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Title: The impacts of climate hazards on sanitation experiences of people with disabilities in Bangladesh: A mixed-methods study

Short title: Climate Hazards and Sanitation Experiences of People with Disabilities in Bangladesh

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Abstract

Human-induced climate change, marked by frequent and severe climate hazards, damages water and sanitation facilities, limiting safe and independent access for people with disabilities. In Bangladesh, where 8% of the population has a disability, the challenges are heightened by climate hazards, including cyclones and floods. Evidence on how these hazards affect the sanitation experiences of people with disabilities and their caregivers is limited. This study aimed to explore the impacts of climate hazards on the sanitation experiences of people with disabilities in Bangladesh, along with the impacts of management strategies in response to them and their caregivers.

This mixed-methods study combined a nationwide population-based survey across 32 districts and a qualitative in-depth assessment across two districts (cyclone-prone Satkhira and flood-prone Gaibandha) of Bangladesh. The survey used the Washington Group Short Set on Functioning to identify 1021 people with and 909 without disabilities, comparing their access to sanitation facilities during climate hazards. Data were analyzed using descriptive statistics and multivariable analyses. The qualitative assessment included 39 people with disabilities and 16 caregivers through purposive and snowball sampling. Methods were in-depth interviews, photovoice ranking, and accessibility audits, with data analyzed thematically.

The survey found that 77% of participants had access to basic sanitation, mainly through pit latrines (47%). 13% of households reported damage to sanitation facilities due to climate hazards, and leading issues included waste overflow during floods (49%) and structural collapse or slab breakage during cyclones (57%). Qualitative findings revealed that both people with disabilities and caregivers sustained injuries while accessing or supporting access to sanitation facilities during and after climate hazards due to muddy, slippery and inaccessible paths.

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The survey also found that 45% of people used alternative sanitation facilities during climate hazards. Additionally, 21% of them reported changing their sanitation behaviours due to using alternative sanitation. Common changes in behaviours included restricting their use of sanitation facilities (61%), limiting or restricting food intake (30%), and fluid intake (9%). There was some evidence that people with disabilities changed sanitation-related behaviours more during floods (AOR 3.83, 0.99-14.86 95%CI, p=0.052) than those without disabilities.

Qualitative data showed flood-affected individuals with disabilities in Gaibandha faced verbal abuse using relative or neighbour's facilities and resorted to open defecation. Privacy concerns and increased reliance on caregivers led to limiting toileting and adjusting food and water intake, especially for women. In Satkhira, cyclone-affected individuals continued using damaged facilities to avoid humiliation despite contact with human waste.

In sub-group analysis of cyclone-affected populations, people with disabilities experiencing incontinence had a 74% lower likelihood of using alternative sanitation facilities than individuals without incontinence (AOR 0.26, 0.07-0.93 95%CI, p=0.038). Damaged facilities led some participants to defecate in clothes and bedding, resulting in faecal contact for both of them and their caregivers and increased physical and emotional stress for caregivers.

This study underscores the challenges faced by people with disabilities and their caregivers due to climate hazards, stressing the need for targeted interventions to promote climate-resilient inclusive sanitation facilities and participation of people with disabilities in disaster planning.

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Introduction

Poor access and use of inadequate sanitation increases exposure to infectious diseases, including diarrhoeal disease, typhoid, soil-transmitted helminths, polio, schistosomiasis, and trachoma [1, 2]. Poor sanitation is associated with a greater risk of undernutrition [3], including both acute malnutrition and stunting in children, and the spread of antimicrobial resistance [1]. Sanitation access, or lack thereof, also affects mental and social well-being, with effects reported on perspectives of privacy, safety, and dignity [4, 5]. Improvements to sanitation services have been shown to reduce diarrhoea risk by 24%, and moving households from unimproved sanitation and providing sewer connections can reduce diarrhoea risk by 47% [6]. Additionally, access to clean water enhances the ability to maintain hygiene and ensures the implementation of safe sanitation practices [7, 8].

Nonetheless, ensuring equal access to safely managed sanitation facilities (see Table 1 for the definition of key terms) remains a major global challenge, with approximately 3.6 billion people lacking access [1, 9]. Marginalized and disadvantaged individuals and groups, such as people with disabilities, women and girls, ethnic minorities, and older adults, can experience worse access to safely managed sanitation facilities than their peers [10-15]. Studies in Cambodia (2021) and Vanuatu (2022) revealed that households with a person with disabilities are less likely to have access to at least basic sanitation, let alone access to safely managed sanitation facilities [13, 16], with children with disabilities being 26% less likely to have improved sanitation facilities compared to their peers as reported by a 2021 UNICEF report [17]. In the same study from Vanuatu (2022) and another study from Guatemala (2018), people with disabilities were additionally less likely to be able to use household sanitation facilities independently compared to those without disabilities [16, 18].

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98 **Table 1. Terms and definitions for sanitation service levels and incontinence**

Definitions of sanitation terms according to the WHO/UNICEF Joint Monitoring Programme [19]		
Improved sanitation	Safely managed sanitation	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or removed and treated offsite.
	Basic sanitation	Use of improved facilities that are not shared with other households.
	Limited	Use of improved facilities shared between two or more households.
Unimproved sanitation	Unimproved	Use of pit latrines without a slab or platform, hanging latrines, or bucket latrines.
	Open defecation	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches, and other open spaces or with solid waste.
Definitions of Incontinence according to Mactaggart et al (2021) and Rosato-Scott et al (2020) [16, 20]		
Incontinence	Incontinence is the medical term to describe the involuntary loss of urine or faeces. It can also be described as leakage of urine or faeces; where a person is not able to control when they urinate or defecate, or where a person is not able to hold on to their urine or faeces. The severity of incontinence varies from managing sporadic to regular leakages, which cause skin sores, smell, urinary infections, and bladder complications.	

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Urinary incontinence	Urinary incontinence is defined as the involuntary loss of urine that is objectively demonstrable and is a social or hygienic problem.
Faecal incontinence	Faecal, or bowel incontinence, is an inability to control bowel movements, resulting in the involuntary passage of stools.
Definition of alternative sanitation facilities used in this study	
Alternative sanitation facility	In this study, alternative sanitation facility refers to any place or toileting system or latrine used by respondents during of immediately after climate hazards other than the usual sanitation facility for urination and defecation. Alternative sanitation facilities include latrines with piped sewer system, latrines with septic tanks, pit latrines with pour flash, ventilated improved pit latrines (VIP), pit latrines with slab, pit latrines without slab / open pit, bucket or bedpan hanging latrine / hanging latrine, open defecation (no facility, bush, field).

A recent nationwide population-based study in Bangladesh revealed that 8% (approximately 13.2 million people) of the population has disabilities [10]. The survey reported that people with disabilities face increased difficulties in accessing sanitation facilities, including struggling to reach the sanitation facility, inaccessible pathways, and challenging distances from the house [10]. Slow and fast onset climate hazards, such as rainfall uncertainty, drought, increased rainfall, flooding, cyclones, and climate change-induced sea level rise, exacerbate the situation [21-23]. The 2021 Intergovernmental Panel on Climate Change (IPCC) assessment report declared that human-induced climate change, marked by more frequent climate hazards such as frequent and severe cyclones and floods, has caused widespread damage to nature, infrastructure and people, particularly affecting the most vulnerable [24]. This includes damage or destruction of water, sanitation and hygiene (WASH) facilities [23, 25, 26]. Thus, these climate hazards will continue to affect health and well-being, increasing the risk of death, non-communicable diseases, the emergence and spread of infectious diseases, and health emergencies [21].

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Bangladesh is one of the most climate-vulnerable countries globally [27, 28]. It experiences frequent climate change hazards encompassing floods, droughts, cyclones, tidal surges, and saltwater intrusion owing to its geographical location and low-lying regions [29]. These changes have severely impacted the national water supply and sanitation sector by causing water stress, quality deterioration, saltwater intrusion, and infrastructure damage [22]. Bangladesh's National Adaptation Programme of Action [30] on climate change and Bangladesh Climate Change Strategy and Action Plan [31] have also indicated that increased temperature, humidity, erratic rainfall, sea level rise, and climate hazards (flooding, cyclones, droughts) will exacerbate water and vector-borne diseases across the country [30, 31].

Cyclones and storm surges are predominant in Bangladesh’s southern low-lying coastal regions, causing immense life causalities, livelihood damages, and economic loss [32, 33]. Cyclones and frequent floods in coastal and flood-prone areas often disrupt regular water supply and sanitation services [29, 34, 35]. A report on category-5 cyclone Amphan revealed that services were severely affected along with causalities and house and livelihood infrastructures: 18,235 water points and 40,894 sanitation facilities were fully or partially destroyed [36]. Flooding can damage and submerge sanitation facilities, contaminating floodwaters with faeces and urine [37]. Consequently, people often shift from using sanitation facilities to open defecation [29, 37-39], which increases the risk of exposure to infectious diseases [29, 34, 40].

People with disabilities are more vulnerable to injuries and health problems, including infectious diseases, during climate hazards [41]. This is partly due to insufficient accessibility in evacuation, response, and recovery efforts [42]. Additionally, existing barriers that limit their participation in public life make it harder for them to express WASH needs and access crucial safety information during such climate hazards [43, 44]. People with disabilities' access to safely managed sanitation services is likely to worsen during climate hazards because of existing inequalities [45, 46]. Additionally, climate hazards may increase the

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WASH support needs of those requiring care, which in turn can hinder the caregiver's ability to recover [14].

Moreover, individuals with incontinence, whether or not they have disabilities, face unique sanitation challenges. People with disabilities may experience incontinence due to the inability to reach an accessible sanitation facility in time, unsafe paths, or difficulty communicating their needs to others [12]. Incontinence can exacerbate difficulties accessing suitable sanitation facilities, particularly during climate hazards when water and sanitation infrastructure are damaged or access is restricted. One study in Vanuatu found that people with disabilities were more likely to experience urinary incontinence and faecal incontinence than people without disabilities [16, 47]. Consequently, people with disabilities experiencing incontinence often require more frequent and immediate access to sanitation facilities and incontinence products. The lack of appropriate sanitation facilities and incontinence products can lead to significant health and dignity issues [16, 47, 48]. Additionally, the demands on caregivers increase [14, 48], as they must provide extra support for managing incontinence under challenging conditions during climate hazards.

Although the impacts of climate hazards on health and well-being are being increasingly documented, the probable disproportionate impacts on the lives and WASH-related experiences of people with disabilities are sparse [28, 49, 50]. A scoping review that explored how climate risks impact WASH services and behaviours in low- and middle-income countries (LMICs) included 22 papers [23]. Of these, 11 included articles that discussed the effects on sanitation facilities and sanitation-related behaviours, but only one included the experiences of people with disabilities, and related data was minimal.

Our study aimed to explore the impact of climate hazards on the sanitation experiences of people with disabilities and their caregivers in Bangladesh. Our research questions were: 1) What are the climate hazards experienced by people with and without disabilities in Bangladesh, and how do these impact these populations' sanitation experiences? 2) How do

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people with disabilities attempt to manage their use of sanitation facilities during climate hazards, and how do these management strategies impact them and their caregivers?

Although this paper does not offer recommendations, we are collaborating with people with disabilities and key stakeholders to develop principles for inclusive, climate-resilient WASH services in Bangladesh. We will share these principles when they are finalised.

Methodology

Study design

This was a mixed methods study comprised of 1) a quantitative, nationwide, population-based survey to identify people with disabilities and compare the access and experience of sanitation services amidst climate hazards between people with and without disabilities, and 2) an in-depth qualitative analysis of the sanitation experiences of people with disabilities, and their caregivers, during and immediately after climate hazards.

Quantitative population based-survey

Study sites

In Bangladesh, most districts across all eight divisions are considered to be at high climate risk [27, 28]. In total, 32 districts were selected from eight divisions using the probability proportion to size (PPS) sampling technique to ensure nationwide representation. From each selected district, we further selected the three smallest rural administrative units (mouzas) and the two smallest urban administrative units (wards), considering the PPS sampling. Each of the 162 smallest administrative areas was further divided into clusters of 30 households, and randomly, one cluster was selected.

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Study population

The study population comprised two major comparison groups: people with disabilities and their age-sex-matched people without disabilities. To identify people with disabilities, a household screening of individuals aged 15+ years was carried out in all 30 households of each cluster using the Washington Group Short Set on Functioning – Enhanced (WG-SS Enhanced) [51]. Those who answered 'a lot of difficulty' or 'cannot do at all' across any of the six functional domains (vision, hearing, mobility, communication, cognition, self-care) were identified as people with disabilities.

Sample size

Based on the Bangladesh Sample Vital Statistics 2018, the all-age prevalence of disability in Bangladesh is 8%. The sample size was computed assuming 30% of the general population and 10% of the people with disability know about the various indicators of WASH and hygiene services. It was estimated that 1312 respondents were required to represent all the eight administrative divisions of Bangladesh.

Data collection

We used an existing population-based survey that was being carried out in 2023 to capture the sanitation experiences between individuals with and without disabilities, considering gender and age (funded by FCDO through PENDA and led by icddr,b) [10]. The survey questionnaire was developed after an extensive literature review and rigorous peer review. We added new questions to this survey in late 2023, focusing on the impact of climate hazards on access to and use of WASH facilities for people with and without disabilities (S1). Participants were recruited between 23 February and 6 June 2023.

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Data management and analysis

icddr, b, conducted the quantitative nationwide population-based survey was conducted by icddr,b, between March to June 2023. Data was collected using the mobile/tablet-based platform Kobo Tool box (https://www.kobotoolbox.org/) and transferred to the secure server of icddr,b. The research team carried out quality checks each day. Data was cleaned and analysed using STATA 14.2 (StataCorp LLC, Texas, USA).

Descriptive statistics were produced on the types of sanitation facilities used, including alternatives during climate hazards, type of climate hazard experiences, extent and type of damage to sanitation facilities, and changes to sanitation-related behaviours, routines, or practices during climate hazards. Differences were calculated among people with and without disability and for different climate hazards (e.g., floods and cyclones). For individuals who used an alternative sanitation facility due to damage to their usual facility, we investigated the type of alternative sanitation facility they utilized and any changes in their daily sanitation routines or practices. To deal with the quasi-separation and low events per variable issues, a penalized generalized equation estimation (PGEE) procedure was applied, adjusting for cluster-level correlation and demographic factors. Considering the hierarchical nature of this multi-level data, the division level was taken as a random effect. All analyses report the multivariable results with crude and adjusted odds ratios (AOR), 95% confidence intervals (CI), and 5% significance levels across all analyses.

Qualitative in-depth analysis

Study sites

Based on Bangladesh's multi-hazard risk level assessments, we selected two districts, Satkhira and Gaibandha, for the in-depth qualitative analysis [28]. Satkhira (southern, coastal) experiences cyclones, rising sea levels, and saltwater intrusion [43, 52], and

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Gaibandha (northern, inland) experiences flooding and river erosion [28]. With differing risks, these districts enable an exploration of the impacts of diverse climate hazards on the WASH experiences of people with disabilities.

Study population and sampling method

We purposively selected individuals with disabilities from rural areas of Satkhira and Gaibandha from lists provided by World Vision Bangladesh that documented their members' names, impairments experienced, age, gender, and geographical location. Some participants were selected through snowball sampling. Participants with disabilities were aged 15+ years and had experienced a climate hazard (e.g. cyclone or flood) within the last five years. We attempted to achieve a gender (17 females and 22 males) and impairment balance. 16 Caregivers of men and women with disability who experienced climate hazards within the last five years were also selected from both districts to participate in in-depth interviews. Participants were recruited between 23 August and 31 November 2023.

Data collection

We developed separate interview topic guides for people with disabilities (S2 File) and caregivers (S3 File). Research team members reviewed the topic guides and revised them accordingly. We modified the guidelines based on participant responses and emerging themes during data collection.

We asked participants the Washington Group Short Set on Functioning – Enhanced (WG-SS Enhanced) questions [51]. Those who answered 'a lot of difficulty' or more across any functional domains (vision, hearing, mobility, communication, cognition, self-care, upper body) were classified as having disabilities. We conducted in-depth interviews, accessibility and safety audits, and photovoice and ranking with participants in Satkhira and Gaibandha (Table 2).

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268 **Table 2. Overview of qualitative data collection methods**

Method	Purpose	Description
In-depth Interview (IDI)	To explore the experiences of people with disabilities in accessing and using sanitation facilities and the impacts during and immediately after climate hazards. To explore the experiences faced by caregivers when providing sanitation support and the impacts during and immediately after climate hazards.	Interviews took from 50 minutes to 1 hour 20 minutes and were recorded on a voice recorder with written informed consent. If the participant did not fully understand the consent process, a proxy (caregiver) was interviewed instead.
Photovoice and ranking	To enable participants to represent their experiences in accessing and using sanitation facilities visually during and immediately after climate hazards and rank these as per the perceived level of importance.	Upon their written consent, participants were asked to take photos of their experiences related to accessing sanitation facilities during and immediately after climate hazards. Interviews were conducted to delve into the meaning behind each image. Participants then provided captions and ranked the photos by their perceived

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		level of importance. The process took around 0.5 days for each participant.
Accessibility and Safety Audit	To observe the experiences of people with disabilities reaching and using sanitation facilities and how climate hazards affect these.	Two team members accompanied participants to their sanitation facilities, discussing and also observing challenges faced in reaching and using facilities during or after climate hazards. Two checklists comprising the route to the facility, entering it, and explaining its use guided the conversations. Participants then completed a satisfaction scale rating their facility during normal times and climate hazards. Each audit lasted 50-60 minutes.

Data management and analysis

Data collection was conducted by icddr,b, and LSHTM between August and October 2023. Interviews were conducted in Bangla and recorded with the participant's written consent, which was witnessed. The research team reviewed field notes daily, discussed findings and emerging themes and revised the topic guidelines accordingly. Interview voice recordings were translated and transcribed into English. Transcriptions were checked against the voice

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recordings by Bangla-speaking research team members to ensure data accuracy and quality.

An iterative thematic analytical approach was carried out, with a priori codebook developed before data collection. Inductive codes were added to the codebook as they emerged during data generation. The transcripts were coded using NVivo 14 (Lumivero, Colorado, USA). Inter-coder and intra-coder reliability were assessed following the completion of coding to strengthen coding consistency and analysis and resolve any disagreements. The research team developed a case-by-case data display matrix to compare and contrast the coded data and identify themes and pertinent quotes. Finally, summaries of the coded data for each theme were prepared by triangulating findings from three qualitative data collection tools. After analysis, these summaries were reviewed, and the results for each thematic area were compiled and presented together.

Ethical considerations

Ethical approval was sought and received for the study by the ethics boards at icddr,b (reference 23072) and the London School of Hygiene and Tropical Medicine (LSHTM) (reference 28925). Written informed consent was sought and obtained before data collection. For participants aged below 18 years or those unable to fully understand the consent process, such as those with intellectual disabilities, assent was sought using simplified information sheets. Consent was then sought from their caregivers. Caregivers were then interviewed as a proxy, but efforts were made to involve participants directly. Information sheets were read aloud to explain the study's purpose, procedures, benefits, risks, confidentiality, and the right to refuse or withdraw. Interviews were conducted privately in Bangla, and participants were assured data confidentiality. Confidentiality and anonymity were strictly maintained according to the law of the Government of the People's Republic of Bangladesh.

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Only adults participated in photovoice and underwent two informed consent processes. Initial written informed consent was obtained before participants took photos, and a second written informed consent was sought before interviews were conducted with participants about the photos. This allowed participants to select how they wanted their photos used (e.g., in research articles, workshops, and presentations) and decide if they wanted their real names or pseudonyms credited when images were used and if they wanted their faces blurred or visible. Consent was sought from any third party captured in the photos, and they chose to have their faces visible or blurred. All photovoice participants wanted their real names credited against their photos, so we have used those in this article. However, pseudonyms are used for the quotes provided by participants.

Results

Characteristics of the study population: a nationwide population-based survey

In total, we surveyed 1930 participants from 162 clusters, comprising 1021 (53%) people with and 909 (47%) without disabilities (Table 3). Gender distribution was similar across both groups, with a slightly higher proportion of females. Age distribution varied notably, with 36% of people with disabilities being 65 years or older compared to 20% of people without disabilities, and a higher proportion of people without disabilities in the 17-30 years age group (13% vs. 9.6%).

Table 3. Characteristics of the study population

Variables	People with Disabilities n (%)	People without Disabilities n (%)

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N	1021	909
Gender		
Male	430 (42)	376 (41)
Female	591 (58)	533 (59)
Age group (years)		
15-17	91 (9)	81 (9)
18-30	98 (10)	115 (13)
31-64	461 (45)	536 (59)
65+	371 (36)	177 (20)
Economic status or wealth quintile		
1 (Poorest)	221 (22)	180 (20)
2	197 (19)	180 (20)
3	211 (21)	173 (19)
4	197 (19)	187 (21)
5 (Richest)	195 (19)	189 (21)
Geographical location		
Barishal	104 (10)	69 (8)
Chattogram	154 (15)	144 (16)
Dhaka	190 (19)	186 (21)
Khulna	164 (16)	147 (16)
Mymensingh	54 (5)	52 (6)
Rajshahi	143 (14)	114 (13)
Rangpur	151 (15)	142 (16)
Sylhet	61 (6)	55 (6)
Impairment type		
Visual	294 (29)	-
Hearing	160 (16)	-
Mobility	530 (52)	-
Cognition	248 (24)	-

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Communication	154 (15)	-
Self-care	252 (25)	-
Multiple[a]	508 (50)	-
[a]Multiple refers to when participants experience limitations across more than one functional domain.		

Geographically, the sample was well-distributed, with the Dhaka division having the highest representation in both groups (19% of people with disabilities and 21% of people without disabilities). Economic status was relatively evenly distributed across both groups. The most common types of impairment identified among people with disabilities were mobility impairments (52%) and multiple impairments (50%), while communication impairments were less common (15%) (Table 3).

Characteristics of the study population: in-depth qualitative component

We generated qualitative data with 39 people with disabilities and 16 caregivers. Of the 39 individuals with disabilities, we conducted 24 in-depth interviews (IDIs),11 accessibility and safety audits, and four photovoice and ranking. Among the 24 IDIs, the gender balance was maintained (13 were men and 11 were women), with the majority aged between 18 and 30. Geographically, more participants were from Satkhira compared to Gaibandha. Participants exhibited a diverse range of impairments, with the majority having multiple impairments followed by mobility impairments (Table 4).

Among the 11 accessibility and safety audits, 7 participants were men, and 4 were women. The majority were aged between 31 and 64 and from Gaibandha. Mobility impairments were predominant, and then multiple impairments. Two women and two men participated in the four photovoice assessments. Half were aged between 31 and 64 years, with participants from Satkhira and Gaibandha equally distributed. Mobility impairments were the most commonly reported (Table 4).

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Table 4. Characteristics of people with disabilities selected for qualitative data collection

Data collection method	In-depth interview n (%)	Accessibility and safety audit n (%)	Photovoice n (%)
N	24	11	4
Gender			
Male	13 (54)	7 (64)	2 (50)
Female	11 (46)	4 (36)	2 (50)
Age group			
15-17	5 (21)	1 (9)	1 (25)
18-30	13 (54)	1 (9)	1 (25)
31-64	5 (21)	9 (82)	2 (50)
65+	1 (4)	-	-
Geographical Location			
Satkhira	14 (58)	1 (9)	2 (50)
Gaibandha	10 (42)	10 (91)	2 (50)
Impairment Type			
Visual	2 (8)	1(9)	-
Hearing	-	-	-
Mobility	6 (25)	7 (64)	3 (75)
Cognition	-	-	-
Communication	-	-	-
Self-care	-	-	-
Multiple[a]	16 (67)	3 (27)	1 (25)

[a]Multiple refers to when participants experience limitations across more than one functional domain

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Among the 16 caregivers interviewed, most supported individuals with multiple impairments, which included people with cognition and self-care, mobility and self-care, cognition, communication and self-care limitations (Table 5).

Table 5. Characteristics of caregivers selected for qualitative data collection

Data collection method	In-depth interview N (%)
Geographical Location	
Satkhira	7(44)
Gaibandha	9(56)
Functional domain of the person with disabilities	
Visual	-
Hearing	-
Mobility	4 (25)
Cognition	-
Communication	-
Self-care	-
Multiple	12 (75)

Damage to sanitation facilities from climate hazards and risks to people with disabilities

Of the 1930 participants surveyed, the majority of the respondents (77%) had access to basic sanitation services, with pit latrines as the most common design (Table 6). Damage to sanitation facilities due to climate hazards (cyclones and floods) was reported by 13% of participants (n=245) (Table 6). Some households reported damage from both floods and cyclones. Of the 160 sanitation facilities damaged by floods, the most common damage reported included waste overflow (49%, n=79), debris into the latrine (32%, n=51), and latrine collapse or breakage of the latrine slab (26%, n=41), among others. Of the 116

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366 sanitation facilities damaged by cyclones, the most common damage reported included
367 latrines collapse or breakage of the latrine slab (57%, n=66) and walls/doors breaking (34%,
368 n=39), among others (Table 6).
369
370 **Table 6. Types of sanitation facilities used and damage to sanitation facilities due to**
371 **climate hazards**

Type of climate change hazard	Flood prone areas n (%)	Cyclone prone areas n (%)	Overall n (%)
N	1572	1319	1930
Type of sanitation facility			
Flush/Pour flush to:			
Piped sewer system	41 (3)	23 (2)	62 (3)
Septic tank	379 (24)	314 (24)	479 (25)
Pit latrine	738 (47)	614 (47)	909 (47)
Non-Flush/Pour to:			
Ventilated improved pit latrine (VIP)	49 (3)	33 (2)	50 (3)
Pit latrine with slab	325 (21)	297 (23)	388 (20)
Pit latrine without slab / open pit	22 (1)	22 (2)	24 (1)
Bucket or bedpan	1 (<1)	1 (<1)	1 (<1)
Hanging latrine	5 (<1)	5 (<1)	5 (<1)
No facility, bush, field	9 (<1)	7 (<1)	9 (<1)
Other	3 (<1)	3 (<1)	3 (<1)
Sanitation definitions			
Basic	1208 (77)	1012 (77)	1487 (77)
Limited	324 (21)	269 (20)	401 (21)
Unimproved	26 (2)	26 (2)	28 (1)

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Open defecation	14 (1)	12 (1)	14 (1)
Damage to sanitation facilities from extreme weather events	160 (10)	116 (9)	245 (13)
Types of damage to sanitation facility (N)	160	116	245
Latrine collapses/slab broke	41 (26)	66 (57)	107 (44)
Latrine platform breaks	10 (6)	15 (13)	23 (9)
Walls/doors collapse	22 (14)	39 (34)	51 (21)
Debris runs into the latrine	51 (32)	12 (10)	59 (24)
Waste overflows	79 (49)	15 (13)	92 (38)
I could not access it due to other storm damage	-	1 (1)	1 (<1)
Latrine submerged	6 (4)	1 (1)	7 (3)
Other	6 (4)	2 (2)	8 (3)

Qualitative data indicated that the most common sanitation facility used in both districts was 'Kacha', which is a traditional sanitation infrastructure (the latrine pit containing rings lined with mud, squatting slab, and latrine pan) constructed with mud-made rings and cement slabs. The superstructures (above-the-ground shelter, i.e. walls, roof, and door providing privacy and protection) were made of sacks, bamboo poles, clay, nipa palms, tin, and jute sticks.

In Satkhira, respondents reported subsequent damage to both the pit and the superstructure after cyclone Amphan. One participant, Akkas, reported that this caused pits to overflow. "*Our latrine was fully blown away during Amphan. There was nothing left of the latrine...But there was water in the latrine pit." (Akkas, male with communication and mobility limitations, Satkhira)*

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In Gaibandha, participants have faced frequent and severe flooding over the past five years, damaging superstructures and overflowing latrine pits. Shongku explained how the recurrent floods affected their latrine.

"*The flood water level was so high that the whole latrine was submerged in the water. The tins [latrine walls made of thin metal sheets] flowed into the pond." (Shongku, male with mobility limitation, Gaibandha)*.

We observed that the paths leading to sanitation facilities in rural areas of both Satkhira and Gaibandha were narrow, uneven, and made of soil. Climate hazards not only damaged the sanitation infrastructures and superstructures but also rendered these paths inaccessible by making them muddy, slippery, or waterlogged. People with disabilities, especially those with mobility limitations, experienced increased difficulties in reaching the sanitation facilities via these paths during and immediately after cyclones and floods. Many participants reported sustaining physical injuries from slipping and falling while navigating the muddy, waterlogged path to the sanitation facilities. Montu Miah, who uses crutches, described how he slipped and fell on the muddy road after the cyclone, resulting in a severe injury. As a result, he was unable to access the household sanitation facility for several days and had to use a bucket for urination and defecation. This situation made him dependent on others to empty and clean the bucket, starkly contrasting his previous independence.

"*When I was going to the latrine with my crutch, my leg slipped, and I fell in the mud. Then, there was a brick on the ground, and my amputated leg side fell on that brick. I cut the upper part of the amputated leg, and blood came out. I used a plastic pot for my toileting at that time, and my mother or wife cleaned it after my defecation and urination" (Montu Miah, male with mobility limitation, Satkhira)*

Participants from Gaibandha also sustained injuries reaching the sanitation facility during a flood: *"I felt difficulties. I needed to go to the latrine and return by crossing the flood water. I fell while going to the latrine during the flood. After the flood water subsided, the roads were*

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all muddy and slippery. So, I slipped while walking and fell." (Shongku, male with mobility limitation, Gaibandha).

Caregivers encountered significant challenges in assisting family members with disabilities in reaching the sanitation facility during and immediately after cyclones and floods. In Gaibandha, where flooding rendered sanitation facilities inaccessible, caregivers struggled to carry or transport individuals with disabilities to the sanitation facility. Some caregivers sustained injuries while navigating through the floodwaters, as Jorina, the mother of a man with multiple impairments, described.

"*During the flood, I slipped and fell frequently while carrying him to the open place. I got hurt several times. Think about this: can you carry a 20-year-old boy? Lifting him is a tough job. So, slipping is a common incident. After the flood, when the path to the latrine became muddy and slippery, I slipped most during that time.*" *(Jorina, female caregiver of a male with multiple impairments, Gaibandha)*

Some study participants from Satkhira attempted to temporarily repair their damaged sanitation facilities after the cyclones and use them rather than other people's sanitation facilities. They mostly used whatever material was instantly available to them to repair the structure, including sacks, bamboo, or tins.

"We fixed that somehow immediately after the storm. Or else what can be done? We needed to go to the latrine. If I want to go to other people's latrines, they can allow me to do so once or twice. But not more than that. So, we somehow managed to fix the latrine.... used jute sacks for fixing the latrine...." (Jaheda, female with multiple impairments, Satkhira)

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Changes to sanitation-related behaviours, practices, and routines

People affected by climate hazards who could not use the damaged sanitation facilities applied various management strategies to continue toileting during climate hazards, including using alternative sanitation facilities and changing their sanitation-related behaviour (Table 7). The population-based survey found that 45% (n=110) of people used alternative sanitation facilities during climate hazards. Most respondents used the same alternative sanitation facility as their household members (88%, n=97), however, some did not. Reasons for not doing so included difficulty using the facilities (77%, n=10), needing help from caregivers (46%, n=6), and difficulty for the caregivers (23%, n=3), among others. Additionally, among those that reported the use of alternative sanitation facilities, 21% (n=23) of people reported that they also changed their sanitation behaviours. Common changes in behaviours included restricting their use of sanitation facilities (61%, n=14), limiting or restricting food intake (30%, n=7), and fluid intake (9%, n =2). Changes to sanitation-related behaviours, routines, and practices by climate hazard can be found in Table 7.

Table 7. Change to sanitation-related behaviours, routines, and practices during climate hazards

Type of climate change hazard	Flood prone n (%)	Cyclone prone n (%)	Overall n (%)
N	1572	1319	1930
Participants with damaged sanitation facility	160 (10)	116 (8.8)	245 (13)
N	160	116	245

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Used alternative latrine/s	87 (54)	35 (30)	110 (45)
N	87	35	110
Use the same alternative sanitation facility as other members of the household	75 (86)	29 (83)	97 (88)
Reasons for not using the same alternative sanitation facility (N)	12	6	13
It would be difficult/impossible for me	10 (83)	4 (67)	10 (77)
A caregiver helps me go to the sanitation facility	5 (42)	1 (17)	6 (46)
Distance to the sanitation facility	2 (17)	0 (0)	2 (15)
Unable to reach the sanitation facility	2 (17)	0 (0)	2 (15)
It is difficult for my caregiver	3 (25)	0 (0)	3 (23)
I would be embarrassed / People would laugh at me	1 (8)	0 (0)	1 (8)
Other	1 (8)	1 (17)	1 (7.7)
N	82	35	110

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Made changes to their sanitation behaviours, practices or routines	20 (24)	4 (11)	23 (21)
Specific changes made to sanitation behaviours, practices or routines (N)	20	4	23
I restrict my use of the sanitation facility	14 (70)	2 (50)	14 (61)
I limit/restrict my food intake	5 (25)	3 (75)	7 (30)
I limit/restrict my fluid intake	1 (5)	1 (25)	2 (9)
Other	4 (20)	0 (0)	2 (9)

More people with disabilities (60%, n=57) reported using alternative sanitation facilities during floods than people without disabilities (46%, n=30). However, the difference was not statistically significant. There was weak evidence for a difference found between people with disabilities and those without disabilities regarding changes in sanitation-related behaviours, practices and routines due to floods (AOR 3.83, 0.99-14.86 95%CI, p=0.052) (Table 8).

Table 8. Differences in sanitation-related behaviours between people with disabilities and people without disabilities during floods

Indicators	Person with disability n (%)	Person without disability n (%)	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (AOR)*	95% Confidence Intervals	p-value
N	834	738				

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Participants with damaged sanitation facility	95 (11)	65 (9)	1.34 (0.95 to 1.88)	1.37	0.97 to 1.95	0.076
N	95	65				
Used alternative sanitation facility/s	57 (60)	30 (46)	2.0 (0.96 to 4.16)	2.02	0.96 to 4.28	0.066
N	52	30				
Changes made to sanitation behaviours, practices, or routines	17 (33)	3 (10)	4.65 (1.13 to 19.07)	3.83	0.99 to 14.86	0.052
Adjusted for gender, age, socio-economic status, region and cluster level variations						

Qualitative data analysis also revealed that individuals with disabilities affected by flooding resorted to open defecation or relied on alternative sanitation facilities. In Gaibandha, people with disabilities and their caregivers used their neighbour's or relative's undamaged sanitation facilities during or after the flood. However, all those respondents and their caregivers needed permission from the owner to use their sanitation facilities and were not always permitted to do so. Some experienced verbal abuse, so they went to another neighbour's sanitation facility or defecated in the open, as explained by Rana.

"During the flood, I tried to use *a neighbour's latrine, and they didn't allow me. Also, they quarrelled with my mother, and my mother rebuked me and forbade me from going there... What could I do then? I had to go to [defecate in] open places." (Rana, male with mobility limitation, Gaibandha)*

One respondent shared that, during the floods, he and his mother initially used a neighbour's sanitation facility with permission. However, after experiencing harassment and humiliation from the neighbours, they began using the sanitation facility secretly to avoid further interactions.

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"...They rebuked me and my mother. They told us not to use their latrine. They also treated us in a bad manner. I cannot even explain to you how bad that was…. we used to go to the neighbour's latrine secretly then so that no one could see us." (Shongku, male with mobility limitation, Gaibandha).

The difference between people with and without disabilities regarding the use of alternative sanitation facilities was less marked with cyclones. There was no statistically significant difference seen between the use of alternative sanitation facilities or changes to sanitation-related behaviours by people with or without disabilities (Table 9).

Table 9. Differences in sanitation-related behaviours between people with disabilities and people without disabilities during cyclones

Indicators	Person with disability n (%)	Person without disability n (%)	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (AOR)*	95% Confidence Intervals	p-value
N	708	611				
Participants with damaged sanitation facility	62 (9)	54 (9)	0.98 (0.66 to 1.45)	0.98	0.65 to 1.47	0.915
N	62	54				
Used alternative sanitation facility/s	17 (27)	18 (33)	0.76 (0.31 to 1.84)	0.56	0.19 to 1.65	0.293
N	17	18				
Changes made to sanitation behaviours, practices or routines	1 (6)	3 (17)	0.40 (0.05 to 3.08)	0.27	0.03 to 2.86	0.278

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Adjusted for gender, age, socio-economic status, region and cluster level variations

Qualitative findings show that most individuals with mobility limitations affected by the cyclone could not use their neighbour's sanitation facility due to its distance from their homes. As a result, while family members might have been able to use the alternative, respondents like Kalu Miah were forced to continue using their overflowing family sanitation facility.

"I had to use the same latrine. When the latrine becomes full, our clothes also get ruined with the faecal waste. Water splashed on me while defecating." (Kalu Miah, male with vision and hearing limitation, Satkhira)

Additionally, some respondents in Satkhira continued using the same sanitation facility during or after the climate hazard due to fear of humiliation, even though it was damaged or overflowed. Using the same sanitation facility repulsed them and impacted their personal hygiene. Khodeja explained that her son chose to use his damaged sanitation facility rather than face the abuse he would endure if he used his neighbour's sanitation facility.

"He thinks that the neighbours might scold him for going to their latrines. He will not feel good if this happens. That's why he continued using this damaged latrine (their latrine). During heavy rain, when the latrine was flooded, the water containing faecal waste splashed up. He didn't like this. He felt bad." (Khodeja, caregiver of a male with multiple impairments, Satkhira)

In the qualitative component, most participants from Gaibandha reported defecating in the open and flood water because their sanitation facilities and surrounding areas of their households had been flooded for 8-10 days. Mahidul Islam, a man from Gaibandha with mobility limitations, illustrated his challenges with using the household sanitation facility and how these difficulties were exacerbated during floods (Fig 1). His sanitation facility is not flood-resilient.

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Fig 1. "During a flood, this latrine went underwater. I had to defecate in an open place or on the flood water." (Mahidul Islam, male with mobility limitation, Gaibandha)

In Gaibandha, people with disabilities and their caregivers made rafts from banana trees to transport them across the flood water to find higher dry ground for defecation. Many people with disabilities had to rely on caregivers to take them, which increased feelings of dependency, as explained by Rana.

"I felt ashamed. I felt what a life I have! If I had been in good physical condition, it would not have been so difficult for me. I could go for defecating through the raft on my own. I felt very helpless, but what could I do? In a word, I cannot express these kinds of feelings. You will never have this feeling, and only those who have such problems will understand." (Rana, male with mobility limitation, Gaibandha)

Qualitative findings highlighted privacy concerns and caregiver dependency as key issues. Flood-affected individuals with disabilities in Gaibandha who defecated in the open reported significant privacy concerns. Combined with their increased reliance on caregivers, these issues led some to limit the frequency of their toileting to avoid further discomfort and dependency. Women with disabilities were more concerned about privacy than their male counterparts. As a result, women with disabilities opted to defecate outside after dark rather than during or immediately after the floods. Putul, for instance, only defecated in the open at night.

"I didn't go to defecate in the daytime. I used to hold the defecation urge…At night, I used to go to defecate at an open place. Because people could not see me then." (Putul, female with mobility limitation, Gaibandha).

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Moreover, both women and men with disabilities who adjusted their food consumption and defecation practices experienced negative health outcomes. For example, delaying defecation and restricting water intake resulted in constipation, as reported by Morjina, the mother of a woman with multiple impairments.

"…It is obvious that when there is gas inside your stomach (gas produced due to not defecating for days), and your stomach remains full, then the demand for eating rice will definitely decrease. She said I don't want to eat. I don't feel good. She defecated after five days." (Morjina, caregiver of a woman with multiple impairments, Satkhira)

Rana consumed food that can cause constipation to limit defecation, which made him lose weight and become weak.

"During the flood, I ate flattened rice as I heard that flattened rice causes constipation. Because then, there will be less urge for defecation during the floods. I also limited my food intake. I was used to eating three meals per day, but I ate two or one meal per day during the flood." [….] I didn't get that much energy to do any work. I also lost weight by eating one meal only a day." (Rana, male with mobility limitation, Gaibandha)

Additional sanitation challenges for people experiencing incontinence

The population-based survey revealed no significant difference in using alternative sanitation facilities or sanitation-related behaviours between people with incontinence and those without during floods (Table 10).

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570 **Table 10. Differences in sanitation-related behaviours between people with**
571 **incontinence and those without during floods**

Indicators	Incontinence n (%)	Non-incontinence n (%)	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (AOR)*	95% Confidence Intervals	p-value
N	71	89				
Used alternative sanitation facility/s	37 (52)	50 (56)	0.71 (0.34 to 1.49)	0.65	0.29 to 1.45	0.297
N	36	46				
Changes made to sanitation behaviours, practices or routines	8 (22)	12 (26)	0.71 (0.23 to 2.23)	0.63	0.20 to 1.99	0.436
Adjusted for gender, age, socio-economic status, region and cluster level variations						

572

573 Among those affected by cyclones, people with incontinence had a 74% lower likelihood of
574 using alternative sanitation facilities than individuals who did not have incontinence (AOR

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0.26, 0.07-0.93, p=0.038) (Table 11). There was no significant difference in sanitation-related behaviours between people with incontinence and those without during cyclones.

Table 11. Differences in sanitation-related behaviours between people with incontinence and those without during cyclones

Indicators	Incontinence n (%)	Non-incontinence n (%)	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (AOR)*	95% Confidence Intervals	p-value
N	44	72				
Used alternative sanitation facility/s	12 (27)	23 (32)	0.77 (0.29 to 1.97)	0.26	0.07 to 0.93	0.038
N	12	23				
Changes made to sanitation behaviours, practices or routines	1 (8)	3 (13)	0.76 (0.09 to 5.90)	0.37	0.02 to 8.08	0.525
Adjusted for gender, age, socio-economic status, region and cluster level variations						

The qualitative data revealed more nuanced insights. People with disabilities experiencing incontinence in Satkhira and Gaibandha reported significantly heightened challenges with toileting and maintaining hygiene during and immediately after climate hazards. In some cases, individuals with incontinence defecated on their clothes or bedding, leading to direct contact with urine and faeces.

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Fulbanu, the mother of Akkas from Satkhira, explained how her son, who experiences incontinence, could not reach the sanitation facility during the cyclone and defecated in the room where he lives. His mother covered stools with a cloth and disposed of them after the storm stopped.

"He defecated in the room while he was hurrying to go to the latrine. Then I covered that stool with some clothes for that night and threw it after the storm stopped the next morning. I got water in the bucket and threw the water on him. "(Fulbanu, female caregiver of male with communication and mobility limitations, Satkhira)

While taking shelter at her relative's house during the cyclone, a woman from Satkhira with mobility impairments and incontinence relieved herself inside her aunt's home. Her mother, Bilkis, had to clean her and her relative's place during the cyclone.

"*My daughter has defecated and urinated in her aunt's room and balcony, and she had spread it everywhere in the room and balcony. As she can't restrict her urination and defecation for long... I had to clean, and it was very difficult for me (Bilkis, female caregiver of a female with mobility limitation, Satkhira)*

Bilkis also expressed disgust regarding the process of cleaning her daughter after defecation, as well as cleaning the used toileting devices (e.g., pan, pot, potty). Her feelings were shared by some other caregivers of individuals with disabilities experiencing incontinence. Bilkis explained:

"I felt it was difficult, and it is still difficult for me to clean her defecation and urination. (crying) She is now an adult girl, so it's more difficult for me. She defecates in the pot in this room. I have to throw it away outside and clean it. I have to clean that, and that is very painful for me" (Bilkis, female caregiver of female with mobility limitation, Satkhira)

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Caregivers of people with disabilities who experience incontinence from Gaibandha frequently cleaned the person, their clothes, and bedding without any gloves during and immediately after a flood.

"She soiled her clothes while going to defecate during the flood sometimes. I cleaned her then and after myself too. I washed her clothes with my hands." (Labonno, female caregiver of female with multiple impairments, Gaibandha)

The photo below (Fig 2) illustrates a mother's challenges in assisting her daughter with a disability during Cyclone Amphan in Satkhira. Shuprova Sarkar provides total care for her daughter, who has multiple impairments and relies entirely on her mother for toileting and personal hygiene.

Fig 2. "Cleaning the pot that she defecates in was harder during the cyclone Amphan because we didn't have enough water to wash and clean" (Shuprova Sarkar, mother of a woman with multiple impairments in Satkhira)

Discussion

This mixed-method study analysed the impacts of climate change-induced hazards on the sanitation experiences of people with disabilities and their caregivers in Bangladesh. The study findings provided in-depth evidence about the accessibility and usability of sanitation facilities for people with disabilities during and immediately after climate hazards. The 'Kacha' sanitation facilities, constructed with mud, bamboo, tin, and jute sticks, were mostly damaged from waste overflow and structural collapse during floods and cyclones, respectively. These climate hazards also rendered paths to sanitation facilities inaccessible, posing significant challenges for individuals with mobility limitations and resulting in physical injuries. Caregivers face additional difficulties in assisting family members with disabilities during cyclones and floods, often sustaining injuries themselves. Management strategies

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included using neighbours' or relatives' sanitation facilities, open defecation, and makeshift repairs, which posed significant accessibility and privacy challenges. Open defecation was prevalent among people with disabilities in flood-prone areas, especially among women. Verbal abuse and humiliation from neighbours often forced people with disabilities to continue using damaged or overflowing facilities in cyclone-prone areas. Individuals with disabilities who experience incontinence face severe challenges due to inaccessibility to sanitation facilities during and immediately after climate hazards. This often resulted in them urinating and defecating in their clothes or bedding, significantly increasing the risk of infectious diseases for both them and their caregivers. The increased responsibilities of caregivers in managing and cleaning up after these toileting needs during and after such hazards were substantial.

Damages to sanitation facilities from climate hazards and risks to people with disabilities

Our study highlights that sanitation facilities used in Satkhira and Gaibandha were not cyclone or flood-resilient, especially in rural areas. Superstructures were frequently damaged, and in some cases, entire sanitation facilities collapsed. Due to cyclones and floods, latrine slabs cracked, and pits or septic tanks flooded or overflowed with water and waste. Similar findings have been reported in other studies. A 2021 study in Satkhira similarly found that 22.5% of respondents experienced damage to their water sources, sanitation, and bathing facilities due to Cyclone Amphan [29]. Additional evidence from Burkina Faso and Bangladesh support our findings, showing that sanitation facilities commonly constructed with light materials were highly susceptible to severe damage or collapse during cyclones or floods [25, 26].

In Gaibandha, the floods fully or partially submerged most participants' sanitation facilities, leaving them inaccessible to people with disabilities and their family members. This situation

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was mirrored in other flood-prone districts of Bangladesh. For example, a cross-sectional study in 2022, with 280 households in Jamalpur, found that nearly 57% of the sanitation facilities, mostly pit latrines, were damaged by floods, leading to an increase in open defecation from 10% to 30.4% [35]. Our study further found that flood-induced damage to sanitation facilities in Gaibandha significantly exacerbated the challenges faced by people with disabilities and their caregivers in accessing and using these essential services. These challenges led to consequences such as sustaining physical injuries while navigating damaged paths or routes to sanitation facilities. This is supported by a study collating evidence from 11 LMICs, which found that people perceive the risk of accidents as highly severe when navigating slippery and uneven paths to reach sanitation facilities, even without climate hazards [53]. This concern became a stark reality for both people with disabilities and their caregivers in Satkhira and Gaibandha. Our study found that people with disabilities, especially those with mobility limitations, frequently reported sustaining physical injuries from slipping and falling on muddy and water-logged paths. Furthermore, caregivers of people with disabilities also sustained injuries while carrying or accompanying those they support to reach sanitation facilities. Other studies have reported similar challenges and that intense rainfall made the steep paths to the sanitation facilities slippery and risky to navigate for people with disabilities, leaving them more susceptible to sustaining falls and injuries [10, 54]. In Bangladesh, a study by Alam et al. [10] found that rural women with mobility limitations reported experiencing multiple falls while navigating through uneven and slippery paths to the sanitation facility during rainy days [10].

Given people's existing functional limitations and vulnerabilities, injuries can result in further adverse health outcomes for people with disabilities. Such injuries may increase their dependency on caregivers, which may, in turn, compromise their caregivers' ability to perform other necessary activities both inside and outside the household. A 2022 study with caregivers of young people with intellectual disabilities in Vanuatu found a decrease in their earning potentiality and time to rebuild their homes following cyclones, as the trauma from

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the cyclones led to increased support needs for the young people [14]. Our findings suggest that prioritizing climate-resilient and inclusive sanitation infrastructure, including superstructures and pathways that are smooth, wide, and resistant to waterlogging, is crucial not only for the safety of people with disabilities but also for their caregivers. Enhancing these facilities could significantly impact the family's ability to recover from climate hazards.

Changes to sanitation-related behaviour, practices, and routines

The World Health Organization reported that climate hazards could damage water supply and sanitation infrastructure, reduce sanitation coverage, increase the use of unsafe water, cause poor sanitary practices, and adversely affect hygiene behaviours [22]. Our study findings also reflect this. The population-based survey revealed that using relatives' or neighbours' sanitation facilities, restricting the usage of sanitation facilities, limiting food and fluid intake, and resorting to open defecation were strategies applied by people with and without disabilities to manage sanitation challenges caused by climate hazards.

Other studies from Bangladesh also identified using a relative's and neighbour's sanitation facilities as a management strategy for sanitation challenges in flood-prone areas [25, 35, 37]. However, our qualitative analysis underscored that individuals with disabilities and their caregivers often faced significant challenges when using a relative's or neighbour's sanitation facility. Many reported experiencing verbal abuse, which made this option untenable for them. This was not the case in Burkina Faso, where Iyer et al. found that climate-impacted communities in Burkina Faso demonstrated solidarity and shared their sanitation facilities during climate hazards [26]. Additionally, survey results from a study in Bangladesh showed that nearly half of the flood-affected people in Jamalpur used their neighbour's sanitation facility [35]. Yet, it was not mentioned whether participants faced verbal abuse for doing so. In our study, however, it remains unclear whether the verbal

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720 abuse experienced by people with disabilities and their caregivers was primarily driven by
721 disability discrimination or by the challenges associated with the current emergency. Further
722 research is needed to clarify this issue.
723
724 Repeatedly requesting permission to use sanitation facilities in other households created
725 fears of being insulted or compromising their dignity. As a result, cyclone-affected
726 participants from our study population prioritized temporarily repairing their damaged
727 sanitation facilities over alternative sanitation facilities. On the contrary, Iyer et al. (2022) and
728 Nuzhat (2023) found that rural people prioritized rebuilding damaged houses and recovering
729 livelihoods over sanitation after extreme rain, cyclones, and floods [25, 26]. We hypothesize
730 that people with disabilities and their families may prioritise ensuring safe, private, and
731 dignified access to sanitation facilities. This concern could significantly influence their focus
732 on sanitation during disaster recovery efforts and needs further research.
733
734 In 2021, UNICEF highlighted that the distance required to access sanitation facilities poses
735 an additional challenge for children with disabilities, compounded by structural barriers that
736 hinder their ability to use these facilities with independence and dignity [17]. During the
737 cyclones in Satkhira, people with disabilities in our study either continued using damaged
738 sanitation facilities or made temporary repairs due to the distance to a relative's or
739 neighbour's sanitation facility and the fear of facing humiliation from sanitation facility
740 owners.
741
742 Our study found that during cyclones and floods, people with disabilities frequently came into
743 contact with urine and faeces, which elicited strong feelings of disgust among them.
744 Other studies have highlighted that people with disabilities often encounter human waste
745 while accessing and using sanitation facilities. Mactaggart et al. (2018) found in a multi-
746 country cross-sectional study that a significant proportion of people with disabilities in
747 Bangladesh, India, Cameroon, and Malawi could not access sanitation facilities without

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coming into contact with faeces [55]. Similarly, a nationwide population-based survey in Bangladesh found that people with mobility, communication, cognition, and self-care limitations were twice as likely to face difficulties using sanitation facilities without encountering faeces or urine, even without the added challenge of climate hazards [10]. Moreover, contact with excreta poses serious risks to health and well-being. Mactaggart et al. (2021) found that in both rural and urban areas of Vanuatu, people with disabilities were significantly more likely than those without disabilities to require assistance, come into contact with excreta, and limit their use of sanitation facilities. [16]. This increased exposure elevates the risk of chronic conditions related to dehydration, faecal contamination, and urinary and bowel control issues, while also potentially increasing the transmission of infectious diseases [16].

Our qualitative findings highlighted that in Gaibandha, floodwaters fully or partially submerged sanitation facilities and the surroundings of households, with this condition persisting for 8-10 days. As a result, some flood-affected people with disabilities resorted to open defecation in dry areas, travelling on makeshift rafts made of banana trees with their caregivers, or defecating in the floodwater as alternative sanitation measures. This has been reported in other studies from Bangladesh's coastal cyclone-prone and flood-prone areas as a standard practice during floods [25, 29, 35, 37]. Our study indicates that people with disabilities with mobility and/or self-care limitations faced increased reliance on caregivers for transportation, which heightened their sense of dependency. While caregiver support might be crucial, this dependency also heightens a lack of independence in performing sanitation activities as needed, potentially affecting their dignity and autonomy [17, 56].

Another study in Bangladesh by Jerin et al. (2023) concluded that 22% more women in flood-prone Jamalpur defecated in the open than men during flood due to damaged sanitation facilities they couldn't repair, lack of clean water, and being less able to use to

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neighbour's ones [35]. A study by Nuzhat et al. (2023) [25] found that women often face significant discomfort when accessing sanitation facilities during floods, particularly when sanitation facilities are inundated or poorly lit, leading many to resort to open defecation. While these studies did not include women with disabilities as participants, our analysis reveals this population's heightened vulnerability to privacy and safety concerns. Privacy concerns are already significant for women with disabilities even under normal circumstances, as highlighted in Alam et al.'s (2023) population-based survey in Bangladesh [10]. Our study found that these privacy concerns were exacerbated during climate hazards. Women with disabilities, facing heightened privacy and safety issues, increasingly resorted to open defecation. As a result, many adopted the strategy of restricting urination and defecation until nightfall during and after floods. Studies in other LMICs have also highlighted the stigma associated with open defecation for people with disabilities, leading women with disabilities to restrict urination and defecation after dark. This practice significantly increases the risk of accidents, sexual assault, and other safety issues [57-60]. It is essential to provide climate-resilient, accessible sanitation facilities near homes for women with disabilities, addressing privacy and safety concerns along with accessibility challenges.

In our study, both men and women with disabilities reported limiting their food and water intake, as well as limiting their usage of sanitation facilities, to avoid the need for open defecation. This is a common strategy applied by people with disabilities in different settings. For instance, Mactaggart et al. (2021) found in Vanuatu that people with disabilities (12%) reported limiting their use of sanitation facilities more than people without disabilities (2%) [16]. Another study conducted by Kuper et al. (2018) [18] discovered that people with disabilities altered their daily sanitation routine due to physical difficulty and the need for assistance in accessing household sanitation facilities. Thus, they limited their food intake (14%) and fluid intake (16%) to avoid using sanitation facilities [18]. In our study, changes in food practices resulted in reported constipation, weight loss, and weakness. These challenges can worsen the existing health vulnerabilities of people with disabilities, with the

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adverse physiological effects further amplified by climate hazards [61]. Barreau et al. [62] and Uddin et al. [40] supported this, noting that people with pre-existing disabilities or chronic diseases often experience worsened health outcomes as a result of droughts cyclones and floods.

Additional sanitation challenges for people experiencing incontinence

People who experience incontinence have a significantly increased need for water supply, private sanitation facilities, and hygiene products for toileting and personal hygiene [47, 63, 64]. Our study found that people with disabilities experiencing incontinence faced heightened challenges in meeting their toileting and hygiene needs due to the effects of cyclones and floods. A significant consequence was the frequent contact with urine and faeces for both individuals with incontinence and their caregivers during and immediately after these climate hazards. People with incontinence require frequent access to sanitation facilities and a reliable, clean water supply for proper hygiene [16, 20, 47, 63]. Studies have shown that managing incontinence is nearly impossible for these individuals without proper sanitation facilities, water supply, or incontinence products, even under normal conditions [20, 47, 63], let alone during emergencies, including climate hazards. In the humanitarian context of Sudan, people with incontinence, regardless of disability status, faced significant challenges in managing their condition. These difficulties were due to limited access to essential incontinence products, a lack of water for personal hygiene and washing, and the long distances to sanitation facilities [48].

Moreover, evidence from Sudanese refugee camps, Vanuatu, Pakistan, Bangladesh, Ghana, Uganda, and Malawi revealed that people with disabilities faced significant challenges managing incontinence. These are exacerbated by long distances to sanitation facilities, lack of assistive devices, and access to hygiene and incontinence products, such

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as bedpans, mattress protectors and incontinence underwear, latrine chairs, and soap [47, 48, 64]. This underscores the urgent need for incontinence products, assistive devices, and accessible sanitation facilities to support people with disabilities and their caregivers during climate hazards to manage incontinence.

Our study found that individuals using pots or buckets for urination and defecation during cyclones and floods came into contact with urine and faeces, as did their caregivers who supported them. Caregivers, unable to clean pots or buckets immediately due to restricted access to water, had to leave them inside the house until the intensity of the disaster decreased. Uncovered bucket latrines present significant health risks, exposing people with disabilities and their families to pathogens in faeces, which can lead to diarrheal diseases [47]. Consequently, individuals with disabilities who experience incontinence and soil their bodies and clothes during cyclones and floods face an elevated risk of disease, as do their caregivers. Many caregivers reported manually cleaning their care recipients' bodies and washing soiled clothes during and immediately after climate events, increasing their risk of infectious diseases. Wilbur et al. [13] found that only a few caregivers in Cambodia had assistive devices like commodes or lifting products, making support for people with disabilities physically demanding and time-consuming. It is essential to provide people with disabilities and their caregivers with access to these assistive devices and incontinence products, both generally and in emergency relief packs in Bangladesh. Additionally, research and development are needed to create effective, reusable incontinence products that are more environmentally friendly than single-use items and to establish a reliable, affordable supply chain. This immediate action is essential to address the severe risks of inadequate incontinence management during crises and for planetary health.

Globally, people with disabilities experience less health coverage and worse health outcomes than those without disabilities due to barriers to accessing healthcare services [65]. They often require higher levels of diagnosis, prevention, and treatment services but

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858 encounter lower quality, unaffordable, and inaccessible healthcare services [65]. Our study
859 underscores the critical link between disability, disruptions in sanitation services due to
860 climate change, and negative health outcomes for people with disabilities. These disruptions
861 lead to injuries, increased contact with urine and faeces, restricted usage of sanitation
862 facilities, limited food intake, heightened dependency on caregivers, and privacy issues. It is
863 imperative to prioritize climate-resilient inclusive sanitation services urgently. Such measures
864 will benefit people with disabilities and their caregivers, ensuring safe and dignified access to
865 sanitation. This will progressively realize the right to sanitation for this vulnerable population,
866 addressing both their immediate sanitation needs and long-term health outcomes.
867

868 Strengths and limitations

869 One of the study's major strengths was applying a mixed methods approach to explore
870 challenges among the climate-vulnerable communities of Bangladesh. The nationwide
871 population-based survey provided an overall view of the impacts of climate hazards on the
872 sanitation experiences of people with and without disabilities. The qualitative research
873 provided a deep exploration of the nuanced challenges faced by people with disabilities and
874 their coping mechanisms in managing the impacts of climate hazards. Additionally, the study
875 benefited from having a diverse team of trained researchers, including individuals with
876 disabilities, all of whom brought professional expertise in WASH, disability, and climate
877 change.
878
879 Some study limitations exist. The population-based survey data analysis found no significant
880 difference between people with and without disabilities regarding sanitation-related
881 behaviours, practices, or routines in climate hazards. Two factors may have contributed to
882 this. First, the sample population included participants from less climate-vulnerable areas,
883 and second, although the study was originally powered to detect differences between
884 groups, the number of participants reporting damage to sanitation was quite low. This

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reduced our ability to detect differences between outcome measures. In some respects, the qualitative data analysis revealed more nuanced data and discussed the in-depth sanitation experiences regarding behaviours, practices, or routine changes of people with disabilities and their caregivers.

Conclusion

This study highlights the complex challenges faced by people with disabilities and their caregivers during climate-related hazards, such as cyclones and floods in Bangladesh. Damage to sanitation facilities during these events worsens existing accessibility barriers, increasing health risks and leading to a reliance on open defecation. This shift threatens planetary health and exacerbates privacy, safety, and emotional well-being issues, particularly for women with disabilities. To build resilience, targeted interventions should focus on developing climate-resilient, inclusive sanitation facilities and integrating people with disabilities into climate adaptation and mitigation strategies at household, community, district, and national levels. Prioritising the meaningful participation of persons with disabilities in such efforts could significantly enhance community resilience to climate change.

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911

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912

913

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Supporting information captions

S1. Survey questions on climate risks through WASH for people with and without disabilities

S2. Guidelines to interview people with disabilities

S3. Guideline to interview caregivers

S4. Guideline for accessibility and safety audit with people with disabilities

S5. Photovoice and ranking guideline

Fig 1. During a flood, this latrine went underwater. I had to defecate in an open place or on the flood water (Mahidul Islam, male with mobility limitation, Gaibandha)

Fig 2. Cleaning the pot that she defecates in was harder during the cyclone Amphan because we didn't have enough water to wash and clean Shuprova Sarkar, mother of a woman with multiple impairments in Satkhira)

Figure 1 Mahidul Islam

Figure 2 Shuprova Sarkar