Impact of Recurrent Floods on the Utilization of Maternal and Newborn Healthcare in Bangladesh

Abdul Baten[1,2] · Pascaline Wallemacq[2] · Joris Adriaan Frank van Loenhout[2] · Debarati Guha-Sapir[2]

1 Department of Statistics, Jagannath University, Dhaka 1100, Bangladesh

2 Centre for Research on the Epidemiology of Disasters (CRED), Institute of Health and Society, Université Catholique de Louvain, Brussels, Belgium

Abstract

Objective: Floods are one of the most common types of disasters in Bangladesh and lead to direct and indirect impacts on health. The aim of the study was to assess the impact of floods on Maternal and Newborn Healthcare (MNH) utilization in Bangladesh between the years 2011 and 2014.

Methods: We used variables from the Bangladesh Demographic and Health Survey (BDHS) 2014 data and georeferenced data of floods between 2011 and 2014 from the Emergency Events Database (EM-DAT). Multivariate logistic regression was used to determine whether the flood-affected exposures were significant in predicting differences in MNH utilization.

Results: The odds for the received antenatal care by skilled providers, institutional deliveries, deliveries by c-section, and postnatal care of the babies were significantly lower (Unadjusted OR=0.81, 0.88, 0.83, and 0.82 respectively; $P<0.05$) in the flood-affected area than the non-affected area. Additionally, the odds of postnatal checkup of women was statistically significant ($P<0.001$) and less likely to be received in flood-affected area (OR=0.76). The odds of all indicators were significantly lower (OR<1) for the women living in the twice and four times flooded areas compared to the once flooded areas.

Conclusion: The study shows that floods can have a negative impact on MNH utilization. In addition, repeated floods have a worse impact on MNH utilization than incidental floods. Extra effort should be put on ensuring access to MNH of women in flood-affected areas.

Keywords: *Bangladesh, Maternal, Newborn, Healthcare, Utilization, Flood-affected*

Significance:

Floods bring substantial damages to human capital, including death and destruction, and produce deleterious consequences on nutrition, education, hospitals, health facilities and health services of a community. The impact of floods on human health, in particular on flood-related diseases and nutrition are described in many papers. But the impact of floods especially recurrent floods on MNH utilization is not extensively explored.

The study fills a gap in the knowledge on the impact of incidental and recurrent flooding on maternal and newborn healthcare utilization, while controlling for other confounders. We found that floods have a negative impact on MNH utilization. In addition, repeated floods have a worse impact on MNH utilization than incidental floods.

Introduction

Environmental hazards such as storms, droughts, heat waves and floods, lead to a substantial disruption on individual and community resources, infrastructure, health and health services (Watts et al. 2015; McMichael 2013; McGlown and Fottler 1996; Callaghan et al. 2007; Cordero 1993). Direct and indirect impact of natural disasters on health care systems lead to reduced accessibility, availability, affordability, coverage, and quality of the health care services (Phalkey and Louis 2016). Failure of any components within a system can affect drug procurement and vertical disease control programs such as immunization, maternal and child health (Phalkey and Louis 2016).

Maternal health is particularly at risk during a disaster and pregnant women are at higher risk for complications due to lack of trained obstetricians in disaster settings (Goodman 2016). During disasters, maternal and neonatal deaths, and physical and sexual violence increase, coupled with limited or no access to reproductive health services such as prenatal care, family planning, assisted delivery, and emergency obstetric care (Chi et al. 2018).

Bangladesh is one of the most natural disaster-prone countries in the world (Disaster Report 2014), and it experienced a total of 129 natural disasters since 2000 (EM-DAT 2018). The disasters that frequently occur in Bangladesh are storms, floods, droughts, earthquakes, landslides, extreme temperatures and epidemics. Flood is the second most frequent disaster in Bangladesh. Since 2000, 28% of all natural disasters in Bangladesh were floods, which killed 2,943 people and directly affected 80 million people physically, mentally and/or economically (EM-DAT 2018).

A 2012 systematic review described the impact of floods on human health, in particular on flood-related diseases and nutrition (Alderman et al. 2012). One study found that breastfeeding and complementary feeding practices for infant and young children in Dhaka slums, Bangladesh were poor and inappropriate in normal times, and were worse in flooding conditions (Goudet et al. 2011). A qualitative study within slums in Dhaka found that flooding is the root cause of malnutrition among pregnant women (Goudet et al. 2011).

However, there is limited evidence on the impact of floods on maternal and newborn healthcare (MNH) utilization. In this study, we fill part of this knowledge gap. Our main hypothesis was that floods have negative impacts on MNH utilization, and repeated floods have a worse impact than a single flood.

Objectives

The general objective of this study is to assess the impact of floods on the utilization of MNH in Bangladesh between the years 2011 and 2014, and to assess whether repeated exposure has a larger impact on MNH utilization than single exposure. The general objective focuses on the following specific objectives:

(i) To compare MNH utilization by women in flood-affected versus non-affected areas.

(ii) To determine correlation if present between MNH utilization and number of flood exposures.

Methods

Data Sources

The Demographic and Health Surveys (DHS) database

Since 1984, technical support has been provided by the DHS Program to more than 300 demographic and health surveys in over 90 countries. The objective of the DHS program is to collect nationally representative data on population and health in developing countries. In this study, Bangladesh Demographic and Health Survey (BDHS) 2014 data is used for the analysis. The survey was designed in such a way that represent the whole country for the rural and the urban areas separately, and for each of the seven administrative divisions. Detailed information about sampling methodologies and data collection procedures can be found in the BDHS reports (Bangladesh Demographic and Health Survey 2014).

The study also used the Global Positioning System (GPS) coordinates of the clusters from the DHS program to identify the individuals cluster number. In the survey, the groupings of households that participated in the survey, known as clusters, are georeferenced.

Georeferenced data of Emergency Events Database (EM-DAT)

The Emergency Events Database (EM-DAT) provides a global systematic overview of the human impact of disasters since 1900 (EM-DAT 2018). In the study, georeferenced data of EM-DAT is used for floods between the years 2011 and 2014. A standardized methodology is applied to each disaster reported into EM-DAT, in which the name of the area(s) impacted by a disaster is (are) extracted from a various panel of sources and this location data is transformed into Global Administrative Unit Layers (GAUL) (Vanderveken and Guha-Sapir 2016). Disasters are recorded both at the 1st (Division of Bangladesh) and 2nd (Districts of Bangladesh) administrative levels of the GAUL database (Global Administrative Unit Layers 2018). Since EM-DAT uses 2nd administrative unit levels of Bangladesh to record disaster events, this study has used this level.

Study Sample

The BDHS 2014 dataset included 17,863 ever-married women. 4,620 of these women had a live birth in the three years preceding the survey, and are included in our study. Subjects with missing data were excluded from the study. A flowchart of the study sample is presented in Figure 1.

Study setting and assigning participants as flood-affected

Bangladesh is located in the Northeastern part of South Asia. Bangladesh occupies an area of 147,570 square kilometers (Bangladesh Demographic and Health Survey 2014). The whole country is administratively divided into 8 divisions, 64 districts, and 491 upazilas or thanas.

During the time period of 2011 to 2014, five floods (one in 2011, two in 2012 and two in 2014) occurred in Bangladesh. By these floods, 19 districts were affected once, 10 districts twice, 7 districts thrice, and 3 districts four times (EM-DAT 2018).

A map was made using QGIS version 2.18.13 and a shapefile of the second administrative level of Bangladesh (districts), obtained from the GAUL database (Figure 2). Then the flood-affected districts and non-affected districts were selected using EM-DAT data. The clusters of the BDHS 2014 were then distributed over the map by using the GPS shape file data obtained from the DHS program (Figure 2). Clusters found in the flood-affected districts were then considered as the exposed clusters and assigned the value 1, while the clusters out of the flood-affected districts were assigned the value 0. Participants in each cluster were segregated into exposed or non-exposed groups, and each participants' number of exposures between 2011 and 2014 was recorded.

Study variables

In the study, seven indicators were considered as outcome variables for the analysis of the impacts of the flood on MNH utilization (Table 1). The exposure variables were the place of residence of the participants, dichotomized as residing in the flood-affected region or not, and the number of times participants were affected.

Household, demographic and socioeconomic characteristics of the selected women were included as potential confounding variables for the determinants of MNH utilization (Table 1).

These factors were selected based on a previous review of the literature, as having an effect on MNH utilization (Chakraborty et al. 2003; Målqvist et al. 2012; Rutaremwa et al. 2015; Gabrysch et al. 2009).

Statistical Analysis

Statistical Packages for the Social Science (SPSS) version 20 was used for data management and descriptive analyses and R software version 3.5.0 was used for logistic regression analyses. Means and standard deviations were calculated for numerical variables and frequencies and percentages for categorical variables. T-tests with a 5% level of significance were conducted to assess the differences in mean of the numerical variables between flood-affected and non-affected areas. Chi-square tests with a level of significance at 5% were conducted to assess the differences in the proportion of the categorical variables between flood-affected and non-affected areas. The variance inflation factor (VIF) was analyzed to identify multicollinearity between the explanatory variables. Then, VIF was obtained by taking the square of GVIF values, and variables with values of VIF exceeding 4 were not considered for the final model (O'brien 2007).

Finally, multivariate logistic regression was used to determine whether the flood-affected region is significant in predicting differences in MNH utilization. Parameters were estimated from the data using the maximum likelihood method (Hosmer and Lemeshow 2004). Regression was carried out unadjusted and adjusted for confounders. Measures of association were presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Ethical Considerations

The study used secondary data from DHS and EM-DAT database under the rules and regulations of the respective databases. We used EM-DAT to identify the flood-affected areas. EM-DAT uses aggregated data from country reports and do not use or collect any data from individuals.

The host country of the DHS (BDHS) obtained the written consent from all the respondents before each interview was conducted. Most importantly, the informed written consent statement emphasizes that the respondent's identity and information will be kept strictly confidential (Demographic and Health Survey 2019). All procedures and questionnaires of standard DHS surveys have been reviewed and approved by ICF international Institutional Review Board (IRB). Moreover, country-specific DHS survey protocols are reviewed by the

ICF international IRB and generally by an IRB in the host country (Demographic and Health Survey 2019).

Results

Household, demographic and socioeconomic characteristics of the study participants

Household, demographic and socioeconomic characteristics of the study participants in the flood-affected and non-affected areas are presented in Table 2. A total of 4,620 women were part of the study, and 2,899 women were living in at least once flood-affected area. The women had an average age of 24 years and average household size of 6 (Table 2). A higher proportion of urban women had lived in the flood-affected areas (29.2% vs 20.9%, p<0.001). On the other hand, a higher proportion of women in non-flood affected area had completed their secondary education (53.2% vs 44.4%, p<0.001). A higher proportion of women in flood-affected area had no education (16.2% vs 10.6%, p<0.001). Likewise, a higher proportion of poorest women were living in the flood-affected area (23.6% vs 18.5%, p<0.001).

About 75% of the participants reported no full-time occupation. The proportion of women with a single birth in the three years preceding the survey was 94%, the remaining had multiple births. Of the flood affected population, 1,341 women were affected by flood once, 780 twice, 589 three times and 189 four times.

MNH indicators in the flood-affected and non-flood affected areas

Of all study participants, only 31.2% of women had attended the required number of antenatal visits (Table 3). The proportion of women in the flood-affected area who had attended four or more antenatal visits (33.1%) was significantly higher compared to the non-affected women (27.9%). The majority of the women who received antenatal care (ANC) by skilled (medically trained) providers, was less in the flood-affected area (62%) than the non-affected area (67.0%, p<0.001).

In total, 57% of women received skilled attendance at birth, and the difference between flood-affected and non-affected area was not significant (p=0.486). The proportions of women by place of delivery also did not differ between living in the flood-affected and non-affected areas. The proportion of women who had caesarian deliveries was significantly lower in flood-affected area. More than 64% of women received postnatal checkup after their delivery. In the non-flooded area, the proportion of postnatal checkup was significantly higher than in the flood-affected area (Table 3).

Impact of floods on MNH indicators

In the study, measures of association between flood and MNH indicators were presented as odds ratios (ORs). Odds ratios above 1 signify a higher likelihood of utilizing MNH, and odds ratios below 1 signify a lower likelihood of utilizing MNH.

In the unadjusted analyses, we found that the odds for the received antenatal care by skilled providers, the institutional delivery, delivered by c-section, and postnatal care of the babies were significantly lower (unadjusted OR=0.81, 0.88, 0.83, 0.76, and 0.82 respectively; $P<0.05$) in the flood-affected area than in the non-affected area (Table 4). However, the odds of four or more antenatal visits (unadjusted OR=1.11) were higher in the flood-affected area.

Additionally, the odds for postnatal checkup of women were statistically significant ($P<0.001$) in the flood-affected area than the non-affected area and the women living in the flood-affected area were less likely to take postnatal checkup (OR=0.76) compared to the non-affected area. The difference in delivery assisted by skilled providers was not statistically significant ($p=0.5415$).

In the adjusted analysis (Table 4), the odds of the four or more antenatal visits for women living in the flood-affected area was significantly higher (adjusted OR=1.20; 95% CI=1.04, 1.38; $P<0.05$) compared to the non-affected area of the country. Similar to the unadjusted analysis, the odds for delivery by c-section, and postnatal care for the babies were significantly lower (adjusted OR=0.84, and 0.82 respectively; $P<0.05$) in the flood-affected area than in non-affected area. Postnatal checkup taken by women was statistically significant ($P<0.001$) and flood-affected women were less likely to take postnatal checkup compared to the non-affected women.

Consequences of repeated floods on MNH utilization

We found that the odds of all indicators were statistically significantly lower ($p<0.05$) for the women in the twice flooded area compared to the once flooded area, except the odds of received antenatal care by skilled provider (Table 5).

For the thrice flooded areas, only the odds of delivered by c-section was significantly lower. The odds for number of ANC visits and institutional delivery were significantly higher in the thrice flooded versus once flooded areas. Women living in areas flooded four times were less likely to utilize MNH compared to once flooded area for all indicators except for the number of antenatal visits and the place of delivery.

Discussion

The study fills a gap in the knowledge on the effects of flooding on MNH utilization. The principal hypothesis of the study was that floods negatively impacts MNH utilization. The findings of the study mostly support this hypothesis, although some unexpected results had found.

In the unadjusted analyses we found that women in the flood-affected areas were less likely to utilize MNH, including ANC by skilled providers, institutional deliveries, deliveries by c-section, and postnatal checkup for themselves and their babies during the study period. The result is as expected, since floods bring substantial damages to human capital, including death and destruction, and produce deleterious consequences on nutrition, education, hospitals, health facilities and health services of a community, as shown in the literature (Goodman 2016; Du et al. 2010; Baez et al. 2010). Previous studies have showed similar types of results for institutional deliveries, and deliveries assisted by skilled providers in some crisis settings (Namasivayam et al. 2017; Tatah et al. 2016). Furthermore, a study has shown that during disasters, maternal and neonatal deaths increase, because of limited or no access to reproductive health services (Chi et al. 2018). Neonatal mortality of flood vs. non flooded area could be also something to look at in further studies if the data were available.

In the case of the 2011 Pakistan flood, 46% of all health facilities in the flood-affected districts were damaged to some extent, which adversely affected reproductive health services as well (Pakistan Flood 2011 Early Recovery Framework 2012). Due to this flood, 55% of births in the affected districts took place at home, with 27% of the births at home not being attended by any medical professional (Pakistan Flood 2011 Early Recovery Framework 2012). Lack of human resources (doctor, nurse, etc.) in the flood-affected area could be a cause of lower utilization of MNH.

Since food becomes scarce and expensive during and after a flood, and income may drop, households can suffer from lack of adequate food. (Shimi et al. 2010). The American College of Obstetricians and Gynecologists noted that the lack of resources in the aftermath of a disaster, including food, water, and shelter adversely impact pregnancies ("ACOG," 2010). The study results could also support the premise that maternal healthcare may not be a top priority in times of floods, as people may be more focused on food security. In addition, diseases such as cholera, (and other diarrhoeal diseases), rotavirus, shigellosis and typhoid fever generally increase due to water contamination during and after floods (Ligon 2006), which also could affect prioritization for maternal and neonatal healthcare.

Both in the adjusted and unadjusted analyses, we have found unexpected findings for the outcome variable 'number of ANC visits'. The study found that women living in flood-affected area were more likely to receive the required number of ANC visits compared to the non-affected area. This outcome could be indicative of interventions and humanitarian assistance specifically targeting women in flood-affected areas to improve birth outcomes and delivery services through the training and deployment of skilled personnel. In Bangladesh, few NGOs like Grameen Bank, Proshika, BRAC and others are trying to incorporate health and hygiene-related motivational activities for their beneficiaries before, during, and after disasters (Shimi et al. 2010). The possible categories of interventions to improve reproductive, maternal and newborn health in crisis settings include expanding the provision of health care from facility-based to non-facility-based systems in homes or the community, rolling out mobile health care services through a mobile clinic van, education and services for ANC, safe delivery and postnatal care (Chi et al. 2018). Based on our findings, we would recommend health NGOs to stay for a period of at least a year after a disaster, so that they can assist all peri-disaster pregnancies with birth and postnatal care through a 3-month infant check-up.

The results of the odds of the outcome variables vary between the unadjusted and the adjusted models, since in the latter, other household, demographic and socio-economic characteristics were taken into account. The impact of floods on the human community is not only related directly to the geographical location but also human demographics, socio-economic, and household characteristics, as was shown in a previous study (Du et al. 2010). For that reason, we have considered the adjusted odds ratios to give a more accurate representation of the actual difference in MNH utilization between flood-affected and non-affected areas.

In the analyses of repeated floods, most MNH indicators of the study were lower for women exposed to twice and four times flooded areas compared to the once flooded areas. The odds of delivery assisted by skilled providers, delivered by c-section, postnatal checkup for women and children were also lower for women living in the thrice flooded area compared to the once flooded area. The results are expected, since frequent floods have devastating and more chronic impact on people, infrastructure, and health in affected areas, compared to areas that were affected only once. For instance, due to the impact of the 2010 flood in Sindh and Balochistan Province of Pakistan, the health infrastructures were already affected. Before the health system could recover, another major flood hit Sindh and Balochistan during August 2011, completely debilitating the already weakened public health infrastructures (Pakistan Flood 2011 Early Recovery Framework 2012). Impact of frequent floods leads to poverty, which is a significant contributor to increase people's vulnerability to flooding (Shimi et al. 2010), and may have an indirect effect on MNH utilization.

Women were more likely to receive ANC by skilled providers, and institutional delivery in the thrice flooded area compare to the once flooded area. One explanation could be that people become more adaptive in frequent floods regions. Due to frequent floods and their devastating impacts, people in the flood prone areas have become used to deal with the problems associated with flood through innovation of their own adaptation mechanism (Shimi et al. 2010). Another explanation could be that future disaster preparedness in the flood-prone areas may include the planning of earlier evacuation of pregnant women to minimize their exposure to severe disaster events, as was done after Hurricane Katrina in the USA (Xiong et al. 2008).

Limitations

Despite filling a gap in the literature, the study has several limitations. Firstly, the area considered as flooded is based on EM-DAT georeferenced data, which can be an over estimation of the flood affected area as it takes into account comparatively large administrative units (2nd level; districts). The analysis of the study would be more precise if one could use smaller administrative units (Upazila or Union).

Secondly, the analysis is based on retrospective outcome measures, which may have led to a recall bias. Thirdly, due to unavailability of data on intensity and severity of the floods, the association between flood severity and MNH utilization could not be examined, although we used the number of times people were affected by floods as a proxy.

Fourthly, we could not relate the timing of births among our study participants to specific flood events. Part of the women in the flood-affected group will have given birth during periods without floods, which we were not able to assess separately. However, the aim of our study was to compare the overall groups non-affected to flood-affected, even though floods were not affecting women in this group continuously.

Fifthly, the indicators for maternal and newborn healthcare utilization used in this study were limited to those around antenatal care, delivery and postnatal care. More indicators are available in the DHS and WHO guidelines and could provide a more comprehensive understanding of other aspects of maternal and neonatal health, such as contraception and birth weight.

Finally, some other covariates that could have influenced MNH care utilization during the flood, such as the quality and availability of healthcare services, and distance to the nearest health facility were not analyzed due to the unavailability of these variables in the BDHS dataset.

Conclusion

The findings of the study have shown that floods can have a negative impact on MNH utilization. Women who experienced floods in Bangladesh between the years 2011 and 2014 were less likely to receive ANC by skilled providers, institutional delivery, delivery by c-section, and postnatal checkup for themselves and for their newborn baby. However, certain aspects of MNH utilization, such as receiving four or more antenatal visits, show better results in the flood-affected area, possibly as a result of people’s adaptive mechanism and/or humanitarian aid interventions to ensure the continuity of some basic healthcare services.

The study found as well that repeated flooding can have a negative impact on utilization of MNH, compared to incidental flooding. Except the number of ANC visits, all indicators of the study have shown lower utilization of MNH in the twice and four times flooded areas.

Extra effort should be put on ensuring access to MNH of women in flood affected areas. A follow-up study evaluating the impact of floods on utilizing MNH could try to consider the smaller administrative units to identify the affected area or to analyze the impact of the severity of floods.

References

Alderman, K., Turner, L. R., & Tong, S. (2012). Floods and human health: A systematic review. *Environment International*, 47, 37–47. https://www.sciencedirect.com/science/article/pii/S0160412012001237?via%3Dihub

American College of Obstetricians and Gynecologists (ACOG). (2010). Preparing for disasters: Perspectives on women. The American College of Obstetricians and Gynecologists Committee. Retrieved from: https://www.acog.org/Clinical-Guidance-and-Publications/Committee-Opinions/Committee-on-Health-Care-for Underserved-Women/Preparing-for-Disasters-Perspectives-on-Women

Baez, J., de la Fuente, A., & Santos, I. (2010). Do Natural Disasters Affect Human Capital? An Assessment Based on Existing Empirical Evidence. IZA Discussion Paper No. 5164 In Washington, D.C. https://www.researchgate.net/publication/46442629_Do_Natural_Disasters_Affect_Human_Capital_An_Assessment_Based_on_Existing_Empirical_Evidence

Bangladesh Demographic and Health Survey. (2014). National Institute of Population Research and Training (NIPORT), Dhaka, Bangladesh., Mitra and Associates, Dhaka, Bangladesh. And Macro International, Inc. https://dhsprogram.com/pubs/pdf/FR311/FR311.pdf

Callaghan, W. M., Rasmussen, S.A., Jamieson, D. J., Ventura, S. J., Farr, S. L., & Sutton, P. D. (2007) Health concern of women and infants in times of natural disasters:Lessons learned from Hurricane Katrina. *Maternal and Child Health Journal*, 11(4), 307–11. DOI: 10.1007/s10995-007-0177-4 PMID: 17253147.

Chakraborty, N., Islam, M. A., Chowdhury, R. I., Bari, W., & Akhter, H. H. (2003). Determinants of the use of maternal health services in rural Bangladesh. *Health Promotion International*, 18(4), 327–337. Doi: https://doi.org/10.1093/heapro/dag414 PMID: 14695364.

Chi, P. C., Urdal, H., Umeora, O. U. J. U. J., Sundby, J., Spiegel, P., & Devane, D. (2018). Improving maternal, newborn and women's reproductive health in crisis settings. *Cochrane Database of Systematic Reviews*, *2018*(8), [CD011829]. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4561524/

Cordero, J.F. (1993). The epidemiology of disasters and adverse reproductive outcomes: Lessons learned. *Environmental Health Perspective*, 101(2), 131–6. doi: 10.1289/ehp.93101s2131 PMID: 8243383

Demographic and Health Survey (DHS). (2019). Protecting the privacy of DHS survey respondents. [Cited 2019 Jan 15]. Retrieved from: https://dhsprogram.com/What-We-Do/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm

Disaster Report 2013. (2014, Oct 31). Relief web. https://reliefweb.int/report/bangladesh/disaster-report-2013

Du, W., FitzGerald, G. J., Clark, M., & Hou, X. Y. (2010). Health Impacts of Floods. *Prehospital Disaster Medicine*, 25(3), 265–272. DOI: https://doi.org/10.1017/S1049023X11000148 PMID: 20586021.

EM-DAT. (2018). The OFDA/CRED International Disaster Database. [cited 2018 Oct 20]. Retrieved from: http://www.emdat.be/database

Gabrysch, S., & Campbell, O. M. (2009). Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy and Childbirth*, (9), 34. https://doi.org/10.1186/1471-2393-9-34 PMID: 19671156.

Global Administrative Unit Layers (GAUL). (2018). UN, FAO; [cited 2018 Mar 1]. Retrieved from: http://www.fao.org/geonetwork/srv/en/metadata.show?currTab=simple&id=12691

Goodman, A. (2016) In the Aftermath of Disasters: The Impact on Women's Health. *Critical Care Obstetrics and Gynecology*, 2(6), 1:5. http://obstetrics.imedpub.com/in-the-aftermath-of-disasters-the-impact-on-womens-health.php?aid=17661

Goudet, S. M., Griffiths, P. L., Bogin, B. A., & Selim, N. (2011). Impact of flooding on feeding practices of infants and young children in Dhaka, Bangladesh Slums: what are the coping strategies? *Maternal and Child Nutrition*, 7, 198–214. https://doi.org/10.1111/j.1740-8709.2010.00250.x PMID: 21108740.

Goudet, S. M., Faiz, S., Bogin, B. A., & Griffiths, P. L. (2011). Pregnant women's and community health workers' perceptions of root causes of malnutrition among infants and young children in the slums of Dhaka, Bangladesh. *American Journal of Public Health*, 101, 1225–33. doi: 10.2105/AJPH.2010.300090 PMID: 21653248.

Hosmer, D. W., & Lemeshow, S. (2004). Applied Logistic Regression. Second. New York: *John Wiley & Sons*, (Probability and Statistics).

Ligon, B. L. (2006). Infectious Diseases that Pose Specific Challenges After Natural Disasters: A Review. *Seminar in Pediatric Infectious Diseases* 17(1), 36–45. Doi: https://doi.org/10.1053/j.spid.2006.01.002 PMID: 16522504.

Målqvist, M., & Hoa, D. T. P., Thomsen, S. (2012). Causes and determinants of inequity in maternal and child health in Vietnam. *BMC Public Health*, (12), 641. doi: https://doi.org/10.1186/1471-2458-12-641 PMID: 22883138.

McGlown, K. J., & Fottler, M. D. (1996). The impact of flooding on the delivery of hospital services in southeastern United States. *Health Care Manage Rev.*, 21(3), 55–71. https://www.ncbi.nlm.nih.gov/pubmed/8832278 PMID: 8832278.

McMichael, A. J. (2013). Globalization, climate change, and human health. The *New England Journal of Medicine*, 368, 1335–43. DOI: 10.1056/NEJMra110934 PMID: 23822791.

Namasivayam, A., González, P. A., Delgado, R. C., & Chi, P. C. (2017). The Effect of Armed Conflict on the Utilization of Maternal Health Services in Uganda: A Population-based Study. *PLoS Curr, 3, 9*. PMID: 29188138

O'brien, R. M. (2007). A Caution Regarding Rules of Thumb for Variance Inflation Factors. *Qual Quant* 41**,** 673–690. https://doi.org/10.1007/s11135-006-9018-6

Pakistan Flood 2011 Early Recovery Framework. (2012). OCHA, UN. https://reliefweb.int/sites/reliefweb.int/files/resources/20120220_Early%20Recovery%20Framework%20Floods%202011_Final.pdf

Phalkey, R. K., & Louis, V. R. (2016). Two hot to handle: How do we manage the simultaneous impact of climate change and natural disasters on human life? *The European Physical Journal Special Topics*, 225, 443–57. https://doi.org/10.1140/epjst/e2016-60071-y

Rutaremwa, G., Wandera, S. O., Jhamba, T., Akiror, E., & Kiconco, A. (2015). Determinants of maternal health services utilization in Uganda. *BMC Health Services Research*, (15), 271. https://doi.org/10.1186/s12913-015-0943-8 PMID: 26184765.

Shimi, A. C., Parvin, G. A., Biswas, C., & Shaw, R. (2010). Impact and adaptation to flood. A focus on water supply, sanitation and health problems of rural community in Bangladesh. *Disaster Prevention and Management*, 19(3), 298–313. https://doi.org/10.1108/09653561011052484

Tatah, L., Delbiso, T. D., Rodriguez-Llanes, J. M., Cuesta, G. G., & Guha-Sapir, D. (2016) Impact of Refugees on Local Health Systems:A Difference-in-Differences Analysis in Cameroon. *PLoS ONE*, 11(12). https://doi.org/10.1371/journal.pone.0168820 PMID: 27992563.

Vanderveken, A., Guha-Sapir, D. (2016). CRED CRUNCH: The EM-DAT higher resolution disaster data. CRED, USAID; Report No.: 43. https://www.cred.be/credcrunch-43-em-dat-higher-resolution-disaster-data

Watts, N., Adgar, W. N., Agnolucci, P., Blackstock, J., Byass, P., & Cai, W. (2015). Health and climate change: Policy responses to protect public health. *The Lancet*, (386), 1861–1914 DOI: https://doi.org/10.1016/S0140-6736(15)60854-6 PMID: 26111439.

World Health Organization (WHO). (2007). Standards for Maternal and Neonatal Care. Geneva, Switzerland: Retrieved from: http://www.who.int/maternal_child_adolescent/documents/a91272/en/

Xiong, X., Harville, E., Mattison, D., Elkind-Hirsch, K., Pridjian, G., & Buekens, P. (2008). Exposure to Hurricane Katrina, post-traumatic stress disorder and birth outcomes. The American Journal of Medical Sciiences, 336, 111–5. DOI: https://doi.org/10.1097/MAJ.0b013e318180f21c PMID: 18703903.

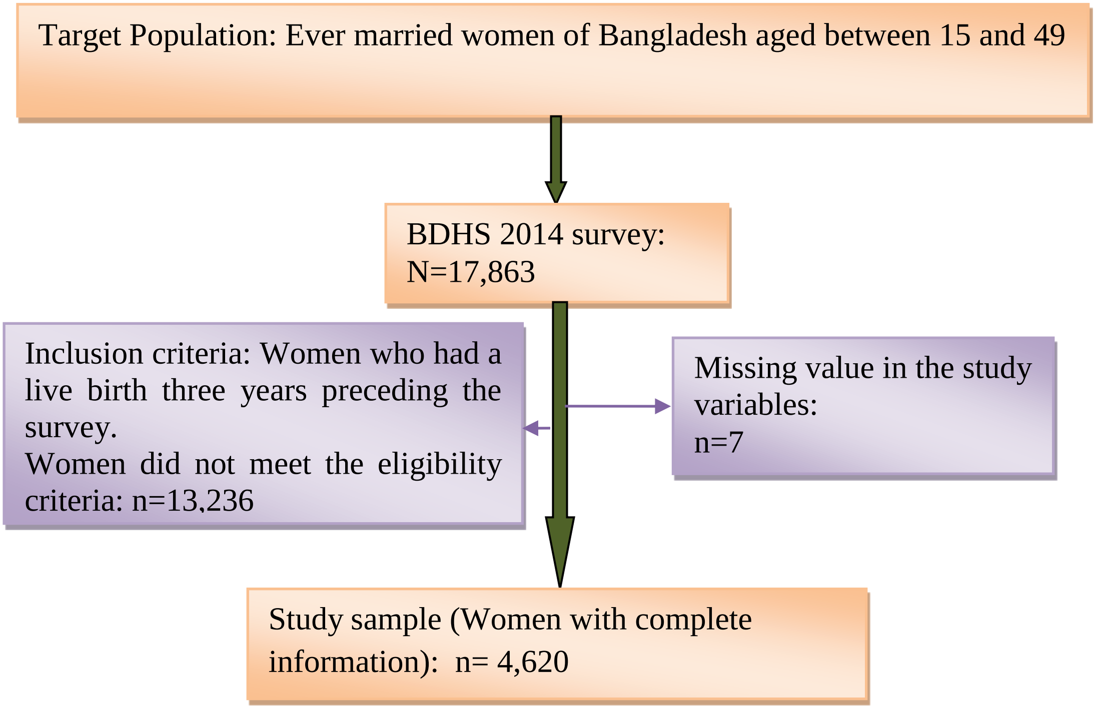

Figure 1: Flowchart showing sample size of the study

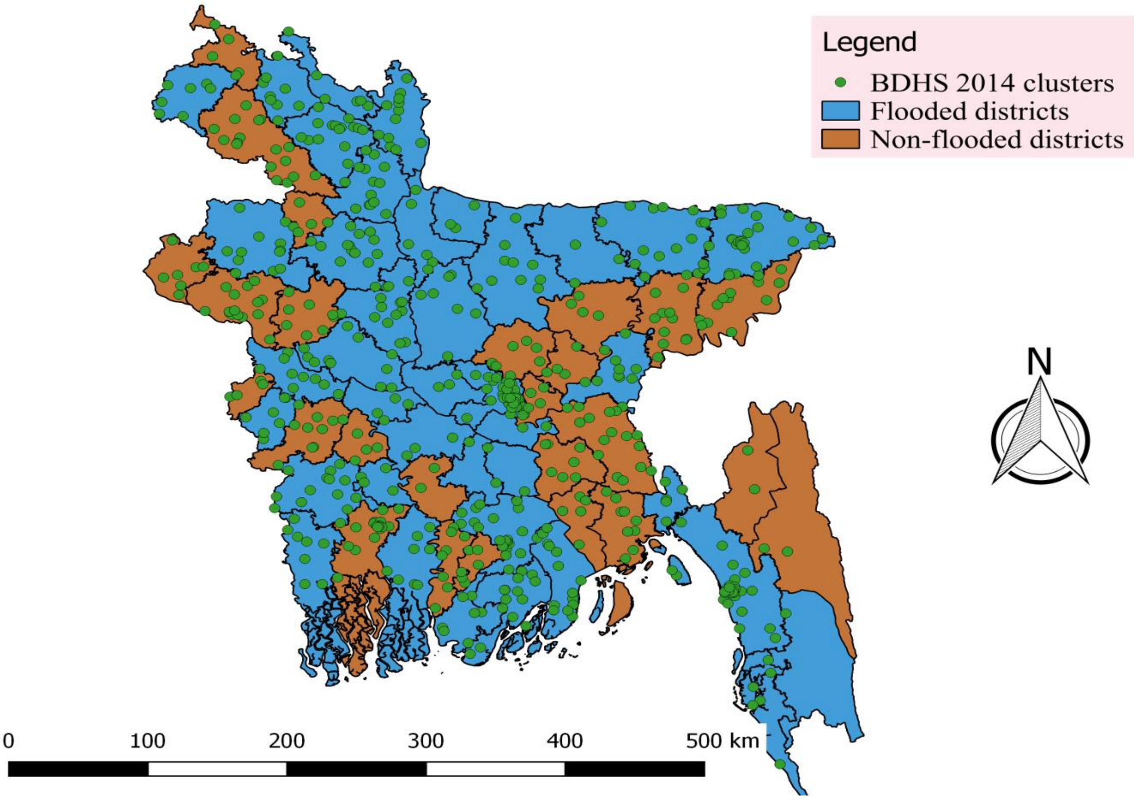

Figure 2: Distribution of BDHS 2014 clusters over the flood-affected and non-flood affected districts of Bangladesh.

Table 1: Description of the study variables

Outcome variables	
Number of antenatal care visits	Grouped as: No: 0-3 visits or Yes: ≥ 4 visits; At least four visits are recommended by WHO guidelines (WHO 2007).
Received ANC from skilled provider	Computed as: No: If care not received by medically trained providers: a qualified doctor, nurse, midwife, paramedic, family welfare visitor (FWV), community skilled birth attendant (CSBA), or sub-assistant community medical officer (SACMO). Yes: If care received by medically trained providers
Delivery assisted by skilled provider	Computed as: No: If not received assistance at birth by medically trained providers: a qualified doctor, nurse, midwife, paramedic, family welfare visitor (FWV), community skilled birth attendant (CSBA), or sub-assistant community medical officer (SACMO). Yes: If received assistance by medically trained providers
Place of Delivery	Grouped as: Home: Respondent's home Institutional: Public hospital/ District hospital/ Maternal and child welfare centre/ Upazilla health complex/ Upazilla health and welfare centre/ other public sector/ Community clinic/ Private hospital/ Non-governmental Organization (NGO) static clinic/ other NGO sector/ other.
Delivery by c-section	Computed as: No: Not delivered by caesarean section Yes: Delivered by caesarean section
Postnatal Check up of the respondents	Computed as: No: Respondent's checkup not done after delivery. Yes: Respondent's checkup done after delivery
Post natal check up of the baby	Computed as: No: Post natal checkup not done within 2 months of the delivery Yes: Post natal checkup done within 2 months of the delivery
Exposure variable or predictor	
Living area of the respondents	Grouped as flood-affected districts or non-flood affected districts
Covariates	
No. of household members	Household member listed per household
Sex of household head	Grouped as male or female
Age	Current age of the respondents
Place of residence	Grouped as Urban or Rural
Education level	Grouped as No education, Primary, Secondary, or Higher.
Number of children ever born	Grouped as 1, 2-3 or ≥ 4
Wealth index**	Grouped as Poorest, Poorer, Middle, Richer or Richest
Respondent occupation	Grouped as Not working, Professional/Tec./Managerial, Sales and services, Agriculture, Household and domestic or Skilled and unskilled manual.
Birth in last three years	Grouped as 1 or 2-3

****Wealth index was used as a proxy variable of the household economic status in this study, as data is generally not collected on household income as part of the DHS survey. The index is constructed using household asset data via principal components analysis. The index is computed, national-level wealth quintiles (from lowest to highest) are obtained by assigning the household score to each of the household member, ranking each person in the population by his or her score, and then dividing the ranking into five equal categories, each comprising 20 percent of the population.

Table 2: Background characteristics of the study participants in the flood-affected area and non-affected area of Bangladesh during 2011 to 2014.

Background Characteristics	Non-flood affected (n=1721)	Flood affected (n=2899)	Total (N=4620)	P-value
Age; Mean (SD)	24.31 (5.73)	24.77 (5.78)	24.60 (5.77)	**0.008
No. of household members; Mean (SD)	6.00 (2.65)	6.06 (2.76)	6.04 (2.72)	**0.422
Sex of Household head				*<0.001
Male	1538 (89.4%)	2687 (92.7%)	4225 (91.5%)	
Female	183 (10.6%)	212 (7.3%)	395 (8.5%)	
Place of residence				*<0.001
Urban	360 (20.9%)	846 (29.2%)	1206 (26.1%)	
Rural	1361 (79.1%)	2053 (70.8%)	3414 (73.9%)	
Education				*<0.001
No education	183 (10.6%)	470 (16.2%)	653 (14.1%)	
Primary	436 (25.3%)	857 (29.6%)	1293 (28.0%)	
Secondary	916 (53.2%)	1288 (44.4%)	2204 (47.7%)	
Higher	186 (10.8%)	284 (9.8%)	470 (10.2%)	
Wealth Index				*<0.001
Poorest	318 (18.5%)	683 (23.6%)	1001 (27.7%)	
Poorer	365 (21.2%)	509 (17.6%)	874 (18.9%)	
Middle	322 (18.7%)	559 (19.3%)	881 (19.1%)	
Richer	398 (23.1%)	557 (19.2%)	955 (20.6%)	
Richest	318 (18.5%)	591 (20.4%)	910 (19.7%)	
Respondent Occupation				*<0.001
Not working	1300 (75.5%)	2151 (74.2%)	3541 (74.7%)	
Professional/Technical/Managerial	24 (1.4%)	58 (2.0%)	82 (1.8%)	
Sales and services	51 (3.0%)	100 (3.4%)	151 (3.3%)	
Agriculture	185 (10.8%)	377 (13.0%)	562 (12.2%)	
Household and Domestic	8 (0.5%)	49 (1.7%)	57 (1.2%)	
Skilled and unskilled manual	153 (8.9%)	164 (5.7%)	317 (6.9%)	
Number of children ever born				*0.014
1	730 (42.4%)	1112 (38.4%)	1842 (39.9%)	
2-3	774 (44.9%)	1365 (47.1%)	2139 (46.3%)	
≥ 4	217 (12.6%)	422 (14.6%)	639 (13.8%)	
Number of birth in last 3 years				*<0.001
1	1652 (96%)	2697 (93.0%)	4349 (94.1%)	
2-3	69 (4.0%)	202 (7.0%)	271 (5.9%)	

**t-test and *chi-squares test

Table 3: MCH indicators stratified by flood-affected and non-affected area for the years 2011 to 2014.

Maternal health indicator	Non-flood affected (n=1721)	Flood-affected (n=2899)	Total (n=4620)	P value
Antenatal visits				<0.001
0-3 (No)	1241 (72.1%)	1938 (66.9%)	3179 (68.8%)	
4+ (Yes)	480 (27.9%)	961 (33.1%)	1441 (31.2%)	
Received ANC by skilled providers				<0.001
No	567 (33.0%)	1103 (38.0%)	1670 (36.2%)	
Yes	1154 (67.0%)	1796 (62.0%)	2950 (63.8%)	
Delivery assisted by skilled providers				0.486
No	983 (57.1%)	1653 (57.0%)	2636 (57.1%)	
Yes	738 (42.9%)	1246 (43.0%)	1984 (42.9%)	
Place of delivery				0.412
Home	1060 (61.6%)	1774 (61.2%)	2834 (61.3%)	
Institution	661 (38.4%)	1125 (38.8%)	1786 (38.7%)	
Delivery by caesarean section				0.013
No	1286 (74.7%)	2215 (76.4%)	3501 (75.8%)	
Yes	435 (25.3%)	684 (23.6%)	1119 (24.2%)	
Women postnatal check up				<0.001
No	560 (32.5%)	1083 (37.4%)	1643 (35.6%)	
Yes	1161 (67.5%)	1816 (62.6%)	2977 (64.4%)	
Baby postnatal check up				0.010
No	593 (34.5%)	1099 (37.9%)	1692 (36.6%)	
Yes	1128 (65.5%)	1800 (62.1%)	2928 (63.4%)	

Table 4: Odds of unadjusted and adjusted logistic regression model for the MNH indicators in the flood-affected and non-affected areas during 2011- 2014.

Outcome Variables	**Non-flood affected vs flood-affected**					
	Unadjusted Model			**[b] Adjusted model**		
	Unadjusted OR	95% CI	P value	Adjusted OR	95% CI	P value
Antenatal Visits						
0-3 (No)	1			1		
4+ (Yes)	1.11	(0.98, 1.27)	0.108	**1.20***	(1.04, 1.38)	<0.05
Received ANC by skilled providers						
No	1			1		
Yes	**0.81***	(0.72, 0.93)	<0.05	0.91	(0.79, 1.05)	0.1846
Delivery assisted by skilled providers						
No	1			1		
Yes	0.90	(0.80, 1.02)	0.0916	0.96	(0.83, 1.10)	0.5415
Place of delivery						
Home	1			1		
Institutional	**0.88***	(0.78, 0.99)	<0.05	0.90	(0.79, 1.04)	0.1664
Delivery by caesarean section						
No	1			1		
Yes	**0.83***	(0.72, 0.96)	<0.05	**0.84***	(0.72, 0.99)	<0.05
Women post natal check up						
No	1			1		
Yes	**0.76****	(0.67, 0.87)	<0.001	**0.78****	(0.68, 0.90)	<0.001
Baby postnatal check up						
No	1			1		
Yes	**0.82***	(0.72, 0.93)	<0.05	**0.84***	(0.73, 0.96)	<0.05

*Figure in bold ** denote ORs with P<0.001*
*Figure in bold and * denote ORs with P<0.05*

[b] *Variables included in the adjusted model: No. of household members, sex of household head, and respondent's age, place of residence, education, wealth index, occupation, number of children ever born, and birth in last three years.*

Table 5: Odds of adjusted logistic regression model for the MNH indicators on the basis of repeated flood from the years 2011 to 2014.

Outcome variables	Once Vs twice affected			Once Vs thrice affected			Once vs fourth affected		
	OR	95% CI of OR	P value	OR	95% CI of OR	P value	OR	95% CI of OR	P value
Number of antenatal visits									
No	1			1			1		
Yes	**0.57** **	(0.46, 0.70)	<0.001	1.19	(0.93, 1.52)	0.1695	0.92	(0.67, 1.26)	0.6033
Received ANC by skilled provider									
No	1			1			1		
Yes	0.95	(0.77, 1.16)	0.594	1.17	(0.89, 1.54)	0.273	**0.66***	(0.48, 0.90)	<0.05
Delivery assisted by skilled provider									
No	1			1			1		
Yes	**0.80***	(0.65, 0.98)	<0.05	0.96	(0.75, 1.24)	0.774	**0.72***	(0.52, 1.00)	<0.05
Place of delivery									
Home	1			1			1		
Institutional	**0.74***	(0.60, 0.91)	<0.05	1.06	(0.82, 1.36)	0.678	0.85	(0.61, 1.18)	0.340
Delivery by c-section									
No	1			1			1		
Yes	**0.67***	(0.52, 0.85)	<0.05	**0.51****	(0.38, 0.69)	<0.001	**0.61***	(0.41, 0.90)	<0.05
Women postnatal checkup									
No	1			1			1		
Yes	**0.77***	(0.64, 0.94)	<0.05	0.87	(0.67, 1.14)	0.315	**0.43****	(0.32, 0.59)	<0.001
Baby postnatal checkup									
No	1			1			1		
Yes	**0.75** *	(0.62, 0.90)	<0.05	0.80	(0.62, 1.03)	0.082	**0.41****	(0.31, 0.55)	<0.001

*Figure in bold and ** denote ORs with P<0.001*
*Figure in bold and * denote ORs with P<0.05*