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Perceived risk of child mortality and fertility choices in climate-vulnerable regions of Bangladesh

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This research examined the influence of perceived child mortality risk on the fertility choices of married women in Bangladesh. Employing a cross-sectional survey conducted in four rural areas, categorized as either vulnerable or not vulnerable to extreme climate events, a total of 759 married women were surveyed through simple random sampling, while 25 women were selected for in-depth interviews through judgment sampling. The findings indicate that women in climate-vulnerable regions express a greater desire for additional children compared to those in non-vulnerable areas. Furthermore, women who perceive increased child mortality risk and have experienced past child loss show a stronger tendency towards wanting more offspring. The qualitative insights from the interviews shed light on the underlying motivations driving these preferences, emphasizing the significance of child replacement and seeking security against potential child loss. These empirical findings provide valuable insights into the complex dynamics between perceptions of child mortality and reproductive decision-making among women in Bangladesh. The implications of this study are crucial for policymakers and practitioners, as they can guide the development of targeted interventions and policies to address reproductive health challenges in climate-vulnerable areas. By acknowledging women's perspectives and considering contextual factors, these strategies can effectively address the reproductive implications of climate vulnerability, empowering women to make informed decisions about their fertility and promoting improved reproductive outcomes and overall well-being in vulnerable communities.

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Introduction

The impact of extreme climate events on population indicators, such as mortality, migration, and fertility, is experiencing notable transformations (Frankenberg et al., 2015; Frey and Singer, 2010; Jiang and Hardee, 2011). Geographers and demographers have extensively investigated the influence of climate-related issues on health (Bakhtsiyarava et al., 2018; Grace et al., 2015), migration (Gray and Mueller, 2011; Gray and Wise, 2016; Thiede et al., 2016), and mortality (De Waal et al., 2006). However, there has been limited scholarly attention to the dynamics of fertility amidst extreme climate events.

Empirical research exploring how extreme climate events may affect fertility and establishing links between extreme climate events and human fertility and reproductive health at the individual and community levels can provide valuable insights into the proximate determinants of fertility dynamics under changing climatic conditions. Such research efforts can contribute significantly to policy development, especially when considering spatial and temporal variability (Grace, 2017). By delving into the relationship between extreme climate events and fertility, we can gain a better understanding of the implications for human populations and can better address the challenges posed by climate change on reproductive outcomes.

Experience with and perceived future risk of extreme climate events can play a pivotal role in influencing fertility rates and shaping preferences regarding childbearing, as concerns about climate issues, including broader environmental changes, individuals, and couples may undergo shifts in their views on family planning (Arnocky et al., 2012; De Rose and Testa, 2015). Moreover, anecdotal evidence suggests that people are increasingly discussing the costs and benefits of being child-free in response to climate issues (Fleming, 2018; Miller, 2018; Relman and Hickey, 2019). However, it remains crucial to investigate the specific mechanisms through which extreme climatic events may affect fertility rates and reproductive preferences.

One potential avenue of influence is the risk of child mortality owing to the escalating occurrence of extreme climate events. Climate change has demonstrated adverse effects on child health and well-being, leading to an increase in child mortality rates in certain regions. For example, child mortality has doubled in Africa since 2009 because of the excessive heat linked to climate change, highlighting the tangible and immediate threat posed to children's lives (Chapman et al., 2022). Furthermore, children bear a disproportionate burden of diseases caused by global climate change, accounting for 88% of such cases (Patz et al., 2007; Zhang et al., 2007).

Several studies have explored the connection between child mortality and total fertility rate, revealing important insights into the interplay between population dynamics and child survival (Frankenberg et al., 2015; Nobles et al., 2015; Pörtner, 2008; Preston, 1978). However, there is a gap in the literature concerning the potential influence of increasing extreme climate events on the risk of child mortality and how they shape decisions regarding childbearing, ultimately impacting fertility rates. Parents residing in regions vulnerable to extreme climatic events may meticulously consider the risk of child mortality when making choices about family planning. This consideration could serve as a coping mechanism to adapt to the adverse impacts of extreme climate events and potentially influence fertility rates.

Given the increasing frequency and intensity of extreme climate events that pose significant threats to human settlements and population trends, there is an urgent need to explore the underlying mechanisms that drive fertility dynamics at the household level in climate-vulnerable areas (Jiang and Hardee, 2011). Policymakers and researchers can develop targeted interventions and strategies to mitigate the potential demographic consequences of climate change by understanding the complex interplay between EWEs, child mortality risks, and fertility preferences.

This study investigated the influence of extreme climate events on fertility preferences by considering the risk of child mortality factors in this relationship. While previous research has examined the relationship between environmental degradation or natural disasters and fertility levels, this study examines the intricate connection between women's fertility preferences and their perceptions and experiences of child mortality. The findings regarding the interplay between these perceptions and fertility preferences offer valuable insights into this complex relationship and can inform the development of targeted policies to mitigate child mortality among populations that are particularly susceptible to extreme climate events.

The remainder of this paper is organized as follows. First, we present an overview of the trends and scenarios of extreme climate events in Bangladesh and delineate spatial variations in fertility and child mortality rates in the country. We also provide a comprehensive literature review that focuses on the linkages between women's perceptions of child mortality, fertility preferences, and extreme climatic events. Subsequently, we detail the methodology section, outlining the quantitative and qualitative methods used for data collection. Our results and analysis are based on the data obtained from the selected sample. Finally, we conclude with suggestions for further research based on the key findings of this study.

Study contexts in Bangladesh

Bangladesh, a subtropical region characterized by a humid climate and monsoon weather, has experienced significant changes in temperature and rainfall patterns. Studies indicate a notable increase in mean minimum and maximum temperatures between 1961 and 2008, with an estimated rise of 0.20 °C per decade (Mohsenipour et al., 2018; M.R. Rahman and Lateh, 2017). Moreover, there was an upward trend in annual rainfall, with an average increase of 7.13 mm per year from 1971 to 2010 (M.R. Rahman and Lateh, 2017). Climate change, including sea-level rise, heavy rainfall, droughts, floods, and cyclones, pose considerable challenges to Bangladesh, the most climate-vulnerable country globally (Karim and Mimura, 2008; Huq, 2001; Salauddin and Ashikuzzaman, 2012).

The vulnerability of Bangladesh to extreme weather events has profound implications for child mortality and fertility. Bangladesh has made progress in reducing child mortality but still accounts for a significant proportion of child deaths worldwide (Wang et al., 2014). Drowning, particularly during the flooding season, remains the leading cause of child mortality, particularly in rural areas (Rahman et al., 2009; Hossain et al., 2015). Research has explored the impact of climatic extremes on child mortality, revealing associations among temperature, rainfall, and mortality rates. Higher temperatures are linked to lower child mortality in hotter months, while both low and high temperatures are associated with increased mortality (Babalola et al., 2018; Lindeboom et al., 2012). Rainfall below 14 mm reduces mortality risk, whereas higher rainfall increases the risk (N. Alam et al., 2012).

Understanding the risk factors and patterns of child mortality in the context of extreme weather events is crucial for comprehending fertility preferences in vulnerable and non-vulnerable areas. Bangladesh experienced a significant decline in the total fertility rate (TFR), reaching a replacement level of 2.1 children per woman in 2015 (NIPORT et al., 2016). However, regional variations existed, with the northeast division of Sylhet having the highest TFR (Islam et al., 2010). Notably, fertility rates are higher in rural regions than in urban areas (Reed et al., 1999). Investigating the relationship between child mortality and fertility preferences can provide insight into the dynamics of population growth and development. Such research aids in understanding the importance of individuals in areas vulnerable to extreme weather events and informs policies and interventions aimed at mitigating the adverse effects of such events on child mortality and fertility rates (Wang et al., 2014; Rahman et al., 2009; Hossain et al., 2015).

Nexus between extreme climate events, risk of child mortality, and fertility preference: theoretical discussion

A substantial body of theoretical research has examined the interplay between fertility levels and child mortality, elucidating two mechanisms: (1) exposure to mortality beyond one's immediate family, and (2) experiencing the death of one's own child. In the context of the first mechanism, the concept of "insurance" fertility is linked to "extrafamilial effects," wherein parents may choose to have more children than they ideally desire, anticipating that some may not survive (Cain, 1981; Pörtner, 2008; Preston, 1978). In addition to this insurance mechanism, other factors may also influence fertility decisions. For instance, an increase in women's fertility could serve as a risk-sharing mechanism at the community level (Conning and Udry, 2005), where community members may derive benefits from the next generation of children. However, exposure to death outside one's own family may lead to lower fertility in women. Instances of voluntary birth control illustrate reduced fertility rates following natural disasters due to negative experiences and concerns about the probability of future calamities (Agadjanian and Prata, 2002). Additionally, witnessing the deaths of family members and friends might induce psychopathological responses (Neria et al., 2008), potentially leading to decreased desire for childbearing, reduced coital frequency, impaired relationship quality, and physiological limitations affecting women's ability to carry a child to term (Parker and Douglas, 2010).

Meanwhile, experiencing the death of one's own child may prompt a couple to attempt to conceive again as a way to replace the lost child. Preston (1978) also pointed out that a child's death can increase fertility due to the cessation of breastfeeding and the resumption of menstruation in women. An illustrative example of the replacement theory can be seen in the aftermath of the 2008 Wenchuan earthquake in China, when the state allowed parents who had lost their only child to have another (Qin et al., 2009). Similarly, in Indonesia, Nobles et al., (2015) found that women who lost one or more children during the 2004 tsunami were more inclined to desire additional children. Women who had no children before the tsunami initiated family building earlier in communities with higher tsunami-related mortality rates (Nobles et al., 2015:15).

In this study, we assumed that individuals living in vulnerable areas with a high risk of child mortality resulting from extreme climate events may express a preference for larger family sizes due to the likelihood of losing a child. Moreover, poorer groups or countries that are disproportionately more susceptible to disasters (Jiang and Hardee, 2011) are likely to have higher fertility rates to replace lost children (Finlay, 2009) and as a form of insurance against the adverse impacts of natural disasters or hazardous environments (Cain, 1981, 1983, 1986; Frankenberg et al., 2015).

Methodology

Study design. We conducted a cross-sectional survey in four rural areas in two of Bangladesh's divisions, Sylhet and Chattogram (Fig. 1).

Selection of the study areas

Areas relatively more prone to extreme climate events. This study established two of the seven Bangladesh divisions with the highest fertility rates during the study period: Sylhet at 2.9 and Chattogram at 2.5. These divisions also had a relatively high child mortality rate (67 and 50 per 1,000, respectively) and a similar poverty rate (25.1% and 26.1%, respectively) (see Fig. 2 and Table 1). A diagram illustrating the process of selecting the study areas and corresponding analysis and outcomes in various stages is shown in Fig. 2. We could not choose further study areas based on fertility rates since recent data are not readily available at the *upazila, union*, or *village* levels.

Because we investigated the relationship between extreme climate events and child mortality and fertility, we based our sampling procedures on the vulnerability of areas to such events. Chattogram, being a coastal region, predominantly experiences cyclones, whereas Sylhet, surrounded by hilly areas, is primarily affected by flash floods. This geographical contrast, along with their high fertility rates, contributed to the selection of these two areas for this study.

Among the cyclone-prone areas in the Chattogram division, the Chattogram district stood out because of its history of the highest number of cyclones, with 32 events recorded from 1900 to 2018, including recent occurrences in 2013, 2015, 2016, and 2017 (BMD, 2020). On the other hand, the Sunamganj district in Sylhet has experienced a considerable number of current flood events, some of which are severe (CRED, 2018). It is a frequently studied wetland area that is vulnerable to flash floods originating from the hills across the border in India (Ahmed et al., 2019; Haq and Ahmed, 2017, 2018, 2019; Islam and Sado, 2000; Kamruzzaman and Shaw, 2018). Notably, Sunamganj has the highest child mortality rate (Gruebner et al., 2017) and total fertility rate (TFR) among all districts in Bangladesh (NIPORT et al., 2011).

Two upazilas (sub-districts) were carefully chosen from the different districts for this study: Banskhali in Chattogram and Tahirpur in Sunamganj. These upazilas frequently experienced extreme climatic events. Its geographic location makes Banskhali susceptible to regular cyclones, tidal surges, and other catastrophic events. In 2013, Cyclone Mahasen struck the region, causing a significant impact on 28 unions in the Chattogram district and affecting approximately 350 people in Banskhali (DDM, 2014). Moreover, the Upazila Nirbahi Officer (UNO) of Banskhali reported that Upazila was severely affected by Cyclone Roanu in 2016, resulting in 24 fatalities.

On the other hand, Tahirpur Upazila in Sunamganj District was selected for its high vulnerability to disasters, particularly flooding (CDMP II, 2014). These upazilas serve as relevant locations for studying the implications of and responses to extreme climate events in Bangladesh.

Table 2 highlights the key informant interviews conducted as part of the study on extreme climate event vulnerability. The Sylhet District Relief and Rehabilitation Officer (DRRO) was interviewed to identify less or less vulnerable upazilas. At the same time, the Upazila Nirbahi Officer (UNO) provided an overview of vulnerable upazilas to select highly vulnerable unions. Additionally, interviews with local government representatives (union chairman) confirmed and outlined the villages within the established unions. These interviews played a crucial role in systematically identifying suitable study areas for research, forming a strong foundation for further investigation of community vulnerability to extreme climate events in the region.

After selecting the *upazilas*, key informant interviews (KIIs) were held with the respective UNOs to select unions within the *upazilas* that were particularly vulnerable to extreme climate events. This interview aimed to gain an overview of the chosen upazilas, their vulnerability to extreme climatic events, and the

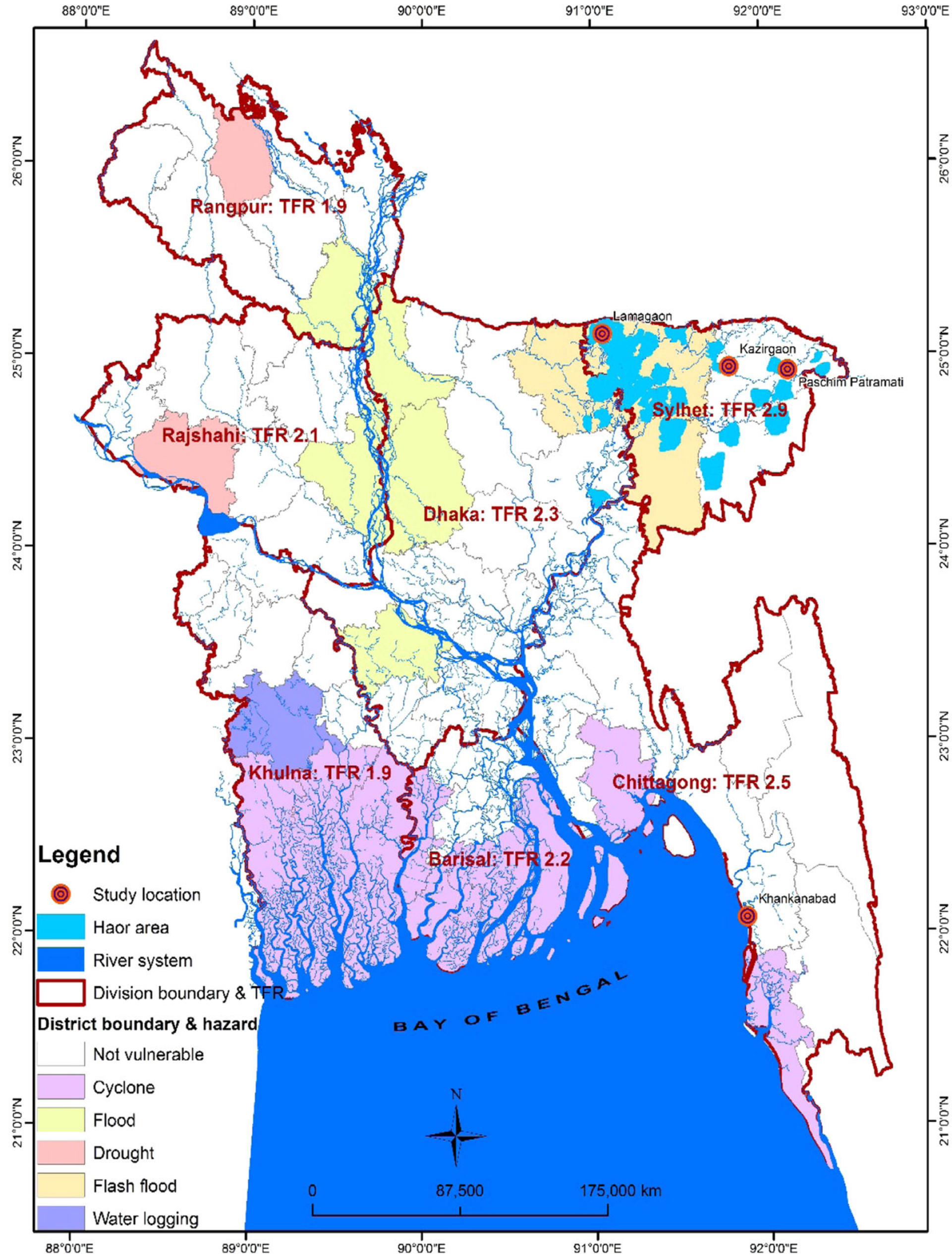

Fig. 1 Divisions and villages included in this study (Bangladesh). The spelling has been changed from Chittagong to the Chattogram.

identification of the most highly vulnerable unions. KIIs were then held with the chairmen of the selected unions to confirm and gain an overview of the highly vulnerable villages within the unions. Lamagaon and Khankhanabad were the villages chosen from Tahirpur and Banskhali, respectively. We also selected Lamagaon and Khankhanabad villages as study areas for another recent study (Haq and Ahmed, 2019).

Areas relatively less prone to extreme climate events. For a comparative analysis, two control villages were selected from the Sylhet district within the Sylhet division, considering that this division had higher child mortality and total fertility rates, which could potentially extend to specific villages within the district. To ensure that these control villages were not susceptible to frequent extreme climate events and had not experienced any events in the past decade, two villages were selected from different upazilas within the district.

The research process commenced with an initial Key Informant Interview (KII) conducted with the District Relief and Rehabilitation Officer (DRRO) in the Sylhet district. This step aided in the selection of the upazilas of Kanaighat and Sylhet Sadar (Fig. 1). Subsequently, KIIs were conducted with the respective Upazila Nirbahi Officers (UNOs) from these upazilas, facilitating the selection of specific unions: Mogalgaon in Sylhet Sadar and Jinghabari in Kanaighat.

Further, KIIs were held with locally elected union chairmen from the chosen unions, eventually leading to the identification of the final villages: Kazirgaon (located in Mogalgaon union, Sylhet Sadar upazila) and Paschim Patramati (situated in Jinghabari union, Kanaighat upazila). Information informally shared by Non-Governmental Organizations (NGOs) affiliated with the Bangladesh Rural Advancement Committee (BRAC), which has been working in the area for an extended period, confirmed that these villages had seldom experienced floods or cyclones over the

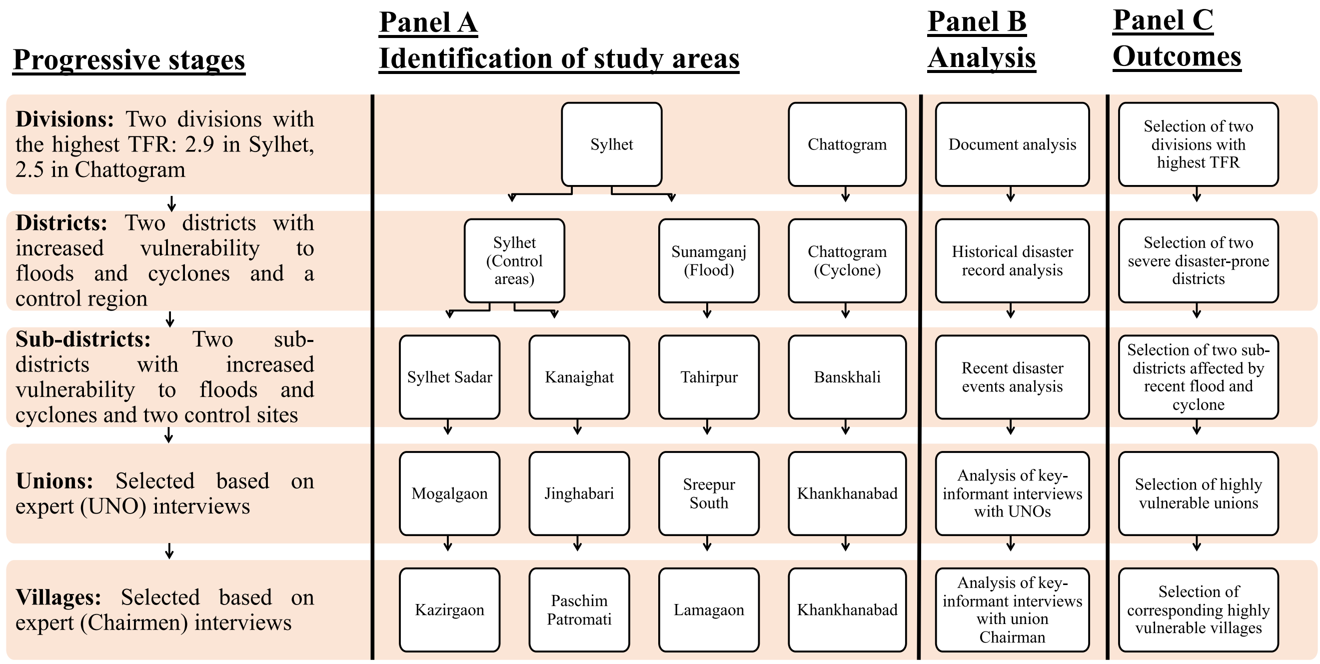

Fig. 2 Integrated process for identifying study areas: a multi-stage approach. The column "Progressive stages" outlines the systematic process employed to select study areas for the research, focusing on divisions with the highest total fertility rates (TFR) in Bangladesh. **A** details the identification of study areas, including the selection of divisions, districts, sub-districts, unions, and villages. Each stage involved a combination of document analysis and key-informant interviews, as depicted in **B**. The document analysis included historical and recent disaster events, providing essential context for the selection process. Key-informant interviews with Upazila Nirbahi Officers (UNOs) and union chairmen were instrumental in identifying highly vulnerable areas. **C** summarizes the outcomes at each stage, emphasizing the successful identification of divisions, districts, sub-districts, unions, and villages with heightened vulnerability to extreme climate events. This figure serves as a visual guide to the comprehensive methodology utilized in the study area selection, combining analytical approaches and expert consultations.

Table 1 Number of extreme climate events, under-5 mortality, and fertility in Bangladesh by division.

Characteristic	Division						
	Barisal	Chattogram	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet
No. of districts[a]	6	11	13	10	8	8	4
Area (km^2)[a]	13,297	33,771	31,120	22,272	18,197	16,317	12,596
Population (thousands)[a]	8.15	28.08	46.73	15.56	18.33	15.67	9.81
Density (km^2)[a]	613	831	1,502	699	1,007	960	779
Rate of poverty (%)[b]	38.3	26.1	30.5	31.9	27.4	42.0	25.1
No. of extreme climate events[c]	97	176	106	86	123	152	49
Under-5 mortality (per 1000)[d]	35	**50**[e]	41	56	43	39	**67**[e]
TFR (15–49 years)[d]	2.2	**2.5**[e]	2.3	1.9	2.1	1.9	**2.9**[e]

TFR total fertility rate.
Sources:
[a]Knoema (2018).
[b]Ahmed et al. (2010).
[c]EM-DAT (2016).
[d]NIPORT et al. (2016).
[e]Indicates the comparatively higher fertility and child mortality in the Chattogram and Sylhet divisions. Study villages are from Chattogram (Khankanabad) and Sylhet (Lamagaon, Paschim Patramati, and Kazirgaon) divisions.

Table 2 Participants of key informant interviews.

KII No.	Name of KII	Targeted expert
KII 1 ($n = 1$)	KII with the District Relief and Rehabilitation Officer (DRRO) in Sylhet district to identify two control upazilas that are relatively less vulnerable to extreme climate events and have not experienced such events in the last 10 years.	District Relief and Rehabilitation Officer (DRRO)
KII 2 ($n = 4$)	KII with Upazila Nirbahi Officer (UNO) to gain an overview of the four upazilas and their vulnerability to extreme climate events and select highly vulnerable unions for study.	Upazila Nirbahi Officer (UNO)
KII 3 ($n = 4$)	KII with local government representative (union Chairman) to confirm and gain an overview of the four villages within the unions.	Local government representative

past ten years. A recent study corroborated that Kazirgaon and Paschim Patramati are not prone to EWE (Haq and Ahmed, 2019).

Research approach. This study employed a combination of qualitative and quantitative approaches to investigate the influence of women's perceived risk of child mortality on their fertility preferences. Integrating qualitative methodologies and fieldwork into quantitative analysis, instead of relying solely on one approach, is advantageous in climate health research as it facilitates a more comprehensive understanding of the research problem by gathering diverse types of data (Creswell and Plano Clark, 2018; Grace and Mikal, 2019). A mixed-methods approach in fertility-related research offers a variety of data collection methods, such as census and survey data, questionnaire surveys, in-depth interviews, ethnographic data, descriptive statistics, and probit regression (Buber and Fliegenschnee, 2011; Thomas and Sporton, 1997).

In this study, we conducted both quantitative (using descriptive and inferential statistics) and qualitative analyses (involving verbatim statements) based on data obtained from structured questionnaire surveys and semi-structured in-depth interviews (see Appendix A). This combination of methods enhances the depth and breadth of insights gained from this research, leading to a more robust understanding of the complex relationship between women's perceived risk of child mortality and their fertility preferences.

Sample size and target population. This study focused on a target population of ever-married women within the reproductive age group of 15–49 years who had given birth at least once and were currently living with their husbands. In line with various studies on fertility (e.g., Carr et al., 2006; Dabral and Malik, 2004; Kannan and Nagarajan, 2008), married women were selected as respondents for specific reasons. Bangladesh has experienced significant progress in women's empowerment, which is attributed to its overall development (Chowdhury et al., 2016; Mainuddin et al., 2015). Women's empowerment is a critical predictor of fertility control behavior (M.A. Alam et al., 2018; M.M. Rahman et al., 2014) and health-seeking behavior (Ghose et al., 2017; Mainuddin et al., 2015). In a study conducted in Bangladesh that explored the association between women's decision-making autonomy and maternal healthcare service utilization, Ghose et al. (2017) found that decisions related to women's healthcare, significant household purchases, children's healthcare, and visits to family or relatives were primarily made jointly by both the husband and wife, rather than by one party alone. Second, it is essential to acknowledge the substantial role of government and non-governmental organizations in influencing these decisions. These organizations can contribute significantly to raising awareness among women regarding contraceptive use and maternal and child health. Moreover, they can empower women through various financial activities, enabling them to make meaningful contributions to food security through initiatives, such as homestead gardening. Ultimately, these efforts work towards enhancing households' overall well-being. Kabir et al. (2017) investigated the decision-making autonomy of women of reproductive age based on data from the 2014 Bangladesh Demographic and Health Survey (BDHS). Their findings indicated that women affiliated with non-government organizations (NGOs) and those employed exhibited higher levels of empowerment. Similarly, Norwood (2011) found that NGO membership significantly influences family planning practices in Ghana. NGOs have been instrumental in promoting microcredit programs specifically designed to empower economically disadvantaged women in rural areas of Bangladesh. Amin et al. (1998) highlighted the pivotal role played by these microcredit programs in empowering the targeted group of women.

During the field survey, it became evident that most couples engaged in mutual discussions and joint decision-making regarding childbearing and contraceptive use in the study areas covered by the household survey questionnaire. Additionally, active support from specific Non-Governmental Organizations (NGOs) was observed in promoting a program focused on enhancing women's participation in reproductive health. The program's objectives included empowering women by facilitating their ability to handle financial transactions, such as accepting cash, opening savings accounts, and managing mobile banking information. Furthermore, the program aimed to improve gender sensitivity, nutrition, health status assessment, and the decision-making skills of frontline government agency staff. Collectively, these initiatives aim to foster an environment conducive to women's involvement in critical nutrition and health decision-making.

During the field survey, it was found that most couples in the study areas represented in the household survey questionnaire discussed and mutually decided to have a child and make decisions about contraceptive use. It was also observed that some NGOs actively supported the program for women's reproductive health. The program aimed to enhance women's involvement in nutrition and health decision-making by helping to improve their capacity to accept cash, open savings accounts, and manage their mobile banking information, as well as improving government frontline staff's responsibility to assess participants' gender sensitivity, nutrition and health status, and decision-making skills.

In this study, Equation 1 was used to determine the sample size, where n is the desired sample size, z is the standard normal variety value (with a 95% confidence interval for the normal variate value, $z = 1.96$), p is the proportion of the population (assumed as 50% or 0.5), $q = 1\text{-p}$ (0.5), d is the degree of accuracy (with a 3% admissible error, $d = 0.03$), and N is the total number of married women in the selected villages.

$$n = \frac{\mathrm{N}z^2\,\mathrm{pq}}{\mathrm{N}d^2 + Z^2\,\mathrm{pq}} \tag{1}$$

We used family planning registration records to establish the population and study sample of each village. To achieve this, we obtained comprehensive lists of ever-married women aged 15–49 years from local community clinics, which maintain household-level records of health-related information for married women. From these lists, we identified eligible women with at least one child who were currently residing with their husbands, excluding newly married couples.

Women were selected for the survey and in-depth interviews based on their eligibility criteria and family planning registration records from the local family planning office. Women were chosen because they represented the target group for family planning initiatives in Bangladesh. Family welfare assistants, who operate in rural areas, engage with married women of reproductive age to discuss reproductive and child health, provide family planning information, and distribute free contraception. Due to their role as mothers and their accessibility to rural areas, women possess a better understanding of their childbearing history.

According to the available records, the number of eligible women amounted to 2,893: 949 in Khankanabad, 629 in Lamagaon, 682 in Paschim Patramati, and 633 in Kazirgaon. Employing Equation 1, the full sample size was determined to be 779. The sample was distributed proportionately based on each village's population, resulting in 255, 169, 184, and 171 eligible women for Khankanabad, Lamagaon, Paschim Patramati, and Kazirgaon, respectively. Utilizing Research Randomizer, a random-number-generation software, we randomly selected eligible women from the lists, yielding a final sample size of 759. The remaining 20 respondents were either unavailable or declined to participate in the study (6, 4, 5, and 5 from Khankanabad, Lamagaon, Paschim Patramati, and Kazirgaon, respectively). We successfully obtained interviews with each selected woman, resulting in an impressive response rate of 97%, with no substitutions for the remaining 3%.

Eligible women participated in a questionnaire survey and a subset of the surveyed women was recruited for face-to-face in-depth interviews based on their willingness to participate. The primary inclusion criteria for in-depth discussions focused on women who had experienced child death or perceived the risk of child mortality (refer to Appendix B).

Data collection and analysis techniques. We conducted a written questionnaire survey among a selected sample of women, gathering data on households' sociodemographic characteristics, extreme weather event-related information, fertility preferences, and child mortality. Following the survey, we identified and invited women for in-depth interviews based on the following specific criteria: willingness expressed during the household surveys to be interviewed, experience of child death, and perception of the probability of future child mortality. Ultimately, 25 women were designated for in-depth interviews, distributed across different study areas as follows: Khankanabad (8), Lamagaon (9), Paschim Patramati (4), and Kazirgaon (4) (see Appendix B).

As institutional review boards and committees are not common in most universities in Bangladesh, we took ethical precautions by providing respondents with a 'participation information sheet' that informed them about the privacy and confidentiality of the data collected during the questionnaire survey and in-depth interviews. Since our research involved fieldwork and human participation, we sought consent from the national and local government administrations following research ethics practices for social sciences in Bangladesh. We obtained written permission from the 'UNO' (Upazila Nirbahi Officer) of the national government and the 'Union Chairman' of the local government to conduct the research in the selected study areas. All participants voluntarily agreed to participate in the study, and written consent was obtained before administering the questionnaire and recording the interviews. Each respondent received a copy of the consent form. We assured respondents that their identities would remain anonymous in any publication based on this study. The data were collected in the local dialect using audio recordings, and later transcribed and translated into English.

In this study, eight research assistants (four men and four women), who were master's students in social sciences at Shahjalal University of Science and Technology, Sylhet, provided valuable assistance. All research assistants were well-versed in the research methodology and conducted interviews. Before conducting the questionnaire survey and in-depth interviews, the participants underwent thorough training in data collection procedures. In-depth interviews were recorded and transcribed by a professional translator experienced in social research transcription. The authors cross-checked the translations and all transcriptions were carefully reviewed. We then summarized the relevant information and manually extracted pertinent statements for the analysis.

SPSS software was used to analyze the quantitative data. Descriptive statistics and χ^2 tests were used for data analysis to compare fertility preferences and other variables between the non-vulnerable and vulnerable areas. The data analysis techniques employed in the study involved a comprehensive approach to explore the relationship between independent variables and women's fertility preferences in areas categorized as vulnerable or not vulnerable to various climate-related risks. Before executing the binary probit regression models, multicollinearity checks were performed on the independent variables to ensure that no high correlation existed between them. This step was crucial for preventing redundant or misleading effects in the subsequent regression analysis. The binary probit regression model was then used to assess the associations between the independent variables and fertility preference, considering vulnerability status as an interaction term. The model's log-likelihood, AIC, and BIC values were calculated to evaluate the model fit and complexity.

Variables included in the binary logistic regression. Previous studies on fertility preferences (for example, Abbawa et al., 2015; Rai et al., 2014), and binary logistic regression identified significant factors in the preference for additional children. In this study, the dependent variable – preference for another child – was coded as No = 0 and Yes = 1. Our operational definition of fertility preference is based on the question, "Would you (and your husband) like to have another child in the next 3 years?" This study also considered explanatory variables (Table 3) suggested by previous studies in many countries; for example, higher fertility is associated with the woman's perceived risk of the child dying (Sandberg, 2006), the experience of child mortality (Adhikari, 2010; Dabral and Malik, 2004); age (Abbawa et al., 2015; Rai et al., 2014); and educational level (Adhikari, 2010; Dabral and Malik, 2004).

Results

This section presents the study's quantitative and qualitative findings. The quantitative results show how perceptions and experiences of child mortality are associated with women's fertility preferences and other significant factors. The qualitative findings describe why and how women may consider having additional children to replace child mortality.

Socio-demographic and economic variations between areas vulnerable and not vulnerable. Table 3 presents descriptive statistics for various variables used in the binary probit regression analysis, comparing areas vulnerable to extreme climate events with non-vulnerable areas. The percentages and counts are provided for each variable in both types of areas, with asterisks indicating the significance level of the differences between them.

Regarding fertility preference, 64.1% of women in non-vulnerable areas preferred to have another child in the next 3 years, while 35.9% did not. In vulnerable areas, the percentages were 48.6% and 51.4%, respectively, with a statistically significant difference of $p < 0.001$. The age distribution showed notable variations, with vulnerable areas having lower percentages of women in the 15–24 age group (12.5%) than in non-vulnerable areas (18.8%), and higher percentages in the 35–44 age group (47.6% vs. 29.0%), also significant at $p < 0.001$.

The educational attainment of husbands differed significantly between the two types of areas, with vulnerable areas having higher percentages of men with no schooling (45.7%) and lower percentages with secondary and higher education (23.6%) compared to non-vulnerable areas (27.5% and 40.0%, respectively), both at $p < 0.001$. Similarly, husbands' primary occupation exhibited significant differences, with vulnerable areas having fewer agricultural workers (56.8%) and more skilled and semi-skilled laborers (23.2%) compared to non-vulnerable areas (75.4% and 8.4%, respectively), both at $p < 0.001$.

Table 3 Definitions and descriptive statistics of variables used for binary probit regression.

Variables	Definitions	Areas not vulnerable % (*N*)	Areas vulnerable % (*N*)
Outcome variables			
Fertility preference	1 if women want to have another child in the next 3 years, 0 otherwise		
No@	–	64.1	48.6
Yes	–	35.9	51.4**
Explanatory variables			
Age	0 if age is 15–24, 1 if 25–34, and 2 if 35–44		
15–24@	–	18.8	12.5
25–34	–	52.2	39.9
35–44	–	29.0	47.6**
Education of wife	0 if women didn't attend schooling, 1 if primary, and 2 if secondary and higher		
No schooling@	–	35.9	33.1
Primary	–	40.0	44.7
Secondary and higher	–	24.1	22.2
Education of husband	0 if women didn't attend schooling, 1 if primary, and 2 if secondary and higher		
No schooling@	–	27.5	45.7
Primary	–	32.5	30.7
Secondary and higher	–	40.0	23.6**
Primary occupation of husband	0 if the occupation is related to agriculture, 1 if business and do professions, and 2 if labor work		
Agricultural workers@	–	75.4	56.8
Business owners and professional	–	16.2	20.0
Skilled and semi-skilled laborer	–	8.4	23.2**
Household monthly income (BDT)	0 if income is below 6000, 1 if between 6001 and 9999, and 2 if more than 10,000		
<6000@	–	36.2	33.1
6001–9999	–	36.2	33.1
>10,000	–	27.6	33.8
Number of children	0 if one child, 1 if 2 children, 2 if 3 children, and 3 if 4 or more children		
1@	–	12.5	11.8
2	–	15.7	12.1
3	–	35.7	29.2
4+	–	36.1	46.9*
Number of sons	0 if no son, 1 if 1 son, 2 if 2 sons, and 3 if 3 or more sons		
No son@	–	15.9	12.6
1	–	37.4	22.5
2	–	27.8	39.5
3+	–	18.9	25.4**
Number of child mortality	0 if women have no experience of her own child death, 1 if has a death of a child, 2 if two or more children died		
No mortality@	–	88.1	64.7
One child	–	8.4	16.2
Two and more	–	3.5	19.1**
Risk of child mortality	1 if women perceive the risk of child death, 0 otherwise		
No@	–	85.5	41.1
Yes	–	14.5	58.9**

*$p < 0.05$, **$p < 0.001$ (using χ^2 test).
@ indicates reference group of variables for binary probit regressions.

Household income and wives' education did not differ significantly between the two types of areas. However, there were statistically significant differences in the number of children and sons. In vulnerable areas, a higher percentage of women had four or more children (46.9% vs. 36.1% in non-vulnerable areas) and two sons (39.5% vs. 27.8% in non-vulnerable areas), both at $p < 0.001$. The vulnerable areas had a higher percentage of women who experienced one child death (16.2% vs. 8.4%) and two or more child deaths (19.1% vs. 3.5%). Differences were considered statistically significant at $p < 0.001$. Additionally, the perceived risk of child mortality differed significantly, with 58.9% of women in vulnerable areas perceiving the risk compared to 14.5% in non-vulnerable regions, a significant difference at $p < 0.001$.

Fertility preference between flood and cyclone-prone areas. Table 4 presents the fertility preferences of women living in flood- and cyclone-prone areas. The percentages indicate that 44.2% of women living in flood-prone regions prefer no children, whereas 51.4% of women living in cyclone-prone areas have the same

Table 4 Fertility preference between the flood- and cyclone-prone areas.

Fertility preference	Areas vulnerable to (%)		Pearson χ^2	p value
	Flood	Cyclone		
No	44.2	51.4	2.039	0.161
Yes	55.8	48.6		

preference. Additionally, 55.8% of women in flood-prone areas and 48.6% in cyclone-prone areas expressed appreciation for having children. The χ^2 test showed a Pearson χ^2 value of 2.039, with a p-value of 0.161, indicating no statistically significant variation in fertility preference between the flood and cyclone-prone areas.

Factors affecting fertility preference: binary probit regression. Table 5 presents the results of the multicollinearity checks for the independent variables. These checks were conducted before the binary probit regression model was executed. The coefficients in the table represent the correlations between different variables. To assess the presence of collinearity, a threshold of 0.80 was used. The results showed that none of the correlation coefficients exceeded the specified threshold, indicating an absence of high collinearity among the independent variables. This outcome is favorable for regression analysis, as it suggests that the variables under consideration are not strongly correlated. The lack of significant collinearity ensures that each independent variable contributes unique information to the regression models without the risk of redundant or misleading effects. Consequently, the results provided confidence in the reliability of the subsequent binary probit regression analysis.

Table 6 presents the findings of a binary probit regression analysis examining the relationship between the independent variables and women's fertility preferences in two areas: vulnerable and not vulnerable. The analysis included 742 participants, excluding 17 women aged 45–49 years. The intercept coefficient ($B = 1.434$, $p < 0.001$) indicates a significant positive baseline fertility preference, with an odds ratio ($\text{Exp(B)} = 4.196$), suggesting higher odds of expressing fertility preference when other factors are absent.

The interaction terms between vulnerability status and number of children revealed significant associations with fertility preference. Vulnerable women with four or more children had higher odds of expressing a fertility preference ($B = 2.445$, $p = 0.008$, $\text{Exp}(B) = 11.531$). The education levels of both wives and husbands also influence fertility preferences. Vulnerable women with secondary or higher education had lower odds of expressing a fertility preference ($B = -1.432$, $p < 0.001$). Household income > 10,000 has a significant negative association with fertility preference in vulnerable areas ($B = -0.771$, $p = 0.015$).

Regarding child mortality, there was no significant association with fertility preference in vulnerable areas, while vulnerable women aged 35–44 years had lower odds of expressing a fertility preference ($B = -2.997$, $p < 0.001$). The number of sons has a varying impact on fertility preference based on vulnerability status. For vulnerable women, having three or more sons is associated with lower odds of expressing a fertility preference, while this relationship is not significant in non-vulnerable areas.

The perceived risk of child death is positively associated with fertility preference in vulnerable areas ($B = 1.283$, $p < 0.001$), but this relationship is not significant in non-vulnerable areas. Employment categories did not consistently correlate with fertility preferences based on vulnerability status.

The log-likelihood (−210.21) indicates a good fit of the binary probit regression model, and the AIC (500.43) and BIC (684.80) values suggest a balanced model fit and complexity. These results shed light on the factors influencing fertility preference in different areas and emphasize the significance of vulnerability status in shaping reproductive decision-making among women.

Experience and perception of child mortality: link to extreme climate events. Excerpts from in-depth interviews with women in Khankanabad village, Banskhali Upazila, who lost their children during cyclone Roanu in 2016, were collected to understand their experiences in areas vulnerable to extreme climate events. Our research indicates that women with more children are more susceptible to cyclones, which increases the likelihood of child loss. A female of 30 years in Khankanabad stated the following:

> *I was terrified when the water started to rise. I had five children, and two were too young to move. I held them tightly to prevent them from being swept away by fast-flowing water. However, it was difficult for me to keep them up. I could not hold onto one of my daughters; she slipped from my grasp. Sadly, I found her lifeless body floating in the water.* (Female, 30 years, Khankanabad)

> *After hearing cyclone signal number 10, indicating extremely high danger, I rushed to my eldest daughter's house to wake her up. As the cyclone approached rapidly, I was unsure about what to do with my younger daughters, who were less than four years old. My older daughter followed me and held my young son and daughter together. Unfortunately, I could not hold them above water level, and the current washed away my young daughter. My older daughter tried to help, but she could not keep my younger daughter afloat. Our neighbor joined the search for my missing children. Eventually, they found my daughter alive, but my son's lifeless body floated in the water.* (Female, 35 years, Khankanabad)

Extreme climatic events have both direct and indirect effects on child mortality. Respondents in flood-affected areas mentioned a lack of adequate health facilities, contributing to the failure to treat various diseases and resulting in child mortality. They also noted that flood-affected areas are more vulnerable to different diseases than neighboring areas unaffected by floods. The absence of proper communication systems prevents flood-affected villages from receiving emergency support.

> *My children frequently suffer from various diseases because they reside in flood-prone areas with unhealthy environments and substandard living conditions. Consequently, children in my village and surrounding regions suffer from different diseases than those unaffected by extreme events.* (Female, 34 years, Lamagaon)

> *Our environment is unsafe, surrounded by water, and lacks nearby health facilities, clinics, and hospitals. People frequently suffer from various diseases. Once, one of my sons had cholera, but it was too late to initiate the appropriate treatment.* (Female, 32 years, Lamagaon)

Drowning is a significant cause of child mortality in flood- and cyclone-affected regions. It is reported to be a common occurrence with a high risk of drowning in young children. Most drownings occur when parents have household chores.

> *People, particularly children* under five years old, *often die during floods because parents cannot keep a constant watch*

Table 5 Multicollinearity checks for independent variables.

	Number of children	Education of wife	Education of husband	Household monthly income	Experience of child mortality	Age	Number of sons	Risk of child death	Area's vulnerability status	Primary income sources of household
Number of children	–	–	–	–	–	–	–	–	–	–
Education of wife	−0.054	–	–	–	–	–	–	–	–	–
Education of husband	0.003	0.263[a]	–	–	–	–	–	–	–	–
Household monthly income	0.150[a]	0.124[a]	0.143[a]	–	–	–	–	–	–	–
Experience of child mortality	0.223[a]	−0.186[a]	−0.189[a]	−0.029	–	–	–	–	–	–
Age	0.345[a]	0.036	0.144[a]	0.152[a]	0.174[a]	–	–	–	–	–
Number of sons	0.460[a]	−0.025	0.079[b]	0.112[a]	0.128[a]	0.594[a]	–	–	–	–
Risk of child death	0.135[a]	−0.129[a]	−0.241[a]	−0.032	0.462[a]	−0.071	0.053	–	–	–
Area's vulnerability status	0.075[b]	0.007	−0.208[a]	0.058	0.283[a]	0.178[a]	0.144[a]	0.454[a]	–	–
Primary income sources of household	−0.069	0.173[a]	0.029	0.186[a]	−0.082[b]	0.058	0.045	0.062	0.218[a]	–

[a]Correlation is significant at the 0.01 level (2-tailed).
[b]Correlation is significant at the 0.05 level (2-tailed).

Table 6 Association between independent variables and fertility preference of women in areas vulnerable and not vulnerable [$N = 742$].

Parameter	*B*	Sig.	Exp (B)
(Intercept)	1.434	<0.001	4.196
Four and more children * vulnerable	2.445	0.008	11.531
Four and more children * not vulnerable	−1.065	0.002	0.345
Three children * vulnerable	2.773	0.003	16.009
Three children * not vulnerable	−0.911	0.001	0.402
Two children * vulnerable	2.465	0.009	11.766
Two children * not vulnerable	−0.226	0.510	0.797
One child * vulnerable	3.165	0.003	23.692
One child * not vulnerable	0[a]	–	1
Secondary or higher school wife * vulnerable	−1.432	<0.001	0.239
Secondary or higher school wife * not vulnerable	−0.477	0.050	0.620
Primary school wife * vulnerable	−0.942	0.002	0.390
Primary school wife * not vulnerable	−0.514	0.016	0.598
No schooling wife * vulnerable	0[a]	–	1
No schooling wife * not vulnerable	0[a]	–	1
Secondary or higher school husband * vulnerable	−2.094	<0.001	0.123
Secondary or higher school husband * not vulnerable	−1.439	<0.001	0.237
Primary school husband * vulnerable	−0.717	0.013	0.488
Primary school husband * not vulnerable	−0.643	0.003	0.526
No schooling husband * vulnerable	0[a]	–	1
No schooling husband * not vulnerable	0[a]	–	1
Household income >10,000 * vulnerable	−0.771	0.015	0.463
Household income >10,000 * not vulnerable	0.229	0.344	1.257
Household income 6001–9999 * vulnerable	−0.253	0.399	0.776
Household income 6001–9999 * not vulnerable	−0.144	0.497	0.865
Household income <6000 * vulnerable	0[a]	–	1
Household income <6000 * not vulnerable	0[a]	–	1
Two or more child mortality * vulnerable	0.473	0.284	1.605
Two or more child mortality * not vulnerable	0.007	0.989	1.007
One child mortality * vulnerable	−0.022	0.951	0.978
One child mortality * not vulnerable	0.436	0.161	1.546
No child mortality * vulnerable	0[a]	–	1
No child mortality * not vulnerable	0[a]	–	1
Age 35–44 * vulnerable	−2.997	<0.001	0.050
Age 35–44 * not vulnerable	−0.517	0.104	0.597
Age 25–34 * vulnerable	−1.295	0.039	0.274
Age 25–34 * not vulnerable	0.263	0.337	1.301
Age 15–24 * vulnerable	0[a]	–	1
Age 15–24 * not vulnerable	0[a]	–	1
Three or more sons * vulnerable	−1.984	<0.001	0.137
Three or more sons * not vulnerable	−0.209	0.570	0.811
Two sons * vulnerable	−0.865	0.058	0.421
Two sons * not vulnerable	−0.416	0.219	0.660
One son * vulnerable	−0.161	0.722	0.851
One son * not vulnerable	−0.533	0.080	0.587
No son * vulnerable	0[a]	–	1
No son * not vulnerable	0[a]	–	1
Risk of child death * vulnerable	1.283	<0.001	3.607
Risk of child death * not vulnerable	0.350	0.158	1.419
No risk of child death * vulnerable	0[a]	–	1
No risk of child death * not vulnerable	0[a]	–	1
Unskilled and semi-skilled * vulnerable	−0.462	0.122	0.630
Business owner and professional * vulnerable	−0.016	0.970	0.984
Agricultural worker * vulnerable	0[a]	–	1
Unskilled and semi-skilled * not vulnerable	0.139	0.661	1.149
Business owner and professional * not vulnerable	1.097	<0.001	2.995
Agricultural worker * not vulnerable	0[a]	–	1
Log-likelihood	**−210.21**		
AIC	**500.43**		
BIC	**684.80**		
Likelihood Ratio Chi-Square	**573.37*****		

[a]indicates the reference group; *** denotes $p < .001$; 17 samples were excluded because they are aged women 45–49.
The bold values specifically represent the assessment criteria of the model, providing crucial information, while the remaining non-bold values correspond to the results derived from each predictor.

on them. Approximately 12 to 15 children die every year due to excessive water flow. (Female, 24 years, Lamagaon)

Last year, my three-year-old son drowned during floods. I was preoccupied with household work, and he went to play outside water. I did not notice him, and the floodwaters swept him away. During flooding, water surrounds us, and parents, especially mothers, fear our children's safety. My husband worked to support our family. (Female, 34 years, Lamagaon)

Based on the qualitative data presented above, it is evident that women struggle to keep a constant watch on their young children, which leads to child loss. Male household members from areas vulnerable to extreme climate events often seek employment in nearby cities or urban areas to meet their families' essential expenses. Limited access to health facilities also contributes to child mortality as severe diseases remain untreated.

Hoarding and replacement effects of child mortality on fertility preference. The analysis of qualitative data revealed that respondents who have encountered the death of a child exhibit concerns regarding the potential loss of another child in future instances of floods and cyclones. Consequently, these women tend to lean towards increasing their childbearing as a means of safeguarding themselves against further loss. The objective of this study was to conduct interviews with individuals who have experienced child mortality, with the aim of gaining insights into their experiences and perspectives on future fertility preferences. It is reasonable to hypothesize that the likelihood of losing a child in the future is higher in areas highly vulnerable to floods and cyclones than in regions not susceptible to such events. Noteworthy statements from in-depth interviews are presented below:

A 30-year-old female resident of Khankanabad stated the following:

I tragically lost my elder son when he drowned. Following his passing, I developed apprehensions about another child's potential loss. I believe that by not having more children, particularly sons, I might end up without any children at all, given that our community is significantly affected by cyclones, which pose a threat to the survival of our young people. (Female, 30 years, Khankanabad)

A 30-year-old female residing in Lamagaon shared the following:

Children are valuable gifts from divine entities. However, we frequently hear of the loss of young children during floods. I fear the loss of more children, as I have already experienced the agony of losing one child. For this reason, I prefer to have four children. (Female, 30 years, Lamagaon)

In addition to the replacement effect resulting from child mortality, the desire for additional children is driven by a preference for male offspring. This preference for sons is evident in areas that are vulnerable to floods and cyclones. Women are more inclined to have another child, particularly if the last child they lost is a son. This finding highlights a strong bias towards male children, especially in regions prone to extreme climatic events.

A 37-year-old female resident of Khankanabad expressed the following sentiment:

I had eight children. Two died from drowning during a cyclone-induced flood, while the other two succumbed to cholera and pneumonia. One of my sons was lost in the last cyclone, Cyclone Roanu in 2016. If I had not lost this son, I would not feel the need to have another child as a replacement. (Female, 37 years, Khankanabad)

Another 32-year-old female resident of Lamagaon stated,

I had five children, but one of my daughters had perished during a flood. I do not desire to have another child, and I am content with the remaining four children—three sons and one daughter. My neighbor lost her son but gave birth to another boy in the last year. Since I already have sons, I do not feel compelled to have more children. Raising children in areas that are prone to frequent flooding is challenging. I know a few women with ten or even 12 children, but only two or three survived. They lost their children because of floods and diseases during the flooding periods. (Female, 32 years, Lamagaon)

Women who have experienced the death of a child expressed their preference to have another child in the control areas. Although the control areas selected for this research come from a region with high fertility and child mortality rates, the number of lost children, surviving children, and women desiring additional children are relatively higher in the experimental areas. However, excerpts from interviews conducted in regions not vulnerable to extreme climate events also reveal that some women desire another child to replace the one they lost.

A 33-year-old female residing in a non-affected village, Paschim Patramati, shared the following perspective:

Having many children is not advisable. However, we are inclined to give birth more because of the loss of several of our children. We have witnessed our mothers, aunts, sisters, and sisters-in-law losing multiple children, and they also have more children. I believe that if they had not experienced further loss, they would not desire more. (Female, 33, Paschim Patramati)

Another 33-year-old female from the non-affected village of Kazirgaon added:

Children are precious gifts from Allah [God in Islam]. Nevertheless, I wish to have another child as I lost my two daughters. Newborn babies fill the void left by those we have lost. If I had not experienced such a loss, I would not have had the desire for another child. (Female, 33, Kazirgaon)

In summary, when women experience the loss of a child, they are more inclined to desire more children. The perceived risk of child mortality influences the number of children who aspire to have it. If a child dies during a flood, cyclone, or epidemic, thus reducing the total number of ideal children, women may reevaluate and opt for an increase in the desired number. The desired number of children is expected to increase in anticipation of child mortality.

Discussion

The results of this study provide valuable insights into the relationship between women's fertility preferences, the perceived risk of child mortality, and vulnerability to extreme climate events. The findings revealed significant differences in fertility preferences between areas vulnerable and not vulnerable to extreme climate events, with women in vulnerable areas expressing a higher preference for additional children. This may have been influenced by their experiences and perceptions of child mortality, which were found to be higher in vulnerable areas.

The binary probit regression analysis examined the intricate interplay between independent variables and fertility preferences among women residing in vulnerable and non-vulnerable areas.

The findings provide compelling insights into the multifaceted factors that shape fertility decisions in diverse contexts. Vulnerability status emerged as a salient moderator influencing the relationship between number of children and fertility preference. Specifically, vulnerable women with a higher number of children exhibited elevated odds of expressing a fertility preference, whereas the converse pattern was observed in non-vulnerable areas. Moreover, educational attainment and household income exert significant effects on fertility preferences, predominantly among vulnerable women. Notably, age manifested a noteworthy negative association with fertility preference among vulnerable women aged 35–44. The binary probit regression confirms that women who live in areas vulnerable to extreme climatic events and perceive a risk of child mortality are more likely to prefer having another child. This aligns with previous research and suggests that having more children may serve as an insurance policy against the adverse impacts of disasters or hazardous environments (Haq, 2023; Cain, 1981, 1983, 1986; Frankenberg et al., 2015; Lutz et al., 2006; Neumayer, 2006; Pörtner, 2008; Sandberg, 2006). Or a replacement effect of child mortality as it was evident in India, Pakistan, Turkey (Finlay, 2009), and Indonesia (Nobles et al., 2015). These findings underscore the paramount importance of context-specific considerations and substantiate the intricate interplay between vulnerability to extreme climate events and an array of factors that shape women's fertility preferences (Ahmed et al., 2023a). Future investigations must diligently incorporate all pertinent variables to facilitate a holistic comprehension of the nuanced dynamics governing fertility decision-making in various sociocultural milieus.

The qualitative interviews provide further insights into the reasons behind women's fertility preferences in vulnerable areas. Women believe that child mortality is more likely during floods or cyclones when parents fail to monitor their children or when male members are absent. This highlights the importance of family support and supervision in reducing the risk of child mortality during extreme climate events. Additionally, the preference for having another child if the last child who died was a son suggests that having sons is considered a safeguard for women in vulnerable areas, leading them to prefer having more children as a security measure.

Our qualitative findings also indicate that in areas vulnerable to extreme climate events, women express a desire to have another child if their last child who died was a son. This preference is statistically significant and aligns with the 2011 Bangladesh Demographic and Health Survey, which reported higher mortality rates for boys aged one to four compared to girls (NIPORT et al., 2013). Having sons is considered a form of safeguard for women in these vulnerable areas, leading them to prefer having more children as a security measure. This finding is consistent with Cain's study conducted in rural Bangladesh in 1981, where having sons in the household was seen as insurance in the face of various natural disasters.

Overall, the study's findings contribute to the existing literature on fertility preferences and vulnerability to extreme climate events, emphasizing the importance of understanding the sociocultural and environmental factors (Ahmed et al., 2023b; Haq et al., 2023) that shape women's reproductive decisions in such contexts. These findings have implications for policies and interventions aimed at supporting women's reproductive health and decision-making in areas prone to extreme climate events. By addressing the perceived risks and challenges associated with child mortality and enhancing support systems during extreme climate events, we can empower women to make informed and autonomous reproductive choices.

Conclusion

In conclusion, this mixed-methods study highlights the significant impact of child mortality on women's fertility preferences, with the tendency to have another child as a replacement for a lost one and as a security measure against possible future loss. It also underscores the higher child mortality and fertility preference in areas vulnerable to extreme climate events compared to non-prone regions. The study findings emphasize the urgent need for government and NGO intervention in Bangladesh to address the challenges of child mortality and fertility preference, particularly in vulnerable areas. The study's strength lies in its comparison of vulnerable and non-vulnerable regions, providing valuable insights into the effects of extreme climate events on child mortality and women's fertility preferences. It fills the existing gaps in the literature by shedding light on the specific impacts of floods and cyclones on child mortality rates.

This study investigated the impact of extreme climate events on fertility preferences in vulnerable areas, providing valuable insights. However, several limitations should be acknowledged for future consideration. First, we did not explore explicit or implicit peer effects on fertility preference in rural families, including the influence of in-laws, relatives, or neighbors' childbearing experiences. Second, we could not thoroughly examine the influence of the age of the last child on fertility preferences because of insufficient data. Third, subjective factors such as previous delivery trauma, pregnancy-related health complexity, healthcare resource constraints, and future migration plans were beyond the scope of this study. Additionally, the study's reliance on the available literature and information for selecting vulnerable areas may have limitations due to the absence of local fertility rate statistics. For future research, we recommend exploring these unexplored dimensions to comprehensively understand the factors that influence family planning decisions in climate-vulnerable areas. Evaluating vulnerability using established frameworks, such as the Climate Vulnerability Index (CVI), would ensure a systematic approach in selecting experimental and control areas. Expanding the study to include a broader range of extreme climate events, considering power dynamics, and access to healthcare and contraceptives, would provide deeper insights. Addressing these aspects can help develop targeted interventions and policies to improve reproductive health outcomes and mitigate the impact of climate vulnerability on vulnerable communities.

Data availability

The data obtained from study participants cannot be shared, as participants were explicitly informed during the data collection process that their information would be kept confidential and not disclosed. To uphold transparency and reproducibility, aggregated and anonymized summary data can be made available upon request by contacting the corresponding author. Participants provided consent solely for the collection of relevant data for the study.

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Author contributions

KJA: conceptualization, methodology, data collection, data cleaning, coding and preparation, formal analysis, writing of the original draft, review, editing, and revised drafts. SMAH: conceptualization, methodology, critical writing and review, editing, revisions, and supervision. All authors substantially contributed to the article and approved the submitted version.

Competing interests

The authors declare no competing interests.

Ethical approval

At the time of the study, no official ethics committee was in place. Recognizing the importance of ethical reviews before initiating any research, retrospective approval for completed studies, including this one, is not feasible. However, to prioritize participant safety and maintain study validity, the research adhered to established ethical standards. Any potential conflicts of interest were transparently addressed, and data management protocols were implemented to ensure participant anonymity.

Informed consent

In this engaging study, the interviewer shared the research goals with the participants, assuring them that the data they shared would remain confidential and solely used for analysis. They also excitedly revealed that the survey's intriguing results and discoveries would be published. To embark on this exciting journey, the participants were kindly requested to provide their consent and actively participate in this valuable study. Participation was completely voluntary, with the freedom to withdraw at any point.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-02640-2.

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