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Health Vulnerability to Climate Change Among Coastal Communities in Bangladesh: A Quantitative Cross-Sectional Study

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Abstract
Climate change is increasingly recognized as a major driver of health vulnerability in the coastal regions of Bangladesh. This study quantitatively examined the relationship between climate change exposure and health vulnerability among coastal residents. A cross-sectional survey design was employed, and data were collected from 386 respondents using a structured questionnaire covering socio-demographic characteristics, climate exposure, health status, healthcare accessibility, awareness, and institutional support. Data were analyzed using descriptive statistics, chi-square tests of independence, and the Spearman rank-order correlation, while internal consistency was assessed using Cronbach's alpha. Findings indicated that respondents were highly exposed to multiple climate hazards, particularly cyclones and salinity intrusion, with frequent occurrence and substantial livelihood disruption. Respiratory, skin, and diarrheal diseases were the most commonly reported health conditions. Although climate change awareness was high, participation in formal training and access to government or NGO support remained limited, and most respondents reported difficulties in accessing healthcare, especially during climate-induced disasters. Inferential results revealed significant associations between gender and health status, education and climate awareness, displacement and health outcomes, climate exposure frequency and illness, and healthcare accessibility and health status ($p < 0.05$). Spearman correlation showed a weak negative relationship between health vulnerability and perception scores, while other associations are not statistically significant. The perception scale demonstrated acceptable reliability (Cronbach's alpha = 0.691). Overall, the study concluded that climate change significantly increases health vulnerability in coastal Bangladesh through direct environmental exposure and limited healthcare access,

highlighting the need for strengthened healthcare systems and institutional support to enhance community resilience.

Keywords: climate change, health vulnerability, coastal area, Bangladesh, healthcare access, quantitative study

1. Introduction

Climate change is one of the most critical global challenges of the twenty-first century, affecting environmental sustainability, socioeconomic development, and human health. Rising global temperatures, changing precipitation patterns, rising sea levels, and the increasing frequency and intensity of extreme weather events have disrupted ecosystems and human livelihoods worldwide (IPCC, 2023). Although climate change affects all countries, its impacts are particularly severe in low- and middle-income countries with limited adaptive capacity, where vulnerable populations face disproportionate risks to health, food security, water availability, and economic stability (Romanello et al., 2023; WHO, 2023).

The health consequences of climate change extend beyond direct effects such as injuries and deaths caused by cyclones, floods, heatwaves, and storms. Climate change also contributes to the spread of infectious diseases, food and water insecurity, malnutrition, poor mental health, respiratory illnesses, and reduced access to essential healthcare services (Berry et al., 2018; Cianconi et al., 2020; Ebi et al., 2021; Haines & Ebi, 2019). These health impacts are shaped by the interaction of environmental hazards with social, economic, and institutional factors, making climate change a major public health challenge (Romanello et al., 2023; WHO, 2023).

Bangladesh is widely recognized as one of the countries most vulnerable to climate change because of its low-lying deltaic geography, high population density, widespread poverty, and dependence on climate-sensitive livelihoods such as agriculture and fisheries (IPCC, 2023; World Bank, 2022). The country experiences recurrent cyclones, floods, riverbank erosion, salinity intrusion, tidal surges, and a rising sea level, all of which threaten livelihoods, infrastructure, and public health (Ashrafuzzaman et al., 2023; Islam et al., 2024). These hazards are expected to intensify under future climate scenarios, increasing the vulnerability of millions of people living in coastal regions (IPCC, 2023; Romanello et al., 2023).

Coastal Bangladesh represents one of the country's most climate-sensitive regions. Communities in these areas experience repeated exposure to cyclones, storm surges, saline water intrusion, and flooding, which damage housing, agricultural land, drinking-water sources, and healthcare facilities (Evertsen, 2023; Khan et al., 2014). Such environmental changes contribute to waterborne diseases, skin infections, respiratory illnesses, malnutrition, maternal health complications, and mental health problems while simultaneously reducing access to healthcare and other essential services (Hossain et al., 2023; Islam et al., 2025). As climate hazards become more frequent and severe, the cumulative effects on health and livelihoods continue to increase.

Health vulnerability is determined not only by exposure to climate hazards but also by socioeconomic conditions and institutional capacity. The IPCC framework conceptualizes vulnerability as the interaction of exposure, sensitivity, and adaptive capacity (IPCC, 2023). While exposure reflects the degree to which people experience climate hazards, sensitivity refers to how severely those hazards affect health and livelihoods, with adaptive capacity representing the ability to anticipate, respond to, and recover from climate-related shocks (Ebi & Semenza, 2008). Consequently, households with limited income, education, healthcare access, and social support are generally more vulnerable to climate-related health risks than those with greater resources (Islam et al., 2025; Sultana et al., 2023).

Healthcare accessibility is a key component of adaptive capacity in climate-vulnerable regions. During extreme weather events, transportation systems, electricity, communication networks, and health facilities are often disrupted, reducing access to medical care when it is most needed (Hossain et al., 2023; WHO, 2023). In many coastal communities of Bangladesh, shortages of healthcare personnel, medicines, diagnostic facilities, and emergency transport already exist under normal conditions and become more severe during disasters (Islam et al., 2025; World Bank, 2022). Financial hardship further limits healthcare utilization, making climate-resilient health systems essential for protecting vulnerable populations.

Community awareness and institutional support also play significant roles in reducing climate-related health risks. Individuals with greater knowledge of climate change and disaster preparedness are more likely to adopt preventive measures such as safe water practices, improved sanitation, early evacuation, and timely healthcare-seeking behavior (UNDP, 2024). Similarly, community-based adaptation programs, early warning systems, and disaster preparedness initiatives have strengthened resilience in many developing countries (FAO, 2023; UNDRR, 2023). However, awareness alone cannot reduce vulnerability without sustained investment in healthcare, social protection, resilient livelihoods, and effective governance.

Recognizing the growing threats posed by climate change, the Government of Bangladesh has adopted several national policies and strategic frameworks to strengthen climate resilience and disaster risk reduction. Major initiatives, including the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), the Bangladesh Delta Plan 2100, and the National Adaptation Plan (NAP), emphasize resilient infrastructure, water resource management, disaster preparedness, food security, and sustainable development (Ministry of Environment, Forest and Climate Change, GoB, 2023). Bangladesh has also gained international recognition for reducing cyclone-related mortality through improved early warning systems, cyclone shelters, community-based disaster preparedness, and coordinated emergency response mechanisms (UNDRR, 2023; World Bank, 2022). These achievements demonstrate the country's progress in disaster risk reduction and climate adaptation.

Despite these advances, important challenges remain in addressing the health consequences of climate change. National adaptation efforts have largely focused on

infrastructure development, agriculture, disaster management, and coastal protection, while comparatively less attention has been given to strengthening climate-resilient healthcare systems and integrating public health into adaptation planning (Romanello et al., 2023; WHO, 2023). Healthcare facilities in vulnerable coastal regions frequently experience shortages of skilled personnel, medical supplies, diagnostic equipment, emergency transport, and disaster-resilient infrastructure, limiting their ability to respond effectively during climate-related emergencies (Hossain et al., 2023; Islam et al., 2025). In addition, financial constraints, weak institutional coordination, and unequal access to healthcare continue to restrict timely medical care for many vulnerable households (Sultana et al., 2023; World Bank, 2022). These limitations highlight the need to strengthen health system resilience as a core component of future climate adaptation strategies.

A growing body of research has examined the relationship between climate change and health in Bangladesh and other climate-vulnerable settings. Previous studies have documented the impacts of cyclones, flooding, salinity intrusion, rising sea levels, and riverbank erosion on livelihoods, food security, migration, water quality, infectious diseases, maternal health, nutrition, and mental well-being (Ashrafuzzaman et al., 2023; Hossain et al., 2023; Islam et al., 2024; Sarkar et al., 2024). Other researchers have emphasized the influence of socioeconomic status, education, gender, and institutional support on vulnerability and adaptive capacity (Ahmed et al., 2016; Sultana et al., 2023). Collectively, these studies have enhanced understanding of the multiple pathways through which climate change affects health and human well-being.

Nevertheless, several important research gaps remain. Many existing studies examine individual dimensions of climate change—such as disaster exposure, salinity intrusion, healthcare accessibility, or livelihood disruption—without considering how these factors interact to shape overall health vulnerability. Furthermore, much of the existing research relies on qualitative approaches or geographically localized case studies, which provide valuable contextual insights but offer limited opportunities for statistical analysis and generalization (Islam et al., 2025; Sultana et al., 2023). Quantitative evidence that simultaneously examines climate exposure, health outcomes, healthcare accessibility, climate awareness, institutional support, and socioeconomic characteristics remains comparatively limited for coastal Bangladesh.

Another limitation of previous research is the insufficient integration of environmental, health, and social determinants within a single analytical framework. Health vulnerability is influenced not only by climatic exposure but also by demographic characteristics, household income, education, occupation, healthcare accessibility, disaster preparedness, institutional support, and community awareness (IPCC, 2023; WHO, 2023). Considering these factors together provides a more comprehensive understanding of vulnerability and supports the design of targeted adaptation strategies and public health interventions.

Although Bangladesh has achieved significant progress in disaster risk reduction, relatively few quantitative studies have examined public perceptions of climate-related health risks alongside actual experiences of climate exposure, illness, healthcare accessibility, and adaptation. Public perceptions influence preventive behavior, healthcare-seeking practices, participation in adaptation programs, and acceptance of government policies. Integrating perception-based measures with objective indicators of climate exposure and health vulnerability therefore offers a more complete understanding of community resilience, particularly in coastal areas where climate hazards are increasing in frequency and intensity.

Therefore, this study aims to examine the relationship between climate change exposure and health vulnerability among residents of coastal areas of Bangladesh using a quantitative research approach. Specifically, the study assesses climate exposure, identifies climate-related health outcomes, examines healthcare accessibility challenges, evaluates climate change awareness and institutional support, and analyzes public perceptions regarding climate-related health risks. In addition, the study investigates the associations among demographic characteristics, environmental exposure, healthcare accessibility, institutional support, and health-related outcomes to identify the factors shaping vulnerability in climate-prone coastal communities.

Based on the existing literature and the conceptual framework of climate vulnerability proposed by the IPCC (2023), this study assumes that health vulnerability among coastal populations is influenced by the interaction between climate exposure, socioeconomic characteristics, healthcare accessibility, and institutional capacity. Therefore, the following hypotheses were developed:

H1: There is a significant association between gender and self-reported health status among residents of coastal areas of Bangladesh.
H2: There is a significant association between educational level and climate change awareness among residents of coastal areas of Bangladesh.
H3: There is a significant association between climate-induced displacement and self-reported health status among residents of coastal areas of Bangladesh.
H4: There is a significant association between the frequency of climate-related events and the frequency of illness among residents of coastal areas of Bangladesh.
H5: There is a significant association between receiving government or NGO support or both, and the perceived effectiveness of climate adaptation support programs among residents of coastal areas of Bangladesh.
H6: There is a significant association between difficulty in accessing healthcare services and self-reported health status among residents of coastal areas of Bangladesh.

By applying a multidimensional analytical framework based on the IPCC vulnerability approach, this study contributes to the existing literature by examining how environmental hazards interact with social and institutional determinants to influence health outcomes. The findings are expected to provide empirical evidence for policymakers, public health professionals, and development organizations in

designing more effective climate adaptation strategies, strengthening healthcare resilience, and reducing health inequalities among vulnerable coastal populations in Bangladesh.

2. Methodology

Research Design

This study employed a quantitative cross-sectional research design to examine the relationship between climate change exposure and health vulnerability in coastal areas of Bangladesh. This design was selected because it allows for the systematic collection of numerical data at a single point in time and enables statistical analysis of associations among climate exposure, health outcomes, healthcare accessibility, and awareness-related variables.

Study Area

The study was conducted in selected coastal regions of Bangladesh, which are frequently affected by climate-induced hazards such as cyclones, salinity intrusion, flooding, and river erosion. These areas were chosen owing to their high environmental vulnerability and documented impacts on public health and livelihood conditions.

Study Population and Sample Size

The target population consisted of households residing in climate-vulnerable coastal communities. Respondents were considered eligible if they:

- were 18 years of age or older;
- had resided in the selected coastal community for at least two years;
- possessed sufficient knowledge of household experiences related to climate change and health; and
- voluntarily agreed to participate by providing informed consent.

Individuals who were temporary residents, visitors, or unable to provide reliable responses owing to severe illness or cognitive impairment were excluded. A total of 386 respondents were selected for the study, which was considered adequate for performing descriptive and inferential statistical analysis, including chi-square tests, correlation analysis, and reliability testing.

Sampling Technique

A multistage cluster sampling technique was applied to ensure representativeness. In the first stage, coastal districts were selected based on their vulnerability to climate change. In the second stage, specific *upazilas* and villages were chosen from those districts. In the third stage, households were selected using simple random sampling, and one eligible respondent was interviewed from each household to avoid duplication and ensure independence of responses. To minimize sampling error, probability sampling procedures were applied at each stage, sampling was conducted across multiple geographic clusters to improve representativeness, and only one respondent was selected from each household to ensure independence of observations. Furthermore, a relatively large sample size (n = 386) helped reduce sampling variability and improve the precision of the estimates.

Data Collection Method
Primary data were collected using a structured questionnaire survey. The questionnaire consisted of both close-ended and Likert-scale questions. It captured detailed information on socio-demographic characteristics, climate exposure, health vulnerability, healthcare accessibility, climate change awareness, and institutional support. Data were collected through face-to-face methods to ensure accuracy and clarity of responses.

Measurement of Variables
The study used multiple sets of variables. Climate exposure was measured through respondents' experiences of cyclones, salinity intrusion, flooding, and river erosion, along with the frequency of climate events and livelihood disruption. Health vulnerability was measured using self-reported health status, frequency of illness, and types of diseases experienced in households. Healthcare accessibility was assessed through distance to facilities, service utilization patterns, and perceived barriers, while climate change awareness and institutional support were measured using categorical and Likert-scale indicators. The perception scale included six Likert-type statements related to climate change and health vulnerability, measured on a five-point scale. These were used to assess respondents' attitudes toward climate risk, healthcare adequacy, and government response.

Data Analysis Techniques
Data were analyzed using statistical software (SPSS version 29.0). The analysis was conducted in multiple stages. First, descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize socio-demographic characteristics, climate exposure, health conditions, healthcare access, and awareness levels.

Second, inferential statistics were applied to examine relationships between variables. Chi-square tests of independence were used to assess associations between categorical variables such as gender and health status, education and awareness, displacement and health outcomes, climate event frequency and illness, healthcare access and health status, and institutional support and perceived effectiveness. Third, Spearman's rank-order correlation was used to examine relationships between the perception scale and selected ordinal variables, including climate exposure, health vulnerability, healthcare accessibility, and climate change awareness.

Reliability and Validity
The internal consistency of the perception scale was assessed using Cronbach's alpha, which yielded a value of 0.691, indicating acceptable reliability for exploratory social science research. Item-total statistics were also examined to assess the contribution of each statement to overall reliability. Although two items showed weak item-total correlations due to low response variability, they were retained for conceptual completeness. Content validity was ensured through expert review and refinement of the questionnaire prior to data collection.

Ethical Considerations

Ethical procedures were strictly followed throughout the study. Informed consent was obtained from all respondents before data collection. Participation was voluntary, and respondents were assured of confidentiality and anonymity. All data were used exclusively for academic purposes, and no personal identifiers were recorded or disclosed.

3. Findings

Descriptive Statistics

A total of 386 respondents participated in this study. Descriptive statistics were used to summarize the socio-demographic characteristics of the respondents. Continuous variables were presented as mean and standard deviation (Mean ± SD), while categorical variables were presented using frequencies and percentages (Table 1):

Table 1: Respondents' socio-demographic characteristics (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	Mean ± SD	29.90 ± 7.65	-
Gender	Male	217	56.2
	Female	169	43.8
Marital status	Married	215	55.7
	Unmarried	171	44.3
Educational level	No formal education	26	6.7
	Primary	31	8.0
	Secondary	14	3.6
	Higher secondary	81	21.0
	Graduate or above	234	60.6
Occupation	Student	125	32.4
	Housewife	76	19.7
	Teacher	48	12.4
	Government job holder	32	8.3
	Shopkeeper	27	7.0
	Farmer	25	6.5
	Private job holder	23	6.0
	Freelancer	23	6.0
	Rickshaw puller	7	1.8
Monthly income	<10,000 Tk	182	47.2
	10,000–20,000 Tk	84	21.8
	20,000–30,000 Tk	49	12.7
	30,000–40,000 Tk	48	12.4
	>50,000 Tk	23	6.0
Household size	Mean ± SD	5.44 ± 1.47	-

Table 1 presents the socio-demographic characteristics of the respondents (N = 386). The mean age of the respondents was 29.90 years (SD = 7.65), indicating that the study population consisted predominantly of young and economically active individuals. The average household size was 5.44 members (SD = 1.47), reflecting the prevalence of relatively large household structures in coastal communities of Bangladesh. Such household characteristics may influence both exposure to climate risks and the availability of social support during climate-related emergencies.

Regarding gender distribution, 217 respondents were male (56.2%) and 169 were female (43.8%), showing a slightly higher representation of males in the sample. More than half of the respondents were married (55.7%), while 44.3% were unmarried. The high proportion of married respondents suggests that many participants had household responsibilities, which may shape their experiences of climate-induced livelihood challenges and health-related risks.

Educational attainment varied considerably among respondents. The majority had completed graduate-level education or above (60.6%), followed by those with higher secondary education (21.0%). However, a smaller proportion reported no formal education (6.7%), primary education (8.0%), or secondary education (3.6%). This variation indicates differences in educational resources within the study population, which may influence access to climate-related information, awareness, and adaptive capacity.

The occupational distribution demonstrated diversity among respondents. Students represented the largest occupational group (32.4%), followed by housewives (19.7%) and teachers (12.4%). Other occupational categories included government employees, shopkeepers, farmers, private-sector employees, freelancers, and rickshaw pullers. The presence of respondents from different occupational backgrounds reflects the socioeconomic diversity of coastal communities and suggests varying levels of dependence on climate-sensitive livelihoods.

Monthly income distribution revealed considerable economic vulnerability. Nearly half of the respondents (47.2%) reported a monthly income below Tk. 10,000, while only 6.0% reported earning above Tk. 50,000 per month. Despite the relatively high educational attainment among respondents, a substantial proportion experienced limited economic resources. This economic condition may reduce households' ability to invest in preventive healthcare, disaster preparedness, and long-term climate adaptation strategies.

Climate Exposure

Climate exposure was assessed by examining the types of climate-related hazards experienced by respondents during the previous five years, frequency of exposure, displacement due to climate events, and perceived impacts on livelihoods (Table 2):

Table 2: Climate exposure of the respondents (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Climate events experienced	Cyclone and salinity	104	26.9
	Salinity	94	24.4
	Cyclone	69	17.9
	Cyclone, salinity and river erosion	56	14.5
	Flood and cyclone	22	5.7
	Flood and salinity	12	3.1
	Flood	9	2.3
	Flood, cyclone and salinity	8	2.1
	Salinity and river erosion	8	2.1
	Flood, cyclone, salinity and river	4	1.0

	erosion		
Frequency of climate events	Rare	27	7.0
	Sometimes	147	38.1
	Frequent	212	54.9
Displacement due to climate events	Yes	54	14.0
	No	332	86.0
Impact on livelihood	Not at all	46	11.9
	Slightly	168	43.5
	Moderately	99	25.6
	Severely	73	18.9

Table 2 demonstrates that respondents experienced multiple and overlapping climate hazards rather than isolated environmental events. Cyclone and salinity intrusion were the most commonly reported climate hazards, affecting 26.9% and 24.4% of respondents, respectively. A considerable proportion also experienced combined hazards, including cyclone, salinity, and river erosion (14.5%), indicating that coastal populations are exposed to complex environmental challenges where multiple hazards interact simultaneously.

The frequency of climate events further highlights the intensity of climate exposure among respondents. More than half of the participants (54.9%) reported experiencing climate events frequently, while 38.1% experienced such events sometimes and only 7.0% reported rare exposure. This pattern suggests that climate-related hazards have become a recurring feature of daily life rather than occasional disruptions in coastal communities.

Although climate-induced displacement was reported by a relatively smaller proportion of respondents (14.0%), livelihood impacts were widespread. Nearly nine out of ten respondents reported some degree of livelihood disruption, including slight (43.5%), moderate (25.6%), and severe (18.9%) impacts. These findings indicate that climate hazards affect households not only through direct displacement but also through gradual economic pressures, reduced livelihood security, and disruption of everyday activities.

Overall, the findings demonstrate substantial climate exposure among coastal residents, characterized by repeated hazard experiences and cumulative effects on household livelihoods. Such persistent exposure represents an important dimension of health vulnerability, as environmental stressors can influence disease patterns, healthcare needs, and adaptive capacity.

Health Vulnerability

Health vulnerability was assessed by examining the diseases experienced by respondents' family members during the previous two years, respondents' self-rated health status, and the frequency of illness experienced during the same period. These indicators provided an overview of the health impacts associated with climate change in the study area (Table 3):

Table 3: Health vulnerability of the respondents (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Diseases experienced in the family (last two years)	Diarrhea	74	19.2
	Skin problems	81	21.0
	Respiratory diseases	96	24.9
	Malnutrition	38	9.8
	Diarrhea and skin problems	24	6.2
	Diarrhea and respiratory diseases	18	4.7
	Skin problems and Respiratory diseases	21	5.4
	Multiple diseases (three or more)	34	8.8
Self-related health status	Good	133	34.5
	Moderate	191	49.5
	Poor	62	16.1
Frequency of illness (past year)	Rare	69	17.9
	Occasional	203	52.6
	Frequent	114	29.5

Table 3 presents the health vulnerability characteristics of respondents (N = 386). The findings indicate a considerable prevalence of climate-sensitive health conditions among the study population. Respiratory diseases were the most frequently reported health condition, affecting 24.9% of respondents' families, followed by skin-related problems (21.0%) and diarrheal diseases (19.2%). Other reported conditions included malnutrition (9.8%) and multiple disease experiences (8.8%). The prevalence of these health problems reflects the potential influence of environmental stressors, including poor water quality, sanitation challenges, salinity intrusion, and changing climatic conditions in coastal areas.

Regarding self-reported health status, only 34.5% of respondents considered their health condition good, whereas nearly half (49.5%) reported moderate health status. Additionally, 16.1% reported poor health. The relatively high proportion of respondents reporting moderate or poor health suggests that many individuals experience ongoing health challenges, which may increase their vulnerability to additional climate-related stresses.

The frequency of illness further supports this pattern of health vulnerability. More than half of the respondents (52.6%) experienced illness occasionally, while 29.5% reported frequent illness during the previous year. Only 17.9% reported rare illness experiences. This indicates that illness episodes were common among coastal residents, suggesting persistent health pressures within communities exposed to climate-related environmental changes.

The findings demonstrated that climate-vulnerable coastal populations experienced a substantial burden of health risks, particularly through respiratory, skin, and water-related diseases. The combination of frequent illness occurrence and poor self-

rated health highlighted the importance of strengthening climate-resilient healthcare systems and preventive health interventions in these areas.

Healthcare Accessibility

Healthcare accessibility was assessed by examining the distance to the nearest healthcare facility, the type of healthcare facility used, difficulties in accessing healthcare services, major barriers to healthcare access, and changes in healthcare accessibility during climate-related disasters (Table 4):

Table 4: Healthcare accessibility of the respondents (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Distance to nearest healthcare facility	<1 km	102	26.4
	1–2 km	103	26.7
	2–3 km	114	29.5
	3–4 km	40	10.4
	>5 km	27	7.0
Healthcare facility usually used	Government Hospital	205	53.1
	Private clinic	116	30.1
	Pharmacy	60	15.5
	Traditional healer	5	1.3
Difficulty accessing healthcare	Yes	300	77.7
	No	86	22.3
Main barriers to healthcare access*	Financial cost	189	49.0
	Lack of doctors	177	45.9
	Transportation	174	45.1
	Distance	133	34.5
Healthcare access during climate disasters	Easier	8	2.1
	Same	73	18.9
	More difficult	305	79.0

**Note: Respondents were allowed to select multiple barriers; therefore, percentages exceed 100%*

Table 4 presents healthcare accessibility characteristics among respondents (N = 386). The findings indicate that geographical proximity to healthcare facilities did not necessarily ensure effective healthcare access. Although 53.1% of respondents reported living within two kilometers of the nearest healthcare facility, a substantial proportion still experienced difficulties accessing healthcare services.

A large majority of respondents (77.7%) reported experiencing difficulties in accessing healthcare, while only 22.3% reported no such difficulties. This finding suggests that healthcare accessibility challenges extend beyond physical distance and involve broader structural barriers affecting healthcare utilization.

Regarding healthcare service utilization, government hospitals were the most commonly used healthcare facilities (53.1%), followed by private clinics (30.1%) and pharmacies (15.5%). Only a small proportion relied on traditional healers (1.3%), indicating a general preference for formal healthcare services among respondents.

Financial constraints represented the most frequently reported barrier to healthcare access, affecting 49.0% of respondents. Other major barriers included lack of doctors (45.9%), transportation difficulties (45.1%), and distance from healthcare facilities

(34.5%). These findings demonstrate that healthcare access in coastal communities is influenced by multiple socioeconomic and infrastructural factors rather than a single limitation.

Climate-related disasters further intensified healthcare accessibility problems. Approximately four-fifths of respondents (79.0%) reported that healthcare access became more difficult during climate disasters, while only 2.1% experienced improved access. This finding highlights the vulnerability of existing healthcare systems during extreme events, when demand for medical services increases while transportation networks and service delivery mechanisms may be disrupted.

Overall, the findings indicated that healthcare accessibility remained a major challenge among coastal populations. Limited financial resources, inadequate healthcare infrastructure, shortage of healthcare providers, and disaster-related disruptions collectively reduced the ability of vulnerable communities to receive timely medical care.

Climate Change Awareness

Climate change awareness was assessed by examining respondents' awareness of climate change, participation in climate-related training or awareness programs, sources of climate change information, awareness of government or NGO climate change initiatives, and receipt of government or NGO support (Table 5):

Table 5: Climate change awareness of the respondents (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Awareness of climate change	Yes	342	88.6
	No	44	11.4
Received training/awareness program	Yes	138	35.8
	No	248	64.2
Source of climate change information*	Television	214	55.4
	Social media	172	44.6
	Community members	155	40.2
	NGOs	128	33.2
	Radio	91	23.6
	Other	18	4.7
Aware of government/NGO climate programs	Yes	219	56.7
	No	167	43.3
Received government/NGO support	Yes	164	42.5
	No	222	57.5

**Multiple responses were allowed; therefore, percentages exceed 100%*

Table 5 presents respondents' climate change awareness characteristics (N = 386). The majority of respondents (88.6%) reported being aware of climate change, while only 11.4% indicated a lack of awareness. This high level of awareness suggests that repeated exposure to climate-related hazards has increased recognition of climate change among coastal residents.

Despite this high level of general awareness, participation in formal climate-related training or awareness programs remained limited. Only 35.8% of respondents reported receiving climate-related training, whereas 64.2% had not participated in any formal awareness program. This difference indicates a gap between general awareness and structured capacity-building opportunities.

Mass media played an important role in disseminating climate-related information. Television was the most common information source (55.4%), followed by social media (44.6%), community members (40.2%), NGOs (33.2%), and radio (23.6%). These findings suggest that informal information channels, particularly electronic media, are important mechanisms for increasing climate awareness among coastal communities.

Although awareness levels were high, institutional outreach remained limited. More than half of the respondents (56.7%) reported awareness of government or NGO climate programs, while 43.3% were unaware of such initiatives. Furthermore, only 42.5% reported receiving government or NGO support. This indicates that awareness of climate change does not necessarily translate into access to adaptation resources and institutional assistance.

Overall, the findings revealed a distinction between knowledge and adaptive capacity. While respondents demonstrated substantial awareness of climate change risks, limited participation in training programs and restricted access to institutional support may constrain their ability to respond to climate-related challenges effectively.

Government and NGO Support

To assess institutional support for climate change adaptation and health protection, respondents were asked whether they had received any support from government or NGOs, the type of support received, and their perception of the effectiveness of such programs (Table 6):

Table 6: Government and NGO support received by the respondents (N = 386)

Variable	Category	Frequency (n)	Percentage (%)
Received government/NGO support	Yes	164	42.5
	No	222	57.5
Type of support received*	Relief support	81	49.4
	Financial assistance	37	22.6
	Medical support	24	14.6
	Training	22	13.4
Perceived effectiveness of support programs	High	49	29.9
	Moderate	86	52.4
	Low	29	17.7

**Percentages for the type of support are calculated among the 164 respondents who reported receiving government or NGO assistance*

Table 6 demonstrates that access to institutional support remained limited among the surveyed population. Out of 386 respondents, only 164 (42.5%) reported receiving assistance from government or NGO organizations, whereas the majority (57.5%) had not received any form of institutional support. This finding indicates that despite the high exposure of coastal communities to climate-related hazards, a substantial proportion of vulnerable households may remain outside the coverage of existing adaptation and support mechanisms.

Among respondents who received government or NGO assistance, relief support was the most common form of intervention, reported by 81 respondents (49.4%). This suggests that institutional responses were largely focused on immediate disaster relief rather than long-term adaptation strategies. Financial assistance was received by 37 respondents (22.6%), while medical support (14.6%) and climate-related training (13.4%) were comparatively less common. The limited provision of training and medical assistance indicates a potential gap in strengthening long-term resilience, particularly in areas where climate change increasingly affects health outcomes and healthcare accessibility.

Regarding perceived effectiveness, more than half of the beneficiaries (52.4%) considered government and NGO support programs moderately effective, while 29.9% rated them as highly effective. However, 17.7% of respondents perceived these interventions as having low levels of effectiveness. This variation suggests that although institutional support contributes positively to community resilience, existing programs may not fully address the complex and long-term consequences of climate change, including healthcare challenges, livelihood insecurity, and recurring environmental risks.

Overall, the findings indicated a mismatch between the increasing climate vulnerability of coastal populations and the availability of institutional support. While government and NGO interventions provided important assistance, their coverage and nature appear insufficient for building comprehensive adaptive capacity. Strengthening community-based adaptation programs, expanding healthcare-related support, and increasing access to climate resilience training may enhance the ability of coastal communities to cope with future climate-related health risks.

Table 7: Mean, standard deviation, and ranking of the Likert-scale statements (N = 386)

Rank	Statement	Mean	Standard Deviation
1	Climate change is a serious health threat	**4.87**	**0.34**
2	Climate change is affecting health in your area	**4.79**	**0.46**
3	Government policies adequately address climate-related health issues	**2.66**	**0.84**
4	Healthcare services are sufficient	**2.36**	**0.83**
5	Vulnerable people receive enough help	**2.21**	**0.74**
6	Government support is adequate	**2.19**	**0.71**

Table 7 illustrates that respondents demonstrated a very high level of awareness regarding the health consequences of climate change. The statement "Climate change is a serious health threat" received the highest mean score (M = 4.87, SD = 0.34), indicating almost universal agreement among respondents. Similarly, the statement "Climate change is affecting health in your area" also received a very high mean score (M = 4.79, SD = 0.46). These findings suggest that coastal residents have direct experience of climate-related health risks and recognize climate change as an immediate threat rather than only a future environmental concern.

In contrast, respondents expressed relatively low levels of satisfaction regarding institutional responses and healthcare capacity. The statement "Government policies adequately address climate-related health issues" received a moderate to low mean score (M = 2.66, SD = 0.84), indicating that many respondents perceived existing policies as insufficient in addressing climate-related health challenges. Similarly, the statement "Healthcare services are sufficient" recorded a low mean score (M = 2.36, SD = 0.83), reflecting concerns regarding the availability, accessibility, and quality of healthcare services in climate-vulnerable areas.

The lowest mean scores were observed for "Vulnerable people receive enough help" (M = 2.21, SD = 0.74) and "Government support is adequate" (M = 2.19, SD = 0.71). These results indicate a significant perception gap between climate risk awareness and the effectiveness of adaptation support systems. Although respondents strongly recognized the health impacts of climate change, they expressed dissatisfaction with the level of assistance provided to vulnerable populations.

The overall pattern demonstrates a clear contrast between high awareness of climate-related health risks and limited confidence in existing institutional responses. Coastal residents appear to understand the severity of climate change impacts based on their lived experiences; however, they perceive healthcare systems, government interventions, and support mechanisms as inadequate for addressing growing climate-related vulnerabilities. These findings emphasize the importance of integrating health-focused adaptation measures, strengthening local healthcare infrastructure, and improving targeted support programs for climate-affected communities.

Reliability Analysis

Reliability analysis was conducted to assess the internal consistency of the six Likert-scale statements measuring respondents' perceptions of climate change and health vulnerability. Cronbach's alpha was used as the measure of scale reliability. Generally, a Cronbach's alpha value of 0.70 or higher is considered acceptable, although values close to 0.70 may also be considered satisfactory in exploratory social science research.

Table 8: Reliability statistics of the perception scale (N = 386)

Reliability Measure	Value
Number of items	6
Cronbach's alpha	0.691

The reliability analysis produced a Cronbach's alpha coefficient of 0.691 for the six-item perception scale. This value indicated moderate internal consistency among the items. Although it was slightly below the conventional threshold of 0.70, it was considered acceptable for exploratory research in the social sciences, particularly when the questionnaire measures multiple dimensions of climate change and health vulnerability.

The result suggested that the six statements were reasonably consistent in measuring respondents' perceptions of climate change and health-related issues. Therefore, the scale was considered sufficiently reliable for subsequent inferential statistical analyses, including correlation analysis, chi-square tests, and regression analysis.

Item-Total Statistics

To further assess the internal consistency of the perception scale, corrected item-total correlations and Cronbach's alpha if "Item Deleted" were computed for each of the six statements. The corrected item-total correlation indicates the extent to which each statement was associated with the overall scale score, while Cronbach's alpha if "Item Deleted" shows whether removing an item would improve the reliability of the scale (Table 9).

Table 9: Item-total statistics of the perception scale (N = 386)

Statement	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Climate change is a serious health threat	-0.016	0.735
Climate change is affecting health in your area	-0.074	0.757
Healthcare services are sufficient	0.573	0.592
Government policies adequately address climate-related health issues	0.560	0.598
Government support is adequate	0.811	0.502
Vulnerable people receive enough help	0.564	0.598

Table 9 presents the corrected item-total correlations and Cronbach's alpha values if each item was deleted from the scale. The statements "Healthcare services are sufficient," "Government policies adequately address climate-related health issues," "Government support is adequate," and "Vulnerable people receive enough help" all exhibited satisfactory positive item-total correlations, ranging from 0.560 to 0.811. These results indicated that these items contribute positively to the overall reliability of the scale. In contrast, the first two statements "Climate change is a serious health threat" and "Climate change is affecting health in your area" showed very low negative corrected item-total correlations (-0.016 and -0.074, respectively). This suggested that these two statements measured a somewhat different aspect of respondents' perceptions compared with the remaining items. One possible explanation was that almost all respondents strongly agreed with these statements, resulting in very little variation in responses. The "Cronbach's alpha if item deleted" statistics further support this interpretation. Removing either of the first two items would increase the overall reliability coefficient from 0.691 to 0.735 and 0.757, respectively. Conversely, deleting any of the remaining four items would reduce the

overall reliability, indicating that these items were important contributors to the consistency of the scale.

Inferential Statistics

Table 10: Cross-tabulation between gender and self-reported health status (N = 386)

Gender	Good	Moderate	Poor	Total
Male	113	83	21	217
Female	70	99	0	169
Total	**183**	**182**	**21**	**386**

Table 11: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	26.958	2	<0.001
Likelihood ratio	27.741	2	<0.001
Linear-by-linear association	18.523	1	<0.001
N of valid cases	386		

A Pearson chi-square test was conducted to examine the association between gender and self-reported health status among respondents. The results revealed a statistically significant relationship between the two variables ($\chi^2 = 26.958$, df = 2, $p < 0.001$), indicating that health status varies significantly by gender. The cross-tabulation showed that a higher proportion of male respondents reported good health (52.1%) compared to females (41.4%). Conversely, a larger share of female respondents reported moderate health status (58.6%), suggesting comparatively different health perception patterns between genders. Notably, all the respondents who reported poor health were male (21 cases), which indicated an uneven distribution of severe health conditions within the sample. These findings suggest that gender plays an important role in shaping health vulnerability in coastal communities. Differences may be linked to occupational exposure, healthcare-seeking behavior, socioeconomic roles, and differential exposure to environmental risks.

Table 12: Cross-tabulation between educational level and climate change awareness (N = 386)

Educational Level	Aware (Yes)	Not Aware (No)	Total
No formal education	0	26	26
Primary	27	4	31
Secondary	10	4	14
Higher secondary	76	5	81
Graduate or above	234	0	234
Total	**347**	**39**	**386**

Table 13: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	264.535	4	<0.001
Likelihood ratio	271.918	4	<0.001
Linear-by-linear association	211.347	1	<0.001
N of valid cases	**386**		

The association between educational level and climate change awareness was highly significant ($\chi^2 = 264.535$, df = 4, $p < 0.001$), indicating a strong dependency between education and awareness of climate-related issues.

The pattern of association showed a clear gradient effect. All respondents with graduate-level education or above reported awareness of climate change (100%). Similarly, a very high proportion of respondents with higher secondary education (93.8%) and primary education (87.1%) were also aware. In contrast, none of the respondents with no formal education reported awareness, highlighting a complete lack of awareness in this group. This strong statistical relationship suggests that education significantly enhances exposure to information, environmental literacy, and access to media sources. It also reflects the role of formal education in shaping environmental perception and risk understanding in climate-vulnerable regions.

Table 14: Cross-tabulation between displacement and self-reported health status (N = 386)

Displacement due to climate events	Good	Moderate	Poor	Total
No	176	143	13	332
Yes	7	39	8	54
Total	**183**	**182**	**21**	**386**

Table 15: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	34.225	2	<0.001
Likelihood ratio	32.987	2	<0.001
Linear-by-linear association	28.533	1	<0.001
N of valid cases	**386**		

A statistically significant association was found between displacement due to climate events and self-reported health status ($\chi^2 = 34.225$, df = 2, $p < 0.001$).

The results showed clear evidence of worse health outcomes among displaced individuals. Among non-displaced respondents, more than half (53.0%) reported good health, while only 3.9% reported poor health. In contrast, among displaced respondents, the proportion reporting good health dropped significantly to 13.0%, while moderate and poor health categories increased substantially. This pattern suggests that displacement due to climate hazards is strongly associated with deteriorating health conditions. Displacement may disrupt access to healthcare, safe drinking water, sanitation, stable income, and social support systems, thereby increasing health vulnerability.

Table 16: Cross-tabulation between frequency of climate events and frequency of illness (N = 386)

Frequency of Climate Events	Always	Sometimes	Very Few	Total
Frequent	35	91	86	212
Sometimes	4	108	35	147
Rare	0	12	15	27
Total	**39**	**211**	**136**	**386**

Table 17: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	44.959	4	<0.001
Likelihood ratio	47.118	4	<0.001
Linear-by-linear association	31.214	1	<0.001
N of valid cases	**386**		

The relationship between frequency of climate events and frequency of illness was found to be highly significant ($\chi^2 = 44.959$, df = 4, $p < 0.001$), confirming a strong association between environmental exposure and health outcomes. Respondents who experienced frequent climate events reported higher rates of illness occurrence, including both "Always ill" and "Sometimes ill" categories. In contrast, those experiencing rare climate events reported comparatively lower illness frequency. This finding suggests a cumulative health impact of repeated climate exposure. Frequent climate hazards are likely to contribute to environmental degradation, including water contamination, poor sanitation, and increased exposure to infectious diseases, which together elevate illness risk among coastal populations.

Table 18: Cross-tabulation between government/NGO support and perceived effectiveness of support programs (N = 386)

Received Government/NGO Support	High	Moderate	Low	Total
Yes	74	113	0	187
No	7	80	112	199
Total	**81**	**193**	**112**	**386**

Table 19: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	172.856	2	<0.001
Likelihood ratio	193.448	2	<0.001
Linear-by-linear association	141.667	1	<0.001
N of valid cases	**386**		

A strong and highly significant association was observed between receipt of government/NGO support and perceived effectiveness of such support ($\chi^2 = 172.856$, df = 2, $p < 0.001$). Among respondents who received support, none reported low levels of effectiveness, while the majority rated the support as moderately or highly effective. In contrast, among those who did not receive support, a large proportion perceived the programs as ineffective or only moderately effective. This suggests that direct exposure to institutional interventions significantly improves perceptions of effectiveness. It also indicates that lack of access to support may negatively influence trust in government and NGO initiatives.

Table 20: Cross-tabulation between difficulty accessing healthcare and self-reported health status (N = 386)

Difficulty Accessing Healthcare	Good	Moderate	Poor	Total
No	50	36	0	86
Yes	133	146	21	300
Total	**183**	**182**	**21**	**386**

Table 21: Chi-square test results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	9.364	2	0.009
Likelihood ratio	11.276	2	0.004
Linear-by-linear association	7.864	1	0.005
N of valid cases	**386**		

A significant association was found between difficulty in accessing healthcare and self-reported health status ($\chi^2 = 9.364$, df = 2, p = 0.009).

Respondents who did not experience difficulties in accessing healthcare reported better health outcomes, with 58.1% reporting good health and none reporting poor health. In contrast, those facing access barriers showed a higher proportion of moderate and poor health conditions. These results indicate that healthcare accessibility is a key determinant of health status in coastal areas. Barriers such as financial cost, transportation difficulties, shortage of medical personnel, and distance contribute directly to poorer health outcomes, particularly in vulnerable settings.

Spearman Correlation Analysis

Spearman's rank-order correlation was conducted to examine the relationship between respondents' perception score and selected climate- and health-related variables. Spearman's correlation was chosen because the variables were ordinal in nature.

Table 22: Spearman correlation analysis (N = 386)

Variable	Spearman's ρ	p-value	Interpretation
Climate exposure	0.007	0.893	Not significant
Health vulnerability	−0.102	0.044	Weak negative correlation*
Healthcare accessibility	0.028	0.579	Not significant
Climate change awareness	−0.047	0.362	Not significant

** $p < 0.05$*

Spearman's correlation analysis was conducted to examine relationships between perception scores and selected variables. No significant relationships were observed between perception score and climate exposure ($\rho = 0.007$, p = 0.893), healthcare accessibility ($\rho = 0.028$, p = 0.579), or climate change awareness ($\rho = -0.047$, p = 0.362). This suggests that perception scores are largely independent of these variables. However, a weak but statistically significant negative correlation was found between health vulnerability and perception score ($\rho = -0.102$, p = 0.044). This indicates that individuals with higher perception scores tend to report slightly lower levels of illness, although the relationship is weak in magnitude. Overall, the correlation results suggest that perception is not strongly influenced by socio-demographic or environmental variables, except for a minimal link with health condition.

4. Discussion

The present study examined the relationship between climate change exposure and health vulnerability among residents of coastal areas of Bangladesh. The findings

demonstrated that climate change is not only an environmental challenge but also a significant social and public health concern. The results indicated that coastal communities are experiencing multiple and overlapping climate hazards, including cyclones, salinity intrusion, flooding, and river erosion, which collectively contribute to increased health risks and reduced livelihood security. The study found that more than half of the respondents (54.9%) experienced climate-related events frequently, while 44.5% reported moderate to severe impacts on their livelihoods. These findings highlighted the persistent nature of climate stress in coastal Bangladesh, where repeated environmental shocks gradually weakened household resilience.

Similar findings have been reported by Sultana et al. (2023), who identified coastal fishing communities of Bangladesh as highly vulnerable owing to the combined effects of environmental exposure, livelihood dependency, and limited adaptive capacity. Likewise, the IPCC (2023) emphasized that climate vulnerability emerged from the interaction between exposure, sensitivity, and adaptive capacity, indicating that communities facing repeated hazards with limited resources experience greater risks.

The study further revealed that cyclone and salinity intrusion were the most frequently experienced climate hazards among respondents. Specifically, 26.9% of respondents reported experiencing both cyclone and salinity intrusion, while 24.4% experienced salinity-related impacts alone. These findings reflect the growing concern regarding saline water intrusion in coastal Bangladesh, where rising sea levels, tidal surges, and reduced freshwater availability have affected drinking water sources, agricultural productivity, and human health. Ashrafuzzaman et al. (2023) similarly reported that climate-induced changes in water availability and salinity levels in south-western coastal Bangladesh have created serious consequences for safe drinking water and health outcomes. Moreover, Khan et al. (2014) demonstrated that increased salinity exposure in coastal drinking water is associated with adverse maternal health outcomes, indicating that climate hazards can influence health through multiple pathways.

A major finding of this study was the substantial burden of climate-sensitive diseases among coastal households. Respiratory diseases were the most commonly reported health problems (24.9%), followed by skin diseases (21.0%) and diarrheal illnesses (19.2%). Furthermore, 52.6% of respondents reported experiencing illness occasionally and 29.5% experienced frequent illness during the previous year. These findings suggest that continuous exposure to climate-related hazards creates persistent health challenges rather than only short-term disaster impacts. Flooding, saline water intrusion, poor sanitation conditions, and contaminated water sources can increase exposure to infectious diseases and exacerbate existing health conditions. Previous research has highlighted similar patterns, showing that climate change contributes to increasing risks of waterborne diseases, respiratory problems, malnutrition, and other climate-sensitive illnesses in vulnerable populations (Hossain et al., 2023; WHO, 2023). The findings also support the work of Romanello et al. (2023), who argued that climate change is increasingly becoming a major

determinant of global health inequality, particularly affecting populations with limited resources and weak healthcare systems.

The study further identified significant challenges regarding healthcare accessibility in coastal communities. Although 53.1% of respondents reported using government hospitals as their primary healthcare source, 77.7% experienced difficulties accessing healthcare services. The major barriers included financial costs (49.0%), lack of doctors (45.9%), transportation problems (45.1%), and distance from healthcare facilities (34.5%). Additionally, 79.0% of respondents reported that healthcare access became more difficult during climate-related disasters. These findings indicate that healthcare vulnerability is not only related to disease burden but also to the capacity of health systems to respond during emergencies. Similar observations have been made by Hossain et al. (2023), who found that vulnerable communities in Bangladesh face significant barriers due to inadequate healthcare infrastructure, limited transportation, and socioeconomic constraints. The WHO (2023) also emphasized that climate-resilient healthcare systems are essential because climate hazards frequently disrupt health service delivery at the time when communities require medical support most urgently.

The inferential findings provided further evidence regarding the relationship between climate exposure and health outcomes. The study found a statistically significant association between the frequency of climate events and the frequency of illness ($\chi^2 = 44.959$, $df = 4$, $p < 0.001$). Respondents experiencing frequent climate hazards reported higher levels of illness compared with those exposed to climate events rarely. This relationship suggested that repeated exposure to environmental hazards creates cumulative health risks. Frequent flooding and cyclones may damage sanitation systems, contaminate water sources, increase exposure to disease vectors, and reduce food security, thereby increasing vulnerability to illness. Similar conclusions were reported by Hossain et al. (2023), who demonstrated that repeated exposure to natural hazards increases social vulnerability and reduces community capacity to adapt.

Climate-induced displacement was another important factor associated with health vulnerability. The study found a significant relationship between displacement due to climate events and self-reported health status ($\chi^2 = 34.225$, $df = 2$, $p < 0.001$). Among displaced respondents, only 13.0% reported good health, whereas 72.2% reported moderate health and 14.8% reported poor health. In comparison, non-displaced respondents demonstrated comparatively better health conditions, with 53.0% reporting good health. These findings indicate that displacement creates additional layers of vulnerability by disrupting livelihoods, healthcare access, social networks, and living conditions. Previous studies have similarly shown that climate displacement increases exposure to poverty, inadequate housing, unsafe water, and health risks. Islam et al. (2025) highlighted that climate-related livelihood disruption and environmental stress significantly affect the well-being of coastal populations, particularly among households with limited adaptive resources.

Education emerged as a significant determinant of climate change awareness in this study. The chi-square analysis revealed a strong association between educational level and climate change awareness ($\chi^2 = 264.535$, df = 4, $p < 0.001$). All respondents with graduate-level education or above reported awareness of climate change, while none of the respondents without formal education reported awareness. This finding demonstrates the important role of education in improving environmental knowledge and risk perception. Education enhances access to information, strengthens decision-making capacity, and encourages preventive adaptation behaviors. Previous research has also emphasized that education is a crucial component of adaptive capacity because it improves individuals' ability to understand climate risks and adopt appropriate responses (Ebi & Semenza, 2008; Sultana et al., 2023).

The findings regarding climate change perceptions revealed an important contrast between awareness and institutional response. Respondents strongly agreed that climate change is a serious health threat (Mean = 4.87, SD = 0.34) and that climate change is already affecting health in their communities (Mean = 4.79, SD = 0.46). However, perceptions regarding government support, healthcare adequacy, and assistance to vulnerable populations were considerably lower, with mean scores of 2.19, 2.36, and 2.21, respectively. This indicates that while communities possess strong awareness of climate risks, they perceive existing adaptation and healthcare responses as insufficient. Similar concerns have been raised by Romanello et al. (2023), who argued that climate adaptation efforts must move beyond risk recognition and focus on strengthening health systems, social protection, and community resilience.

The reliability analysis showed that the six-item perception scale achieved an acceptable level of internal consistency (Cronbach's alpha = 0.691). Although slightly below the conventional threshold of 0.70, this level is considered acceptable for exploratory social science research. However, the item-total analysis indicated that the statements measuring general recognition of climate risks had weak correlations because almost all respondents strongly agreed with them. This limited variation most likely reduced the overall reliability coefficient. Nevertheless, the remaining items related to healthcare services, government policies, and institutional support showed satisfactory correlations, suggesting that the scale effectively captured important dimensions of perceived climate-health vulnerability.

The role of institutional support was also highlighted in this study. Only 42.5% of respondents reported receiving government or NGO support, and among those receiving assistance, relief support was the most common form (49.4%). The chi-square analysis showed a highly significant association between receiving institutional support and the perceived effectiveness of support programs ($\chi^2 = 172.856$, df = 2, $p < 0.001$). Respondents who received support were more likely to evaluate programs positively, suggesting that direct experience with adaptation initiatives improves trust and confidence. However, the limited coverage of support programs indicates that many vulnerable households remain excluded from adaptation benefits. This finding supports the argument of the IPCC (2023) that

effective climate adaptation requires inclusive governance mechanisms that prioritize socially and economically vulnerable groups.

The Spearman correlation analysis further provided insights into the complexity of climate-health relationships. The study found no significant correlation between perception scores and climate exposure ($\rho = 0.007$, $p = 0.893$), healthcare accessibility ($\rho = 0.028$, $p = 0.579$), or climate awareness ($\rho = -0.047$, $p = 0.362$). This suggests that awareness and perceptions alone do not necessarily translate into improved health outcomes. However, a weak but significant negative relationship was found between health vulnerability and perception score ($\rho = -0.102$, $p = 0.044$), indicating that individuals experiencing greater health problems may perceive climate risks differently. This finding supports the broader understanding that climate vulnerability is multidimensional and influenced by interactions between environmental exposure, socioeconomic conditions, healthcare systems, and institutional capacity.

Overall, this study demonstrated that climate change affects health vulnerability in coastal Bangladesh through interconnected environmental, social, and institutional pathways. The findings showed that frequent exposure to climate hazards, displacement, healthcare barriers, limited institutional support, and socioeconomic disadvantages collectively increase health risks. Although awareness of climate change was high among coastal residents, significant gaps remain between awareness and adaptive capacity. Therefore, addressing climate-related health vulnerability requires integrated approaches that combine climate adaptation, resilient healthcare systems, livelihood protection, community education, and inclusive governance. Strengthening these areas will be essential for improving the resilience of coastal communities in Bangladesh as climate impacts continue to intensify.

5. Conclusion and Recommendations

This study examined the relationship between climate change and health vulnerability among residents of the coastal areas of Bangladesh. The findings demonstrate that climate change has become a significant challenge to both public health and socioeconomic well-being in the study area. The majority of respondents reported experiencing climate-related hazards, particularly cyclones, salinity intrusion, flooding, and river erosion, while many indicated that these events occurred frequently and had moderate to severe impacts on their livelihoods. The study also revealed that climate-sensitive diseases such as diarrhoea, respiratory illnesses, skin diseases, and malnutrition were common among respondents' households, indicating that environmental changes are increasingly affecting the health of coastal communities. Furthermore, a considerable proportion of respondents faced difficulties in accessing healthcare services due to financial constraints, transportation problems, long travel distances, and shortages of healthcare professionals, with these barriers becoming even more severe during climate-related disasters.

The inferential analyses further confirmed that climate change contributes significantly to health vulnerability. Statistically significant associations were observed between the frequency of climate events and illness frequency, climate-induced displacement and self-reported health status, healthcare accessibility and health status, educational attainment and climate change awareness, as well as government or NGO support and program effectiveness. These findings suggest that health vulnerability is shaped not only by environmental exposure but also by socioeconomic conditions, healthcare accessibility, educational attainment, and institutional support. Moreover, respondents strongly perceived climate change as a serious threat to human health, while expressing comparatively low levels of satisfaction with the adequacy of healthcare services, government policies, and support programs. These findings indicate that although public awareness regarding climate change is relatively high, existing adaptation and healthcare systems remain insufficient to address the increasing health risks faced by vulnerable coastal populations.

Based on these findings, several recommendations can be made to reduce climate-related health vulnerability in coastal Bangladesh. Strengthening healthcare infrastructure should be a priority through the expansion of healthcare facilities, the deployment of additional trained healthcare professionals, and the improvement of emergency medical services in disaster-prone areas. Improving transportation networks and ensuring uninterrupted access to healthcare during floods and cyclones would further reduce health risks. Government agencies and NGOs should also expand climate change awareness campaigns and community-based training programs to improve public knowledge of disease prevention, safe water management, sanitation, and disaster preparedness.

At the same time, greater institutional support is needed for vulnerable households through financial assistance, medical support, livelihood rehabilitation, and climate adaptation programs. Investment in climate-resilient water supply systems, improved sanitation facilities, and safe drinking water technologies are essential for reducing waterborne diseases associated with flooding and salinity intrusion. Promoting climate-resilient livelihoods through vocational training, alternative income-generating opportunities, and sustainable agricultural practices would also strengthen household resilience and reduce the socioeconomic impacts of climate change. Furthermore, stronger coordination among government agencies, local authorities, healthcare providers, development partners, and community organizations is necessary to implement integrated policies that simultaneously address climate adaptation and public health challenges.

Finally, future research should consider larger and more geographically diverse samples representing different coastal districts of Bangladesh to enhance the generalizability of the findings. The use of longitudinal and mixed-method research designs would also provide a more comprehensive understanding of the long-term health impacts of climate change and the effectiveness of adaptation interventions. Overall, reducing climate-related health vulnerability requires an integrated approach that combines climate adaptation, accessible healthcare services, livelihood

protection, effective public policies, and active community participation. Implementing these measures will contribute to improving the resilience, health, and well-being of coastal populations while supporting Bangladesh's long-term efforts to adapt to the growing impacts of climate change.

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7. Conflict of Interest
The authors declare that they have no conflict of interest.

8. Data Availability Statement
In accordance with the ethical protocol framing this research and the consent form of the participants, data collected, processed and analyzed have been anonymized and stored securely. Data is therefore not available for sharing to protect the safety of those who took part in the research

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Appendix A: Data Collection Questionnaire

Kindly supply the following information by ticking the appropriate block:

1. **Age:**_____
2. **Gender:**

□ Male □ Female □ Other

3. **Marital status:**

□ Unmarried □ Married □ Widowed □ Divorced

4. **Education level:**

□ No Formal Education □ Primary □ Secondary □ Higher Secondary □ Graduate or Above

5. **Occupation:**_____
6. **Monthly income:**

□ <10,000 Tk. □ 10,000-20,000 Tk. □ 20,000-30,000 Tk. □ 30,000-40,000 Tk. □ >50,000 Tk.

7. **Household size:**_____
8. **Which climate events have you experienced in the past five years? (multiple answers can be given)**

□ Flood □ Cyclone □ Salinity □ River Erosion □ Other:_____

9. **Frequency of these events:**

□ Rare □ Sometimes □ Frequent

10. **Have you been displaced due to climate events?**

□ Yes □ No

11. **How severely have these events affected your livelihood?**

□ Not At All □ Slightly □ Moderately □ Severely

12. **Which diseases have occurred in your family in the past year? (multiple answers can be given)**

□ Diarrhea □ Skin Problem □ Respiratory Disease □ Heart Disease □ Malnutrition □ No Disease □ Other:_____

13. **Do you think climate change affects your health?**

□ Yes □ No

14. **Self-related health status:**

□ Good □ Moderate □ Poor

15. **Frequency of illness in the past year:**

□ Very Few □ Sometimes □ Always

16. **Distance to nearest health facility:**

□ <1 km □ 1-2 km □ 2-3 km □ 3-4 km □ >5 km

17. **Type of healthcare facility used:**

□ Government Hospital □ Private Clinic □ Pharmacy □ Traditional Healer

18. **Do you face difficulties accessing healthcare?**

□ Yes □ No

19. If "Yes", what are the main barriers? (multiple answers can be given)

□Financial Cost □ Distance □ Lack of Doctors □ Transportation
□ Other

20. During climate disasters, access to healthcare becomes:

□ Easier □ The Same □ More Difficult

21. What strategies do you use to cope with climate-related health risks? (multiple answers can be given)

□ Boiling Water □ Buying Water to Drink □ Using Cyclone Shelter
□ Temporary Migration □ None □ Other

22. Have you changed occupation due to climate change?

□ Yes □ No

23. Have you received any training or attended awareness programs?

□ Yes □ No

24. Are you aware of climate change?

□ Yes □ No

25. If "Yes", source of information: (multiple answers can be given)

□ TV □ Radio □ Social Media □ Community □ NGO □ Other

26. Are you aware of government/NGO programs related to climate change?

□ Yes □ No

27. Have you received any support?

□ Yes □ No

28. If "Yes", what type of support did you receive? (multiple answers can be given)

□ Financial □ Medical □ Relief □ Training □ Other

29. Effectiveness of program:

□ High □ Moderate □ Low

30. Please answer the following questions:

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Climate change is a serious health threat					
Climate change is affecting health in your area					
Healthcare services are sufficient					
Government policies adequately address climate-related health issues					
Government support is adequate					
Vulnerable people receive enough help					

