



Household-level effects of providing forecast-based cash in anticipation of extreme weather events: Quasi-experimental evidence from humanitarian interventions in the 2017 floods in Bangladesh

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ARTICLE INFO

Keywords:

Cash transfer
Climate adaptation
Vulnerability
Forecast
Floods
Bangladesh

ABSTRACT

In 2017, Bangladesh experienced the worst floods in recent decades. Based on a forecast and pre-defined trigger level, a Red Cross Red Crescent project distributed an unconditional cash grant of BDT 5000 (USD 60 equivalent) to 1039 poor households in highly vulnerable, flood-prone communities in the Brahmaputra river basin before an early flood peak. Systems that can deliver forecast-based cash grants are a potential adaptation strategy to deal with changes in extreme events linked to climate change. This paper presents the results of a mixed-methods, quasi-experimental study, based on a post-disaster household survey. The research assesses the effectiveness of the forecast-based cash distribution in helping beneficiaries to take preparatory early actions and reduce the negative impacts of the flood on their health, well-being, assets and livelihoods. The assessment shows that the cash grants contributed to improving households' access to food, a reduction in high-interest debt accrual of vulnerable households, and reduced psychosocial stress during and after the flood period, compared to a control group of similarly vulnerable and flood-affected communities that did not receive the forecast-based cash assistance. The intervention may also have prevented households from being forced to make destitution sales of valuable assets, as indicated by qualitative data collected in July, but we do not see these benefits sustained after a second flood peak in August 2017. There is a need for further research to assess the longer-term effects of forecast-based cash on the socio-economic development and well-being of the most vulnerable.

1. Introduction and literature review

Forecast-based Financing (FbF) refers to the use of weather forecast and risk data to trigger funding for action before a disaster event or before acute impacts are experienced by the population at risk [1]. It is an innovative approach in the humanitarian sector to reducing disaster impacts through anticipatory action, rather than waiting to initiate action in a post-disaster response capacity [2]. FbF builds on an extensive body of Early Warning Early Action (EWEA) work within the humanitarian sector and was born out of considerable institutional learning on

implementing early actions based on early warnings [3–6].

Forecasts have been used successfully to inform early warnings across a growing set of hazards and time scales. The range and extent of anticipatory actions taken typically varies with the forecast's lead time and thus the degree of uncertainty: storms and cyclones are short-term risks that can be forecast with relatively high skill; actions based on early warning systems in cyclone-prone areas have saved millions of lives and prevented significant damage, in part because affected populations can act when they know with near certainty that a cyclone is imminent to strike [7,8,9,39]. Based on weather forecasts, as many as

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<https://doi.org/10.1016/j.ijdr.2019.101275>

Received 21 November 2018; Received in revised form 10 April 2019; Accepted 10 August 2019

Available online 27 August 2019

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800,000 people were evacuated within the 48 h before Cyclone Phailin made landfall in India in 2013 [10]. These large-scale anticipatory measures are less feasible in the context of long-term risk or when forecasts have high uncertainties, as is often the case for floods, especially in data-scarce areas. However, there are a number of risk reduction actions that can be taken with a seasonal lead time to prevent disaster losses in coming months. In the West Africa regional office of the International Federation of Red Cross and Red Crescent Societies (IFRC), disaster management supplies were sourced ahead of time based on a 2008 seasonal forecast of above-normal rainfall. The anticipatory action improved the supply availability from about 40 days to two days when flooding did occur in the region [11]. In other locations, volunteers have used information about heightened risk at seasonal time scales to reinforce latrines to reduce the risk of diarrheal disease outbreaks when above-normal rainfall is likely to occur [12].

The number of successful examples of institutionalized early warning systems in the development and humanitarian sectors is growing; prominent examples include the regional Famine Early Warning System Network [13] and the Global Framework for Climate Services [14]. Heatwave early warning systems tend to have longer lead times and also trigger action to reduce mortality, but these are more frequent in developed countries [15–17].

Previously, the ability to release humanitarian funds based on a forecast and within the lead time afforded by a forecast was a significant barrier to effective early action. With FbF, the financing mechanism enables the automated release of funds in anticipation of an extreme weather event to implement predefined actions through an Early Action Protocol (EAP). In the EAP, all involved parties pre-agree on a set of actions, the forecast-based trigger that initiates them, how they are to be implemented and by which institutional actors [1]. In doing so, decisions are automatic once a disaster event of a specified magnitude is forecasted above a specified threshold of probability, which allows actors to make the best use of limited lead-times, avoid making rushed decisions, and better enables plans to be made with sufficient consultation of stakeholders.

Bangladesh is one of the most disaster-prone countries in the world and highly vulnerable to climate change because of its geophysical settings. Investments in flood forecasting in the country have enabled strong early warning systems, including impact-based forecasting, flood damage functions to anticipate who will be flooded in any given event [18], and warnings for at-risk communities [19–21]. Such early warning systems to reduce disaster impacts are a key strategy to address the rising risks due to climate change [22].

Based on well-developed early warning systems, Bangladesh was one of the first countries to operationalize FbF and the first ever to implement a forecast-based cash distribution in anticipation of a natural disaster due to flooding. The district of Bogra is located in the northern part of Bangladesh within the Brahmaputra basin, the country's biggest river. Flooding is an annual recurring event during the monsoon season, when 80% of the annual amount of rain falls. Two to three weeks after peak rainfall in July, the rivers in the Jamuna/Brahmaputra basin reach their maximum discharge [23], in an area that is prone to severe flooding and waterlogging, constituting one of the most vulnerable and fragile ecosystems in the country.

Poor and landless families are most severely impacted by the floods as they regularly settle on temporary islands known as *chars*, riverine sand and silt land masses which are created and older ones washed away by the river [20]. River flooding therefore acutely threatens the assets and livelihoods of entire communities in northern Bangladesh if they are unable to evacuate before the floods occur [24]. The population has developed a level of resilience and adapted their livelihood strategies to the flood patterns [25,26]. However, in some years the magnitude of the floods far exceeds the usual area covered and the coping capacity of communities, leading to the destruction of homes, assets and crops. Floods in Bangladesh have been linked to physical and mental illness in affected populations, as well as economic losses and damage to

infrastructure [18,24,27].

While conditional and unconditional cash transfers to assist vulnerable populations have long become widely used in development programs [28], their deployment in humanitarian relief is a more recent phenomenon. Although there are examples of cash being provided as a form of emergency assistance as early as the 1980s, the use of cash for disaster relief has started to increase significantly from the early 2000s, along with the number of studies and evaluations commissioned by humanitarian agencies and donors on the topic [29].

This Bangladesh study is part of the Action Plan of the German Federal Foreign Office for humanitarian adaptation to climate change. It aims to assess the effectiveness of forecast-based cash distributions in helping vulnerable populations to take preparatory early actions, and to prevent and reduce negative natural disaster impacts on their health, well-being, assets and livelihoods. It was implemented in the FbF pilot phase during which project countries focused on small-scale interventions to test and refine the approach. The FbF project in Bogra district subject to this study was piloted by the Bangladesh Red Crescent Society (BDRCS), with support from the German Red Cross (GRC) and technical assistance from the Red Cross Red Crescent Climate Centre (RCCC).

The expected benefits of forecast-based cash in advance of flooding in Bogra were identified based on community-level consultations, a literature review, and consultations with RCCC, GRC and BDRCS staff. In this paper, we test the hypotheses that households who receive forecast-based cash before the flood are better able to evacuate flood-affected areas when needed, make fewer destitution sales of valuable assets to cope with the flood impacts, accrue fewer debts during the flood period, consume more and better-quality food, experience less psychosocial stress, suffer less from diseases in the aftermath of the flood, and resume productive activities sooner than non-FbF-assisted households after the flood period.

2. Methods

2.1. Forecast-based cash eligibility criteria, trigger methodology and selection of early actions

The eligibility of households to be included as beneficiaries in the FbF project was assessed based on a vulnerability score for each household using six criteria: the quality of the housing structure; level of inundation during previous floods; monthly expenditure; number of household members who are children, elderly, or disabled; being a female-headed household, widowed or divorced; and livelihood strategies.¹ About 50% of households in the survey area primarily pursued on and off-farm day labor; between 13 and 18% are small-scale farmers on their own land, while five to six per cent are sharecroppers. The livelihood sources of the remaining households included other small-scale agriculture, petty trading, other informal activities, social protection payments and remittances. The 1045 most vulnerable households from across the four communities were selected as beneficiaries for the FbF intervention.

An unconditional cash transfer of BDT 5000 (USD 60 equivalent as of 1 July 2017) was selected as the most viable forecast-based action, in

¹ Supplementary Material, Table S1 provides the details of the vulnerability scoring system; Fig. S1 contains an overview of the main livelihood sources across the intervention and comparison households. There are no statistically significant differences between the intervention and comparison groups.

consultation with the beneficiary population,² for the following reasons: (1) many of the likely flood impacts identified in the community focus group discussions could be addressed by the availability of cash; (2) the BDRCS and GRC in-country teams had experience with post-disaster cash distributions and at the time BDRCS was receiving cash readiness support such that they felt able to undertake a forecast-based cash distribution; (3) there is strong evidence in the literature on the value of unconditional cash transfers [28]; and (4) no other action being considered appeared to have greater benefits than an unconditional cash distribution. The cash amount was determined broadly following the BDT 5400 monthly average value of the 2016/2017 Minimum Expenditure Basket (MEB) for Northwest Bangladesh, and in consultation with Bangladesh's Cash Working Group (Cash Working Group in Bangladesh, 2017). In 2017, the working group recommended a Multi-Purpose Cash Grant (MPCG) of BDT 4,000, later revised to BDT 4,500, to cover 75% of the average MEB in the aftermath of any disaster (Cash Working Group in Bangladesh, 2018). The MPCG value is based on a review the Government of Bangladesh *Cash Assistance Packages* for humanitarian crisis and a Household Economic Approach (HEA) study of *char* and river basin communities in Northwest Bangladesh [30]. The amount of FbF cash per household is thus set between the MPCG of BDT 4500 and the MEB of BDT 5400.

Based on a review of secondary data and a household survey in early 2016, four flood-prone communities with the highest concentration of vulnerable households were selected as FbF intervention communities in Bogra district, with two of the communities located on *char* islands and two communities on the banks of the Brahmaputra river (see map, Fig. 1 below). The beneficiary communities would only receive the intervention in the event that a forecast of an extreme weather event triggered the activation of the program.

The trigger for the intervention was based on a hydrological model for fluvial inundation which takes into consideration upstream conditions, rather than rainfall within the program area. River gauges were installed in each of the four selected communities and their readings correlated with an official gauge station in Sariakandi of the Bangladesh Flood Forecasting and Warning Centre (FFWC). In early 2017, the GRC in-country team adjusted the trigger points for flood events to allow for an increased preparatory time ahead of the flooding. A trigger was considered to be reached when the flood crossed the pre-determined Danger Level (DL) and stayed above the DL for at least three days.

2.2. Triggering of forecast-based cash distributions during the 2017 floods in Bangladesh

Beginning in June 2017, heavy monsoon rains throughout the region, including Bangladesh, India, Nepal and Bhutan, created severe riverine flooding. In Bangladesh, the network of rivers overflowed their

² First, a long-list of early actions was generated via community level consultations. Multiple focus groups were organized to discuss previous flood impacts, indigenous coping strategies, livelihoods and adaptive actions and response interventions they had experienced in the past. The early actions considered by the communities included: (1) Unconditional cash as the most fungible resource; (2) fortifying homes with rope and bamboo; (3) distributing saline, food (rice, lentils, potato, oil) and fodder; (4) temporary latrines and tube wells; (5) vaccines for livestock; (6) containers to keep items dry above water; (7) after evacuation: standard relief items, including tarps/tents, fuel, jerry cans, mosquito nets, gumboots for persons developing foot problems, candles, matches, gas cooker, torch; (8) nets for fish farms; (9) airtight drums to protect harvested paddy. During these consultations, a number of impact areas were brought forward that the FbF intervention could aim to mitigate: Taking out high-interest loans for need of emergency cash; selling assets at destitution prices to access cash; experiencing water-borne disease; losing privacy/dignity while evacuated; having assets stolen from the homestead while in evacuation; inability to pay for boat transport to evacuate; and meal reduction and drinking dirty water came out as strong recurring themes in each of the focus groups.

banks in areas covering one third of the country; this was considered to be the worst flooding in Bangladesh in the past 30–40 years [23]. Flash flooding and landslides also occurred throughout the affected areas. The National Disaster Response Coordination Centre (NDRCC) reported almost 6.9 million people affected, with 114 people reported dead and at least 297,250 people displaced. Approximately 593,250 houses were destroyed [33].

Observations of upstream flooding across borders improved the ability to anticipate peak flood impacts downstream in Bangladesh – especially in the Ganges, Jamuna and Brahmaputra rivers. There were multiple flood peaks in the Brahmaputra river, with the most severe flooding occurring in mid to late August. The FbF pilot project in Bogra district triggered for an earlier flood peak between 4th and 9th July 2017. While the danger level crossed the predetermined threshold again in August, a second triggering for the next peak was not initiated because early action for multiple peaks was not part of the pre-defined standard operating procedure at the time and resources were not available for a second activation. This experience has informed the development of improved trigger models.³

The Bangladesh Red Crescent Society, through a collaboration with the Post Office, implemented the cash distribution to a total of 1039 pre-registered beneficiaries in the four intervention communities between 7th and 11th July 2017; this was seven days before the flood peak in Kamalpur, five days ahead of the flood peak in Kazla, while in Bhandarbari 6&7 as well as Bhandarbari 3 cash was distributed four and three days in advance of the flood peak, respectively. The peak flood level occurred on 14 July which was also the median evacuation date of the sample households.

2.3. Study design

The flood-related activation of FbF in Bangladesh's Bogra district in July 2017 was accompanied by an empirical, quasi-experimental study to estimate the impact of the forecast-based provision of cash (the intervention) on the target population of vulnerable households. The assessment sought to test the pilot project's hypotheses about the expected benefits of the FbF cash distribution as summarized in the introduction.

The project resources were sufficient to assist four at-risk communities only. Therefore, in the flood-prone area, the intervention was assigned to four communities based on their vulnerability profile. For the purposes of this study, four nearby communities with a similar vulnerability profile were selected to serve as the comparison group that would constitute the counterfactual. In the intervention communities, the 1039 most vulnerable households who received forecast-based cash assistance constitute the intervention group of the study. In the comparison communities, the same vulnerability criteria as described in section 2.1 were applied to select the most vulnerable households to be eligible for inclusion in the survey sample; they constitute the comparison group that did not receive FbF cash assistance.

A random sample of 410 households was drawn from the

³ Apart from the FbF trigger early in the monsoon season, an IFRC Emergency Appeal was issued and approved for the Bangladesh floods with CHF 4,813,498 released on 23 August 2017. This enabled the Bangladesh Red Crescent and IFRC to provide 100,000 vulnerable persons with support in health, shelter, relief items, water, sanitation and hygiene, food security and livelihoods. By the end of August, as the flood levels were receding, the number of affected persons in Bangladesh was estimated at 8.1 million with 140 people dead, 697,000 damaged or destroyed homes, 4,680,000 ha of inundated farmland and widespread damage to roads and embankments (see <http://media.ifrc.org/ifrc/2017/08/28/millions-flood-affected-people-bangladesh-live-life-uncertainty-despite-decreasing-water-levels/>, accessed on 1 August 2018). The crisis added additional pressure on displaced persons, including Rohingya refugees, both in terms of the flood-related impacts they experienced as well as reducing the capacity of state and non-state actors to provide them with ongoing support.

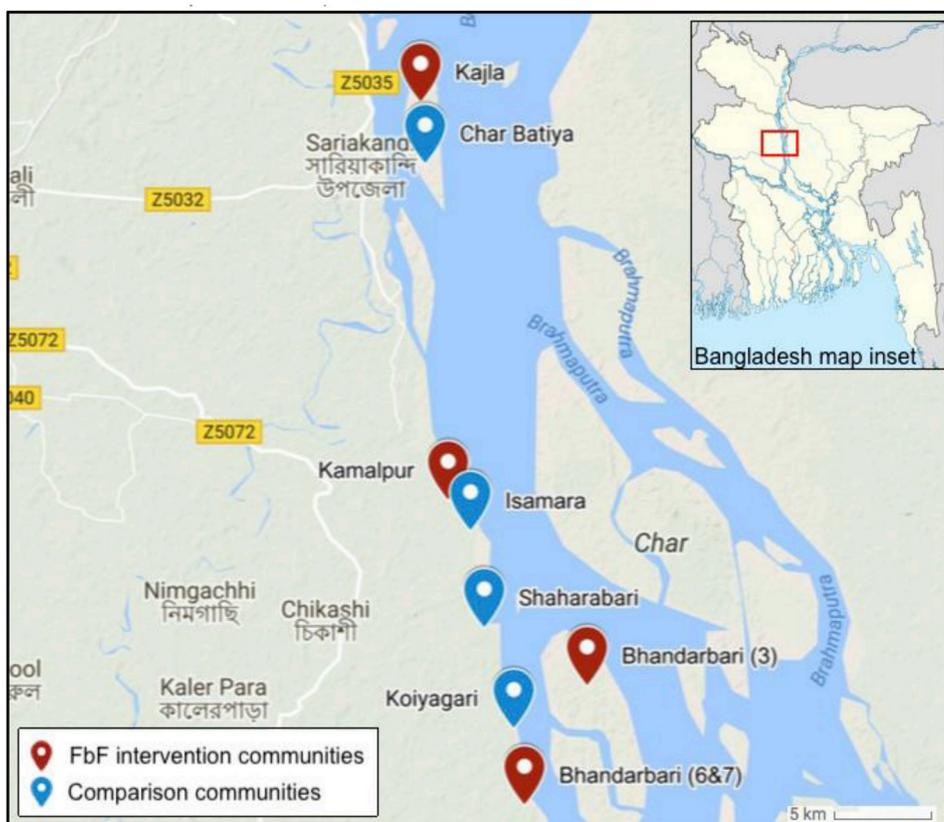


Fig. 1. Location of FbF intervention and comparison communities in Bangladesh's Bogra district [31,32].

intervention and comparison groups and interviewed during a baseline survey that was conducted in May 2016 to gather socio-economic background data on variables that could potentially mediate the effect of the intervention on outcomes. A follow-up household survey was carried out in early October 2017, approximately one month after the flood waters had receded. 390 complete responses were collected, 174 (or 45%) from intervention households and 216 (55%) from comparison households. For both surveys, BDRCS volunteers were trained on a structured questionnaire and deployed to the field using Open Data Kit (ODK) as a mobile data entry and management platform.⁴

Qualitative data was collected by means of 16 focus group discussions and 16 key informant interviews in intervention and comparison communities, conducted in late July 2017, at a time when many households were still experiencing direct flood impacts but before the second flood peak in August 2017.⁵ The purpose of the qualitative data

⁴ The use of BDRCS volunteers as enumerators constitutes a potential source of bias in the survey data. The respondents in the intervention communities may have felt reluctant to share criticism openly with representatives of the organization that provided the pre-flood assistance, and the BDRCS volunteers may have had a - conscious or unconscious - predisposition for recording the most favorable feedback possible. While the enumerator training sought to minimize this potential bias and the authors carefully analyzed the data with this caveat in mind, an influence on the results cannot be ruled out.

⁵ Focus group participants comprised randomly selected members of the most vulnerable groups: landless, elderly, disabled, day laborers. Discussions were brought together separately by age and gender, i.e. younger and older, men and women groups were convened separately. Key informants were selected based on their roles and access to information during and after the flood period: health centre staff and community health committee members; disaster management committee members; local agricultural office and livestock department staff; women's group or other active civil society group leaders; as well as boatmen and shopkeepers.

collection was to triangulate the quantitative information about people's experiences during the flood period, to generate a deeper understanding of the early warning information they had access to, the early actions they took and the impacts they experienced.

2.4. Addressing potential bias due to confounding factors

Table 1.a shows that the FbF-assisted households and non-FbF-assisted households are comparable on most socio-economic key variables. However, there were several significant differences in these pre-treatment covariates: The intervention group appears to be more vulnerable on several economic indicators. FbF-assisted households live in lower-quality houses than the comparison households and productive land ownership is significantly more prevalent among comparison households than among intervention households, although the average monthly cash income of both groups is nearly identical, around 5000 Bangladeshi Taka. A greater proportion of FbF-assisted households were headed by a woman, indicating potentially more fragile livelihood conditions. However, the primary school completion rate among intervention households was more than double that of comparison households (13.2 vs. 6.0%). The correlation between the two variables, sex of the household head and educational attainment, is weak and statistically insignificant in this sample.

There is a significant difference between intervention and comparison households regarding the location of their houses from the relative flood safety of the embankment. The houses of the intervention group are an average of 806 m away from the nearest embankment (median distance: 524 m), compared to 285 m for the comparison group (median distance: 91 m). This could mean that the evacuation of the household in the event of flooding is logistically and financially more demanding of intervention households as compared to non-FbF-assisted households.

Given the differences in pre-treatment covariates, propensity score matching (PSM) was used to reduce bias due to potentially confounding

variables. Non-matching observations were dropped from the dataset.⁶ Table 1.b shows the differences in covariate means after the propensity score matching. Note that the total number of complete observations was reduced from $N = 390$ to $N = 348$ matching units between the intervention and comparison group. The PSM procedure has effectively eliminated the significant differences on variables related to housing structures and, to a lesser extent, land ownership. However, the other differences remain as discussed above and are statistically significant. The review of covariates confirms that the FbF project appropriately targeted the most vulnerable households and suggests that the intervention group is likely to be significantly more vulnerable than the comparison group. Other research has confirmed that the *char* island dwellers, in addition to facing natural hazards such as floods and soil erosion, are subject to complex power dynamics, discrimination [34] and forced displacement [35]. This caveat regarding the difference in vulnerability must be considered when interpreting the survey results.

3. Results and discussion

The post-disaster survey data, together with the qualitative information collected from intervention and comparison households, was used to test the hypothesis about the expected benefits of the FbF cash distribution in Bogra district in anticipation of the flood.

3.1. Uses of FbF cash

Beneficiary households were asked what they used the FbF cash for, how much they spent and when they made the majority of their purchases. Fig. 2 shows that almost all beneficiaries (92%) spent a portion of their cash grant on food; two thirds of the intervention group (65%) used FbF money to pay for health expenses; and nearly half of the beneficiaries (45%) bought non-food items (NFIs) such as soap, jerrycans, buckets or clothing. One third (35%) spent some FbF cash towards evacuation costs, including boat transport and hiring labor to help move household items or livestock.

Beneficiaries who spent FbF cash on food or evacuation expenses used almost half of the value of their BDT 5000 cash grant towards these purposes (on average BDT 2337 and 2332 respectively; Supplementary Material, Fig. S2). The asset purchase category, which included livestock such as goats, fishing equipment or tin sheets, registered the highest spending by individual households with an average expenditure of BDT 3,540, and was only surpassed by debt repayments with BDT 3844. However, since only one in ten beneficiary households (9%) used the FbF cash to buy assets and one in twenty beneficiaries (5%) paid back debts with FbF resources, the amounts spent on these purposes are almost negligible when weighted by the proportion of beneficiaries who spent FbF cash on the respective categories and when compared to the amounts spent on food (Fig. S3). Nearly 90% of the FbF recipients spent the majority of their cash assistance before the flood peak, indicating that the additional resources were put to use immediately in support of preparatory actions and coping strategies.

3.2. Household-led early actions

The decision and timing to take early actions, including to evacuate may depend on whether the household received an early warning of the

⁶ A propensity score was estimated for each survey respondent, indicating the predicted probability of receiving FbF assistance, based on a logistic regression model with a binary treatment/non-treatment outcome variable and independent variables as listed in Fig. 4 below. In a second step, a nearest neighbor matching algorithm was executed whereby comparison matches are chosen for each treated unit one at a time, selecting the comparison unit that is not yet matched but is closest to the treated unit on the distance measure (smallest difference in propensity scores).

impending flood. The data show that virtually all households in intervention and comparison communities (99%) received an early warning, FbF-assisted households on average three days earlier than comparison households (7 July 2017 vs. 10 July 2017), mainly through BDRCS volunteers in conjunction with the cash distribution.⁷ The most important sources of early warning were word of mouth, radio/TV, and people's flood experiences from previous years.

Fig. 3 shows the early actions that households took in anticipation of the flood; the following differences between the two groups are statistically significant: 57% of FbF beneficiary households purchased food compared to 38% of comparison households. The proportion of households who reinforced the roof or walls of their house is almost twice as high in the intervention group (32%) compared to the group who did not receive FbF cash assistance (17%). Strikingly, almost one fifth of the comparison group indicated that they did not take any early action, compared to only seven per cent of intervention group households who did not act early. Among those who did not take any early actions, 70% of the comparison households said that they did not think the warning was correct, compared to only 25% among beneficiary households (Supplementary Material, Table S4). This may point to the greater trustworthiness of BDRCS volunteers as a source of early warning compared to TV/radio or other means of communication.⁸

The ability to evacuate the entire household from the flood-affected areas when needed can be assessed by analyzing (a) whether households evacuated or stayed, (b) how timely the relocation occurred (sooner than later) and (c) how it was financed which will be assessed further below.

86% of FbF-assisted households evacuated their homes entirely in response to the rising flood waters, compared to 76% of comparison households.⁹ While intervention households evacuated a day earlier than non-FbF-assisted households on average, there is no significant difference when comparing the median evacuation dates and times. Therefore, it appears to be unlikely that the timing of the early warning influenced the timing and decision to evacuate the household in its entirety. Differences observed in evacuation times may also be due to the location of the communities and the individual households regarding their elevation and flood exposure.

The results from the logistic regression analysis presented in Table 2 confirm a strong positive and statistically significant effect of FbF assistance on the odds of households evacuating the flood-affected areas. The effect persists when controlling for other factors that may influence the necessity and ability of households to relocate. Note that the intervention households are generally located farther from the relative safety of the embankment than comparison households, as noted above. When controlling for the households' distance from the embankment, the effect of FbF assistance on the odds of evacuating is reduced from a 90% increase (model 1) to a 74% increase (model 2) but remains strong and significant. The other predictor variables do not significantly affect the log odds of evacuation.

⁷ The difference between the two groups in the timing of the early warning was not intentionally designed. It is partially explained by the distribution of FbF cash between 7th and 11th July 2017 when warnings may have been issued by the BDRCS who managed the distribution process. However, only 45% of beneficiary households indicated that a warning came from a (BDRCS) volunteer, among other sources (Supplementary Material, Table S2), and only a small majority of 57% of intervention households were warned on or before 7th July. It did not have a significant effect on households' ability to evacuate the flood area.

⁸ Fig. 3 also indicates that sixty per cent of beneficiary households started to evacuate individual household members after having received the early warning, compared to 54% of non-beneficiaries, although this difference is not statistically significant; this also applies to the remaining early action categories.

⁹ The difference between the two groups is statistically significant (p -value = 0.02).

Table 1

Comparison of sample means before and after propensity score matching; intervention = FbF assistance (statistically significant differences in bold print).

Variables	a. Before propensity score matching			b. After propensity score matching		
	Intervention	Comparison	p-value	Intervention	Comparison	p-value
	Age of household head	49.99	49.26	0.62	49.99	49.74
Size of the household	4.30	4.34	0.86	4.30	4.40	0.83
Woman-headed household	27.0	16.7	0.01***	27.0	19.0	0.08*
Educational attainment						
No formal education	14.9	14.4	0.87	14.9	16.1	0.77
Some primary	17.2	22.7	0.18	17.2	18.4	0.78
Completed primary	13.2	6.0	0.02**	13.2	7.5	0.09*
Some secondary	28.7	27.8	0.84	28.7	28.7	1.00
Completed secondary	14.4	16.7	0.53	14.4	17.2	0.46
Any post-secondary	11.5	12.0	0.87	11.5	12.1	0.87
Housing structure						
Kutcha	76.4	67.1	0.04**	76.4	71.8	0.33
Single roofing	23.0	31.0	0.07*	23.0	26.4	0.46
Semi pucca	0.6	1.9	0.24	0.6	1.7	0.32
Land tenure						
Landless	51.2	43.1	0.11	51.2	49.2	0.75
Don't own any land, lease some land	25.3	11.1	0.00***	25.3	13.8	0.01***
Own some land and lease some land	5.7	7.4	0.51	5.7	8.1	0.40
Own land and don't lease any to others	10.9	20.8	0.01***	10.9	20.1	0.02**
Own land and lease some land to others	5.7	17.6	0.00***	5.7	8.6	0.30
Monthly household income (Taka)	5046	5488	0.11	5046	5434	0.19
Received any remittances	26.4	19.9	0.13	26.4	19.5	0.13
Distance from embankment (meters)	806	285	0.00***	806	332	0.00***
N	174	216		174	174	

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

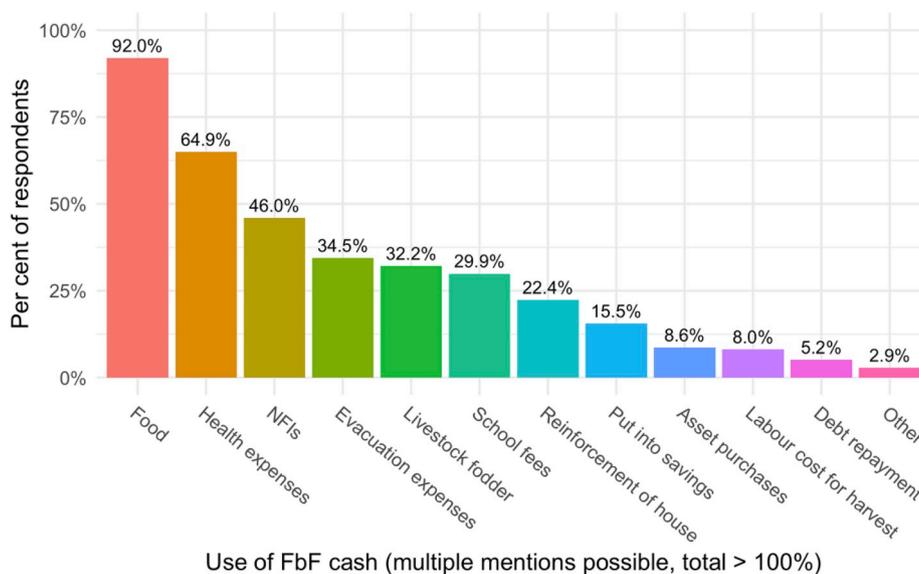


Fig. 2. Proportion of intervention beneficiaries who spent FbF cash, by spending category (multiple mentions possible; total can be greater than 100%).

The evidence points towards a confirmation of the effectiveness of FbF in helping households to evacuate in a timely manner when needed. However, reliable household-level data on the impact of the flood, such as rising water levels over time, are not available. Therefore, the observed evacuation patterns cannot be assessed in relation to the *de facto* urgency and needs the effectiveness of FbF in this regard can be confirmed with a note of caution only.

3.3. Destitution sales of valuable assets to cope with the flood impacts

Selling valuable household assets, such as furniture, cookstoves or livestock, in exchange for money or food is a common coping strategy in times of crisis. The survey data showed that 20% of households in FbF-assisted communities and 25% of households in comparison

communities sold any type of valuable asset. The difference between the two groups is not statistically significant (p-value = 0.251). The majority sold their cook stove, others a variety of goods such as goats, chickens or jute fibers. For example, a male focus group participant in a comparison community shared that “I sold my goat to manage the money. I got 1000 taka less price than the usual”.

There is a revealing discrepancy between the quantitative and the qualitative data regarding destitution sales: In the 16 community focus group discussions that were held in the four intervention and four comparison communities in late July 2017, before the second flood peak in August 2017, the sale of valuable assets - predominantly livestock - was only mentioned three times by FbF beneficiaries and 18 times in the discussions with comparison community groups. By the time the quantitative survey was conducted in early October 2017, all households had

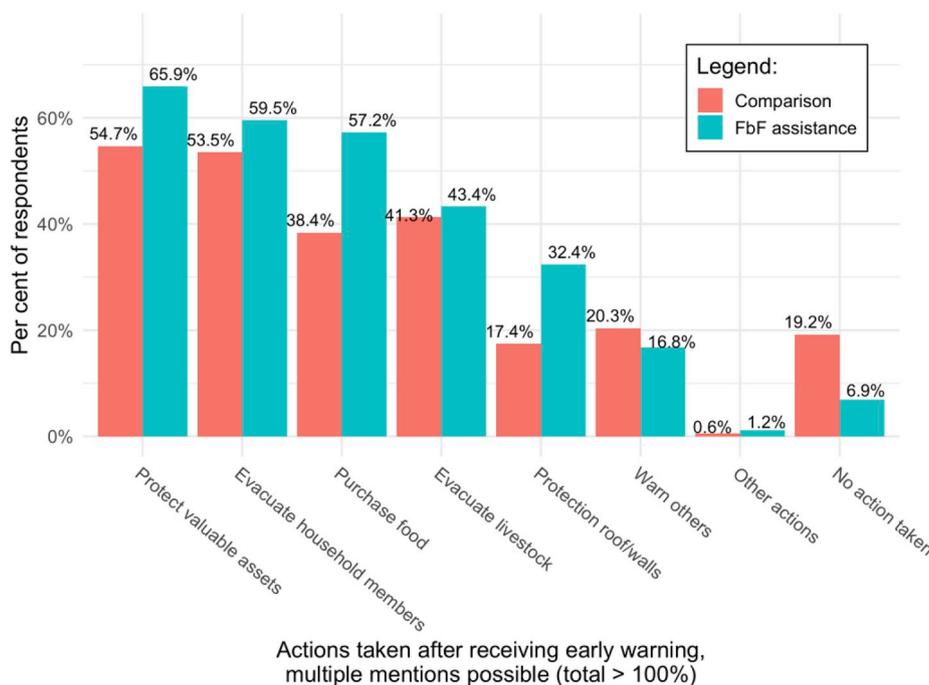


Fig. 3. Early actions taken after having received a warning; means comparison of FbF-assisted (intervention) and comparison households who received an early warning of the flood; p-values reported in Table S3.

Table 2
The effect of receiving FbF assistance on the odds of evacuating (logistic regression analysis).^a

	Dependent variable: Evacuated (yes/no)	
	(1)	(2)
FbF assistance	0.604** (0.288)	0.553* (0.301)
Age of household head	-0.012 (0.010)	-0.012 (0.010)
Size of household	0.120 (0.083)	0.126 (0.084)
Woman-headed household	0.172 (0.371)	0.175 (0.371)
Completed primary education	0.294 (0.513)	0.261 (0.516)
Land tenure (don't own any land, leasing some land)	0.277 (0.385)	0.239 (0.391)
Monthly household income (Taka)	-0.00004 (0.0001)	-0.00004 (0.0001)
Received any remittances	-0.257 (0.335)	-0.235 (0.337)
Distance to embankment (m)	0.0001 (0.0002)	0.0001 (0.0002)
Constant	1.425* (0.731)	1.357* (0.743)
N	348	348
Log Likelihood	-165.149	-164.989
Akaike Inf. Crit	348.297	349.978

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Significance indicated in bold print. Standard errors in (parentheses).

^a For all logistic regression analysis results presented in this paper, the coefficients shown in the table indicate the change in the log odds of the outcome for a one unit increase in the independent (predictor) variable. How to interpret the results: For every one unit change in FbF assistance (i.e. from 'not being assisted' to 'receiving assistance'), the log odds of evacuating the flood-prone area (versus not evacuating) increase by 0.553. This means that receiving FbF assistance increases the odds of evacuating by 74% since $\exp(0.553) = 1.738$.

experienced a second flood peak in August 2017 and a significant difference between the two groups in undertaking destitution sales was not detected anymore.

Therefore, there is not enough evidence from the Bangladesh FbF project to conclusively confirm or disprove the effectiveness of FbF cash to prevent destitution sales. In this study, we did see an indicative difference between the intervention and the comparison group in their behavior to sell valuable assets in response to the first flood peak, but not to the second flood described in section 2.2. It is also important to note

the intervention group was considerably more vulnerable than the comparison group based on the differences in their housing conditions, productive land ownership and proportion of women-headed households which could have influenced these results.

3.4. Debt accrual during the flood period

In addition to selling valuable assets, households may take out new loans to finance immediate needs during the flood period. Fig. 4 shows a large and statistically significant difference in the borrowing behavior between the intervention and comparison groups. 58% of FbF-assisted households indicated that they did not need to take out any new loans during or immediately after the floods to cope with the impacts, compared to only 40% in households who did not receive forecast-based cash assistance. Comparison households are also three times more likely to have taken out large loans of over BDT 10,001 and over BDT 20,001, respectively. The differences observed in the other loan size brackets are not significant (see Supplementary Material, Table S5).

The majority of households in intervention and comparison communities who took out new loans borrowed money from family members. However, households who did not receive FbF cash assistance were more than four times as likely to borrow from banks at interest rates typically above 20%, depending on the total loan amount and repayment schedule [36]. They were also more than twice as likely to take out loans from private money lenders at potentially even higher interest rates (Supplementary Material, Table S6). It must be noted that the proportion of households who borrowed from other sources or did not indicate the type of lender was substantially higher in the intervention group. If they were evenly distributed across the other three sources of funding (family, banks, private lenders), there would still be a significant difference between the intervention and comparison groups in borrowing from banks, although the significance in the difference in borrowing from private lenders would disappear.

The data thus confirm that households who received FbF cash assistance before the flood accrued fewer debts during and immediately after the flood period.

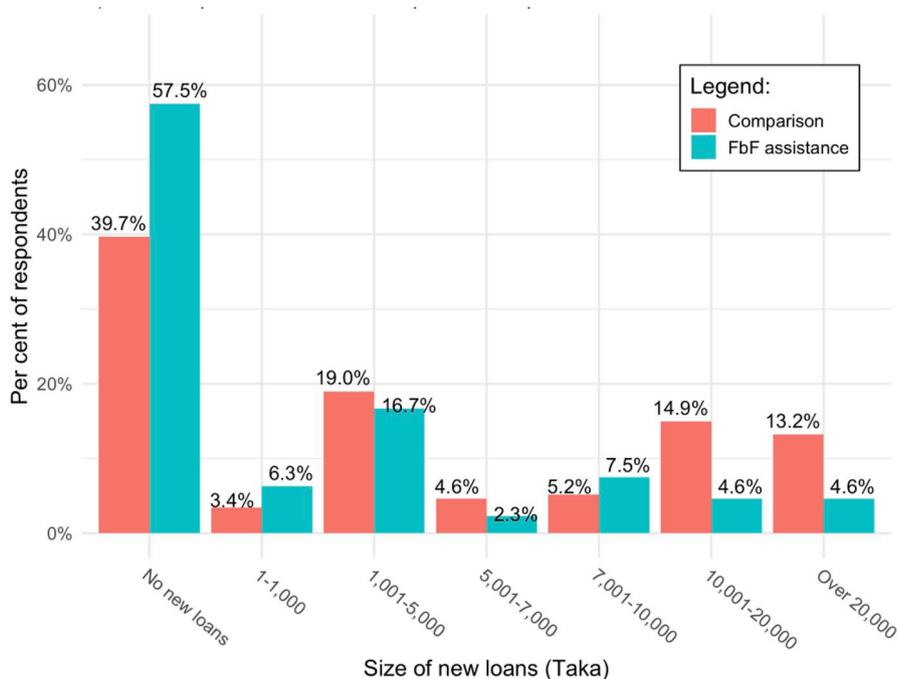


Fig. 4. Size of new loans taken out during and immediately after the flood period; means comparison of FbF-assisted (intervention) and comparison households; p-values reported in Table S5.

3.5. Effects of FbF cash on the quantity and quality of food consumed by households

When the availability of food in the market is limited and livelihood opportunities are constrained due to the impacts of the flood, families may be forced to reduce the number, size and variety of their meals because they cannot access or afford the foodstuffs they need. 89% of households in the intervention group and 93% of households in the comparison communities said that they had to reduce the number of meals or the size of their meals at some point during the flood period, with no significant differences between the two groups.

When asked about how frequently they had to skip meals or reduce the size of their meals, the comparison group was over three times more likely to have had to skip meals or reduce meal sizes more than ten times (28%), compared to only 8% of households in the intervention group (Supplementary Material, Fig. S4). The difference is statistically significant.

Regarding the quality of the food that households consumed during and immediately after the flood period, it is considered a danger sign when any household member is forced to eat only rice for a whole day because they cannot access or afford anything more nutritious. Almost all respondents from comparison communities (95%) indicated that this happened in their households, while it occurred significantly less frequently in the intervention group (71%, p -value = 0.00) (Fig. 5). The deprivation of nutritious food was significantly more severe among households that did not receive FbF assistance before the flood, with one third indicating that they had only rice to eat on more than ten days during the month immediately after the flood period. This is twice the incidence experienced by households in the intervention group (16%) and is not surprising given that 92% of beneficiaries spent some portion of their FbF cash grant on purchasing food. The results confirm the effectiveness of forecast-based cash in increasing the beneficiaries'

ability to eat regularly and nutritious food during the flood period.¹⁰

3.6. Morbidity and psychosocial distress in the aftermath of the flood

One expected benefit of providing a cash transfer before the flood peak was a reduced disease incidence in beneficiary households due to their increased ability to afford medical treatment, nutritious food and water purification means. While health expenses were the second most frequent expenditure category for the use of FbF cash, as discussed in the beginning of section 3.3, this did not result in significant differences between the intervention and comparison group in the experience of illnesses among adults or children, a significant effect of forecast-based

¹⁰ The different food consumption patterns could be due to communities having received different emergency distributions of food aid from external organizations after the flood peak. Independent of the FbF pilot project, the government handed out a variety of food assistance packages that varied by location. When asked what type of external food aid the households had received, the only statistically significant difference was that about one in every eight intervention households had received a small package of lentils and soybean oil from the government, compared to one in twenty comparison households who received the same package (Supplementary Material, Table S9). It is unlikely that this accounts for the large difference in the frequency with which the two groups had only rice to eat for ten days or more; further statistical tests confirmed the significance of FbF assistance and found no significant effect of the lentil and soybean oil package. When testing the effect of FbF assistance and the smallest food package on the odds of (a) having to eat only rice for a whole day and (b) having had only rice to eat for ten days or more, FbF assistance significantly decreases the odds for (a) by 89% and the odds for (b) by 67% while the effect of the food package is insignificant (Supplementary Material, Table S10). The modeling also shows that living in a woman-headed household decreases the odds of any household member having had only rice to eat for a whole day by 50%; leasing some land reduces the odds by 66%. It is also worth noting that a greater proportion of the comparison group reported to have some savings (21% vis-à-vis 14% of FbF beneficiary households) which does not appear to have influenced their ability to access food.

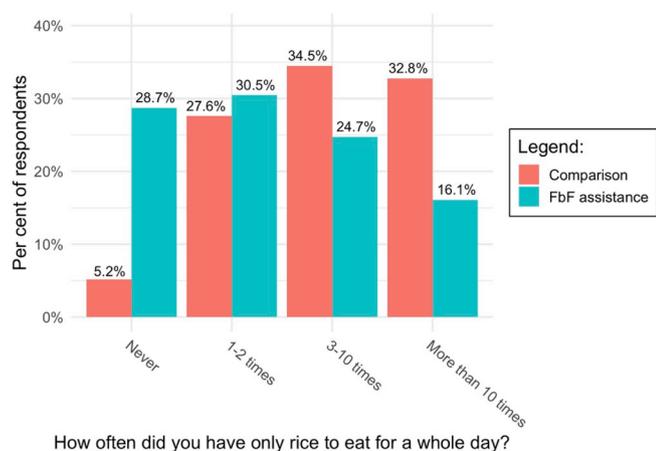


Fig. 5. Frequency of any household member having only rice to eat for a whole day during and immediately after the flood period; means comparison of FbF-assisted (intervention) and comparison households; p-values reported in Table S8.

cash could not be detected (Supplementary Material, Figs. S5 and S6).

Experiencing a severe flood may also cause psychological distress. The quantitative survey and the qualitative data collection included questions to gauge anxiety and stress among the responding household heads. The survey items were loosely based on the standardized Perceived Stress Scale (PSS [37]); but reduced to three questions to keep the survey as short as possible, given the respondents' difficult circumstances. Thus, we only have a crude measure of psychosocial distress. The survey data show that households who did not receive FbF assistance felt miserable or unhappy significantly more frequently after the flood than the intervention group who received cash assistance. Similarly, FbF-assisted households were significantly less likely to have felt anxious or depressed in the last seven days before the survey (29 vs. 43%, Supplementary Material, Figs. S7 and S8). There are no statistically significant differences disaggregated by gender or age groups.

The quantitative trends align with the patterns observed in the qualitative data from focus group discussions immediately after the flood peak period. Respondents from comparison communities spoke about anxiousness and stress significantly more than focus group participants from intervention communities. For example, a woman from a comparison community shared that "I could not sleep last night. I heard that the dacoits [NB: bandits/criminals] came to loot our animals. I was very scared". A female focus group participant from another community said that "we are in great misery. I was thinking of what to cook today, how to feed my children".

The findings from the quantitative and qualitative data analysis, although based on a crude measure and therefore not to be over-interpreted, appear to corroborate the project hypothesis that FbF-assisted households experience less psychosocial distress than non-FbF-assisted households in the aftermath of the flood.

3.7. Productive activities and livelihoods

Livelihood opportunities can be negatively affected by psychosocial distress, physical injury or illness, poor nutrition, damages to productive assets such as fields, livestock or tools, or the inaccessibility of places of work. Forecast-based cash is expected to mitigate some of these effects by giving families the means to care for, prepare and protect their family members and their assets, saving them from psychosocial and physical stress. The study sought to assess the effect of FbF cash on household livelihoods by means of a proxy indicator: the ability of working household members to pursue their livelihood activities and the duration for which they were unable to work due to the flood impacts.

Almost all households in intervention (87%) and comparison

communities (86%) indicated that at least one adult household member was unable to work as a consequence of the flood, for an average duration of 17 days among the intervention and 18 days among the comparison group, although the difference is not statistically significant (Supplementary Material, Table S14).

The main reasons for having been unable to work were damages to farms, fields and productive assets (77% in FbF-assisted communities and 83% in comparison communities, no statistically significant difference). Around one fifth of respondents across both groups also reported illness as a reason for being unable to work. Only a small minority of respondents said that they were unable to work because their place of work - farms, livestock shelters or shops - were not accessible due to the flood waters (Supplementary Material, Table S15). The data do not lend support to the hypothesis that FbF-assisted households resumed productive activities sooner than non-FbF-assisted households after the flood period.

4. Conclusion

The analysis of household-level effects of a forecast-based cash distribution in Bangladesh's Bogra district in anticipation of the 2017 floods has shown that the FbF cash transfer increased the regularity and quality of beneficiary households' food intake, reduced the need to take out high-interest loans and appears to have reduced psychosocial stress in the aftermath of the flood. The intervention may have also prevented households from having to make destitution sales of valuable assets when compared to similarly affected households, as suggested by the qualitative data; however, after a second flood peak occurred in August 2017, this benefit was not detected anymore in the survey data from early October 2017.

While the evidence on the effect of FbF cash on the efficiency of household evacuations is not conclusive, the data suggest that the forecast-based cash distribution did not reduce the disease incidence in beneficiary households compared to non-FbF-assisted households or the time period that adults were unable to work due to the consequences of the flood.

Two important caveats apply to these results and have likely reduced any observable positive effects of forecast-based cash on beneficiary households: the intervention group, especially the *char* island dwellers, was considerably more vulnerable than the comparison group, based on the differences in their level of education, productive land ownership and proportion of women-headed households. More importantly, all study households were affected by a second extreme flood peak in August 2017, a month after the first flood instance which triggered the intervention. The project was not designed to address two events of this magnitude. Therefore, benefits which may have been observable after the first flood peak in July may have been wiped out by the second flood peak in August and before the survey in October.

The learnings from this research have led to the re-definition of the forecast-based trigger methodology and the scale of the program in Bangladesh. The Government of Bangladesh is currently reviewing its Standing Orders on Disaster (SOD), integrating FbF into the country's disaster risk reduction (DRR) system. The new draft SOD includes a section on FbF with its definition and future setup in Bangladesh; the policy-related section two of the SOD includes details on operationalization and the establishment of an FbF Technical Advisory Committee with key DRR stakeholders in Bangladesh.

The results of this assessment have also informed a new design of FbF projects more widely: Countries now strive to implement FbF at national-level scale using an impact-based forecasting approach that integrates weather forecasts, impact analysis and risk data for the definition of trigger points. The International Federation of Red Cross and Red Crescent Societies (IFRC) has created a funding window dedicated to forecast-based action as part of its Disaster Relief Emergency Fund [38]. The systemic adoption of FbF can be considered to be systems-level adaptation: Where FbF is integrated into the national disaster risk

management and DRR institutional ecosystems, flexibility is established to use the window of opportunity between forecast and extreme event to prevent and mitigate disaster impacts on the most vulnerable.

The experience and findings from this study point to several areas for further research: our survey did not collect independent observational data on the physical, household-level impacts of the flood. More reliable data on inundation levels and the damages and losses incurred by households would enable a more robust analysis of the extent to which FbF cash influenced the beneficiaries' preparatory and evacuation behavior and whether it helped to mitigate physical flood impacts of housing structures and assets. The provision of forecast-based cash in advance of the flood peak may also have contributed to mitigating some long-term negative consequences of taking out high-interest loans, poor nutrition and high stress levels. A longitudinal study with periodic, longer-term data collections would be required to assess these long-term effects, which was beyond the scope of this analysis.

Funding

This work was supported by the German Federal Foreign Office, under the Action Plan of the Federal Foreign Office for humanitarian adaptation to climate change.

Declaration of interest

None.

Acknowledgements

The authors would like to thank the Bangladesh Red Crescent Society, under the leadership of Mr. Md. Belal Hossain, Director for Disaster Risk Management, whose staff and volunteers implemented the cash transfer intervention, supported the data collection underlying this study and work tirelessly to assist vulnerable populations in Bangladesh with relief and recovery efforts. We thank the survey respondents and focus group discussion participants for sharing their experiences with us. The authors also gratefully acknowledge the German Red Cross for establishing and supporting the FbF pilot projects and for the support of their staff in Bangladesh and Germany. The research project received funding from the German Federal Foreign Office, under the Action Plan of the Federal Foreign Office for humanitarian adaptation to climate change. We are grateful to the anonymous reviewers for their constructive comments that contributed to improving the revised version of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2019.101275>.

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