Title

“Waterlogging, Health and Healthcare Access in Southwest Bangladesh”

Authors

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Abstract:

Waterlogging, a form of stagnant flooding, is increasingly affecting southwest Bangladesh and is expected to intensify with the expansion of shrimp farming and climate change, contributing to environmental degradation. However, its impacts on health, health service utilisation and household health expenditures remain poorly understood. We conducted a quantitative study between August and September 2022 in Tala, a disaster-prone sub-district in southwest Satkhira. Data were collected from 596 randomly selected households. 1266 adults were surveyed, from which 768 reported recent illness. Of these 768 adults, 213 reported formal health care utilisation for their first visit. Information about household's exposure to waterlogging in the past 12 months was also collected from the households. Bivariate analyses were used to test the association between the outcome variables (illness report, formal health care utilisation, and out-of-pocket expenditure) and other variables (age, gender, education, being the head of the household, type of illness, wealth index of the household, household size and experience of waterlogging in the past 12 months). Two probit models followed for illness report and formal health care utilisation. Of these 1266 adults, waterlogging experience was significantly associated with illness reporting [Coef: 0.47; CI 0.14,0.80], p=0.006). However, it was not significantly associated with health care utilisation for the 768 adults reporting any illness [Coef: -0.11; CI -0.51,0.029], p=0.600). Bivariate analyses for the association of healthcare expenditure and waterlogging present no significant association (p=0.635). Considering significant associations, household wealth (wealthiest/poorest) and age (older/younger), were positively associated with illness reporting. In contrast, gender (males/females) and household size (larger/smaller) were negatively associated with illness reporting. For formal health service utilisation, on the 768 adults reporting illness, a negative association was observed for education (compared to higher education), and a positive association for wealth (average wealthy/poorest) and for chronic illness (/acute). These findings highlight the need to account for the detrimental health impacts of waterlogging when strengthening Bangladesh's health system.

Key words: waterlogging, health, health care access, out-of-pocket expenditure, , Bangladesh

Introduction

Climate change is not only causing a rise in global temperature. The warming of the planet also bears important repercussions on rainfall, with unpreceded rainfall patterns, resulting in both droughts and extreme rainfall, becoming more common (IPCC 2021). As a consequence of disrupted rainfall patterns, both rural and urban settings around the globe are increasingly experiencing flooding and waterlogging. Nonetheless, waterlogging in particular, defined as the submergence or inundation of areas for a long time without adequate drainage, does not appear prominently in the climate change and health agenda, if not in emergency cases, when cities are affected by waterlogging following extreme rainfall (Ding et al. 2024; Zhang et al. 2020).

Yet, agricultural experts warn us that waterlogging represents a major constant problem (Tian et al. 2021) both for rural communities, affecting 15-20% of all global wheat cropping regions each year (Kaur et al. 2020), and for some cities, which are now affected by the problem year after year (Hossain 2013). Likewise, some authors have argued that under the current climate crisis, the effects of waterlogging could be catastrophic, with the strongest effects being observed in Southern Asia (Liu et al. 2023; Nóia Júnior et al. 2023).

Bangladesh is known for continuous exposure to waterlogging, both in its cities (R. Alam et al. 2023), especially during the monsoon season, and in the coastal South-West regions, given the combination of riverbed siltation and back water effect due to sea-level rise, low flow upstream and high tide (Dewan 2021; Awal et Islam 2020; Tareq et al. 2018). Reflecting a global pattern, the literature examining the impact of waterlogging in Bangladesh focuses primarily on adverse effects on livelihood, infrastructure, economy, and the environment. For instance, Rahaman and colleagues report disruptions to infrastructure, such as damages to roads and houses and routine economic activities (Rahaman et al. 2020). Similarly, other authors have reported that waterlogging results in crop damage, ultimately affecting a household economic's well-being (Md. S. Alam, Sasaki, et Datta 2017). This emerging literature on the effects of waterlogging is complemented by a richer literature examining risk factors associated with waterlogging to identify high-vulnerability areas, using also geospatial analysis (R. Alam et al. 2023; Md. R. Islam et Raja 2021).

What is surprising is the limited number of studies that have specifically examined the relationship between waterlogging and health. Rahaman and colleagues report that in their study in Noakhali Pourashava, respondents to their survey recognised the existence of a close link between polluted stagnant water due to waterlogging and often to disruption in the sewage system and water-borne diseases (Rahaman et al. 2020). An earlier study conducted among youth in southwest Bangladesh also detected poorer health and educational outcomes among orphans in facilities exposed to waterlogging (Md. M. Masud 2018). Kabir and colleagues report a decline in psychological health following the Monsoon season among communities exposed to sea-level rise in southwest Bangladesh, suggesting an association between waterlogging and mental health (S. Kabir et al. 2024). More in general, the literature recognises that due to its specific geographical location, its landscape, and human-built environment, Bangladesh is one of the most climate-vulnerable countries, with water systems being most affected, increasing waterborne and vector-borne diseases (Anik et al. 2023).

Interestingly, however, the scientific literature, both globally and specific to Bangladesh, has paid limited attention to how waterlogging affects health service utilisation and household expenditures on health. Across contexts, the scientific literature on access has addressed the effects of floods (Baten et al. 2020; Petricola et al. 2022; Wiesehahn et Kaifie 2024), but has not examined what the effect of prolonged exposure to excess surface water can be on health service utilisation and household expenditures on health. Evidence on how waterlogging affects health service utilisation and household expenditure on health is needed to inform the planning and development of adequate adaptation strategies, especially in a country like Bangladesh, which struggles on its path to Universal Health Coverage.

Our study sets to fill the abovementioned gap in knowledge by examining the effect of exposure to waterlogging on health service utilisation and related household out-of-pocket expenditure using population-level data collected in the Tala upazila, in the district of Satkhira, southwest Bangladesh, where waterlogging has been expanding for the past decades (Tareq et al. 2018). We modelled health service utilisation and out-of-pocket expenditure conditional on illness reporting to discern the effect that exposure to waterlogging bears on service utilisation and expenditure from the effect that waterlogging bears on illness reporting.

Methods

Data sources & study setting

This study was conducted as part of the ClimHB project, an exploratory research project aimed at understanding the links between climate change, migration and health system resilience, with specific emphasis on access to formal healthcare services (Clech et al. 2022a). We used data from a cross-sectional household survey conducted among households in Tala upazila, Bangladesh, during the monsoon season in August and September 2022. Tala upazila is a rural disaster-prone sub-district of Satkhira on the interior coast of southwestern Bangladesh, relying mostly on agriculture and with a high prevalence of out-migration. Respondents were interviewed about their illness status, utilisation of health care services and related out-of-pocket expenditures. Preliminary qualitative work indicated that waterlogging alongside the Covid-19 pandemic and cyclones were the most cited recent events impacting the Tala population.

Conceptual approach and data structure

Waterlogging is a recurrent problem in Tala that lasts several weeks or months. It usually occurs during the monsoon and sometimes continues for a long time afterwards (Clech et al. 2024; Tareq et al. 2018). In affected areas, waterlogging impacts several dimensions of livelihood, including health (Clech et al. 2024; Talukder et al. 2023). We explored the relationship between waterlogging which is handled as exposure, illness reporting, formal health service utilisation, and related out-of-pocket expenditures, all defined as outcomes. We approached the question in a three-step process. First, respondents recognise that they have an illness; upon reporting ill, they decide whether or not to seek formal health care; and finally, they report an expenditure (Fig.1). From a conceptual standpoint, we recognise that waterlogging could play a role at each step, First, waterlogging is expected to be associated with a greater probability of reporting an illness since we expect people exposed to waterlogging to experience challenges in accessing clean water and/or to be more exposed to waterborne diseases. Second, given this higher disease burden, we could expect people exposed to waterlogging to enjoy a greater probability of using healthcare services. At the same time, we recognise that waterlogging could also reduce access to care by acting both on demand, limiting communities' mobility due to flooding, and supply, limiting health service provisions due to negative consequences of flooding. Last, due to both an expected increase in service use and an increased use of resources needed to produce health services in an unfavourable (flooded) setting, waterlogging is expected to result in higher expenditure on health.

Sampling

Household selection

Households were selected for inclusion in the survey if they included 1) any member who had suffered or was suffering from any illness over the last 30 days, or (2) a pregnant woman, or (3) a mother of any child under two years of age. A listing survey identified 2919 households meeting the inclusion criteria. 596 households were selected randomly from this list, divided over 10 clusters, five in clusters vulnerable to flooding and five in clusters less vulnerable to flooding (Clech et al. 2022b). All clusters were centred around a randomly selected health service provider and had a 2-3 km radius (depending on estimated population density).

Respondent selection

Within a household, we did not interview all members. Whenever possible, we interviewed an adult male and an adult female from 1) the 18-59 age group and 2) the 60-year-old or above age group. In addition, any pregnant women or mothers of children under two were also interviewed.

Data

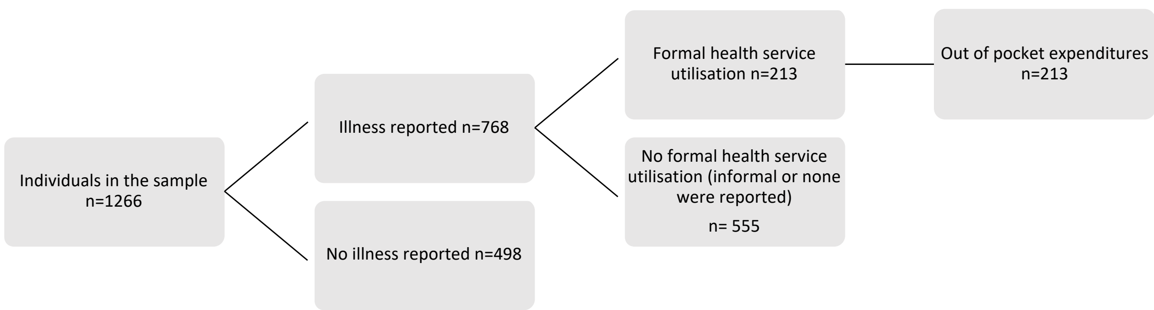
We interviewed a total of 1268 individuals from 596 households about their illness reporting, health service utilisation, and OOPE. Information was also collected on individual socio-demographic and economic characteristics as well as on the overall household economic profile. Only questionnaires with full information for the variables of interest were included; we excluded two individuals due to missing data. The final sample size includes 1266 respondents from 596 households (Fig1).

Variable description

Outcome variables

Three outcome variables are considered for this study: 1- illness reporting, 2-utilisation of formal health services (given illness reporting), and 3- out-of-pocket expenditure on medical care. Figure 1 illustrates the logic flow of individuals through the different outcomes considered for our analysis while Table 1 reports measurements for both outcome and exposure variables. An individual was classified as having reported an illness if they had reported either an acute illness in the past 30 days or a chronic illness, i.e. a condition lasting more than three consecutive months. Among those who reported an illness, we distinguished individuals who sought formal care from a health professional (=1) from those who did not (=0). The latter group may have relied on informal healthcare, visited a pharmacist, used self-treatment, consulted traditional healers, or taken no action. Finally, for those individuals who sought formal medical care, we measured out-of-pocket expenditure on formal medical care, captured as the sum paid by the respondents for consultation with the doctor, lab tests, medications, and any other medical expenses (e.g. physiotherapy, healthcare instruments, blood, oxygen, etc.). This amount was measured in Bangladeshi Taka.

Fig.1 Data structure for illness reporting, formal health service utilisation and out-of-pocket expenditures



Exposure variables

In line with our research question and conceptual model, the main exposure of interest was waterlogging, measured as having experienced waterlogging at least once in the past 12 months, based on respondents' recalling. We purposively traced waterlogging exposure back to a prolonged period because we assumed that the effects of the exposure to waterlogging can be accrued with time delay, possibly bearing consequences on health care seeking for an extensive period of time. Moreover, we considered that communities are often exposed to waterlogging for months at a time and not just for a few days, with important effects on their socioeconomic well-being as well as on their health (Clech et al. 2024; Dewan 2021; Neelormi, adri, et Ahmed 2009).

Our models included an additional number of individual and household-level characteristics as co-variates, both to control for confounding and to examine their effect on the outcomes of interest. These additional variables were selected based on variables identified in prior literature as relevant to influence health service utilisation and OOPE. Age was categorised as younger than 50 years old (incl.) or older than 50 years old, to reflect a categorisation of younger vs. elder individuals. Household size was categorised as fewer than 4 persons or more than 4 persons to reflect the median household size of 4. Household wealth was calculated using an asset-based measure, reflecting the standard asset composition and computational method using Principal Component Analysis indicated by the DHS (see Appendix). Based on the index, we further classified households into quintiles (Appendix).

Data collection and management

Data were collected by a team of 20 trained field assistants using SurveyCTO software, version 2.70.

Analysis

Our analysis proceeded in stages. First, we used univariate and bivariate descriptive statistics to examine the data distribution for illness reporting and health service utilisation samples. Chi-square tests were used to identify the association between the two first outcomes of interest and the exposure variables.

Second, we initially decided to model the decision to use health services conditional upon illness reporting using a Heckman selection model (Van De Ven et Van Praag 1981). As displayed also graphically in Fig 1, we selected this modelling approach because we wished to correct for the sample selection bias arising from the fact that health service utilisation could only be observed for those individuals who had previously reported either a chronic or acute illness (Pokhrel et al. 2010). Based on the results of the descriptive statistics indicating that waterlogging was associated with illness reporting, but not with service use, we selected it as an independent variable in the selection model estimating the probability of illness reporting, but not in the main equation estimating health service utilisation. Once we run the model, however, the likelihood-ratio test of independent equations indicated that the measured correlation in the errors of the two equations was not significantly different from zero (LR chi2 (df)=2.18(1), p=0.140). This suggested that case self-selection could not be ascertained in our specific and that the results of the Heckman model were effectively equivalent to those of simpler two-step models run on truncated samples.
Therefore, as a third step, we ran two separate probit models on two distinct, yet related samples. We first estimated the probability of an individual reporting any illness (n=1266), either chronic or acute, and then conditional upon this reporting, we estimated the probability of the individual using modern health care services (n=768). Both models include waterlogging as an exposure variable. In our results, we report the results of the two separate probit models as our primary results and report the results of the Heckman model only in the Appendix.

Finally, we examined the distribution of medical costs. Only nine individuals out of the 213 ones who had sought care reported not having incurred any health expenditures. Therefore, we retained all individuals in the analysis of out-of-pocket expenditures (OOPE) and performed Welch Two Sample t-tests and Kruskal-Wallis tests to examine differences in OOPE across categories. These tests were chosen given the uneven distribution in our samples.

Data management and software

Data management and preliminary descriptive statistics were conducted using Rstudio software (Version 2023.03.1+446 (2023.03.1+446). The Heckman and the probit models were run using Stata software (BE-Basic edition, version 18.0).

Ethics approval and consent to participate

Ethics approval was granted from the Institutional Review Board (IRB) of the BRAC James P Grant School of Public Health, BRAC University (ref: IRB-19 November'20–050) in Bangladesh. Respondents were provided information about the study prior to data collection and their written informed consent was sought before each interview.

Results

Socio-economic and health profiles of the respondents

Table 1 presents the socio-economic and health profiles of the respondents and their households. 73.9% of the respondents were up to 50 years of age, 51.7% were women, 19.1% received no education, 3.6% received a higher education, and 44.2% were head of household. 63.8% of the respondents came from households with up to 4 persons, 22.7% were classified as coming from the poorest households, while 27.3% belonged to the wealthiest households. 5.6% of the respondents were from households that had experienced waterlogging in the past 12 months. Of all respondents, 39.3% reported no illness, 28.8% reported an acute illness only, 19.7% a chronic illness only, and 12.2% reported both chronic and acute illnesses.

Table 1: Univariate distribution in the three samples used in the study: the sample, sample of individuals reporting any illness, sample of individuals reporting use of formal healthcare services given illness reporting

Background factors and Outcomes	Measurement	Full sample, n (%)	Sample of individuals reporting any illness, n (%)	Sample of individuals reporting use of formal healthcare services given illness reporting (%)
Sample size		1266	768	213
Outcome variables				
Illness declaration				
Yes	Yes=1	768 (60.7%)	768	213
No	No=0	498 (39.3%)	-	-

Formal health service use				
Yes	Yes=1	-	213 (27.7%)	213
No	No=0	-	555 (72.3%)	-
Medical costs	Continuous Variable (takas)			
Zero cost		-	-	9
Min-max		-	-	0-31200
Mean(median)		-	-	4718(2900)
SD		-	-	5612.49
Individual factors				
Age group				
Younger than 50	Younger than 50=0	935 (73.9%)	541 (70.4%)	154 (72.3%)
Older than 50	Older than 50=1	331 (26.1%)	227 (29.6%)	59 (27.7%)
Gender				
Male	Male=0	611 (48.3%)	333 (43.4%)	78 (36.6%)
Female	Female=1	655 (51.7%)	435 (56.6%)	135 (63.4%)
Education status				
No education	No education=0	241 (19.1%)	156 (20.3%)	41 (19.2%)
Primary	Primary=1	380 (30.0%)	228 (29.7%)	62 (29.1%)
Secondary	Secondary=2	599 (47.3%)	354 (46.1%)	96 (45.1%)
Higher	Higher=3	46 (3.6%)	30 (3.9%)	14 (6.6%)
Head of household				
Yes	Yes=1	560 (44.2%)	313 (40.8%)	77 (36.2%)
No	No=0	706 (55.8%)	455 (59.2%)	136 (63.8%)
Household factors				
Household size				
Up to four persons	Up to 4 persons=0	808 (63.8%)	504 (65.6%)	145 (68.1%)
More than four persons	More than 4 persons=1	458 (36.2%)	264 (34.4%)	68 (31.9%)
Wealth				
Poorest	Poorest=0	287 (22.7%)	167 (21.7%)	39 (18.3%)
Average poor	Average poor=1	317 (25.0%)	192 (25%)	47 (22.1%)
Average wealthy	Average wealthy=2	317 (25.0%)	183 (23.8%)	68 (31.9%)
Wealthiest	Wealthiest=3	345 (27.3%)	226 (29.4%)	59 (27.7%)

Experienced Waterlogging in the past 12 months				
Waterlogged	Waterlogged=1	71 (5.6%)	53 (6.9%)	13 (6.1%)
Not waterlogged	Not waterlogged=0	1195 (94.4%)	715 (93.1%)	200 (93.9%)
Health factors				
Declared Illness types				
None	None=0	498 (39.3%)	-	-
Acute	Acute=1	365 (28.8%)	365 (47.5%)	72 (33.8%)
Chronic	Chronic=2	249 (19.7%)	249 (32.4%)	72 (33.8%)
Both acute and chronic	Both acute and chronic=3	154 (12.2%)	154 (20.1%)	69 (32.4%)

Bivariate analyses for illness reporting

Table 2 presents bivariate analyses for respondents reporting an illness. Our analysis suggests that important differences existed between individuals who reported and individuals who did not report an illness. In comparison to respondents who did not report illness, respondents who reported any illness were more likely to be older than 50 (29.6% vs 20.9%, p<0.001), female (56.6% vs. 44.2%, p<0.001), not being the head of the household (59.2% vs. 50.4%, p=0.002) and coming from the household that had experienced waterlogging in the past year (6.9% vs. 3.6%, p=0.018).

Table 2: Bivariate analyses of illness reporting (n=1266)

Outcomes and background factors	Have reported any illness in the full sample		Have not reported any illness in the full sample		Pearson Chi2	
	n (768)	%	n (498)	%	Chi2	p-value
Age group (*)					11.326	0.000
Younger than 50 (incl.)	541	70.4	394	79.1		
Older than 50	227	29.6	104	20.9		
Gender (*)					18.300	0.000
Male	333	43.4	278	55.8		
Female	435	56.6	220	44.2		
Education status					2.755	0.431

No education	156	20.3	85	17.1		
Primary	228	29.7	152	30.5		
Secondary	354	46.1	245	49.2		
Higher	30	3.9	16	3.2		
Head of household (*)					9.222	0.002
Yes	313	40.8	247	49.6		
No	455	59.2	251	50.4		
Household size (*)					2.551	0.110
Up to four persons	504	65.6	304	61.0		
More than four persons	264	34.4	194	39.0		
Wealth					5.274	0.153
Poorest	167	21.7	120	24.1		
Average poor	192	25.0	125	25.1		
Average wealthy	183	23.8	134	26.9		
Wealthiest	226	29.4	119	23.9		
Experienced Waterlogging in the past 12 months (*)					5.559	0.018
Waterlogged	53	6.9	18	3.6		
Not waterlogged	715	93.1	480	96.4		

Notes: (*) Dummy variable- Chi2 with Yates's continuity correction

Bivariate analyses for formal health service utilisation

Table 3 presents bivariate analyses for respondents reporting formal health service utilisation compared to those who did not use it, conditional upon illness reporting. Respondents reporting formal health service utilisation compared to those who did not were more likely to be female (63.4% vs. 54.1%, p=0.024), to come from the highest two quintiles of the wealth index (31.9 and 27.7% vs 20.7 and 30.1%, p=0.012) and to have reported more often both chronic and acute illnesses (32.4% vs. 15.3%, p<0.001). Waterlogging exposure was not significantly associated with health service utilisation.

Table 3: bivariate analyses of health service utilisation conditional upon illness reporting

Outcomes and background factors	Used formal care	Did not use formal care	Pearson Chi2

	n (213)	%	n (555)	%	Chi2	p-value
Age group (*)					0.373	0.541
Younger than 50 (incl.)	154	72.3	387	69.7		
Older than 50	59	27.7	168	30.3		
Gender (*)					5.078	0.024
Male	78	36.6	255	45.9		
Female	135	63.4	300	54.1		
Education status					5.630	0.131
No education	41	19.2	115	20.7		
Primary	62	29.1	166	29.9		
Secondary	96	45.1	258	46.5		
Higher	14	6.6	16	2.9		
Head of household (*)					2.331	0.127
Yes	77	36.2	236	42.5		
No	136	63.8	319	57.5		
Household size (*)					0.641	0.423
Up to four persons	145	68.1	359	64.7		
More than four persons	68	31.9	196	35.3		
Wealth					11.023	0.012
Poorest	39	18.3	128	23.1		
Average poor	47	22.1	145	26.1		
Average wealthy	68	31.9	115	20.7		
Wealthiest	59	27.7	167	30.1		
Experienced Waterlogging in the past 12 months (*)					0.145	0.703
Waterlogged	13	6.1	40	7.2		
Not waterlogged	200	93.9	515	92.8		
Illness type					34.244	0.000
Acute	72	33.8	293	52.8		
Chronic	72	33.8	177	31.9		
Both	69	32.4	85	15.3		

Notes: (*) Dummy variable- Chi2 with Yates's continuity correction

Probit model estimates for illness declaration

Given the Heckman model's non-superiority, we decided to focus the analysis on the two independent probit models run on the truncated samples. We report findings accordingly and start by examining factors associated with illness reporting first and service use second. Results from the Heckman selection model are reported in the Appendix for completeness and comparability.

Confirming results from bivariate analysis, our probit model indicated that respondents from households experiencing waterlogging [Coef: 0.47; CI 0.14,0.80], p=0.006) were more likely to report an illness compared to respondents from households not experiencing one. Moreover, respondents older than 50 [Coef: 0.35; CI 0.16,0.54], p<0.001) and from wealthier quintiles [Coef: 0.26; CI 0.04,-0.48], p=0.018) were also more likely to report an illness compared to other respondents while males were less likely than females to do so [Coef: -0.38; CI -0.62,-0.15], p=0.001) as well as respondents coming from larger household [Coef: -0.20; CI -0.36,-0.04], p=0.013).

Probit model estimates for formal health service utilisation

213 out of the 768 respondents having reported an illness declared using health services in the prior month (27.7%). Table 4 presents the results of a probit for formal health service utilisation. Confirming results from the bivariate analysis, the model detected no significant association between waterlogging and service use. Health service use was found to be associated with higher education (no education compared to higher [Coef: -0.70; CI -1.24,-0.16], p=0.011, primary compared to higher education: [Coef: -0.63; CI -1.14, -0.13], p=0.014 and secondary compared to higher education [Coef: -0.67; CI -1.16,0.18], p=0.007); household wealth, with the poorest experiencing the lowest utilisation, and illness type with respondents reporting chronic and both chronic and acute illnesses being more likely to seek formal care than those reporting only an acute condition (chronic: [Coef: 0.28; CI 0.52,0.52], p=0.017, chronic and acute: [Coef: 0.71; CI 0.46,0.97], p<0.001).

Table 4 (new): **Probit for illness declaration and health service utilisation**

	Model 1		Model 2	
	Illness reporting		**Formal health service utilisation**	
Background characteristics	**Coef. (C.I.)**	**P-value**	**Coef. (C.I.)**	**P-value**
Age group				
Younger than 50	Ref.		Ref.	
Elders (50+ years old)	0.35(0.16,0.54)	0.000***	-0.05(-0.30,0.19)	0.668
Gender				
Female	Ref.		Ref.	
Male	-0.38(-0.62,-0.15)	0.001***	-0.23(-0.55,0.08)	0.150
Education status				
Higher education	Ref.		Ref.	
No education	-0.23(-0.66,0.20)	0.288	-0.70(-1.24,-0.16)	0.011*
Primary	-0.19(-0.59,0.22)	0.360	-0.63(-1.14,-0.13)	0.014*
Secondary	-0.27(-0.67,0.12)	0.169	-0.67(-1.16,0.18)	0.007*
Head of household				
Yes	Ref.		Ref.	
No	-0.01(-0.24,0.23)	0.963	0.01(-0.30,0.32)	0.940
Household size				
4 pers. or less	Ref.		Ref.	
5 or more pers.	-0.20(-0.36,-0.04)	0.013*	-0.08(-0.30,0.14)	0.489
Wealth				
Poorest	Ref.		Ref.	
Average poor	0.01(-0.08,0.34)	0.224	0.05(-0.25,0.35)	0.755
Average wealthy	0.02(-0,19,0.23)	0.829	0.41(0.12,0.70)	0.006**
Weathiest	0.26(0.04,0.48)	0.018*	0.09(-0.22,0.39)	0.575
Waterloggging				
No	Ref.		Ref.	
Yes	0.47(0.14,0.80)	0.006**	-0.11(-0.51,0.29)	0.600
Illness reporting				
Acute illness	-	-	Ref.	
Chronic illness	-	-	0.28(0.52,0.52)	0.017*
Acute and chronic	-	-	0.71(0.46,0.97)	0.000***
Constant	0.55(0.07,1.02)	0.024*	-0.21(-.83,0.40)	0.497
Model statistics				
/athrho	-	-	-	-
Rho	-	-	-	-
Wald chi2 (df)				
LR chi2(df)	56.73(11)	0.000***	56.09(13)	0.000***
LR chi2 (df) test of indpt eqns. (Rho=0)	-	-	-	-
Selected observations	-	-	-	-
Non selected observations	-	-	-	-
Total observations	1266		768	
Pseudo R2	0.033		0.062	-

Notes: Coef. (C.I.): coefficient (Confidence Intervals). *0.05, **0.01***0.001.

Mean medical costs for formal healthcare

Only 9 individuals out of a total of 213 reported no medical healthcare costs, which means that 95.8% of respondents reported out-of-pocket expenditures for medical costs (mean:4718 takas, SD:5612.49, median:2900 takas, with 1 USD being equivalent to approximately 121 takas - Table 1). Table 5 shows that respondents from average wealthy and wealthiest households reported significantly higher costs (mean=5345 takas, mean=5933 takas) compared to respondents from poorest households (mean=3309 takas) and average poor (mean 3453 takas), p=0.029. Respondents reporting acute illness had significantly lower costs (mean=2555 takas) compared to respondents reporting chronic (median=5817 takas) or both types of illnesses (mean=5827 takas), p<0.001. Having experienced waterlogging was not found to be associated with higher medical costs in formal healthcare (p=0.635).

Table 5: bivariate analyses for the mean medical costs for respondents reporting formal healthcare access (n=213)

Background factors and outcomes	Mean medical costs for health service utilisation (Takas)	
	Mean	P-value
N Total	213	
Age group		0.473
Younger than 50	4556.75	
Older than 50	5137.63	
Gender		0.813
Male	4818.53	
Female	4659.36	
Education status		0.622
No education	5187 (median=3550)	
Primary	4171 (median=2553)	
Secondary	4306 (median=2500)	
Higher	8584 (median=5730)	
Head of household		0.3709
Yes	4298.69	
No	4954.85	

Household size		0.2701
Up to 4 persons	4447.22	
More than 4 persons	5294.29	
Wealth		0.029*
Poorest	3309 (median=1700)	
Average poor	3453 (median=1650)	
Average wealthy	5345 (median=3854)	
Wealthiest	5933 (median=3400)	
Experienced Waterlogging in the past 12 months		0.6354
Yes	5444.23	
No	4670.42	
Illness reporting		0.000***
Acute	2555 (median=800)	
Chronic	5817 (median=5010)	
Both acute and chronic	5827 (median=3700)	

Notes: Welch Two Sample t-test were performed when two categories and Kruskal-Wallis test for three or more categories

Discussion

This article presents the results of an original study aimed at understanding the association between waterlogging, the health of populations and their use of healthcare in a region of a country facing numerous events linked to climate (Chowdhury, Hasan, et Islam 2022; Clech et al. 2022a). The results confirm our conceptual standpoint on the association between waterlogging during the last 12 months of the survey and the declaration of episodes of illness, whether chronic or acute. Moreover, and thanks to a rigorous analytical approach, the study does not confirm the hypothesis of an association between waterlogging and the use of health services. The same applies to healthcare expenditure, the association with waterlogging is not verified. People exposed to waterlogging reported feeling sicker but did not appear to face greater barriers in access to care nor greater expenditure. This study provides relatively original insights into the role of waterlogging but also confirms more general trends.

First we note that research into health services utilisation has not yet given much thought to the role of waterlogging and its possible impacts (Palmeiro-Silva, Rivera, et Hartinger 2025; Chowdhury, Hasan, et Islam 2022). While the link between waterlogging and people's lives is much analysed in agricultural or climate research, limited if any attention has been paid to its effects on health, particularly in relation to health systems (R. Alam et al. 2023; Nóia Júnior et al. 2023; Tian et al. 2021; Md. S. Alam, Sasaki, et Datta 2017). This is one of the first studies to look at human health and, above all, access to care and financial protection, essential elements of health systems which together with others are often overlooked in climate research in Bangladesh (Md. S. Alam, Sasaki, et Datta 2017). As one of the determinants of population health, the health system is also often overlooked in climate research (Clech et al. 2022a; Ridde et al. 2019). For One Health experts, the association between waterlogging and the occurrence of episodes of illness is not surprising, given that we know to what extent environmental health and human health are intertwined (McKenzie et al. 2016), particularly in Bangladesh (Anik et al. 2023; Chowdhury, Hasan, et Islam 2022; Hasan, Shahriar, et Jim 2019; M. A. Masud 2018). Despite few studies, soil contamination by saltwater intrusion impacts the agricultural system and human health (Palmeiro-Silva, Rivera, et Hartinger 2025). Studies in Bangladesh all confirm the effects of the environment on human health and the onset of disease, such as water salinity on hypertension, pre-eclampsia (Khan et al. 2014; Shammi et al. 2019) and mental health (S. Kabir et al. 2024). In the Khulna district, close to our study area, a qualitative study shows that the population is well aware that the lack of "*pure drinking water aggravated the spread of waterborne diseases*" (R. Kabir et al. 2016) after the cyclones.

Perhaps more surprising is that, conditional on illness reporting, we did not detect higher health service utilisation, and subsequently also higher healthcare expenditure, among individuals exposed to waterlogging. At the same time, we note that waterlogging was also not associated with reduced utilisation of formal healthcare services. Therefore, both hypotheses we advanced ex-ante were disattended by our findings, suggesting that in spite of higher health needs, people exposed to waterlogging do not tend to seek more care, yet they do not necessarily face greater barriers to access than those not exposed to waterlogging. This finding partially contradicts evidence emerging from the literature on floods, suggesting that health service use is affected negatively for up to three subsequent years (Baten et al. 2020). To this respect, our study highlights the importance of investigating waterlogging as a distinct phenomenon from floods. We note, however, that the conceptual underpinning of the Universal Health Coverage (UHC) concept is that the more health needs people have, the more they should be able to be treated without becoming impoverished (Abiiro et De Allegri 2015). Our study clearly indicates that many people are still forgoing care and when receiving care, they pay a very high price for it. In Bangladesh, studies have long shown that while the country is well ahead in preventive services such as (free) vaccinations (Sarkar et al. 2017), barriers to accessing curative services (not free) are very high, as shown by the two recent national surveys (DHS 2024; icddr,b 2024). The spatial distribution of curative services and payment arrangements can partly explain those barriers (Chowdhury, Hasan, et Islam 2022; Joarder, Chaudhury, et Mannan 2019). The latest DHS for Bangladesh in 2022 shows that 84%, 75% and 66% of children who reported an episode of ARI, fever or diarrhoea, respectively, sought advice or treatment. However, this relatively high figure does not apply to traditional practitioners and includes all forms of recourse (public and private sectors, NGOs) (DHS 2024). Most of them went to a pharmacy/drug store, confirming the challenges of providing a quality service at a lower cost. Moreover, the Bangladeshi healthcare system is highly fragmented and not always well adapted to dealing with environmental crises (M. Sarker et al. 2022). In the Khulna division, where our study area is located (Satkhira district), there is a low level of training and supervision of routine staff compared with the rest of the country, and this is the division where the percentage of facilities offering curative services is the lowest. It is the 3rd lowest for all essential services, including standard deliveries (icddr,b 2024).

Moreover, the people of Bangladesh, as elsewhere in Southeast Asia, are paying a heavy financial price in a context where user fees continue to be the norm due to low effective implementation of social health protection systems (Fahim et al. 2019; International Labour Organisation (ILO) 2021; Joarder, Chaudhury, et Mannan 2019). Our study in Tala confirms that out-of-pocket payments remain considerably high, with the average value being equivalent to USD 38, and that the ability to pay for care influences healthcare spending, posing a challenge to the equity of the healthcare system (Mitra et Mridha 2023; A. R. Sarker et al. 2021). Over 70% of healthcare payments in Bangladesh are made directly by households, far more than India and Pakistan, and this proportion has been rising steadily over the last 20 years (WHO 2025). Only 0.3% of women aged between 15 and 49 have health insurance in Bangladesh, and the two main problems preventing them from using health services are the lack of money to pay for treatment and the distance from the facility (DHS 2024). So, in waterlogging areas exacerbated by climate change, people have more significant needs (both physical and mental) but are faced with a health system that does not have the resources to cope. Yet the responsiveness of healthcare systems is one of the essential characteristics of their performance (WHO 2000). In addition, studies on the resilience of healthcare systems show that it is necessary to anticipate these chronic or acute shocks to better plan adaptation strategies to meet the needs of populations (Blanchet 2025; Gilson et al. 2017). The status quo is not an option, and the shortage of rural health workers and the continuation of user fees without the organisation of health insurance systems will continue to fail to meet people's needs. However these needs are bound to increase in the context of climate change, with waterlogging being only one of the many consequences, not even the primary one (Palmeiro-Silva, Rivera, et Hartinger 2025). So, experts in Bangladesh argue that "*A climate change resilient health care system needs to be developed*" (Chowdhury, Hasan, et Islam 2022). The political will announced for UHC in Bangladesh (M. Sarker et al. 2022) must now take concrete form, especially in the current context where the public calls for significant changes to be organised in favour of social protection.

More generally, our study confirms the burden of chronic disease in this part of the world, including in Bangladesh's relatively rural and isolated area. On a national scale, managing chronic diseases (and non-communicable diseases) is becoming a priority, given the extent of their burden in the context of the epidemiological transition (DHS 2024; S. M. S. Islam et al. 2023). This poses another major challenge in terms of adapting the healthcare system, especially as the Tala study confirms that people living with a chronic illness incur higher healthcare costs than others. In addition, the results confirm the influence of age, gender and socio-economic status on illness reporting, confirming what Sen (Sen 2002) already postulated a long time ago. This question poses another challenge, given that the expression of a health need significantly influences the use of healthcare beyond the issues linked to the healthcare system (Levesque, Harris, et Russell 2013).

While this study is original, it is important to note certain limitations. Firstly, we emphasise the relatively small sample size and the fact that few people in our sample recalled exposure to waterlogging. Data were collected at the end of the monsoon season, but it was a year of drought. The drought might explain the small number of respondents from households that experienced waterlogging in the past year, reflecting perhaps an intense vulnerability to waterlogging in standard years. Secondly, the structure of our data only allows us to explore associations and not to detect causality. Third, all measures used in the study are self-reported, with all associated limitations that must be acknowledged. Yet, we recognise that no better data are currently available in the country to examine this association between waterlogging, service use, and expenditure. Last, we note that we could not integrate into the model supply-side factors, such as actual service availability and quality of care indicators, due to a lack of pertinent data. Furthermore, we chose to operationalise the research question concerning the use of formal healthcare services, but this does not mean that informal care is not being used either.

Conclusion

This study demonstrates that waterlogging, defined as persistent stagnant water on land, is associated with a higher probability of reporting illness but not with a higher probability of seeking formal care or reporting higher health expenditure. While the country has improved dramatically in terms of health in the past 50 years (Perry et Chowdhury 2024), Bangladesh is facing a serious threat to its development: deteriorating environmental conditions related to land and water management choices, exacerbated by climate change (Clech et al. 2024; Dewan 2021; Tareq et al. 2018). This study shows that new efforts are needed to strengthen health systems and meet increasing health needs in time of climate change, so that the financial burden is not left to the people living in affected areas.

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Appendix

Bivariate probit with sample selection for formal health service utilisation conditional on illness declaration (heckprobit model)

	Bivariate probit with sample selection (heckprobit)			
	Illness declaration (selection equation)		**Formal health service utilisation (outcome equation)**	
Background characteristics	**Coef. (C.I.)**	**P-value**	**Coef. (C.I.)**	**P-value**
Age group				
Younger than 50	Ref.		Ref.	
Elders (50+ years old)	0.36(0.18,0.55)	0.000***	0.09(-0.12,0.30)	0.406
Gender				
Female	Ref.		Ref.	
Male	-0.38(-0.61,-0.15)	0.001***	-0.34(-0.61,-0.07)	0.012*
Education status				
Higher education	Ref.		Ref.	
No education	-0.26(-0.69,0.17)	0.238	-0.64(-1.1,-0.19)	0.006**
Primary	-0.20(-0.60,0.20)	0.322	-0.57(-1.00,-0.15)	0.008**
Secondary	-0.29(-0,68,0.11)	0.153	-0.64(-1.1,-0.2)	0.002**
Head of household				
Yes	Ref.		Ref.	
No	0.01(-0.22,0.25)	0.901	-0.004(-0,27,0.26)	0.976
Household size				
4 pers. or less	Ref.		Ref.	
5 or more pers.	-0.22(-0.37,-0.06)	0.007**	-0.13(-0.32,0.06)	0.189
Wealth				
Poorest	Ref.		Ref.	
Average poor	0.14(-0.07,0.35)	0.189	0.08(-0.17,0.34)	0.531
Average wealthy	0.03(-0.18,0.23)	0.802	0.33(0.08,0.57)	0.010**
Weathiest	0.27(0.05,0.48)	0.015*	0.17(-0.09,0.43)	0.209
Waterloggging			-	-
No	Ref.		-	-
Yes	0.46(0.14,0.78)	0.005**	-	-
Illness report				
Acute illness	-	-	Ref.	
Chronic illness	-	-	0.23(0.04,0.42)	0.017*
Acute and chronic	-	-	0.59(0.39,0.78)	0.000***
Wealth*Illness report	-	-	-	-
Poorest*acute	-	-	-	-
Average poor*both	-	-	-	-
Average poor*chronic	-	-	-	-
Average wealthy*both	-	-	-	-
Average wealthy*chronic	-	-	-	-
Wealthiest*both	-	-	-	-
Wealthiest*chronic	-	-	-	-
Constant	0.54(-0.07,1.02)	0.024*	-0.56(-1.08,_0.04)	0.035*
Model statistics				
/athrho	3.65(-93.51,100.81)	0.941		
Rho	1.00(-1,1)			
Wald chi2 (df)	68.17 (12)	0.000***		
LR chi2(df)	-	-		
LR chi2 (df) test of indpt eqns. (Rho=0)	2.18 (1)	0.139		
Selected observations	768	-		
Non selected observations	498	-		
Total observations	1266	-		
Pseudo R2	-	-		

Notes: Coef. (C.I.): coefficient (Confidence Intervals). *0.05, **0.01***0.001.