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Health expenditures, remittances, and climate vulnerability: Evidence from Bangladesh

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Gazi M Hassan
The University of Waikato
Centre for Applied Macroeconomic Analysis, ANU

Sakib Mahmud
University of Wisconsin-Superior

Abstract

Remittances' effect on a household's health outcome (e.g. Infant mortality) is ambiguous, but the impact on health expenditure is positive and less equivocal in literature. This paper puts the relationship between health expenditure and remittances into a stress test to see whether it survives the adverse impact of climate change. Using a natural experiment of rainfall-driven remittances, I provide an experimental measure for remittances' effect on the health expenditure among rural households in southern Bangladesh. Health expenditure and remittances are jointly related; therefore, I use the instrumental variable approach. The treatment of remittances is randomly assigned to households who suffered losses due to a natural shock from the cyclone-Roanu enabling the instrument, exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations, to identify the average treatment effect for the treatment group (cyclone-affected remittances recipient households). I find that while remittances cause household health expenditures to increase, the marginal effect of remittances is heterogeneous and negative conditional on the household's exposure to the level of vulnerability proxied by the household's distance to cyclone shelter. In other words, the health expenditure-remittances nexus gets weaker with the adverse effect of climate change. Specifically, I find that an increase in remittances by a Taka increases health expenditure by 0.24 Taka (24 Paisa) in the absence of any climate hazard but reduces health expenditure by 0.10 Taka (or 10 Paisa) if the measure of climate vulnerability increases by one standard deviation from its mean value. For countries like Bangladesh, which is exceptionally vulnerable to natural hazards, climate vulnerabilities can render the financing of health care costs through remittances unsustainable even if households receive regular and sizable flows.

Keywords

Health expenditure, remittances, climate vulnerability, climate change, endogeneity, natural experiment.

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Address for correspondence:

(E) cama.admin@anu.edu.au

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HEALTH EXPENDITURES, REMITTANCES, AND CLIMATE VULNERABILITY: EVIDENCE FROM BANGLADESH

Gazi M. Hassan[1]
The University Of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
&
Reseach Associate, CAMA, Crawford School Of Public Policy, Canberra, Australian National University
Email: gmhassan@waikato.ac.nz

Sakib Mahmud
University of Wisconsin-Superior
Belknap & Catlin, PO Box 2000, Superior, WI 54880, USA
Email: smahmud@uwsuper.edu

Abstract:

Remittances' effect on a household's health outcome (e.g. Infant mortality) is ambiguous, but the impact on health expenditure is positive and less equivocal in literature. This paper puts the relationship between health expenditure and remittances into a stress test to see whether it survives the adverse impact of climate change. Using a natural experiment of rainfall-driven remittances, we provide an experimental measure for remittances' effect on the health expenditure among rural households in southern Bangladesh. Health expenditure and remittances are jointly related; therefore, we use the instrumental variable approach. The treatment of remittances is randomly assigned to households who suffered losses due to a natural shock from the cyclone-Roanu enabling the instrument, exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations, to identify the average treatment effect for the treatment group (cyclone-affected remittances recipient households). We find that while remittances *cause* household health expenditures to increase, the marginal effect of remittances is heterogeneous and negative conditional on the household's exposure to the level of vulnerability proxied by the household's distance to cyclone shelter. In other words, the health expenditure-remittances nexus gets weaker with the adverse effect of climate change. Specifically, we find that an increase in remittances by a *Taka* increases health expenditure by 0.24 Taka (24 Paisa) in the absence of any climate hazard but reduces health expenditure by 0.10 Taka (or 10 Paisa) if the measure of climate vulnerability increases by one standard deviation from its mean value. For countries like Bangladesh, which is exceptionally vulnerable to natural hazards, climate vulnerabilities can render the financing of health care costs through remittances unsustainable even if households receive regular and sizable flows.

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[1] Corresponding author.

1. *Introduction*

Three facts motivate this paper. First, a critical concern related to financing health care costs in developing countries is the heavy dependency of total expenditure on health (TEH) on the out-of-pocket (OOP) payment (O'Donnell et al. 2008). In countries like Bangladesh or Nepal, health care is financed almost exclusively from OOP. Seventy per cent of TEH in Bangladesh is financed through OOP, which is relatively high even compared to the average percentage observed in South Asia (Global Burden of Disease Health Financing Collaborator Network, 2019). Second, international migration and remittances flows have become a substantial global phenomenon. There are now an estimated 258 million people living in a country other than their country of birth. Household incomes in developing countries have experienced a steady rise in part through the tremendous growth in remittances that these migrants send to origin countries (World Bank, 2018)[2]. Some scholars believe that remittances income in developing countries could be an important source of funds for OOP payment alongside other traditional sources such as savings, borrowing, selling assets or cutting current expenses, and foregoing further medical care costs (McIntyre et al., 2006). Third, climate change is adversely affecting the health of populations around the world, with the greatest impacts in low-income countries (Confalonieri et al., 2007; WHO, 2002, 2009). The health consequences are especially unfavourable for vulnerable populations and create global health disparity (Haines and Patz, 2004; Kovats and Haines, 1995). The detrimental health impacts on people and damage to critical public health infrastructure associated with climate change are expected to rise over coming decades as the frequency and intensity of some types of extreme weather events are expected to rise as a consequence of climate change (IPCC, 2007).

[2] According to the World Bank estimates officially recorded remittances to developing countries will increase by roughly 11 percent to reach $528 billion (USD) in 2018. (https://www.worldbank.org/en/news/press-release/2018/12/08/accelerated-remittances-growth-to-low-and-middle-income-countries-in-2018)

What connection, if any, is shared by these three factors? In other words, how health expenditure, remittances, and climate change are related? This question is the primary inquiry of this paper. Likely, households in developing countries will increasingly rely on alternative private funding sources for their health care costs, such as remittances from overseas migrants. Existing studies support the view that remittances improve health outcomes in the migrant's family mainly through enabling higher allocation to TEH (Adams and Cuecuecha, 2010, 2013; Amuedo-Dorantes and Pozo, 2011; Hildebrandt and McKenzie, 2005, Ponce et al. 2011)[3]. However, climate change can moderate the health-remittances relationship as it creates an adverse impact on population health and the public health infrastructure leading to additional health care costs for the vulnerable families and a reallocation of budget for health expenditure. This issue is largely overlooked in existing studies. So, we investigate how the exposure of migrant households to climate hazards alters the health expenditure and remittances relationship.

The mechanism that governs the conditioning role of climate vulnerability on the health-remittances relationship is not obvious. A plausible conjecture could be it emanates from possible substitutions between health expenditure and adaptation expenditure to mitigate climate change. In general, remittances flows are characteristically predictable, sustainable, adequate, and accessible, which meet the requirements of climate finance (Bendandi & Pauw, 2016). Some migrant destination countries endeavour to tap this into channelling towards adaptation finance to achieve the scale of financing needed for adaptation in the Pacific. For instance, Australia and New Zealand through their Seasonal Work/Employer Program (Maclellan and Mead, 2016). Other evidence suggests that

[3] Adams, R. H., Jr., & Cuecuecha, A. (2010). Remittances, household expenditure and investment in Guatemala. *World Development*, *38*(11), 1626–1641.
Adams, R. H., Jr., & Cuecuecha, A. (2013). The impact of remittances on investment and poverty in Ghana. *World Development*, *50*, 24–40.
Amuedo-Dorantes, C., & Pozo, S. (2011). New evidence on the role of remittances on health care expenditures by Mexican households. *Review of Economics of the Household*, *9*(1), 69–98.

remittances tend to finance adaptation cost in diversifying flood management infrastructure, improved drainage, resilient housing facility, etc. (IPCC, 2014). Likewise, Mahmud and Hassan (2018) have found that remittances income has been utilised to undertake adaptation cost such as private storm protection investment for home improvement after a major cyclone. Therefore, in climate-vulnerable regions, remittances are probably shared between adaptation expenses and other household expenditures, including health. Anecdotal evidence does support such substitutive behaviour. A non-profit organisation Uttaran found through a survey in May and December 2020 in Asashuni Upazila in coastal Bangladesh that people spent for adaptation after the Cyclone Amphan by reducing consumption and healthcare expenditure as coping strategies[4]. As a result, it is plausible that a household vulnerable to climate change will have fewer funds available for spending on health from remittances income than its less vulnerable counterpart.

Decisions on migration, remittances, expenditure allocation, and health care are usually made simultaneously. The set of academic papers that have analysed the impact of migration and remittances on health outcomes, taking the endogeneity problem into account, have used different instruments as identification strategy such as historic state-level migration rates (Hildebrandt and McKenzie, 2005)); municipal rainfall pattern (Lopez Cordoba, 2006); transaction cost of sending remittances (Ponce et al., 2011); distance to U.S. border and U.S. wages (Amuedo-Dorantes and Pozo, 2011).

While these studies do well in terms of causal identification, in most cases, the issue of non-random selection remains a concern because the estimated effects do not provide an experimental measure. Given this, we make two contributions to the paper. First, we revisit the remittance-health expenditure nexus using a natural experiment, an alternative and a more robust identification strategy

[4] https://en.gaonconnection.com/bangladesh-coronavirus-covid19-poverty-water-food-security-amphan-cyclone/

than its predecessors that deal with endogeneity and non-random selection. Second, we estimate a conditional impact of climate vulnerability of the migrant household on the health-remittances relationship. To the best of my knowledge, prior studies are yet to investigate this issue.

Not all regions are homogenously affected by adverse climate change events. So, we have selected Bangladesh as a case study because it is disproportionally more vulnerable than others to climate change-induced extreme weather like an abrupt and severe storm or cyclone or flood (GCRI, 2019)[5]. The southern part of Bangladesh is in a low-lying delta, especially vulnerable to sea-level rise, severe storm surges, floods, and salinity intrusion (Ministry of Health and Family Welfare, GoB, 2009). Therefore, southern Bangladesh represents geographical regions characterised by broad coastal areas vulnerable to climate changes and sea level rises, such as small island developing countries.

Remittances depend on many factors that also matter for household health expenditure. Therefore, to address the endogeneity issue, the identification strategy in this paper uses a natural experiment armed with a plausibly exogenous variation in rainfall driven instrument for the *level* of remittances received. Therefore, a critical distinguishable facet of this paper is it provides an experimental measure for the impact of remittances that minimises the problem of omitted variables and non-random sample selection bedevilling cross-sectional research. For Bangladeshi households with overseas migrants, the paper finds international remittances *causes* the amount of expenditure allocated for health care to rise, but the effect becomes weaker as the migrant household face greater climate vulnerability.

The natural experiment demonstrating that remittances cause an increase in health expenditure among rural households in Bangladesh uses plausibly exogenous variation in rainfall interacted with

[5] Global Climate Risk Index (GCRI) (2019) Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017, Bonn: Germanwatch e.V.

cyclone-affected migrant household's distance to the local weather stations as an instrument for remittances received among cyclone-hit remittances-recipient families in Bangladesh.

The rationale behind this instrument is that rainfall is a critical factor determining the yield of a rainfed crop that generates the primary source of household income from agriculture in countries characterised by a subtropical monsoon climate. Therefore, it is a good predictor of remittances that respond to the income shocks to the household (Yang and Choi, 2007).[6] The instrument also relieves major worries about endogeneity bias arising from reverse causality and measurement error. Furthermore, to circumvent the problem of non-random selection of migrant households from the general population, the paper harnesses a natural shock triggered by the cyclone-Roanu that allows for a random assignment of the treatment of remittances. [7] Therefore, a critical distinguishable facet of this paper is it provides an experimental measure for the impact of remittances that minimises the problem of omitted variables bedevilling cross-sectional research. we use households' average expenditure for health care as the dependent variable. The instrumental variable (IV) results demonstrate that remittances significantly increase the recipient household's health expenses.

The endogeneity bias in estimation can come from three separate sources: reverse causality (households with better health conditions enjoy favourable socio-economic conditions that attract higher remittances), measurement error (remittances data were self-reported and less educated families might report remittances data less accurately) and non-random selection. To combat these concerns, and noting the fact that after a natural disaster, a migrant household tends to receive larger than the usual amount of remittances (Clarke and Wallsten 2004), we use a natural experiment of

[6] The instrumentation strategy is similar to Yang and Choi (2007) but with a key difference: Yang and Choi (2007) use rainfall to instrument for income shock, I use rainfall to instrument for remittances.

[7] The Cyclone Roanu made its landfall on 21 May 2016 in southern coastal regions of Bangladesh (survey area) and the data for this project was collected during October-November 2016. The random assignment of treatment is achieved through multiplying the instrument with an indicator variable equal to one if the remittances-recipient household suffered losses due to the cyclone-Roanu and zero otherwise.

rainfall driven remittances interacted with cyclone-affected migrant household's (hereafter, the treatment group) distance to the nearest weather station to construct an innovative cross-sectional instrument that provides an experimental measure for the impact of remittances.

[Insert Figure 1, about here]

To track plausibly exogenous variation in remittances receipts that is uncorrelated with cyclone-affected household's socio-economic conditions, we use variation in average local rainfall. As Figure 1 shows, remittances sent to the cyclone-affected households in southern Bangladesh are negatively correlated with household-level rainfall measure (first stage relationship)[8]. Specifically, we interact the exogenous variation in the deviation of district-level average aggregate rainfall from its long-run trend with cyclone-affected households' distance to the nearest weather station (located in the nearest town centre) as an instrument for remittances. The instrument, therefore, identifies the average treatment effect for households who suffered losses due to the landfall of cyclone-Roanu in southern Bangladesh.

For a total sample of 610 households where 105 households have one or more member living and working abroad, the IV results show that remittances enhance healthcare expenditure by the recipient households. The study's outcome applies to the coastal communities in southern Bangladesh that are more likely to be adversely affected by climate change. The results find that for one Taka increase in household remittances income, household health expenditure increases by 0.16 Taka. With a 1 per cent increase in remittance income, health expenditure increases by 25 Taka in percentage term. However, the effect of remittances is conditional on the degree to which a migrant household is vulnerable to climate change. Using remoteness as a criterion to gauge climate vulnerability, we find

[8] Inadequate rainfall leads to crop failure and remittances respond in opposite direction.

that the impact of remittances on health expenditure is higher in households that are less climate-vulnerable than otherwise. The findings are reliable because of the natural experiment framework and provide unique evidence on the strength of remittances-health relationship by considering the impact of climate hazards faced by the households.

The findings are robust to alternate specifications, alternative instruments, and possible omitted variable bias arising from post-cyclone recovery expenses financed through remittances [9] and potential violations of the exclusion restriction. There are four plausible channels through which rainfall-driven instruments could affect the health expenditure independent of remittances flows: domestic income from other sources, other household expenditures, labour market participation and access to credit. The findings are robust to specifications that take these other channels into account.

The remainder of the paper is structured as follows: Section 2 provides a review of relevant literature. Section 3 discusses the empirical strategy and data. Section 4 presents the results, and section 5 provides the conclusions.

2. *Literature Review*

The connections between overseas remittances and health outcomes are much less explored by academic literature. Usually, there are two related, but different outcome studied. One group of studies is devoted to finding the impact on family health indicators such as infant mortality or child weight. Others study whether migration affects health expenditure. In either case, it is also not a-priori conclusive the direction in which remittances income should be affecting health outcome. Migration can disrupt family life and put more stress on the family members who are left behind.

[9] Remittances flowing in to finance damages due to cyclone during same time. Control for q132

On the other hand, remittances may relax income constraints and allow households to invest in human capital. Earlier studies have found that remittances often lead to investments in households' health and education (see; Adams, 2005 and 1998; Edwards and Ureta, 2003; Yang, 2005; Alderman, 1996). Besides, migration may allow households access to better healthcare information, and that positive impact may be reinforced by health expenditures financed by remittance income (Lopez-Cordova, 2006; McKenzie and Sasin, 2007).

Using retrospective data collected in Mexican communities located in central Mexico, Kanaiaupuni and Donato (1999) explore the effects of migration on infant mortality but finds that infant mortality increases as migration rates intensify. Similarly, Hildebrandt and McKenzie (2005) evaluate the impact of international migration on child health outcomes in rural Mexico and find that children in households with a migrant member are estimated to be less likely to die in the first year. Lopez Cordoba (2006), using a cross-section data of Mexican Municipalities, finds that increases in the fraction of households receiving international remittances are generally correlated with better schooling and health outcomes and reductions of dimensions of poverty.

Ponce et al. (2011) find no significant impact on long-term child health variables but observe that remittances impact preventive health activities and health expenditures in Ecuador. Amuedo-Dorantes and Pozo (2011) find that international remittances raise health care expenditures among remittance-receiving households in Mexico. Ambrosius and Cuecuecha (2013) find that being a substitute for credit remittances finance hospitalisation cost in case of a major health shock in the migrant family in Mexico. Valero-Gil (2009) considers the effect of remittances on the share of health expenditures in total household expenditure in Mexico and finds a positive and statistically significant effect of remittances on the household health expenditure. At the macro level, using a dataset on workers' remittances, health outcomes, and educational attainment of 122 developing countries from

1990 to 2015, Azizi (2018) finds remittances raise per capita health expenditures and reduces child mortality rate.

Decisions on migration, remittances, expenditure allocation, and health care are usually made simultaneously. A set of academic papers analyse the impact of international migration and remittances on health outcomes, taking the endogeneity problem into account. These studies have used different instruments as the identification strategy to address the endogeneity issue. Hildebrandt and McKenzie (2005) use historic state-level migration rates as an instrument, while Lopez Cordoba (2006) adopts municipal rainfall patterns and the distance to Guadalajara as instrumental variables. Acosta et al. (2008) create a counterfactual income prior to migration by multiplying remittances dummy with the second quintile of the income distribution to compare post-migration welfare. Ponce et al. (2011) exploit exogenous variation in the transaction costs of international transfer as an instrument for remittances to identify its causal effect on health. Likewise, Amuedo-Dorantes and Pozo (2011) use distance to U.S. border and U.S. wages in Mexican emigrant destination states as an instrument. Azizi (2018) uses bilateral remittances to create weighted indicators as instruments. While these instruments address the identification problem, it does not solve the problem of non-

3. Empirical Strategy and Data

3.1 Regression equation of interest

To explore the causal effect of remittances on a household's health expenditure, the regression equation of interest is given by a linear model for health expenditure as a starting exercise. More formally, let $HEALTH_i$, represent household health expenditure to be modelled as a linear reduced form as follows:

$$HEALTH_I = \beta_0 + \beta_1 REMIT_i + \beta_3 \boldsymbol{X}_i + e_i \qquad [1]$$

The independent variable of interest is $REMIT_i$ which is the monthly average amount of remittances money the household *i* receives from overseas is measured in local currency (*Taka*). While migration can disrupt family life and put more stress on the family members left behind, remittances may relax income constraints and allow households to invest in human capital. Past evidence suggests that remittances received by the households do enhance health expenditures. This means the coefficient on the *REMIT* term (β_1) should be positive. $\boldsymbol{X}_i$ is a set of household characteristics (size of household, number of female family members, number of working female members, number of female students aged above 7, number of school-going children below 7, number of overseas migrants, number of years migrant living abroad), economic characteristics (acres of agricultural land and other assets owned), household head characteristics (age of household head, education and profession. Finally, e_i is a standard normally distributed residual assumed independent of the independent variables.

3.2 Climate Vulnerability

While remittances can affect household activity through a host of different channels, in the second set of regression equation of interest, we examine one specific link between remittances and health expenditure, specifically the one that working through climate vulnerability. The central hypothesis we would like to test is whether the degree of climate vulnerability of the migrant household affects the impact of remittances on household health expenditures. To this end, we interact the remittances variable with an indicator of climate vulnerability and test the significance of the interacted coefficient. A negative coefficient would indicate that remittances are more effective in boosting health expenditures in households with a low level of climate vulnerability. On the other hand, a positive interaction would imply remittances enhance health expenditures in more vulnerable households.

So, the main regression equation of interest is:

$$HEALTH_I = b_0 + b_1 REMIT_i + b_2\, CLIMATE_i + b_3 (REMIT \times CLIMATE)_i + b_4 \boldsymbol{X}_i + \mu_i \qquad [2]$$

All the variables are the same as Eq. [1] and $CLIMATE_i$ is a variable that measures the degree of climate vulnerability of the migrant household. Climate vulnerability is the degree of inability to anticipate, cope with, resist, and recover from the impacts of disasters [WHO, 2002, 2009]. The Intergovernmental Panel on Climate Change (IPCC) defines climate vulnerability as the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change (IPCC, 2007). It also provides a framework to identify and assess a vulnerable household under three dimensions: "exposure", "sensitivity", and "adaptive-capacity". Which one of these criteria is more practical to use at the grassroots level when assessing household vulnerability differs from case to case. Some academics and practitioners prefer to address vulnerability from the "exposure" dimension defined as group or individual stress due to social and environmental change that disrupts livelihoods (Adger, 1999).

we measure climate vulnerability through the 'exposure' dimension. Ahsan and Warner (2014) have provided some indicators of exposure vulnerability in the context of Bangladesh. The main indicators they use to measure exposure to natural hazards or disasters are the percentage of households not willing to go to cyclone shelter, percentage of households not having a place in cyclone shelter or with neighbours, and the number of cyclones in the last five years. Considering this, we use the household's distance to the cyclone shelter to measure climate vulnerability. The logic is that a longer distance represents that the household is located in a remote area; therefore, it is more exposed to a natural hazard or disaster, making it more vulnerable to climate change. The variable *CLIMATE* is measured as the distance, in kilometre, of the household to the nearest cyclone shelter.

3.3 Endogeneity

A concern with the regression equation of interest is that attempts to gauge the causal impact of remittances on health expenditure use will suffer from endogeneity bias. The direction and magnitude of this bias, however, are likely to be influenced by the relative effects of reverse causality and measurement error.

On the former, the decision to migrate and remit earnings are often driven by poverty and a shortage of economic opportunities in the home country, which correlate with the household's expenditure allocation. If a household's underlying low health expenditure status is positively correlated with the receipt of remittances, this will tend to bias downward the effect of remittances health expenses. On the latter, mismeasurement of remittances does not seem to be random: poorer households, presumably with lower tracking capacities because of their low level of numeracy, are more prone to mismeasure remittances receipts. From an econometric standpoint, the prevalence of underreporting and the existence of systematic measurement error tend to attenuate the coefficient estimate of remittances on household's choice on clean energy. Thus, the presence of non-random measurement error will tend to downward bias the coefficient estimates.

3.4 Natural Experiment

One strategy to mitigate this endogeneity problem is to identify an instrument for remittances. we use a natural experiment linking plausibly exogenous variation in local rainfall in three districts of southern Bangladesh that interacted with the cyclone-affected households (treatment group) distance to the nearest weather station.

Two stylised facts make this an interesting natural experiment. First, the amount of remittances received by the cyclone-affected households tracks the variability of local rainfall. A major determinant of fluctuations in crop yield is year-to-year changes in climatic variables (Anderson and Hazell, 1987). The main agricultural crop rice (*Oryza sativa*) in Bangladesh, contributes significantly to the employment and livelihood of the rural people (Government of Bangladesh, 2014). Furthermore, the yield of the major rice crop *Aman* (sown in July-August and harvested in November-December) in southern Bangladesh is almost entirely rain-dependent (Sarker et al., 2017). The volume of rainfall during the wet season of July to September when *Aman* is sown is a critical determinant of crop yield and a good predictor of remittances that, like insurance, respond to income shocks (Yang and Choi, 2007). Thus, the wet seasonal rainfall provides a plausibly exogenous source of variation in remittances inflow that is unrelated to the economic and social conditions of the households in southern Bangladesh.

The second stylised fact is that a fair share of remittances received by the household in the treatment group emanated from the overseas migrant's emergency response to the losses suffered by the family due to the landfall of the cyclone-Roanu[10]. In general, migrants boost the amount they remit to their families immediately after a natural disaster in the home country (Bragg et al., 2017[11] ; Mahapatra et al. 2012 and Clarke and Wallsten, 2004). These two stylised facts underlie the construction of the instrument. Specifically, we interact with the exogenous variation in the deviation of district-level average aggregate rainfall from its long-run trend with the cyclone-affected household's distance to the nearest weather station (located in the nearest town centre) as an instrument for remittances.[12] Therefore, the instrument identifies the average treatment effect for households who suffered losses due to the landfall of cyclone-Roanu in southern Bangladesh.

This identification strategy is similar to that employed by Yang and Choi (2007) to gauge the impact of rainfall driven income shock on remittances flows. This paper's instrument differs from that of Yang and Choi on one key dimension. It instruments for remittances rather than household income by focusing on the level relationship between the preceding period's rainfall and the current period's remittances receipts. Specifically, this paper instruments the current period's (i.e., 2016) level of

[10] Data on remittances was collected within six months after cyclone-Roanu's landfall.
[11] (Remittances as aid following major sudden-onset natural disasters)
[12] There are thirty five weather stations all over in Bangladesh. Among these three weather stations – Bhola, Khepupara and Patuakhali – are located in the study area from the distance to the household was calculated.

remittances, with preceding rainy season's (i.e., 2015) level of rainfall measured as the deviation of the average precipitations from its long-run trend during the period when *Aman* rice is sown. Because inadequate rainfall in the preceding sowing season will most likely reduce the current period's *Aman* yield below the trend level, severing current family income to which remittances respond by moving in the opposite direction. Furthermore, we provide an experimental measure concerning the impact of remittances that minimises the problem of omitted variables bedevilling cross-sectional research.

Armed with this instrument, the reduced-form two-stage regression setup is:

$$Second\ Stage:\ HEALTH_i = b_0 + b_1 REMIT_i + b_2\, CLIMATE_i \qquad [3]$$

$$+ b_3 (REMIT \times CLIMATE)_i + b_4 \boldsymbol{X}_i + \mu_i$$

$$First\ Stage:\ REMIT_i = \alpha + \beta (DIST_i \times RAIN_j) + \delta' \boldsymbol{X}_i + \varepsilon_i, \qquad [4]$$

The structural equation [3] (second stage)[13] is of main interest where the dependent variable is $HEALTH$. The reduced form equation [4] (first stage) explains the variation in the endogenous variable, $REMIT$, in terms of strictly exogenous variables, including the IV $(DIST_i \times RAIN_j)$ that is excluded from the structural equation. Note that we use a just identified model and instrument only *REMIT* but not the interaction term. While we am particularly interested in identifying the causal impact of remittances (i.e. coefficient b_1) to health expenditure, my query is only limited to the estimated sign of the interaction term (i.e. sign of b_3). As in the linear instrumental variable estimator, the model is estimated in a two-stage process. Consistent estimation is based on the assumption that $(u_{i\,,}\varepsilon_i)$ are independently and identically distributed multivariate normal. Violation of this assumption requires clustered standard errors to control for the lack of independence (Maddala, 1983). The standard errors in the first and second stage are conservatively clustered by villages to allow for

[13] There is another second stage structural equation which is Eq. [1] but not the primary equation of interest.

arbitrary correlation in the error structure. Moreover, because the two equations are estimated jointly, the errors in the second stage take into account the estimation error in the first stage.

In the structural equation or the second stage regression, the coefficient on remittances income will measure the "average treatment effect" for a group of households who received remittances from overseas *and* was affected by the cyclone-Roanu.[14] Finally, the instrumental variable results are generalisable if the households in the control and treatment groups do not differ on pre-treatment observable characteristics. For instance, during the treatment period, the typical remittances receiving cyclone-affected household and non-affected household did not differ on household head's age and education up to higher secondary level, number of children above and below seven years of age, distance to forest, number of overseas migrants or average remittances receipts.[15]

3.5 Identifying Assumption

The identification assumption maintained in the empirical strategy is that the instrument – district-level rainfall interacted with cyclone-affected household's distance to the nearest weather station – affects household health expenditures only through remittances. An important concern with regard to the identifying assumption is that all households in a local area get affected by rainfall. Because of this, at least part of the effects found in household health expenditures may be due to locality-level economic conditions violating the exclusion restriction criteria. Several possible channels and mechanisms are conceivable to stem from the localised economic conditions that might contaminate the identification. Rainfall might directly affect household health expenditures independently of remittances through the local economic conditions such as the labour market, income from other

[14] The "control" or "counterfactual" group therefore is the group of remittances receiving households who were not affected by the cyclone-Roanu.

[15] Across the treatment and control groups, the p-value on t-statistics (reported in parentheses) comparing the group means on household head age (0.06), education up to higher secondary level (0.84), number of children above 7 (0.14), number of children below 7 (0.19), distance to forest (0.28), number of overseas migrants (0.35) and average remittances receipts (0.12) are not statistically different from each other at the 5% confidence level.

sources and other household expenditures. Another conceivable factor that might derive from the localised economic condition and could directly affect household health expenditures at source is the availability and access to credit. To safeguard the results of the study from the potential violation of the exclusion restrictions, it is ensured that the findings are robust to specifications that take these channels, which might potentially contaminate identification into account.

3.6 Data and summary statistics

The data was collected through a household survey from three coastal districts - Bhola, Barguna, and Patuakhali - of the Barisal division in southern Bangladesh.[16] These districts are the most affected zones from frequent cyclones, according to the Disaster Management Bureau (DMB) of Bangladesh. From each district, an Upazila (sub-district) was selected, including Monpura from Bhola, Amtoli from Barguna and Kalapara from Patuakhali. For the purpose of data collection, two unions from each upazilla were identified based on the DMB – Bangladesh's information about the number of affected households from Cyclone-Roanu, which made landfall on 23rd May 2016. Applying the "Two-Stage Sampling Methods" based on the Kish Grid/Allocation formula,[17] a simple random sampling (SRS) was used to pick two villages from each union for the purpose of conducting the household survey. Thereafter, systematic random sampling was employed to pick at least fifty households to survey from each village to finally enable a sample size of 610 households that were interviewed with the aid of a

[16] Administratively, Bangladesh has 6 divisions, 64 districts or zilas, 508 sub-districts or upazilas and 4466 unions. The term 'union' refers to the lowest administrative unit in the rural areas of Bangladesh. Under the Village Chaukidari Act of 1870, villages were grouped into unions to provide for a system of watches and wards in each village.

[17] Sample size was determined according to the following formula: $Sample\ Size = n_{initial} = \frac{N^2 + Z^2 + S^2}{MOE^2}$; Where, **N** = Total number of beneficiary households= 818,137; **Z =** Critical value from Normal Probability Distribution = 1.96; **S=** Standard deviation of the distribution of beneficiary data = 0. (Assume that since beneficiary data is not available) and, Margin of error (MOE) to be +/- 5% with 95% confidence interval. Sample size for random sampling is determined at 400 for household population size of 818,137. Considering the two stage sampling procedure, the design effect (DE) has been fixed at 1.5. This allows the sample size to be determined approximately at 600 households.

structured questionnaire.[18] The survey began in October 2016 and was fully completed by November 2016.

The dependent variable is household health expenditure. The key independent variable is remittances received from the overseas migrant member. It is a continuous variable measured in thousands of unit of local Bangladeshi currency (Taka). The data represents the average amount of remittances the family receives per month.[19] Other independent variables include household head's characteristics (age, education and occupation); demographic information (household size, number of female members, number of female students age seven or above, number of children below seven and number of children below seven years of age attending school), and various socio-economic characteristics (average monthly domestic income, average monthly health expenditures, average monthly food and housing expenditures, acres of agricultural land owned, amount of outstanding loan, access to clean water and sanitation, and ownership of other short-term assets).

[Table 1, about here]

Table 1 presents the summary statistics for 610 households used in the empirical analysis. Migrant households are those with overseas workers in October 2016. The 105 migrant households represent 17.2 per cent of the sample of households. The table begins with presenting the summary statistics of

[18] There were six data collectors for three districts with two for each Upazilla. On average, each data collector interviewed five household respondents per day. A field-coordinator was assigned to ensure the quality of the household survey. Prior to the main household survey, a pilot survey was conducted to improve the final version of the questionnaire. For successful completion of the fieldwork, enumerators with graduate level degrees in social science subjects were selected. A day long orientation was conducted involving the enumerators whose main job was to collect qualitative and quantitative data from the targeted villages. The training included a detail discussion of each question on the questionnaire as well as how to record the questionnaire data for each household survey. Since the data collection method was mobile app based with inclusion of recording the global positioning system (GPS) of each household, importance of maintaining highest level of consistency in data collection was communicated during the training program.

[19] The question used to collect remittances data is: "On average, how much money does he(/she/they) send home per month?"

variables used in constructing the instruments. The rainfall measure reported is the deviation of average wet-seasonal rainfall in 2015 from its long-term trend is used for instrumenting remittances. The second variable is another instrument constructed as the deviation of the average yield of Aman rice from the trend. This variable is also used to check for robustness purpose. The rest of the table summarises all variables used in the empirical analysis.

4. Results

4.1 Instrumental Variable Approach

The results are presented in Table 2, starting with the OLS model, which is estimated as a baseline regression to compare the magnitude of bias, if any, with the IV results (see; columns 1). It is recognisable OLS underestimates the effect of remittances on health expenditure. The downward bias is neither too large nor significant at 5 per cent. The rest of the regressions take an instrumental variable approach.

[Insert Table 2 here]

Table 2 presents the main results from the IV regressions. The first stage is presented in the lower panel of Table 2. Looking into the main coefficients of the first-stage of the IV regressions, few things are immediately noticeable. First, the instrument – interaction of rainfall and household's distance to weather stations – demonstrates a statistically significant effect on remittances. Second, the coefficient estimate of the instrument has a negative sign which is expected and confirms the first-stage relationship illustrated in Figure 1; a decrease in the instrument (lower rainfall than the historical trend) induces a positive effect on inflowing remittances. Third, the regressions are estimated with the primary variable of interest - remittances - measured in units of Taka and its log. In the regressions where *REMIT* is instrumented (columns 2, 4 and 5), the table shows that the estimated F-statistics on the excluded instrument are smaller than the conservative threshold of weak instruments of 9.6

suggested by Stock, Wright, and Yogo (2002). In practice, however, there is no clear critical value for the F-statistic to test for instrument relevance because it depends on many factors (Cameron and Trivedi, 2005, 2009). Furthermore, weak instruments are usually not a problem in just-identified models provided the instrument is significant in the first-stage (Angrist and Pischke, 2008, p. 209 and Angrist and Pischke, 2009).[20] Likewise, Asatryan et al. (2017) justified their low first-stage F-statistics than the benchmark value of 10. Reassuringly, though, the regressions where the log of *REMIT* is instrumented, the F-statistics on the excluded instrument well exceeds the threshold level of the weak instrument. Therefore, with a high value of F-statistics at the first stage and the lowest RMSE, the IV regressions that instrument log of *REMIT* give the most reliable results on which the paper's conclusion are drawn.

The second-stage estimates are presented in the upper panel of table 2. The most important result is the positive effect of remittances on household health expenditures; see columns 2-4. The effect is not only statistically significant but also substantively meaningful: A *Taka* increase in remittances income corresponds to a roughly 0.16 *Taka* (or 16 *Paisa*) increase in health expenditure (column 2). A 1% increase in remittances income leads to a 25.27 *Taka* increase in health expenditure (column 3).[21] As a further check, in column 4, the variable remittances per migrant worker is instrumented with no substantial change to the results. The results reveal the substantially positive role overseas remittances play in migrant households' allocation of health expenditure comparable to previous

[20] According to Angrist and Pischke (2008, page 209) and Angrist and Pischke (2009), as long as the first-stage coefficient is not zero, weak instruments are usually not a problem in just-identified models as the bias on the coefficient of the endogenous variable resulting from a weak instrument is not "serious". According to Angrist and Pischke (AP), any problems with too weak instruments in just-identified models are mirrored in the standard errors of the second-stage but they do not cause the second stage to be biased. This paper indeed shows significant second-stage effects; following the argument by AP this implies that the weak instrument does not seriously bias the effect of remittances. The key message in Angrist and Pischke (2009, page 1) is: "[…] bias with a just-identified model is not usually worth worrying about because if the instruments are so weak that just-identified IV is seriously biased, then you'll easily see the cosmic weakness of your first stage in such cases by virtue of large second-stage standard errors."

[21] The model in column 3 where log of remittances is instrumented is easy to interpret and its first stage F-stat exceeds 9.6 threshold.

studies on the same topic. Furthermore, across the IV regressions in table 2, the control variables have the expected effect on health expenditure. Age, demography, asset holdings, education and occupation, are all found significant.

How does the role that overseas remittances play in migrant households' allocation to health expenditure change with climate vulnerability? To explore the heterogeneous effect of remittances conditional on climate vulnerability, the primary motivation of the paper, we include an interacted term between remittance and climate vulnerability which is either (*REMIT*×*CLIMATE*) or (log (*REMIT*)×*CLIMATE*) depending on the variable that is instrumented. The conjecture is that climate vulnerability will make households spend less out of remittances on health because they now must also finance added adaptation expenditure. So, the estimated coefficient of the interaction should be negative and significant to confirm the conditioning role of climate vulnerability on the remittances and health expenditures nexus. Instrumenting directly for remittances and the log of remittances and controlling for the interaction term and its other constitutive part generates a negative and significant marginal effect reported in columns 5 and 6. The significant coefficient estimate captures the heterogeneous effect of remittances on household health expenditures, i.e., the marginal effect of remittances on health expenditures decreases as the level of climate vulnerability increases. In other words, remittances and climate vulnerability are complementary with regard to the impact of health expenditure.

There are few important things to note. First, the preferred model is given in column (6), where log*(REMIT)* instrumented. Because its F-statistics (12.52) on excluded instrument exceeds the critical threshold of the weak instrument, its RMSE is low compared to the other estimates, such as where *REMIT* is instrumented (column 5). The marginal impact shows that a 1 per cent increase in remittances will increase health expenditure by 38.01 Taka, which is substantive. The second important thing to note is that only the *REMIT* or log (*REMIT*) is instrumented but not the interacted term. This is because the primary objective in the paper is gauging the causal impact of remittances on health expenditure and estimating only the sign on the interaction term. Nonetheless, in a separate regression in column 7, we also instrument the interaction term controlling for its other constituents for a comparison. The results help sustain a causal interpretation of the interaction term that remittances cause a heterogeneous effect on health expenditure through climate vulnerability.

we also check the sensitivity of the results by employing an alternative instrument. we explore the available data on crop productivity in the study area to utilise it as an alternative instrument. Conceptually, remittances respond to rainfall only because the latter generates shocks to household's income through agricultural production. Therefore, the yield variability of the major rice crop Aman provides a credibly exogenous source of variation in remittances. Utilising the deviation of *Aman's* annual yield from its trend as an instrument, we estimate the IV regression presented in column 9. The new instrument possesses a negative sign and significantly affects remittances, and the corresponding marginal effect of remittances is positive and significant in the second stage.

The causal impact of remittances is established through the preferred regressions in columns 6 and 7, where log(*REMIT*) is instrumented. However, in providing the marginal analysis and the interpretation of the interaction effect, we find it is easier to use the IV regression where *REMIT* is instrumented. Based on the regression in column 5, we calculate the marginal effect of remittances at three different values – low, medium and high – of climate vulnerability. The values represent the mean distance to cyclone shelter and one standard deviation below and above the mean value. In the first panel in Figure 2, the linear prediction of the model shows the average marginal effect of remittances on health expenditure is decreasing, and the calculated slopes are 0.16, 0.04 and -0.10 for the above three different values, respectively. Specifically, it shows that an additional flow in remittances by a Taka increases health expenditure by 0.24 Taka (24 Paisa) in the absence of any climate vulnerability, but the same increment reduces health expenditure by – 0.10 Taka (or 10 Paisa) if the household's location is one standard deviation away from the average distance to cyclone shelter. we show a combination of predictive margins for various levels of remittances and climate vulnerabilities. The graph is shown in the second panel of Figure 2. It shows that the marginal effect of remittances is positive for low levels of climate vulnerability but is clearly negative for greater distance from a cyclone shelter.

4.2 Sensitivity Analysis

The criteria we have taken to measure climate vulnerability by distance to cyclone centre can be extended. In its recommendation to identify vulnerable groups and communities through geographical targeting, the United Nations Framework Convention on Climate Change (2018) suggests that the government or responsible authority identifies priority regions or boundaries whose groups and communities should be prioritised based on specific criteria. Such criteria may include arid or semi-arid lands, mountain regions, or remote areas. While distance to cyclone centre is one such criterion, others also fulfil the characteristics of remoteness. we find two such measures of climate vulnerabilities: the household's distance to the nearest vehicular road and the nearest primary school. we use these vulnerability indicators as a sensitivity test to the overall significance of remittances and the interaction term.

we present the sensitivity results in Table 3. As usual, we instrument both *REMIT* and log(*REMIT*). It can be noted that according to the diagnostic statistics, the modelling improves in Table 3 from the previous one – most of the first-stage F-statistics exceeds the critical threshold, and the instrument is negative and significant, confirming the first stage relationship. The causal impact of remittances shown in column 1-4 is positive as before, as shown in the estimated coefficients of *REMIT* and log(*REMIT*). The magnitude of the coefficients is comparable to those in Table 2. The interaction terms with respect to distance to vehicular road and primary school are negative, showing a falling marginal effect of remittances along with these two new indicators of climate vulnerability. In the last two columns, 5-6, we repeat the same IV regressions in the previous two columns using the alternative instrument of rice yield. Reassuringly there are no changes to the results. Therefore, the sensitivity analysis shows that the core results are and does not vary with different indicators of climate vulnerability.

[Insert Table 3 here]

4.3 Robustness check

We discuss the threats to identification and evidence against alternative channels (other than remittances) of the instrument's effects and against a critical potential confounding factor (expenditure undertaken by households to mitigate home damage caused by cyclone-Roanu).

4.3.1 Potential violation of exclusion restrictions

A significant concern about the identifying assumption is that all households in a local area get affected by rainfall. Because of this, at least part of the instrument's effects on household health expenditure may be due to locality-level economic conditions violating the exclusion restriction criteria. Several possible channels and mechanisms are conceivable to stem from the localised economic conditions that might contaminate the identification. First, rainfall might affect the household's health expenditure independently of remittances through impacting the localised economic conditions in a manner that could affect the sources of household's domestic income other than remittances. For instance, the sources of household income stemming from production activities related to agriculture or fishing can be directly affected by rainfall and other weather conditions. Second, on the same note, rainfall driven conditions can also affect other household expenditures, impacting the spending on health care. Third, rainfall could influence the household's labour supply response and affect health expenditure independently of remittances via the local labour market condition. For example, inadequate rainfall may depress local labour market conditions, and a household member goes further away for work reducing demand for health care. Fourth, rainfall can also affect health expenditure independently of remittances through the credit channel. The onset of weather-related conditions might generate greater demand for credit for either smoothing consumption or for other purposes such as health care cost.

To test whether such concerns have any basis, it is helpful to test the stability of the marginal effects remittances in Table 2 (column 6) to the inclusion of control variables likely to violate the exclusion criteria in various alternative channels. We include control variables for domestic household income, other expenditures, working adult members in the house and amount of credit undertaken. Any substantial change in the IV estimates when these control variables are included would cast doubt on the assumption that the effects of rainfall are working primarily through remittances. The main results are presented in Table 4. None of these variables directly affect health expenditures as they are not statistically significant and therefore relives the estimations from the worry of any identification problem. Furthermore, the marginal effect of the log of remittances is stable, and so is the interaction term. Therefore there is no evidence of a violation of exclusion restriction criteria after controlling for these alternative channels as hardly any substantial impact is found on the signs or magnitudes of the marginal effects of remittances health expenditure (see columns 1-4).

[Table 4, about here]

4.3.2 Omitted variable concern due to cyclone-Ruano

Another general identification issue arises when the paper uses a natural experiment by using plausibly exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations as an instrument for remittances. Although various socio-economic characteristics of the household have been controlled for, a possible omitted factor could be the cyclone-affected household's post-disaster mitigation expenditure. Anecdotal evidence suggests a likely substitutive behaviour between adaptation and household expenditures. According to Uttaran, a non-profit organisation, people in coastal Bangladesh spend on adaptation after the Cyclone Amphan by reducing consumption and healthcare expenditure as a part of coping strategies[22].

Adaptation expenditure such as rebuilding and renovating damaged property in the aftermath of the cyclone-Roanu could directly affect health expenditure. It is possible that rainfall could be influencing adaptation expenditure for various reasons. Therefore omitting the post-Roanu adaptation expenditure can contaminate identification and create a bias for the impact of remittance.

To counter this, we control for the amount (in thousands of local currency) of household's explicit expenditures on home improvement (rebuilding work related to the house and in the homestead area) in the aftermath of cyclone-Roanu. No direct effect of post-Roanu adaptation expenditure is found on health expenditure. Neither noticeable change is observed in the estimated marginal effect of remittances (see column 5 in Table 4) and the interaction term. This relieves the worry that any omitted factor drives the marginal effect of remittances.

[22] https://en.gaonconnection.com/bangladesh-coronavirus-covid19-poverty-water-food-security-amphan-cyclone/

5. Conclusion

Given the worldwide flow of migrants and the consequent workers' remittances, understanding the various functions that these remittances serve for the recipient households is a challenging but necessary task to gauge a clear portrait of its consequences in terms of the benefits and costs to the origin country.

Previous studies have shown that while the effect of remittances on a household's health outcome (e.g., Infant mortality) is ambiguous, the impact on health expenditure is positive and less equivocal. In this paper, we test if the effects of remittances on health expenditure is linear or heterogeneous. To this end, we put the health expenditure and remittances relationship into a stress test to see whether it survives the adverse impact of climate vulnerability. Using a natural experiment of rainfall-driven remittances, we provide an experimental measure for the effect of remittances on the health expenditure among rural households in southern Bangladesh.

Health expenditure and remittances are jointly related; therefore, we use the instrumental variable approach. The treatment of remittances is randomly assigned to households who suffered losses due to a natural shock from the cyclone-Roanu enabling the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations – to identify the average treatment effect for the treatment group (cyclone-affected remittances recipient households).

The empirical analysis uses remittances and their interaction with climate vulnerability to model health expenditure. Climate vulnerability is conceptualised from the perspective of households' exposure to natural hazards based on location remoteness and proxied with the measure of distance in kilometres to the nearest cyclone shelter. We find that while remittances *cause* household health expenditures to increase, the marginal effect of remittances is heterogeneous and negative conditional on the household's exposure to the level of vulnerability, proxied by the household's distance to cyclone shelter. In other words, the health expenditure-remittances nexus gets weaker by the adverse effect of climate change. Specifically, an increase in remittances by a *Taka* increases health expenditure by 0.24 Taka (24 Paisa) in the absence of any climate hazard but reduces health expenditure by 0.10 Taka (or 10 Paisa) if the measure of climate vulnerability increases by one standard deviation from its mean value.

We use alternative instrumented variables in level and log form and an additional instrument based on crop yield to check the robustness of results. We also used alternative indicators of climate vulnerability such as distance to vehicular school and primary school to check for the sensitivity of results. The findings are also robust to possible omitted variable and potential violations of the exclusion restriction. There are four plausible channels through which rainfall-driven instruments could affect the health expenditure independent of remittances flows: domestic income from other sources, other household expenditures, labour market participation and access to credit. The findings are robust to specifications that take these other channels into account.

The paper contains a key message: climate vulnerability can undo many good things. The benefits households receive from overseas remittances are not always sustainable as they can break down under some climate-related stress. To this end, the case study shows the role remittances play by providing funds for health expenditure is conditional on environmental risk hazards. The findings are applicable and useful to academics and policymakers in developing countries like Bangladesh, which is at greater risk of being exceptionally vulnerable to climate change where many households must partly depend on remittances to finance their health care cost almost exclusively from out-of-pocket payment. Climate vulnerabilities can render the financing of health care cost unsustainable even if households receive regular and sizable remittances.

TABLE 1.— SUMMARY STATISTICS

VARIABLES	OBS	MEAN	STD. DEV.	MIN	MAX
WEATHER					
Rainfall	3	275.518	16.715	251.82	288.37
Yield of *Aman* rice	3	0.584	1.331	-1.2	1.94
HOUSEHOLD HEAD (HH) CHARACTERISTICS					
Age	610	41.485	13.975	14	95
Age-squared	610	1916.016	1246.358	196	9025
HH EDUCATION					
Primary	610	0.441	0.497	0	1
Secondary	610	0.154	0.361	0	1
Higher Secondary	610	0.070	0.256	0	1
Madarasa	610	0.051	0.220	0	1
HH OCCUPATION					
Farming and Fishing	610	0.330	0.470	0	1
Wage earners	610	0.216	0.412	0	1
Shrimp farmer	610	0.305	0.461	0	1
Business	610	0.057	0.233	0	1
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS					
Total members	610	5.761	2.290	1	18
Total female members	610	2.777	1.457	0	12
Working male members	610	1.713	0.886	0	7
Working female members	610	0.163	0.431	0	3
Total children below 7 years	610	0.718	0.787	0	6
Total children below 7 years attending school	610	0.338	0.556	0	3
Total female children aged 7 or above attending school	610	0.675	0.804	0	7
MIGRATION AND REMITTANCES					
Number of overseas migrants	105	1.133	0.369	1	3
Number of years migrant living overseas	105	4.219	2.703	0	15
Average amount of remittances received per month	105	25690.48	19285.60	1000	150000
Log of remittances received per month	105	9.906	0.768	6.907	11.918
Average remittances received per overseas migrant	105	24273.02	19634.71	1000	150000

VARIABLES	OBS	MEAN	STD. DEV.	MIN	MAX
HOUSEHOLD FINANCIAL CHARACTERISTICS					
Average domestic income per month	610	16894.75	14656.47	0	150000
Average food expenditure per month	610	6646.89	4137.53	700	45000
Average housing expenditure per month	610	410.98	640.83	0	5000
Average health expenditure per month	610	1648.77	1318.40	0	10000
Average education expenditure per month	610	1922.95	2196.35	0	20000
Amount of credit taken from NGO	610	22096.91	70034.37	0	1000000
HOUSEHOLD ASSETS					
Agriculture land	610	98.72	248.55	0	2660
Orchard	610	0.792	0.406	0	1
Poultry	610	0.543	0.499	0	1
Mechanised vehicle	610	0.226	0.419	0	1
Mechanised boat	610	0.382	0.486	0	1

TABLE 2. —REMITTANCES, HEALTH EXPENDITURE AND CLIMATE VULNARIBILTY – I

SECOND-STAGE REGRESSION								
INSTRUMENTED VARIABLES	(1) OLS	(2) 2SLS-IV	(3) 2SLS-IV	(4) 2SLS-IV	(5) 2SLS-IV	(6) 2SLS-IV	(7) 2SLS-IV	(8) 2SLS-IV
REMIT	0.013 (0.007)*	0.164 (0.067)**			0.236 (0.092)***			
Log (REMIT)			2526.89 (856.14)***			3801.80 (1240.87)***		6067.85 (2304.74)***
REMIT per migrant				0.168 (0.069)**				
Log (REMIT) ×CLIMATE							-4616.34 (2284.49)**	
CONTROL VARIABLES								
REMIT ×CLIMATE					-0.151 (0.078)*			
Log (REMIT) ×CLIMATE						-2337.71 (1006.34**)		-3961.85 (1640.57)**
Log (REMIT)							4945.90 (2055.79)**	
CLIMATE					3472.46 (1783.64)*	23120.97 (9956.43)**	45385.21 (22580.15)**	39217.83 (16370.15)**
Cons.	-850.84 (1494.80)	-3003.32 (1603.79)*	-23581.47 (7571.38)***	-4780.03 (1619.47)***	-6791.228 (2942.66)**	-37793.28 (12248.38)	-50236.21 (20983.81)**	-59977.13 (22764.66)***
No. of observations	105	104	104	104	104	104	104	104
Overall F (P-value)	267.48 (0.00)***	44.02 (0.00)***	44.29 (0.00)***	13.02 (0.00)***	166.09 (0.00)***	111.40 (0.00)***	170.87 (0.00)**	97.00 (0.00)***
Root MSE	1481.2	1916	1592	1894	1730	1503	1971	2026
FIRST-STAGE REGRESSION								
Rainfall × distance		-0.635 (0.281)**	-0.00004 (0.00001)***	-0.620 (0.279)**	-0.421 (0.162)**	-0.00003 (7.29e-06)***	0.00001 (9.28e-06)**	

Rice_yield × distance								-0.0036 (0.002)**
F-statistic on instrument		5.12	11.01	4.92	6.69	12.52	3.97	5.40

Two stage least square - 2SLS-IV regressions. Dependent variable is household's average monthly health expenditure in local currencies (Taka). Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. REMIT is measured in local currencies. All specifications include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of schools going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, other household assets and household head's age, education and profession. All regressions except no. 8 use the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations. Regression 8 uses alternative instrument based on exogenous variation in rice yield.

TABLE 3. —REMITTANCES, HEALTH EXPENDITURE AND CLIMATE VULNARIBILTY – II

SECOND-STAGE REGRESSIONS						
INSTRUMENTED VARIABLES	(1) 2SLS-IV	(2) 2SLS-IV	(3) 2SLS-IV	(4) 2SLS-IV	(5) 2SLS-IV	(6) 2SLS-IV
REMIT	0.133 (0.039)***	0.269 (0.123)**				
Log (REMIT)			2257.01 (683.45)***	4322.91 (1642.15)***	2946.82 (954.043)***	7087.53 (3136.33)**
CONTROL VARIABLES:						
REMIT × Distance to Vehicular Road	-0.043 (0.020)**					
Distance to Vehicular Road	965.419 (2.06)**					
REMIT × Distance to School		-0.193 (0.108)*				
Distance to School		4101.91 (2365.65)*				
Log(REMIT) × Distance to Vehicular Road			-612.58 (389.44)		-899.899 (508.22)*	
Distance to Vehicular Road			5906.20 (3844.77)		8708.30 (5077.48)*	
Log(REMIT) × Distance to School				-3018.83 (1357.24)**		-5213.79 (2489.12)**
Distance to School				29585.67 (13420.87)**		51240.69 (24607.99)**
Cons.	-3161.78 (1452.815)**	-7940.55 (3916.82)***	-21173.98 (6302.97)***	-43300.66 (16344.52)***	-27357.98 (8875.27)***	-70799.08 (31098.24)**
No. of observations	104	104	104	104	104	104
Overall F (P-value)	1397.61 (0.00)***	758.34 (0.00)***	127.23 (0.00)***	103.46 (0.00)***	85.94 (0.00)***	35.11 (0.00)***

Root MSE	1451	1857	1440	1554	1644	2182
FIRST-STAGE REGRESSION						
Rainfall × distance	-0.857 (0.203)***	-0.357 (0.139)**	-0.00005 (0.00001)***	-0.00002 (6.45e-06)***		
Rice_yield					-0.009 (0.002)	-0.003 (0.001)**
F-statistic on instrument	17.77	6.56	16.63	11.61	14.55	4.50

Two stage least square - 2SLS-IV regressions. Dependent variable is household's average monthly health expenditure in local currencies (Taka). Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. REMIT is measured in local currencies. All specifications include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of schools going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, other household assets and household head's age, education and profession. All regressions except no. 5 & 6 use the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations. Regression 5 & 6 use alternative instrument based on exogenous variation in rice yield.

TABLE 4.—TESTS OF THE EXCLUSION RESTRICTIONS

SECOND-STAGE REGRESSION:

INSTRUMENTED VARIABLES:	(1) OLS	(2) 2SLS-IV	(3) 2SLS-IV	(4) 2SLS-IV	(5) 2SLS-IV
Log (REMIT)	4374.02 (1439.75)***	3073.11 (1487.68)**	3811.85 (1247.13)***	3691.93 (1188.02)***	3828.88 (1472.04)***
CONTROL VARIABLES:					
Log (REMIT) × CLIMATE	-2405.38 (983.88)**	-1952.73 (1084.54)*	-2343.41 (1006.25)**	-2249.51 (948.82)**	-2357.22 (1111.18)**
CLIMATE	23761.7 (9712.16)**	19373.84 (10653.13)*	23184.57 (9957.60)**	22251.51 (9395.24)	23311.82 (10973.8)**
Domestic Income	-0.033 (0.021)				
Other expenditure		0.128 (0.115)			
Working members in household			-49.162 (291.51)		
Credit from micro finance institutions				0.004 (0.008)	
Post cyclone-Roanu home improvement expenditure					0.001 (0.017)
Cons	-42891.12 (13927.88)***	-31149.62 (14507.5)**	-37961.39 (12381.23)***	-36795.56 (11818.99)***	
Number of observations	104	104	104	104	104
Overall F	94.12 (0.00)***	746.42 (0.00)***	149.67 (0.00)***	759.28 (0.00)***	555.53 (0.00)***
Root MSE	1531	1351	1505	1481	1509

Two stage least square - 2SLS-IV regressions. Dependent variable is household's average monthly health expenditure in local currencies (Taka). Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. REMIT is measured in local currencies. All specifications include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of schools going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, other household assets and household head's age, education and profession. All regressions except no. 5 & 6 use the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations. Regression 5 & 6 use alternative instrument based on exogenous variation in rice yield.

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FIGURE 1. RAINFALL AND REMITTANCES

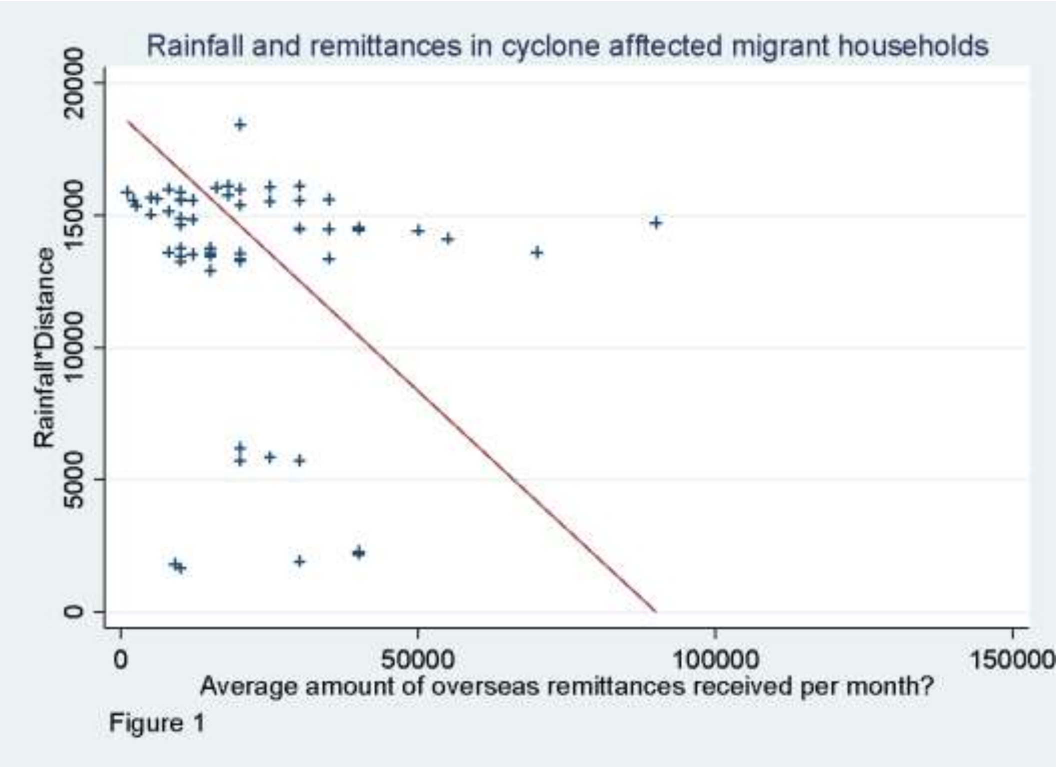

FIGURE 2. MARGINAL EFFECTS OF REMITTANCES