Review Status: ?

Version 1

Reviewer Report 15 June 2020

https://doi.org/10.5256/f1000research.25665.r64014

?

Siyan Yi
[1] Saw Swee Hock School of Public Health, National University of Singapore, Singapore, Singapore
[2] KHANA Center for Population Health Research, Phnom Penh, Cambodia
[3] Center for Global Health Research, Touro University California, Vallejo, CA, USA

General comments: This study used data from Cambodia Demographic and Health Surveys to identify risk factors associated with diarrhea in children aged 12 to 35 months. Overall, the study findings are interesting and may contribute to the literature in this area given the scarcity of data in low- and middle-income countries. The analyses appeared appropriate. The quality of the writing is acceptable, although more careful proofreading is required before the paper can be published.

Here are my specific comments:

Title:

1. The term 'influence' may not be appropriate for this study as it can only tell the associations of variables, not causal relationships.

Abstract:

1. Methods: The first sentence "A cross-sectional study was conducted using the combination of two datasets from the Cambodia Demographic and Health Survey 2014" is hard to understand. The authors may want to make it clear that this study used secondary data from CDHS. What are the two data sets?

2. What was the time frame for the prevalence of diarrhea - past month or lifetime?

Introduction:

1. Please provide a reference for the statement in the second sentence, paragraph 1.

2. Avoid starting sentences with numbers.

3. It would be helpful for readers if authors could define some terminology; e.g., neonatal deaths, post-neonatal deaths, under-five deaths, etc.

4. Paragraph 2:
   - "...and 692 deaths of children under five due to diarrhea (6%)." What is the denominator of the 6%? In the following sentence, the authors stated that 'diarrhea alone account for one fifth of the deaths of children under the age of five in Cambodia." Please clarify these.
   - "High rates of diarrhea alone account for...' Diarrhea alone?
   - It is confusing that this study used data from CDHS 2014, but also cited the prevalence of diarrhea in the same population and from the same data, while claiming that no national studies on childhood diarrhea in Cambodia have yet been published. - The rationale of the study needs improvement.

Methods:

1. What 'province domains' mean?

2. What does this mean: '...,which comprised the 2008 Cambodian General Population Census (GPC)?'

3. 'The sample considered any domain...' is not understandable.

4. Although the CDHS 2014 was referred to, some variables require a clear definition; e.g., improved/unimproved water sources, toilet facilities, adequate/inadequate hygiene, sanitary/unsanitary disposal of children's stools, etc.

5. Data analyses:
   - It is not accurate to state this "Continuous data were treated as means, standard deviations, and ranges for analysis." Perhaps something like 'For continuous variables, mean and standard deviations were calculated..."
   - I am not sure what authors wanted to tell by this "A weighting variable was used in the form of the woman's individual sample weighting."
   - Any independent variables significant at $p<0.25$ in bivariate analyses were entered into the initial model.
   -Multicolinearity assessment was performed...

Results:

1. ...and one third (33.32%) in Tonle Sap region?

2. It should be mean (SD xx).

3. "More than half the mothers (51.08%) attended primary school." Did this include mothers who had no education?

4. Any details to define the breastfeeding - duration, exclusivity...?

5. Please check this data: "...and 77.97% of them had never been vaccinated." This could be very wrong as the immunization coverage in Cambodia has been globally recognized as very high.

Discussion:

1. This section can be improved by extending more in-depth literature in this area and link to the policy implication of the findings.

2. Further limitations of the study should also be included (e.g., self-reporting measures, recall bias...).

3. Conclusions and recommendations can be combined.

4. Recommendations can be summarized.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Epidemiology, community-based intervention and evaluation, infectious diseases

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 29 Jun 2020

PISEY VONG, Khon Kaen University, Khon Kaen, Thailand

Review1

Title:
The term 'influence' may not be appropriate for this study as it can only tell the associations

of variables, not causal relationships.
A: Agree with the reviewer. As suggested, we have revised the term to “The association”. See title, para 1 on page 1
Abstract:
1. Methods: The first sentence "A cross-sectional study was conducted using the combination of two datasets from the Cambodia Demographic and Health Survey 2014" is hard to understand. The authors may want to make it clear that this study used secondary data from CDHS. What are the two data sets?
A: Taken care. "A cross-sectional study of the secondary data from the Cambodia Demographic and Health Survey (CDHS) 2014 was conducted using the combination of household data and children’s data. See Abstract, 1st sentence, para 2 on page 1
2. What was the time frame for the prevalence of diarrhea - past month or lifetime?
A: Taken care. The authors added the text “in the last 2 weeks”. See Abstract, 2nd sentence, para 3 on page 1
Introduction:
1. Please provide a reference for the statement in the second sentence, paragraph
A: Taken care. “1,2”. See 2nd sentence, para 1 on page 3.
2. Avoid starting sentences with numbers.

A: Taken care. Globally, 88% of diarrhea cases are attributable..... See 4th sentence, para 1 on page 3.
3. It would be helpful for readers if authors could define some terminology; e.g., neonatal deaths, post-neonatal deaths, under-five deaths, etc.
A: We are sorry, we do not agree with the peer reviewer on this. Authors have retained our original because we think it is not much helpful to add terminology of neonatal deaths, post-neonatal deaths, under-five deaths.
4. Paragraph 2:
- "...and 692 deaths of children under five due to diarrhea (6%)." What is the denominator of the 6%? In the following sentence, the authors stated that 'diarrhea alone account for one fifth of the deaths of children under the age of five in Cambodia." Please clarify these.
- "High rates of diarrhea alone account for...’Diarrhea alone?
- It is confusing that this study used data from CDHS 2014, but also cited the prevalence of diarrhea in the same population and from the same data, while claiming that no national studies on childhood diarrhea in Cambodia have yet been published. - The rationale of the study needs improvement.

A: The denominator of the 6% is the “number of under five children”, however in the data from UNICEF, they do not put it. They just put only “under five deaths due to diarrhea: 692”; and “% underfive deaths due to diarrhoea: (6%)”. According to calculation by the authors, denominator of (6%) is about 11,533.
A: Please, see the reference on number 26 which mentioned as “High incidences of diarrhoeal diseases alone account for one fifth of the deaths of children age five and under in Cambodia, and an estimated 10,000 overall deaths annually, largely owing to lack of sanitation and poor hygiene practices”.
A: Agree with the reviewer. As suggested, we have revised the text to “There are no existing studies on the association in this age group, and no national studies on the associated factors with childhood diarrhea in Cambodia have yet been published”. See 2nd sentence,

para 3 on page 3.

Methods:
1.What 'province domains' mean?
A. Province domains means the 19 sampling domains of provinces. There are 24 provinces in Cambodia in CDHS 2014, of which fourteen individual provinces (Banteay Meanchey, Kampong Cham, Kampong Chhnang, Kampong Speu, Kampong Thom, Kandal, Kratie, Phnom Penh, Prey Veng, Pursat, Siem Reap, Svay Rieng, Takeo, and Otdar Meanchey); and five groups of provinces (Battambang and Pailin, Kampot and Kep, Preah Sihanouk and Koh Kong, Preah Vihear and Stung Treng, and Mondul Kiri and Ratanak Kiri)
2. What does this mean: '..., which comprised the 2008 Cambodian General Population Census (GPC)?'
A. It means “which used the 2008 Cambodian General Population Census”
That has been mentioned in CDHS 2014 as “The sampling frame used for the 2014 CDHS was derived from the list of all enumeration areas (EAs) created for the 2008 Cambodia General Population Census (GPC), provided by NIS

3. The sample considered any domain...' is not understandable.
A: Taken care. We have revised the text to “The sample was allocated into urban and rural in each domain with a power allocation preventing oversample urban, and can represent Cambodia is mainly rural. See 3rd sentence, para 3 on page 3.
4. Although the CDHS 2014 was referred to, some variables require a clear definition; e.g., improved/unimproved water sources, toilet facilities, adequate/inadequate hygiene, sanitary/unsanitary disposal of children's stools, etc.
A: Agree with the reviewer. As suggested, we have added the text “World Health Organization (WHO) guidelines on water, sanitation and hygiene (WASH) were used to classify WASH as either improved or unimproved according to the WHO/UNICEF Joint Monitoring Programme (Table1 and Table 2). See 3rd sentence, para 2 on page 4; and we also added the Table 1 and Table 2. See on page 11 and 12.
5. Data analyses:
- It is not accurate to state this "Continuous data were treated as means, standard deviations, and ranges for analysis." Perhaps something like 'For continuous variables, mean and standard deviations were calculated..."
- I am not sure what authors wanted to tell by this "A weighting variable was used in the form of the woman’s individual sample weighting."
- Any independent variables significant at $p<0.25$ in bivariate analyses were entered into the initial model.
-Multicolinearity assessment was performed...

A: Agree with the reviewer. As suggested, we have revised the text “Categorical variable were analyzed to provide frequency and percentage. Continuous variable were calculated as means, standard deviations, and ranges”. See 1st sentence, para 3 on page 4.
A: Because it is survey data, by providing national representative, we used Woman’s individual weighting because child data was accessed by asking for their mother.
A: Yes, please see in the “Result” on 2nd sentence, para 2 on page 6.
A: Taken care “Multicolinearity assessment was performed...”
Results:

...and one third (33.32%) in Tonle Sap region?
A. Taken care. We have revised by adding “lived”. See on 2nd sentence, para 1 page 5
2. It should be mean (SD xx).
A. Taken care.
3."More than half the mothers (51.08%) attended primary school." Did this include mothers who had no education?
A: No, It did not include mothers who had no education
4. Any details to define the breastfeeding - duration, exclusivity...?
A: No, in the data showing only “ever breastfed (not currently breastfeed, never breastfed, still breastfeeding”; so we group as “ever and never”.
5. Please check this data: "...and 77.97% of them had never been vaccinated." This could be very wrong as the immunization coverage in Cambodia has been globally recognized as very high.
A: Agree with the reviewer. As in the data of 2828 showed that 2.15% was *no*, 22.03% was *yes*, 0.27% was *don’t know*, and 75.55 was *missing*. The authors request to delete this variable since it is too much missing, moreover according to literature review this variable is not related with childhood diarrhea, only rotavirus vaccination is associated.
Discussion:
1. This section can be improved by extending more in-depth literature in this area and link to the policy implication of the findings.
A: Agree with the reviewer. However, we do not extending more in-depth literature. We have retained our original.
2. Further limitations of the study should also be included (e.g., self-reporting measures, recall bias...).
A. Taken care. See 4th sentence, para 3 on page 7.

3. Conclusions and recommendations can be combined.
A: Authors have retained our original because it will be a good idea to separate the limitation, recommendations and conclusion. Moreover, conclusion is an important part of the paper.

4. Recommendations can be summarized.
A: Taken care. As suggested, the authors have summarized the text in Recommendations part. See page 8.

Competing Interests: No competing interests