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The Impact of Floods on Maternal and Newborn Healthcare in Pakistan

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Master Thesis

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July 26, 2021

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Master Thesis Project

Author: Bc. Angjelina Kotarja

Supervisor: Andreas Menzel, Ph.D.

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Topic: The Impact of Floods on Maternal and Newborn Healthcare in Pakistan

Motivation and Literature Review:

Floods are the most prevalent natural disaster in South Azia. They often result in significant fatalities, which vary according to the nature, frequency, and vulnerability of the exposed population. According to the Khyber Pakhtunkhwa Provincial Disaster Management Authorities report, the 2010 flood was the most catastrophic in the history of disasters in Pakistan, affecting more than 24 million people's lives in various ways (KPPDMA,2014). The majority of the research on the impact of floods relates to human health, mortality, and morbidity, emphasizing that the direct and indirect impact of natural disasters on healthcare systems leads to reduced accessibility, availability, and affordability of healthcare services (Phalkey and Louis 2016). These conditions lead to adverse health outcomes for most vulnerable exposed groups, including women, children, and the elderly, who are at higher risk of health complications (Goodman 2016). Nevertheless, there is limited evidence on the causal impact of floods on a sub-vulnerable group, pregnant women, and their newborn health.

Research Question and Contribution:

Several longitudinal studies have examined the adverse health outcomes of flooding disasters, with most papers focusing on children's health. Sajid and Bevis (2021) examine the impact of flooding on the health and human capital of children exposed to floods in Pakistan and find that floods increase the mortality rates among children and negatively affect their human capital growth. Similarly, Mallett and Etzel (2018) investigate the impact of floods on the health of pregnant women and children and argue that floods may exacerbate a range of negative psychological and physiological child and reproductive health outcomes coped with an increasing number of fatalities. However, few studies examine the causes of the adverse impact on pregnancy outcomes. A study in Dhaka slums (Bangladesh) shows that flooding negatively impacts infants and young children's nutritional and health status, resulting in poor and inappropriate breastfeeding and complementary feeding practices for infants and young children in normal times and worse during flooding periods (Goudet et al. 2011). Hetherington et al. (2021) examine the impact of the Calgary 2013 flood on pregnancy complications and maternal health and find a minor increase in gestational hypertension in women living in flooded areas compared to non-flooded areas. The authors suggest that universal prenatal care and the magnitude of the disaster may have minimized the impacts of the flood on pregnant women. This study examines Pakistan's maternal and newborn health care practices after a flood. To the best of my knowledge, it will be the first to examine the effects of exposure to a single flood disaster on maternal and infant health care utilization in Pakistan.

The main hypothesis is that floods negatively impact maternal and newborn health utilization.

Methodology:

I intend to examine the causal impact using a difference-in-difference (DID) study design among two sets of data in the Pakistan region, the Emergency Events Database (EM-DAT) and the Demographic and Health Survey (DHS). The DID study design attempts to overcome challenges associated with regional comparisons and pre-post designs. The estimation will broadly follow the 2013 Calgary flood example, with the treatment group being women living in a flood area during the year of the flood (exposure group). Control groups will be (1) women in a non-flood area during the year of the flood, (2) women living in a flood area in a non-flood year, and (3) women living in a non-flood area in a non-flood year. However, I estimate the results using a logistic regression which is in line with most of the papers that examine maternal and newborn health utilization in disaster settings (Baten et al. 2020), but adding to this strand of literature on the impact of floods, the examined logistic difference in difference estimator.

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Contents

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Bibliographic note

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Abstract

Floods can occur unexpectedly and affect certain groups more than others. I use a difference-in-difference method to identify the causal impact of the 2010 Pakistan flood on maternal and newborn health care utilization. To estimate the likelihood of health care utilization, I use Pakistan Demographic and Health Surveys data two years before and one year after the event, combined with the georeferenced data on the flood among studied years. Through logistic regressions, I determine whether flood-affected communities significantly predicted the differences in the utilization of health care services. Results show that the odds ratio of attending the required number of antenatal visits and postnatal checks was lower in flooded areas than in non-flooded areas. Similarly, the child's size at birth was reported as less than average in the exposed districts. Therefore, medical protection should be enhanced for vulnerable groups, and extra effort should be considered to ensure access to maternal health care services to protect pregnant women's livelihoods in similar disaster settings.

Key Words: Difference-In-Difference, Flood, Maternal, Newborn, Pakistan

Abstrakt

Povodně se mohou objevit neočekávaně a zasáhnout určité skupiny více než jiné. K identifikaci kauzálního dopadu povodní v Pákistánu v roce 2010 na využití zdravotní péče o matky a novorozence používám metodu rozdílu v rozdílu. K odhadu pravděpodobnosti využití zdravotní péče používám data z Pákistánských demografických a zdravotních průzkumů dva roky před a jeden rok po události v kombinaci s georeferenčními údaji o povodních ve studovaných letech. Prostřednictvím logistických regresí zjišťuji, zda komunity postižené povodněmi významně predikovaly rozdíly ve využívání zdravotnických služeb. Výsledky ukazují, že pravděpodobnost účasti na požadovaném počtu prenatálních návštěv a poporodních kontrol byla v zaplavených oblastech nižší než v nezaplavených. Stejně tak velikost dítěte při narození byla v exponovaných okresech hlášena jako menší než průměr. Proto by měla být posílena lékařská ochrana pro skupiny ohrožené nemocemi a mělo by být zváženo zvláštní úsilí o zajištění přístupu ke službám zdravotní péče pro matky, aby se ochránilo živobytí těhotných žen v podobných katastrofických situacích.

Klíčová slova: Rozdíl-I-Rozdílu, Povodeň, Mateřská, Novorozenec, Pákistán

Introduction

Due to climate change, hydro-meteorological disasters in South Asian countries, including Pakistan, have increased in recent years (Arnell and Lloyd-Hughes 2014). Ministry of Water Resources in Pakistan has listed seven years of the past decade as major flood years compared to three in the preceding six decades (Watto, Mitchell and Akhtar 2021). Pakistan experienced the most catastrophic flood in 2010, affecting more than 24 million people, damaging more than 2 million hectares of farmland, and causing economic losses of more than $ 10 billion (Syed and Syed 2012). Apart from the economic impacts of natural disasters on human life, many studies focus on the health outcome of the affected population. After every major flood, news reports increase the risk of infectious diseases and livelihood losses. Understanding the impact of flooding on human health is necessary not only for regional policies around flooding disasters but also to provide insight into climate change's influence on future human welfare.

The impact of natural disasters is difficult to quantify due to the varied nature and intensity of the extreme event and the differences in the social and physical infrastructure of the exposed communities (League et al. 2019). Therefore, the individualized reactions to the mass event will depend on the pre-existing vulnerabilities and managing of resources (De Pryck 2021). In investigating household vulnerability to flooding-induced public health risk in Pakistan, Shah et al. (2020) consider many socio-economic and demographic attributes and show that women, children, and the elderly are the most vulnerable groups in society. Adding to the vulnerability concept, which recognizes that sub-populations are at differential risk of a natural disaster according to social status, this thesis considers pregnant women and their infants as a more vulnerable subgroup among all women that experience flood disasters. This is in line with Goodman (2016), which shows that pregnant women and maternal health are at higher risk for complications in disaster settings.

Reproductive health care, the care the woman receives before, during, and after delivery, is important for the survival and well-being of the mother and her child (Franny 2013). Although many studies focus on examining the broad patterns of disaster impacts on pregnancy, including the adverse environmental exposures and fatalities, few consider the mediators that lead to the causes of adverse outcomes. A topical review Harville et al. (2021) suggests that disasters may impact family functioning decisions which, in turn, lead to a lack of access to health care or negative behavioral changes among pregnant women. Similarly, Chi et al. (2015) explains that maternal and neonatal deaths, coupled with limited or no access to reproductive health services such as prenatal care, family planning, assisted delivery, and emergency obstetric care, increase the number of fatalities.

This thesis analyses the challenges pregnant women experience in flooded to non-flooded regions by considering the difference in the number of prenatal visits, the chances of being assisted by health care professionals during or after delivery, and postnatal checkups. The aim of this thesis is to examine the impact the 2010 flood had on maternal and newborn healthcare utilization. Nevertheless, the increase in women's challenges in a disaster setting is due to both interrelated biological and social determinants: the reproductive health needs combining with an intensification of existing social inequities along the "intersectional" lines of gender, caste, number of children, education, which are few of control variables used in the specified model of this paper. These challenges conclude in fatalities, pregnancy or birth complications for pregnant, birthing, or postpartum women, poor nutrition, breastfeeding challenges, or even difficulty obtaining adequate sanitary supplements (Crenshaw 2013). Surveillance after Hurricane Katrina found that 3% had a visit for obstetric reasons and more than 15% of the evacuees required Special Supplemental Nutrition Program for Women and Infants services or birth control (Disease Control, (CDC et al. 2006).

In addition, researchers have attempted to study the biological effects of natural disasters on prenatal maternal stress and the implications for birth outcomes (King et al. 2012) or even early child development (Olson et al. 2019). However, the literature linking the disaster to birth outcomes is mixed and mostly limited to developed countries. In some studies, women—and their young children—are susceptible to specifically gendered health problems immediately following a disaster and show increases in preterm birth or low birthweight. For example, Chen et al. (2013) associates these results with hurricane Katrina and several earthquakes. At the same time, other studies that use administrative records tend to show no differences in birth outcomes (Harville et al. 2021; Evans, Cordova and Sipole 2014). For instance, Sugawara and colleagues compared the incidence of low birth weight and preterm birth in coastal regions to inland regions in Japan after a tsunami in 2011 and found no differences; however, the authors could not account for residual confounding due to regional differences (Evans, Cordova and Sipole 2014).

While there is a strong rationale for improving the utilization of health services to improve maternal health, limited studies identify factors affecting the uptake of maternal health services, especially among vulnerable groups in Pakistan. In addition, studying health outcomes after a natural disaster becomes even more challenging in developing countries. Participant recruitment can be difficult because of the disruption caused by the disaster, which may result in significant selection bias and challenges in obtaining an adequate control group (Nelson 2020). Studies that rely on administrative or routinely collected data can improve the sample size, but having the appropriate control group and quantifying exposure remains challenging. Because of the non-predictive nature of natural disasters, most studies rely on regional comparisons, for instance, coastal vs. inland residents for hurricane exposure. However, this study design lack to account for baseline differences between groups living in different areas, which may result in unmeasured confounding. The pre-post designs are also examined, but these studies cannot account for temporal trends due to demographic shifts in the population (Tong, Zotti and Hsia 2011). This paper adds value to the literature using a difference in difference (DID) study design which attempts to overcome the challenges associated with regional comparisons and pre-post designs. The DID design is used to study the causal relationships between two groups in different periods.

A substantial part of the literature focuses on examining the immediate health impact of disasters on children and women or the elderly (Sajid and Bevis 2021). In contrast, little attention has been given to maternal and newborn health. Goudet et al. (2011) find that breastfeeding and complementary feeding practices for infants and young children in Bangladesh were poor and inappropriate in normal times and were worse in flooding conditions and show that flooding is the root cause of malnutrition among pregnant women. In addition, Baten et al. (2020) study shares a few of the considered variables in this paper due to the usage of the same source of the dataset (DHS) in the corresponding countries; however, it differs in the identification strategy used. Therefore, to the best of my knowledge, this paper is the first to examine the impact of flooding on pregnant women and their newborns in Pakistan using a difference-in-difference design. Furthermore, it attempts to focus on the importance of specifically designed policies for this group in communities so they would have the potential to improve the situation without discounting the potential of more targeted approaches.

The flood-affected and non-affected districts were selected using the QGIS program. The Emergency Events Database (EM-DAT), which contains data on the flooded districts, was distributed over the map of the administrative level of Pakistan and using the GPS shape file data obtained from the Pakistan Demographic and Health Surveys (PDHS), the treatment dummy was generated. A dummy variable for clusters corresponding to the flood-affected districts was considered the exposed clusters and assigned the value 1. In contrast, the clusters out of the food-affected districts were assigned the value 0. Using logistic regression, I obtained the difference in differences estimator to determine whether the flood-affected exposures significantly predicted differences in maternal and newborn health care. The result shows that the odds of four or more antenatal visits were significantly lower (unadjusted OR=0.853, $P<0.049$) in the flood-affected than in the non-affected area. Additionally, the odds ratio for a postnatal checkup for infants and their average birth weight are lower in flooded regions than in non-flooded regions (unadjusted OR=0.400, OR=0.851, respectively). Therefore, with the increase in disasters due to climate change and the ongoing coronavirus pandemic, the effects of disasters and their human health consequences need refinement and, more importantly, should be applied to interventions that improve disaster prevention, mitigation, and response.

The structure of the rest of the thesis is as follows. Section 1 gives a background description of the event and follows up with the relevant literature review. Section 2 summarizes the sources and construction of the data used in this thesis and the user-dependent and independent variables. I discuss the approaches to identification in this context: the selection of observables and difference-in-differences in Section 3. The main results of the thesis are presented in section 4. In addition, I assess the sensitivity of the main results using various robustness checks, including alternative definitions of the treatment. Then, I present limitations and conclusions.

1 Background and Literature Review

This section consists of background information on the 2010 flood disaster in Pakistan and a literature review on the impact of floods and natural disasters on pregnant women and infants' health care utilization.

1.1 Flooding History of Pakistan

Floods are the most prevalent natural disaster in developed and developing countries, accounting for 73.9 % of all hydro-meteorological natural disasters (Du et al. 2010; Engle et al. 2020). The United States National Weather Service defines *floods* as '[a]ny high flow, overflow, or inundation by water which causes or threatens damage.' The 21st century thus far has an estimated 600 billion USD lost globally due to 2900 floods and 290 drought events, while nearly 300,000 people suffered from flood-related physical injuries during 2001–2018 (Engle et al. 2020; Panwar and Sen 2020). Asia is the most flood-prone region among all continents that experience natural disasters, accounting for over half of all flood-related deaths in the late twentieth century (Piyasil et al. 2007). Since the 1970s, evidence suggests that the frequency and duration of tropical storms and hurricanes have grown significantly, exacerbating flooding disasters (Solomon 2007). Climate change has contributed to increased extreme weather events, and it is predicted that more significant rainfall will result in more frequent and intense flooding in the future (Menne, Murray, Organization et al. 2013). The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment 2022 report predicts that coastal cities, especially in South and Southeast Asia, are expected to significantly increase average annual economic losses between 2005 and 2050 due to flooding. In addition, the report emphasizes that these increased floods and droughts will have an increased adverse impact on human health and wellbeing with varying types of magnitudes across Asia (Meyer et al. 2021). [1]

Pakistan has been experiencing inundations for years. Typically, from July to September, summer monsoons originating from the Bay of Bengal arrive in Pakistan from the north-eastern side and result in heavy precipitation (Akhtar 2011). Summer monsoons also originate from the Arabian Sea during these months, bringing showers to the southern area of Sindh province (Haider 2010). Under specific climatic conditions, Pakistan's active flood plains experience floods yearly with lesser intensities. When flood waters cross their expected flooding limits, it develops into a hazardous situation. Such events have emerged frequently in Pakistan's history, including in 1973, 1976, 1988, 1992, and 2010 floods (Syed and Syed 2012) Table: A1. The 2010 Pakistan flood crisis began in July following heavy monsoon rains in the provinces of Khyber Pakhtunkhwa, Sindh, Punjab, and Balochistan. About 21 million people were impacted, and around 2000 people were killed. Nearly 20 percent of Pakistan's total land area was submerged (Watto, Mitchell and Akhtar 2021).

Administratively, Pakistan is composed of four provinces along with the Federally Administrative Tribal Areas (FATA) and the Gilgit Baltistan region. The floods in Pakistan are frequently activated by Indus River. The Indus River is a major trans-limit waterway in Asia with nine tributaries and it around 2,800 kilometers (km) long, with 2682 km of it extended in the middle of northern and southern restrictions Pakistan. It begins on the Kailas Parbat Mountain, passes through Himalayan range and gathers spillover from Hindu Kush and

1. Check Figure: A1 for a global overview of floods and droughts in years.

Suleiman ranges (Figure 1). Historically the cause of floods in Pakistan are the extraordinary torrential rain, the flash floods that result to flood wave development due to precipitations (Syed and Syed 2012). The rapid glacier melt caused by the excessive precipitation in the Hindu-Kush and Karakoram Mountain ranges resulted in unusual floodwater in the Indus River. Uncontrolled deforestation in Sindh and Punjab's fields has deprived the rivers of their wave-engulfing shield. The heavy downpours put water into the main water channels like River Indus and Jhelum. Due to their inadequate water storage capabilities, these water courses start to overflow and cause significant submerges (Khan, Iqbal and Yosufzai 2011). A heavily populated area is typically continually in danger from natural disasters. One can use the Upper and Lower Indus plains as an example, which, despite being the most densely populated area of the nation, have consistently been the main flood victims throughout the nation's history. Even under normal circumstances, the life cycles of about 40 percent of the people in this region are inflexible as these people are living under the poverty line with limited access to health facilities (Khan, Iqbal and Yosufzai 2011). Therefore, during floods, their lives are made even more miserable because they have to deal with the worst possible outcomes, including illnesses, psychological trauma, and fatalities.

Flooding in any part of the world even in more economically developed countries it causes many socio-economic problems, but for the less developed countries every challenge has the same meanings for every individual of the society (Shah et al. 2018). In August 2010, UNICEF published a report titled Pakistan Monsoon Floods describing how the summer flood of 2010 was the most destructive in the history of Pakistan (Shabir 2013). The country's health, transportation, and educational infrastructures were severely damaged. In addition, availability of food and fresh water at filthy and unsafe camps had become a problem. An outbreak of skin disorders, gastroenteritis, and diarrhea diseases were present due to a lack of adequate drinking water and sanitation. Asian Development Bank and World Bank, in 2010 published a DNA (Damage and Needs Assessment) emphasizing that during July-September 2010 flood, 515 health facilities (5.3 percent) out of 9721 health facilities all over the country were damaged or destroyed (Bukhari and Rizvi 2015). The most vulnerable people, including the elderly, disabled, women, and children, were left without aid and were targeted by traffickers. Humanitarian efforts were impeded further by rugged logistical terrain, infrastructure damage, and the threat of terrorist attacks on relief agencies (Haider 2010). All these factors contributed to this emergency response being one of the most difficult in recent memory. All emergency work had to be done in a dangerous and challenging operating environment. These flood events are likely to occur more frequently due to climate change, and their negative consequences will be more severe in the future Keeping this in mind, the Sendai Framework for Disaster Risk Reduction involves strengthening resilience and encouraging adaptive behavior in response to extreme weather events to reduce vulnerability to them (Arnell and Lloyd-Hughes 2014).

1.2 Literature Review

The impact of natural disasters spans across the health, social, demographic, and economic aspects of human life. Apart from social and economic factors, most research focuses on the effects disasters have on people's health-seeking behaviors and the consequences of non-surviving healthcare institutions on health outcomes of exposed population (Sudaryo et al. 2012; Phalkey and Louis 2016). Although the impact on health remains common across disasters, the frequency of each impact (for example, mortality, morbidity, etc.) varies according to the nature, the intensity of the disaster, and the vulnerability of the population (Diaz-Sarachaga and Jato-Espino 2020). The "vulnerable population" is defined as those people who are more susceptible to uncertain events (floods) due to poor health status or lack of access to health care facilities (Weathers et al. 2004). Many factors should be considered to measure individual vulnerability. Shah et al. (2020) investigate household vulnerability to flooding-induced public health risk in Pakistan and illustrate that socioeconomic and demographic attributes, including age, gender, education, income, and social networks, are the key factors influencing households' flood vulnerability.

Age is an important determinant of vulnerability as the capacities of individuals to deal with the adverse effects of disasters are strongly age-related (Thacker et al. 2008; Ochola, Eitel and Olago 2010; Kuhlicke and Steinführer 2015). Thacker et al. (2008) find that senior citizens and youth (i.e., those older than 65 years and younger than 18) are more susceptible to the health risks posed by natural disasters, such as floods, compared to working-age adults. Likewise, Menne, Murray, Organization et al. (2013) argues that infants are especially vulnerable because of their limited mobility, strength and balance, and immature immune systems. Furthermore, Rasyif, Kato et al. (2015) through a meta-analysis of flood disaster case studies (1997-2013) identify female households in a flooded area as more exposed to the induced health threat due to patriarchy and the unequal distribution of opportunities. Similarly, Shah et al. (2018) findings suggest that women are more vulnerable as they take the primary role as caregivers for children and older family members, which could lead them to compromise their safety during climate-induced natural disasters. Therefore, during and post-disaster environments, reproductive health demands and the aggravation of already-existing societal imbalances along the "intersectional" lines of gender, wealth, caste, ethnicity, and education threaten women's health. These gender and age-specific challenges are combined with the more generally experienced lack of adequate shelter, clothing, food, or clean water in disaster settings (Care 2010).

Adding to the vulnerability concept, which recognizes that sub-populations are at differential risk of a natural disaster according to social status and other socioeconomic and demographic attributes, this thesis examines pregnant women as a more vulnerable subgroup among all females that experience flood disasters. Many studies have examined the adverse impact of floods on pregnancy outcomes. However, the causes of the adverse outcomes are not always clear as they are interrelated with psychological stressors, lack of health care, or other environmental pollutant exposures. Understanding which aspects of disaster exposure are the main contributors to the adverse outcomes help to establish effective proactive disaster responses to protect the health of pregnant women and their newborn. Harville et al. (2021) in a topical review examines the expected short- and long-term effects of disasters on pregnancy-related outcomes, including pregnancy loss, congenital disabilities, and adverse child development. Authors describe the short-term impacts, such as physical trauma or risk of injury, as less likely to occur because of the limited exposure of pregnant women to outside negative environmental consequences Harville et al. (2021). However, pregnant women confront various reproductive health challenges during the short-term recovery after a disaster, as displaced females have to stay around the clock at filthy relief camps, many of which lack the necessities (Shah et al. 2018). These lead to difficulties with pregnancy or childbirth, complications with breastfeeding, or trouble finding sufficient and hygienic supplements (Brunson 2017). Moreover, a defining characteristic of disasters is a housing disruption, which depending on the severity of the disaster and location, may increase the risk of preterm labor in exposed women due to acute trauma, heat, environmental exposures, or physical exertion (Bernard and Mathews 2008). The refugee status associated with the displacement and short-term reallocation reduces women's likelihood of accessing prenatal, delivery, and postnatal care. As such, refugee status is linked with worse mental health problems, preterm births, and increased fatalities (Heslehurst et al. 2018). Makanga et al. (2017) argue that it is unclear whether the reduced opportunities are associated with the seasonal nature of maternal morbidity. However, women need emergency obstetric care when it is least likely accessible.

Maternal and newborn health is promoted through access to services such as prenatal care (ANC), skilled birth attendance, emergency obstetric and neonatal care, postnatal care, and comprehensive maternal and newborn immunization. The American College of Obstetricians and Gynecologists notes that the lack of access to basic services in the aftermath of a disaster adversely impacts pregnancy and pregnancy outcome (Care 2010). Makanga et al. (2017) develops a Spatio-temporal model to describe the geographic proximity to health facilities as a known determinant of access to maternal care in substantial rainfall and flooding season. Similarly, Harville, Xiong and Buekens (2010) considers health care access as a short and long-term mediator of disasters' impact on pregnant and infant health. Nevertheless, a part of the literature considers the impact of environmental hazards not only on accessibility but also on availability, affordability, and quality of the health care services (Phalkey and Louis 2016; Care 2010). Phalkey and Louis (2016) suggest that the health systems impact of natural disasters generally includes primary and secondary failure. Primary failures are due to physical damage to the health care infrastructure, such as structural damages that result in the inability to function or the impact on the workforce health (e.g., death or migration of staff). The secondary failures may result from inadequate surge capacity, exhaustion of supplies, staff burnout, and the systematic failure of parallel infrastructures such as communication, transport, or emergency systems. Authors argue that failure of any of the secondary or primary components within a system could affect the drug procurement and interrupt critical vertical disease programs affecting the immunization of pregnant women and their newborns. Therefore, due to limited or no access to reproductive health services such as assisted delivery and emergency obstetric care, pregnant women and maternal health are at greater risk of complications (Goodman 2016; Chi et al. 2015).

Furthermore, a lack of insurance or money for treatments can make receiving care more challenging if jobs or savings are lost. Even if there are care providers, the strain of a disaster, evacuation, and the rigors of recovery and reconstruction may prevent women from getting the treatment they need as promptly as they should. Medication access could be restricted during a disaster for supply-chain or financial reasons. After a disaster, doctors, relief organizations, and the general public frequently place less importance on reproductive health care, making birth control less accessible (Behrman and Weitzman 2016). Contraception may be against local cultural or religious standards, and its provision, particularly for teens or single people, is contentious. The values of aid agencies may contradict communities' views. They can result in a significant unmet need for contraception, which may manifest itself in an increase in unplanned pregnancy, as was observed after Hurricane Katrina (Kissinger et al. 2007), along with the common post-disaster increase in the need to prevent pregnancy (as families tend to avoid pregnancy immediately after). Poorer health outcomes for women and children are linked to unplanned pregnancies, particularly when they occur under trying circumstances (Sedgh, Singh and Hussain 2014). After a tragedy, prenatal clinics are typically closed, at least temporarily. As a result, many pregnant women are inclined to skip prenatal care appointments. Although the effect is not as consistent as it could be expected, post-disaster studies typically find an increase in the percentage of women receiving delayed or inadequate prenatal care (Pan et al. 2021).

As of the Pakistan 2010 flood, the workforce was displaced, and infrastructure was damaged, so the health facilities were not fully functional to help the affected women (Arnell and Lloyd-Hughes 2014). Syed and Syed (2012) mention that as of 2010 flood in Pakistan occurred, the possibility of death at the time of delivery of mothers was 1 in 80. The article highlights that compared to other South Asian countries, Pakistan had been far behind in immunization coverage and contraceptive use, while the infant mortality rates were increasing. It also emphasizes that during the 2010 floods, 100 000 pregnant women were expecting to deliver within the month of the starting flood, which had been ill-treated, particularly at camps, and did not receive the required medical care (Baloch, Khaskheli and Sheeba 2012). The UN estimated that 320 women die for every 100 000 live births in Pakistan, and they believe maternal health is extensively affected. As the population in the flood-affected areas were displaced, more than 70 percent were women, among which 500 000 were pregnant (League et al. 2019).

Besides the impact on the access to healthcare services, the flood significantly impacts the mental health of pregnant women, which indirectly affects the health of newborn babies. Studies on women who experience flooded disasters associate prenatal stress with poor pregnancy outcomes, such as preterm birth and lower birthweight (Antipova and Curtis 2015; Harville, Xiong and Buekens 2010). King et al. (2012) show that the stress during pregnancy can adversely impact fetal growth and is associated with lower birthweight and shorter gestation length. The lower infant birthweight is mainly linked to a higher risk of infant mortality and morbidity (Harville and Rabito 2018). Prenatal maternal stress on pregnant mothers exposed to a flooding disaster may originate from displacement. More than 70 percent of pregnant women experienced displacement in flooding conditions in Thailand, which was associated with lowering infant birthweight than that of infants born to non-displaced women (Sanguanklin et al. 2014).

In addition, Zahran et al. (2013) suggests that displacement may affect access to prenatal care. However, it is unclear how inattentive prenatal care following disasters may manifest in infant health. On the one hand, researchers show that despite the strong correlation, the frequency of prenatal care visits has not been definitively proven to reduce birth weight (Dowswell et al. 2015). Treatment for problems such prenatal diabetes, infectious diseases like HIV and syphilis (Kidd et al. 2018), and probable delivery indicators like pre-eclampsia and fetal growth restriction are more closely associated with expertise access to care. Cost and insurance coverage concerns are obstacles to receiving care from skilled providers in nations lacking universal health coverage (Schrag et al. 2003). On the other hand, many disasters are combined with secondary environmental exposure, including storage of chemicals (Erickson et al. 2019) or mold infection, especially in hot and humid climates. The chemical exposure, hot weather, and mold are associated with an increase in congenital anomalies, low birthweight, and preterm birth (Knap and Rusyn 2016; Harville and Rabito 2018). Research has shown that extreme precipitation events in warm and cold seasons influence the birth outcomes (Schrag et al. 2003). Flooding from tropical storms and hurricanes leads to increased transmitting diseases, including Zika, malaria, and dengue, which are associated with pre-eclampsia, preterm birth, and transmission of infection (Erickson et al. 2019).

Furthermore, floods in developing countries have been linked to mother and infant malnutrition, food instability, and lower breastfeeding rates in rural regions (Goudet et al. 2011). According to Goudet et al. (2011) flooding in Bangladesh is the critical cause of malnutrition and lower breastfeeding, as they consumed less variety and amount of food, and alternate milk sources were rare. The inadequate nutrition, dislocation, and stress cause mothers to quit breastfeeding in disaster areas. Breastfeeding is essential during floods. Artificial feeding in such a setting is challenging because it necessitates considerable resources. It is also dangerous because non-breastfed newborns are especially prone to contaminated water, diarrhea, malnutrition, and illness (Palmquist and Gribble 2018). Alternatively, using infant formula and other breast milk substitutes carries a considerable danger, particularly in places with no constant supply of clean water or refrigeration for storage. A case-control study conducted in Botswana in 2006 revealed that formula-fed newborns were 50 times more likely to have diarrhea than breastfed infants (Arvelo et al. 2010). According to field research, giving vital protective care centered on formula feeding and nursing is critical in crises to prevent diarrhea.

2 Data and Variables of Interest

This chapter explain the data used and variables of interest for the analysis of the thesis research question.

2.1 Flooding Data

The five main rivers in the Pakistan river system originating from the Himalayas in the north include Jhelum, Chenab, Ravi, Sutlej, and Indus (Fig.1). Indus is the longest river with a total length of 3180 km and stretches from north to south, passing through three out of four provinces of Pakistan- Punjab, Sindh, and Khyber Pakhtunkhwa. Indus and its tributaries swell from July to September due to heavy rain and melting a glacier in the Himalayas. Even though the Indus flooding does not cause major problems for the population living on the flood plain every year, over the past two decades, the intensity and frequency of flooding have increased (Solomon 2007). The 2010 flood was the largest in Pakistan's history of flooding, submerging more than 20 % of the country (Haider 2010).

Figure 1: Indus and its tributaries Map Credit: Pakistan Water Gateway

Since 1900 the World Health Organization (WHO) Collaborating Center for Research on the Epidemiology of Disasters has maintained the Emergency Events Database (EM-DAT) of natural disasters. The EM-DAT classifies a natural event as a disaster if at least ten people were killed and 100 were affected, or the affected state either declared a state of emergency or called for international assistance (EM-DAT 2012). The EM-DAT database contains information on the disaster type, time of occurrence, and the damage incurred. Each event has a geographic specificity, such as the name of the city, village, province, or district, depending on the relevance. These data are broadly used in disaster and health and economics literature (Strömberg 2007; Toya and Skidmore 2007). The first data source used in this thesis is the georeferenced data of EM-DAT for the geographic flood occurrence in Pakistan in 2010. The district name and the provinces are recorded for the event using a standardized process applied to the reported disasters into EM-DAT. The affected provinces include Balochistan, Punjab, Sindh, North-West Frontier, Jammu, and Kashmir (EM-DAT 2012).

Then, the EM-DAT second administrative unit levels are used to distinguish the flooded and non-flooded districts. I constructed a map in the QGIS program with the second administrative level of Pakistan obtained from GAUL to match with georeferenced data from EMDAT to distinguish the flood affected from non-affected districts. As the last step, I distributed clusters of GPS shape file data from the DHS over the map. Clusters in the flooded areas were assigned the value 1, and clusters out of the affected districts the value 0 (Fig.2).

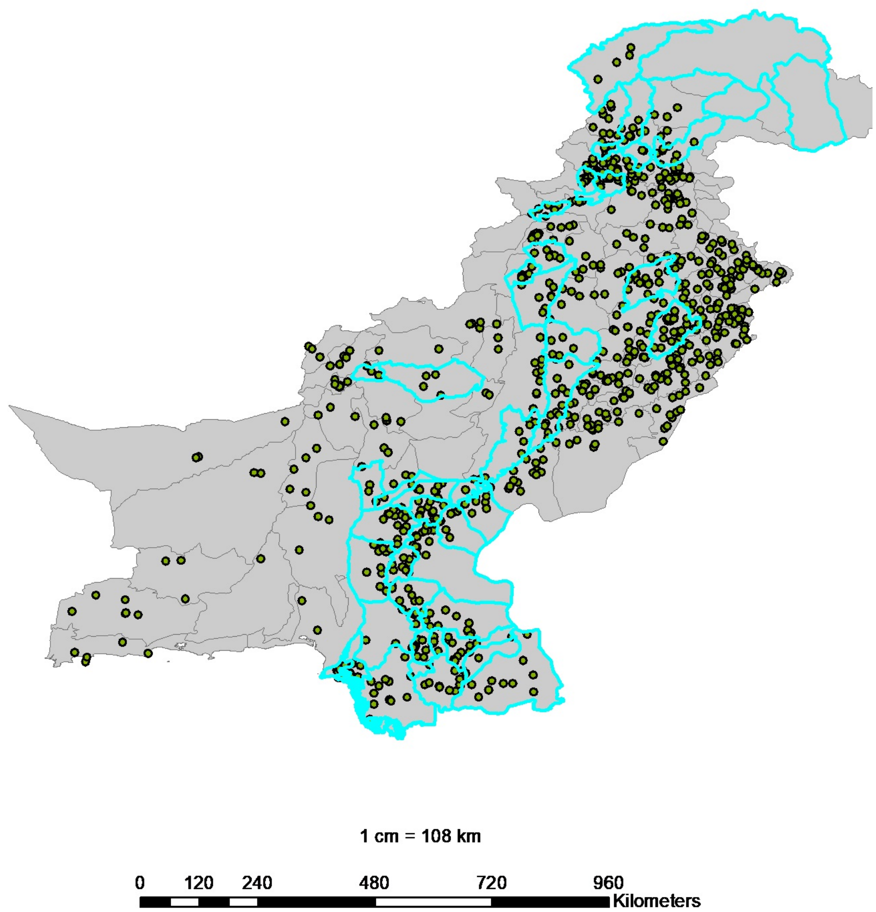

Figure 2: Distribution of PDHS clusters over the flood-affected and non-flood affected districts of Pakistan

2.2 Pakistan Demographic and Health Surveys (PDHS) Data

In this study, I use three Pakistan Demographic and Health Surveys (PDHS) in 1990-1991, 2006-2007, and 2012-2013. Since 1984 over 90 countries, the DHS has provided technical support to more than 300 demographic health surveys. The DHS program aims to collect nationally representative data on population and health in developing countries, including the maternal and child health, infant mortality levels, and nutritional status of mothers and children (Mahmood and Sultan 2006). Question for the reproductive health section of each interview aims to provide a health indicator for maternal mortality information as one of the serious challenges in developing countries. As nearly 90 percent of all maternal deaths occur in low-income countries, the International Conference on Population and Development Action Program (ICPD) set targets for a reduction in maternal mortality by at least one-half of the 1990 levels and a further half reduction by 2015 (Jalal 2012). Unfortunately, many developing countries, including Pakistan, did not achieve these targets. Pakistan's Maternal, Newborn, and Child Health Program set a goal of reducing the maternal mortality ratio (MMR) to 140 maternal deaths per 100,000 live births by 2015 (Jalal 2012) however the MMR in Pakistan is still 276 maternal deaths per 100,000 live births. (Figure: B2).

Moreover, there is evidence that for every woman who dies from a pregnancy-related complication, at least 30 suffer a disability (Marsh 2005). About 60 million deliveries globally take place at home each year without professional care, even though most maternal deaths occur around the time of delivery and are linked to a lack of skilled care at birth (Khan et al. 2009). The provision of trained birth attendants and emergency obstetric care are among the interventions required to reach these women. The DHS datasets' reproductive health care chapter includes research on reproductive health status and practices, emphasizing using maternal health services (Bhutta et al. 2012). The reproductive health care chapter of the DHS datasets presents findings on reproductive health status and practices, focusing mainly on using maternal health services. Numerous studies have demonstrated that factors such as education level, location of living, area of domicile, occupation, mobility, and religious views significantly impact reproductive health behaviors and the utilization of reproductive health care. (Asim, Sohail and Manj 2015). The variables of interest for this study and differentials by women's background characteristics are presented below (Table: 1).

2.3 Sample Selection

The target population for this study was the ever-married women of Pakistan aged between 15 and 49 years. As an inclusion criterion, I set women with a live birth three years preceding the survey 7,353 of these women satisfied the criteria. Subjects with missing data were excluded from the study. The variables chosen from PDHS datasets are present in all three samples. The final dataset included 11,601 participants. The mean and standard deviations were calculated for the numerical variables (age, number of household members), and T-tests with a 5% level of significance were conducted to assess the differences in non-flooded and flooded districts. At the same time, percentages and frequencies were calculated for the used categorical variables and chi-square tests with a significance level of 5% for the categorical variables of interest to assess the differences in proportion between flooded and non-flooded districts.

Table 1: Description of the study variables

Outcome Variables	
Number of antenatal care visits:	Grouped as: No: 0-3 visits or Yes: ≥ 4 visits. *Recommended by WHO guidelines*
Received ANC from skilled provider:	No: If care not received by medically trained providers. Yes: If care received by medically trained providers
Delivery assisted by skilled provider:	No: If not received assistance at birth by medically trained providers. Yes: If received assistance by medically trained providers.
Place of Delivery:	Home: Respondent's home Institutional: Public hospital/Private hospital
Postnatal check up of the baby:	No: Infant's checkup not done until 2 months post delivery. Yes: Respondent's checkup done in first 2 months post delivery.
Weight of baby at birth:	No: Weighted Less than the average. Yes: Weighted average or more than the average .
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
Last Pregnancy Wanted	Grouped as Yes: Desired or No:Undesired

2.4 Dependent Variables

Indicators representing maternal and newborn health care utilization are considered based on the literature examining the factors affecting uptake of maternal health services (Rutaremwa et al. 2015). The PDHS had a set of questions on maternal health services. These included: the number of ANC visits in the last birth, place, and provider of ANC, provider of skilled assistance in ANC visits, place of delivery, provider of assistance at delivery, a postnatal checkup for the infant, and the weight of the baby at birth recorded as a categorical variable. This thesis uses the questions to generate the indicators treated as dependent variables in the analysis. In the ideal scenario, women attend at least 4ANC (HIV/AIDS (UNAIDS) et al. 2007), assisted by a skilled provider, delivered in a health facility, and took their babies for a checkup within two months following delivery. Out of all study participants, only 32.98% of women had attended the required number of antenatal visits, with a non-significant difference between women who live in flood-affected areas and non-affected areas ($P = 0.957$). The number of women that did not receive skilled provider assistance during delivery in flooded areas was lower than in non-affected areas (48.53% vs. 50.84%). In addition, 61.20% of women reported that the weight at birth of their child was below average in flooded regions compared to 54.99% percent in non-flooded regions. The proportion of women who received skilled attendance during ANC visits in flood-affected areas was 96.51% compared to 93.71% in non-flooded areas. While the proportion of women who visit a health institution at delivery was lower in nonfood-affected areas. More than 30% of newborn babies received postnatal checkups after their delivery. In the non-flooded area, the proportion of postnatal checkups was significantly higher than in the food-affected area (Table: 3).

2.5 Independent Variables

Andersen's behavioral model of health care services utilization is a model that has been widely applied to survey data on various health services and populations (Andersen 2008). The model is used to guide the selection of covariates that could affect maternal health services (MHS) utilization and examine the individual-level relationship between socioeconomic and demographic factors and the utilization of a specific package of maternal health services. According to Andersen's behavioral model, the three significant elements of health care utilization are: enabling factors (e.g., income), predisposing factors (socio-demographic factors), and health care needs such as chronic illinesses (Andersen 2008). The socio-demographic factors considered in the model and this paper are age, education, type of residence, sex of head of the household, and the number of children born. (Table: 2).

The study sample consists of ever-married women of Pakistan aged between 15 and 49 who had a live birth in the three years preceding the survey. The women's average age in my sample is 27 years, and the household size of 9 (Table: 2). The background characteristics of the study represented separately for flood-affected and non-affected districts show that a higher proportion of urban women had lived in the flood-affected areas (44.95% vs. 41.48%, P<0.001). On the one hand, a higher proportion of women in non-flood affected area had completed their higher education (9.7% vs. 8.7%). On the other hand, in the flood-affected areas, the proportion of women with no education is higher than in non-flood-affected areas (63.78% vs. 53.37%). Likewise, a higher proportion of women who report more than four children ever born lived in the flood-affected area (31.84% vs. 3078%). More than 70% of women reported a single birth; the remaining had multiple births.

Table 2: Background characteristics of the study participants in the flood-affected area and non-affected area of Pakistan

Background characteristics	Non-flood affected	Flood affected	Total	P-value
Sex of household head				$< 0.001^*$
Male	5528 (91.93%)	5274 (94.38%)	10802	
Female	485 (8.07%)	314 (5.62%)	799	
Place of residence				$< 0.001^*$
Urban	2494 (41.48%)	2512 (44.95%)	5006	
Rural	3519 (58.52%)	3076 (55.05%)	6595	
Education				$< 0.001^*$
No education	3209 (53.37%)	3564 (63.78%)	6773	
Primary	970 (16.13%)	682 (12.20%)	1652	
Secondary	1250(20.79%)	855(15.30%)	2105	
Higher	584(9.71%)	487(8.72%)	1071	
Number of children ever born				$< 0.066^*$
1	1444 (24.01%)	1376 (24.62%)	2820	
2-3	2718(45.20%)	2433(43.54%)	5151	
≥ 4	1851(30.78%)	1779(31.84%)	3630	
Number of birth in last 3 years				$< 0.348^*$
1	2547(69.95%)	2655(71.52%)	5202	
2-3	1094(30.04%)	1057(28.48%)	2151	
Age Mean (SD)	27.33 (5.34)	26.49 (5.32)	26.92	$< 1.00^{**}$
No.HH member Mean (SD)	9.14 (5.36)	9.22 (5.066)	9.18	$< 0.0076^{**}$

* Chi-squares test
** t-test

Table 3: Health indicators stratified by flood-affected and non-affected area for the years of study

Background characteristics	Non-flood affected	Flood affected	Total	P-value
Antenatal visits				0.957
0-3(no)	4034 (67.14%)	3731 (66.89%)	7765 (67.02%)	
4+(yes)	1974 (32.86%)	1847 (33.11%)	3820 (32.98%)	
Received ANC by skilled providers				< 0.001
No	244 (6.29%)	130 (3.49%)	347 (4.92%)	
Yes	3638 (93.71%)	3594 (96.51%)	7232 (95.08%)	
Delivery assisted by skilled providers				< 0.001
No	2889 (50.84%)	2539 (48.53%)	5428 (49.73%)	
Yes	2794 (49.16%)	2693 (51.475%)	6595 (50.27%)	
Place of delivery				< 0.001
No	3524 (58.65%)	3113 (55.72%)	6637 (57.24%)	
Yes	2485 (41.35%)	2474 (44.28%)	4959 (42.76%)	
Baby postnatal check up				< 0.102
No	2332 (62.28%)	2087 (61.40%)	4419 (62.38%)	
Yes	1353 (36.72%)	1312 (38.60%)	2665 (37.62%)	
Baby weight at birth				< 0.001
No	2608 (54.99%)	2778 (61.20%)	5386 (58.03%)	
Yes	2135 (44.95%)	1761 (38.86%)	3893 (41.97%)	

3 Methodology and Identification Strategy

In a traditional randomized controlled trial (RCT) design, the researchers manage the random assignment of people into the exposure/treatment and control groups and compare outcomes between the groups. The mechanism of randomly assigning people into exposure/treatment and control groups is fundamental, as it implies that, on average, people in those groups are similar to each other in both the known and unknown pre-exposure characteristics (Leatherdale 2019). The equivalence in the pre-exposure ensures any confounding effects and isolates the treatment effect to measure the causal impact of policies and programs. Despite the appealing features, RCTs usually are not a practical and feasible option since large RCTs are rare or might be unethical. As such, Difference-In-Difference (DID), Regression Discontinuity Design (RDD), and Instrumental Variables (IV) estimators are techniques for conducting "natural experiments" as a solution to the lack of a randomized experimental design.

Disasters due to natural hazards often happen with little or no warning and impact any population regardless of their attributes, providing the circumstances for implementing a natural experimental design. The natural experimental framework has increasingly been used in broad natural hazard contexts. For example, the framework has been developed to analyze the impact of arguably one of the most critical natural/anthropogenic hazards we face today: climate change (Cavicchioli et al. 2019). As such, the treatment in this paper is the regions exposed to flooding, and it is assumed to be exogenous as the flood occurred unexpectantly. To estimate the causal effect, the researchers mostly use non-experimental program evaluation methods based on multiple pre- and post-treatment periods. The Difference-In-Difference (DID), Regression Discontinuity Design (RDD), and Difference-In-Difference-In-Difference (DDD) methodologies are used to determine the impact of flood disasters on human health and recover the Average Treated on the Treated (ATT) or Local Average Treatment Effects (LATE). Although many papers consider DID method when examining the impact of a natural disaster on health care and other outcome variables, few consider DID designs when studying the impact of floods on maternal and newborn health. In this paper, I use the difference-in-difference methodology to estimate the causal impact using nonlinear regressions while accounting for observables.

3.1 Difference in Difference

In non-randomized settings, the Difference-in-difference (DID) is a workhorse for causal inference. The pre- to post-intervention outcome changes among those exposed to the intervention compared with contemporaneous outcomes in a comparison group (Lechner et al. 2011). The DID design has been around since the middle of the nineteenth century when John Snow published his DID study showing that cholera is transmitted through the water supply rather than air (Snow 2020; Dimick and Ryan 2014). This design is usually based on comparing *de facto* four different groups of objects where three of these groups are control groups not affected by the treatment. Therefore, the idea of this empirical strategy is that if the two treated and the two non-treated groups are subject to the same time trends, and the treatment has no effect in the pre-treatment period, then the estimation of the effect of the treatment on the period in which is expected to have one is used to remove the confounding factors in both comparison groups.

Throughout this paper, I use $g = 1...G$ to index the geographical areas and $t = 1...T$ to index periods representing years. In the standard model of the DID design, the researchers are mostly concerned with the outcomes in two treatment regimes: the treatment and control condition. If unit g is exposed to treatment in period t, $D_{gt} = 1$ and $D_{gt} = 0$ represent the assignment to the treatment and control groups, respectively. To measure the potential outcome in each unit and time, $Y(1)_{gt}$ represents an outcome of interest under a hypothetical scenario in which the treatment was active in g at t. Thus, the treatment effect for the specific time unit is $\Delta = Y(1)_{gt} - Y(0)_{gt}$. However, this could not be easily done since an identical unit cannot be observed under two different scenarios. Therefore, for a given unit and time we can observe: $Y_{gt} = Y(0)_{gt} + [Y(1)_{gt} - Y(0)_{gt}]D_{gt}$. Replacing the potential outcomes with model specification gives the standard DID estimation equation as:[2]

$$Y_{gt} = \beta_0 + \beta_{post} * Post + \beta_{expo} * Exposure + \beta_{interaction} * Post * Exposure + \epsilon_{it} \qquad (1)$$

where Y_{gt} is the expected mean value for subject g at time t, *Post* is a binary indicator that the outcome measure was made in the post period, *Exposure* is a binary indicator that represents the exposure of the subject to the intervention, and ϵ_{it} is the error term for the outcome measure of subject i at time t, assumed to be normally distributed with a mean of zero.

I estimate the causal impact of the 2010 flood on the exposed women and infants in the post-flood period using DID method for a logistic regression equation. Kahn-Lang and Lang (2020) argue that any DID paper should address three main issues. Firstly, the researcher should justify that the baseline characteristics of the treatment and control groups do not differ. Secondly, contrary to Ai and Norton (2003), authors argue that using probit or logit coefficients on the interaction term in a DID model is appropriate since the parallel trend assumption should not be viewed as just a statistical process, but it requires a justification of the functional form. Authors dispute that researchers' belief on the "correct" model matters since they assume different counterfactuals. Lastly, Kahn-Lang and Lang (2020) argues that rejecting the null hypothesis of nonparallel trends does not confirm the existence of a parallel trend, and the purely statistical approach might generate wrong standard errors. In a regression context, the authors suggest as more natural to consider whether adding a linear trend that interacted with group membership would change the results. I follow Kahn-Lang and Lang (2020) suggestions and analyze these three issues in detail.

To represent the expected outcome of group g in year t if it is treated we write $E(Y_{gt}(D_1))$ and $E(Y_{gt}(D_0))$ if it is not. Setting $S = 1$ as the membership of group g in the treatment group, in a standard experimental framework, the potential outcome is:

$$E(Y_{gt}(D_1)|S_g = 1) = E(Y_{gt}(D_1)|S_g = 0) \qquad (2)$$

and

$$E(Y_{gt}(D_0)|S_g = 1) = E(Y_{gt}(D_0)|S_g = 0). \qquad (3)$$

A problem arises when factors that may be correlated with the outcome of interest influence the membership in the experimental group differently; equation (1) or (2) does not hold. A key to identifying the DID estimator is that the outcomes between the pre-period and the treatment period would have moved in parallel in the absence of the treatment even if the

2. Check Wing, Simon and Bello-Gomez (2018) for a detailed mathematical explanation.

pre-period outcomes may differ, that is,

$$E(Y_{g1}(D_0)|S_g = 1) - E(Y_{g0}(D_0)|S_g = 1) = E(Y_{g1}(D_0)|S_g = 0) - E(Y_{g0}(D_0)|S_g = 0). \quad (4)$$

The underlying assumption of the dependent variable in this model shifts vertically without affecting the slope of the time trend due to some initial difference between groups. This is the first addressed issue of Kahn-Lang and Lang (2020), who is required to justify why levels varied in the pre-period and how this might influence the interpretation of counterfactual changes. As the pre-period control of the outcomes improve precision and, therefore, efficiency in Table 4 I present the summary statistics separated into flood and non-flood affected groups in the pre-flood period, this satisfies the first point of Kahn-Lang and Lang (2020) discussion. There were statistically significant differences between non-flooded districts and flooded districts before the occurrence of the 2010 flood.

Besides differences between Pakistan's urban and rural areas, DHS reports differences in women's characteristics in regions (province level). Balochistan has the most significant percentage of women who have never attended school (85 percent), followed by Khyber Pakhtunkhwa (72 percent), Gilgit Baltistan (68 percent), Sindh (58 percent), Punjab (51 percent), and ICT Islamabad (16 percent) (Mahmood and Sultan 2006). As well as a regional analysis shows that ICT Islamabad has the highest literacy level among women and the lowest in Balochistan. Residents of ICT Islamabad are more likely to fall in the highest wealth quintile (69 percent) than people in other regions. In contrast, Gilgit Baltistan, Balochistan, and Sindh have the highest proportions of residents in the lowest wealth quintile (50 percent, 44 percent, and 32 percent, respectively) (Jabeen and Khan 2022). These differences are reflected in Table 4 also, as the 2010 flood affected mostly the Khyber Pakhtunkhwa, Sindh, and Punjab provinces, leaving the majority of regions in Balochistan untreated (EM-DAT 2012). Even though the analysis is done at the second administrative level, the district, to account for standard errors, differences exist among flood-affected and non-affected groups. Women in the flooded districts, on average, report the last pregnancy as less desired than women in non-flooded districts. In addition, women in the flooded districts have a higher level of education and are more literate than those in non-affected regions. Similarly, a higher proportion of people in flood-affected regions live in urban areas. To account for these differences and remove any confounding effect, I control for the respondents' characteristics in the regression analysis estimation.

The DID model in its common form can be written as:

$$E(h(Y_{gt}(D))) = \beta D_{gt} + \gamma_t + \alpha_g \quad (5)$$

and can be represented in regression form as:

$$h(y_{gti}) = \beta D_{gt} + \gamma_t + \alpha_g + \epsilon_{gti} \quad (6)$$

.

In estimating the model only in the post-period, leaving out the group dummies α_g, the assumption $E(\alpha_g D_{gt}|t) = 0$ needs to hold. However, when we do not have an actual experiment, the assumption is less compelling, and we need to control for the membership S in the treated group. Even though we may believe that the treatment is as good as randomly assigned at the group level, the number of groups is important for the orthogonality assumption, which might be violated. With a small number of groups, group dummies would be necessary as there might still be group-specific time-invariant errors (see Cameron and Miller (2015) for a review). As the treated and non-treated assignments in this paper are at the second administrative level of Pakistan, at the district level, this is not an issue for the estimation. However, a set of all α terms that are not perfectly collinear with D are included as a robustness check in Section 4.

Table 4: Summary Statistics by group, pre-flood

	Flooded Districts	Non-Flooded Districts	Diff.(FD - NFD)	S.E	Obs
Pregnancy Wanted	0.634	0.678	-0.044***	(0.010)	8747
HH members	8.639	8.922	-0.282**	(0.111)	8747
Age	29.963	28.327	1.636***	(0.155)	8747
Sex of HH head	1.090	1.056	0.033***	(0.006)	8747
Children ever born	2.970	2.931	0.039*	(0.024)	8747
Education	0.716	0.576	0.140***	(0.021)	8747
Residence(Urban)	1.583	1.536	0.046***	(0.011)	8747
Observations	8747				

3.2 Counterfactual Functional Form

Aside from the assumption of parallel trends that researchers make, which in the absence of the intervention, assumes that the variable of interest would have changed similarly in the control and treatment groups when using DID model, the functional form of the chosen specification should be consistent with these patterns (Kahn-Lang and Lang 2020). As Meyer (1995) notes that other than when the distribution of the outcomes in the experimental [3]and control group is initially the same, the effect of any changes associated with time cannot be the same both if the model is specified in, for example, levels and if it is specified in logarithms. Choosing the functional form for Equation 6 is a key decision on the researcher's part and requires justification.

The functional form assumptions in DID models are that group outcomes have moved by the same absolute amount, by the same percentage, or according to the logit/probit model. For example, in a standard linear (probability) model, groups move by the same absolute amount under the counterfactual. Alternatively, based on the shape of logistic and normal distribution, probit assumes that in the counterfactual, the control and treatment groups would have moved by the same number of standard deviations (of the standard normal error) while logit makes a similar assumption in terms of logits (Kahn-Lang and Lang 2020). The chosen counterfactuals in the examined causal inference of this paper rely on official data sources on flooded regions from EM DAT that has been broadly used in the literature. I combine them with the DHS data at the cluster level to identify the exposed and non-exposed women by the flood as correctly as possible. There are districts in Pakistan that were affected by the flood (e.g., Azad Jammu Kashmir), but DHS did not cover those regions due to weather (snow) conditions, politically unsafe environment, threats, and concerns by the residents (Mahmood and Sultan 2006). Therefore, this condition does not help to make a

3. "experimental" and "treatment" group are used interchangeably throughout the paper

strong justification for the chosen counterfactual.

Ai and Norton (2003) argue that the coefficients from the probit or logit estimation of DID model give the "wrong answer." However, (Kahn-Lang and Lang 2020) discusses the issue and argues appositely. In an analogous equation to (5), I will present a discussion on the topic as well as the model specification of this paper. Let

$$y_{igt} = c + \alpha d_g + \gamma_p + \beta D_{gt} + \epsilon_{igt}, \tag{7}$$

where y is the outcome indicator for the maternal and infant health care utilization, d is a dummy for being in the flooded region, γ_t is an indicator for the post-treatment period (after 2010), and D is an interaction between being in the treated group in the post-period. Given that I am using logit, I have assumed that

$$P(y_{igt} = 1) = \frac{e^{c+\beta D_{gt}+\gamma_p+\alpha d_{ig}}}{1 + e^{c+\beta D_{gt}+\gamma_p+\alpha d_{ig}}} \tag{8}$$

The DID effect on P is given by

$$DID = \left(\frac{e^{c+\beta D_{gt}+\gamma_p+\alpha d_{ig}}}{1 + e^{c+\beta D_{gt}+\gamma_p+\alpha d_{ig}}} - \frac{e^{c+\alpha}}{1 + e^{c+\alpha}} \right) - \left(\frac{e^{c+\gamma}}{1 + e^{c+\gamma}} - \frac{e^{c}}{1 + e^{c}} \right). \tag{9}$$

The numerator of this expression is given as

$$N = e^{c+a}(e^{\beta+\gamma} - 1)(1 + e^{c+\gamma})(1 + e^{c}) - e^{c}(e^{\gamma} - 1)(1 + e^{c+\beta+\gamma+\alpha})(1 + e^{c+\alpha}). \tag{10}$$

If $\beta = 0$, the equation of numerator would reduce to:

$$N = e^{c}(1 - e^{\gamma})(1 - e^{\alpha})(1 - e^{2c+\gamma+\alpha}) \tag{11}$$

Thus, in this case the "true" DID estimate will be 0 if the γ equal 0, α or $2c + \alpha + \gamma$ equals 0. If $\gamma = 0$ or $\alpha = 0$, it is the case when we could do a simple difference over time using only the treatment and control group. Ai and Norton (2003) argue that it is wrong to test β equals to 0 in the main equation (6) because the DID estimate can be nonzero when $\beta = 0$. Ai and Norton's argument implicitly claim that consistent with the standard linear model, the counterfactual should be a constant absolute change as the probability of an event between the pre-period and treatment period. However, the answer is wrong only because the absolute change in the probability between groups can change even when the interaction term in probit or logit is zero. In line with (Kahn-Lang and Lang 2020), I believe that the appropriate counterfactual functional form is what matters rather than simply identifying as "right" or "wrong." Therefore, Kahn-Lang and Lang (2020) additionally argues that the choice of the functional form of the model used for the DID estimator is decided by the researchers, and adjusting the coefficient on the interaction term to test the counterfactual implicitly in the linear model would be a mistake. As most of the papers in the MHS utilization use simple logit/probit models, I decided to use a nonlinear model to estimate the DID. I believe this model captures the effect of the explanatory variables of interest. Before discussing the estimation of DID with logit regression and then alternatively discussing a changes-in-changes approach by Athey and Imbens (2006), the next section considers the broad assumptions underlying this estimation technique and the testing of preexisting trends of DID.

3.3 Testing Assumptions

The standard DID model implicitly relies on these assumptions: the stable unit treatment assumption (SUTVA), which assumes that the outcome of one unit is unaffected by the treatment assignment of another unit; homogeneity assumption, which assumes that the covariates X_i are not influenced by the treatment; and on the assumption that the treatment effect has no effect in the pre-treatment population group (Lechner et al. 2011). The key assumption of difference-in-difference is testing for parallel trends using a "pre-trends" test. There is two most generally used method of testing the "pre-trends." The first most used method when there is a modest number of periods available, as in this paper case, is to replicate the model for two periods before the treatment period. The second period becomes the placebo treatment period. The other method considers a base year prior to the treatment and estimates the difference between the control and treatment groups in each previous year relative to the base year. We can write the potential outcome for a group g at time t as

$$Y_{gt}(D) = f(D, u_{gt})$$

where u_{gt} is a group-specific shock. The framework requires that $f(0, u_{g0}) - f(0, u_{g-1})$ to hold. Kearney and Levine (2015) and Jaeger, Joyce and Kaestner (2020) follow this approach and test if the coefficients on the treatment group in the pre-period are individually or jointly statistically different from zero. In this case, a one-sided chi-squared test evaluating whether the coefficients are all positive or directly testing for a linear pre-trend is appropriate. Therefore, I examine the falsification check, incorrectly setting the treatment year to a year prior to the flood occurring year. For example, it is defined that the flood event occurred in 2006 using the 2006 DHS survey data instead of 2010, in which the 2012 data set was used as the treatment period, to perform analysis during the pre-treatment period 1990 DHS data to the post-treatment years as 2006 survey data. No effect may be expected from the falsification check if the common trend hypothesis is satisfied.

4 Results

4.1 Empirical Specification

In this paper, each outcome is a binary variable that measures MNH utilization. I estimate the following empirical specification:

$$Y_{it} = c + \alpha treated_{it} + \gamma post_t + \beta(post_t \times treated_{it}) + \delta X_{it} + \epsilon_{it} \tag{12}$$

where

- y_{it} is the health care indicator for person i at time t
- $treated_{it}$ equals one if i is in the treatment group
- $post_t$ denotes a dummy variable that equals one if the observation is from 2012/2013 survey (after the flood).
- X_{it} denotes a vector of individual characteristics that include gender, educational attainment, number of household members, number of children, sex of household head, living area (urban), and a binary indicator if the last pregnancy was wanted.

The parameter β provides the estimated effect of flood on the maternal health care indicator services in the treatment group relative to the control group. The unobservables ϵ_{it} potentially contain other variables that are endogenous to the utilization of natal care services. Specifically, age, educational qualification, residence, number of children, number of household members, and the sex of the household head are some of the characteristics that explain the behavior of pregnant women in taking health care services in disaster settings. A logistic regression model was used to estimate variations in the probability of uptake of maternal health services among women aged 15 to 49. This model allows each category of an unordered response variable to be compared to an arbitrary reference category.

Table 5 and 6 show the main results of this thesis. The casual impact of the 2010 flood on MNH utilization is presented in odds ratios (ORs). Odds ratios below 1 signify a lower likelihood of utilizing MNH, and above one show a higher likelihood of utilizing it. In the unadjusted analyses, I find that the odds ratio for four or more antenatal visits was significantly lower (unadjusted OR=0.853, P<0.049) in the flood-affected than in the non-affected area Table 5. However, the odds ratio of assisted delivery and ANC received by skilled providers were higher in the flooded-affected districts (1.688, P<0.03;1.324, P<0.001) than in non-affected districts. Additionally, the odds for a postnatal checkup for the infants two months after birth and the weight of the child at birth reported as above or below average were statistically significant (P<0.001;P<0.07). The infants in the flood-affected areas were less likely to take postnatal checkups (OR=0.400) and less likely to weight more than average (OR=0.851) in the flood-affected districts compared to non-affected districts.

When adjusted for the number of household members, sex of household head, respondent's age, place of residence, education, and the number of children ever born, the odds for received ANC by a skilled provider and delivery by cesarean section is higher in the flood-affected area than in non-affected ones Table 6. Similar to the unadjusted analysis, the odds of four or more antenatal visits for women living in the flood-affected area were significantly lower (adjusted OR 0.834; 95% CI 0.696,2.852; P<0.021) in the flood-affected area than in non-affected area. The received ANC and delivery by skilled providers are still significantly higher after adjusting for the respondents' characteristics (1.763, P<0.021; 1.351, P<0.001, respectively). Even though the odds ratio for giving birth in one of the delivery institutions is lower in the flood-exposed area than in the non-exposed areas for both the adjusted and unadjusted ,models, the result is statistically insignificant (P=0.509,P=0.364).

Table 5: Impact of 2010 flood in MNH indicators in Pakistan: Unadjusted Model

Outcome Variables	Unadjusted Model		
	Unadjusted OR	95% CI	P value
Antenatal visits (4+)	0.853**	(0.728,0.999)	<0.049
Received ANC by skilled providers	1.688 **	(1.048,2.719)	<0.031
Delivery assisted by skilled	1.324***	(1.126,1.555)	<0.001
Place of delivery	0.931	(0.798,1.086)	0.364
Postnatal check up (Infant)	0.400***	(0.320,0.500)	<0.001
Size of child at birth	0.851*	(0.715,1.014)	<0.072

* Denote ORs with $p < 0.1$
** Denote ORs $p < 0.05$
*** Denote ORs with $p < 0.01$

Table 6: Impact of 2010 flood in MNH indicators in Pakistan: Adjusted Model

Outcome Variables	Adjusted Model[a]		
	Adjusted OR	95%CI	P value
Antenatal visits (4+)	0.834 **	(0.696,0.999)	< 0.049
Received ANC by skilled providers	1.763**	(1.085, 2.852)	< 0.021
Delivery assisted by skilled	1.351***	(1.128, 1.618)	< 0.001
Place of delivery	0.943	(0.792,1.122)	0.509
Postnatal check up (Infant)	0.387***	(0.308,0.483)	<0.001
Size of child at birth	0.837*	(0.690,1.015)	<0.072

* Denote ORs with $p < 0.1$
** Denote ORs $p < 0.05$
*** Denote ORs with $p < 0.01$

4.2 Discussion and Robustness Check

The principal hypothesis of this study was that flood's effect on maternal and infant health utilization is negative. The findings of the study support this hypothesis as the odds ratio on the number of antenatal visits, postnatal checks up, and size of children at birth in the flood-affected area were lower than in non-flooded areas. The results are as expected and shown in the literature since floods bring substantial damages and consequences on nutrition, education, hospitals, and health facilities in exposed areas (Shimi et al. 2010). Previous studies have shown similar results in crisis settings on the MNH utilization, including the frequency of antenatal visits and the place of delivery (**namasivayam2017effect**; Baten et al. 2020). Furthermore, Chi et al. (2017) show that the increase in neonatal and maternal deaths is because of the limited or no access to reproductive health services. In the 2010 Pakistani flood, 46% of all health facilities in the districts hit by the flood had some damage, which was reported to have a possible negative impact on reproductive health services in line with the results-driven (Shabir 2013).

During and after the flood, the food, shelter, and clean water become scarce, influencing the household decisions on their top priorities actions in such settings (Shimi et al. 2010). The aftermath of a disaster condition is reported to adversely impact pregnancies (Chauhan et al. 2006). Maternal health may not be a top priority as people focus on food and shelter security. In addition, due to water contamination and lack of food supply, researchers find that different types of diseases that could affect maternal and neonatal healthcare increase (Shimi et al. 2010). Similarly, the results in this paper show that the size of the child at birth converted as a binary indicator that represents the newborn's weight is significant and more likely to be less than average in flooded districts than in non-flooded districts.

Nevertheless, I found surprising results in both models for assistance received during delivery and ANC visits by type of providers. The study finds that the odds for ANC visits by skilled assistance and delivery assistance by skilled providers are higher in flooded districts than in non-flooded districts. This outcome could indicate interventions and humanitarian assistance provided through the training and deployment of skilled personnel in flooded areas explicitly targeting women to improve their birth outcomes. In Pakistan, the National Disaster Management Authority (NDMA) coordinated and carried assistance as an initial response to the flood. The experience and capacity already formed from the Pakistan earthquake of 2005 allowed for the early mobilization of response to the flood, particularly in Khyber Pakhtunkhwa province, where the recovery phase was still in progress following the earthquake (Kulling et al. 2010). However, the Government of Pakistan sought help from the international community as soon as the floods continued to overwhelm and exhaust the country's resources and capacity. By early August 2010, the UN appealed for $459 million through the Pakistan Initial Floods Emergency Response Plan (PIFERP) to cover the immediate relief period. At the head of Pakistan, the government prioritized four clusters (Food, Health, Shelter and Water, Sanitation and Hygiene) (Shabir 2013). Within weeks, the humanitarian response to the Pakistan floods became the most significant relief operation launched by the international community in recent history, comprising various United Nations agencies, international non-governmental organizations, foreign governments, and donors. The possible interventions in these settings to improve maternal and newborn health include the facility and non-facility-based systems in homes and communities, health care services through a mobile clinic van, and education and services for ANC. Based on the findings of this study, I would recommend the health NGOs to stay more extended periods after a disaster, so they assist in the postnatal care through a more than three-month infant check-up.

To give a more accurate representation of the impact of food on maternal and newborn health, I have considered adjusted odds ratios. The results in the adjusted and unadjusted models differ as I take into account the respondents' characteristics. Besides the geographical location, the impact of the flood is influenced by other related households' economic or demographic characteristics, as shown in studies (Du et al. 2010). Finally, other covariates that may influence the health of pregnant women or their children include the distance to health care institutions, wealth index, or quality of health service due to unmeasured variables in DHS datasets I have not incorporated in the analysis.

Robustness Check To provide evidence that the pre-intervention trends do not differ across groups, I pooled the data and conducted a mixed effects model, with a binary treatment indicator predicting variation in the outcome's pre-intervention slope. As the coefficients lost significance, I have some evidence that any difference between slopes is not statistically significant in the binary outcome variables. Additionally, following the "pre-trend" technique, I estimated the unadjusted logit model in a different treatment year (2006), and Table 7 shows that the results are insignificant, providing further evidence of the satisfied pre-trend assumption. Furthermore, as the last check, I estimated the average treatment effect using the changes-in-changes model (Athey and Imbens 2006). Athey and Imbens (2006) loosened many of the assumptions of the standard DID model, and that is why they argue that the standard DID model is nested in their CID model. In the standard DID model, groups and time periods are treated symmetrically: the mean of the individual outcomes in the absence of the treatment is additive in group and time fixed effects. This is the classical "parallel trends" assumption. In contrast, the CIC model, which also nests the Discrete CIC model, allows for time periods and groups to be treated asymmetrically in pre-treatment and even accommodates selection on treatment benefits. The results in Table 8 are significant with a similar impact to the paper's main results.

Table 7: Robustness check

Outcome Variables	Unadjusted Model		
	Unadjusted OR	95% CI	P value
Antenatal visits (4+)			
	0.875	(0.714, 1.072)	P= 0.200 P*= 0.626
Received ANC by skilled providers			
	1.229	(0.745,2.026)	P=0.418 P*= 0.376
Delivery assisted by skilled			
	1.024	(0.840,1.249)	P=0.808 P*= 0.890

* Denotes the P value from the mixed effects model.

Table 8: ATE estimate of 2010 flood on MNH indicators using Discrete CIC: Adjusted Model

Discrete CiC	Adjusted Model		
	Coefficient	95% CI	P value
Delivery assisted by skilled			
	0.031**	(-.003, 0.063)	<0.050
Postnatal check up (Infant)			
	-0.193***	(-0.251, -0.135)	<0.001
Size of child at birth			
	-0.114***	(-0.149,-0.078)	<0.001

*** Denote coeff. with $p < 0.001$

4.3 Limitations

Despite the contribution to the literature, the study has several limitations, mostly on the data used. The EM-DAT georeferenced data uses a second administrative unit specification, which can be an overestimation of the flooded areas considered in the analysis. Also, for more precise results, smaller administrative units are needed. In addition, the analysis is based on retrospective outcome measures, which may lead to a recall bias. Although the overall aim of the study was to compare the flood-affected group and non-affected group, I could not relate the timing of the births among the participants with the occurrence of the flood event, which did not allow for separate women that gave birth during or after the flood to examine the association among the two events. In addition, the indicator variable's result on the child's weight at birth should be read with causation. As these are self-reported statistics, further research on the exact birthweight among infants is suggested. Finally, the indicators for maternal and infant health services were scarce and limited to those available in the three datasets used in this study. Therefore, a follow-up study evaluating the impact of foods on utilizing MNH could consider the smaller administrative units to identify the affected area or to analyze the impact of the severity of floods.

5 Conclusion

This thesis examines the pregnant women's experience in flooded and non-flooded regions in Pakistan by considering the differences in the number of prenatal visits, the chances of being assisted by health care professionals during and after the delivery, and birthweight and postnatal checkups on infants. A substantial part of the literature examines the immediate adverse impact of disasters on pregnancy outcomes. However, few consider the underlying causes of the adverse outcome on MNH utilization. I used three PDHS data for two years prior to the flood and one year after. In addition, EM-DAT flooding data at the regional level is used to distinguish the respondents that were exposed to the event from those not exposed. The study's target population was ever-married women of Pakistan aged between 15 to 49 years and with a live birth three years preceding the surveys. I considered Andersen's behavioral model of health care services utilization to guide in selecting the covariates that could affect maternal health services utilization and the individual level relationship among socioeconomic and demographic factors. The covariates considered include the number of household members, sex of household head, age of the respondent, place of residence, education level, number of children ever born, and an indicator if the last pregnancy was a desired pregnancy. To the best of my knowledge, this is the first paper that considers the impact of the 2010 flood on maternal and infant healthcare utilization in Pakistan.

Furthermore, this paper adds value to the literature using difference in difference (DID) study design in a logistic regression which attempts to overcome the challenges associated with regional comparisons and pre-post designs. The DID design is used to study the causal relationships between two groups in different periods. It is interpreted as the difference in differences estimator of the intervention effect in the log-odds metric. The findings of the study support the principal hypothesis that flood's effect on maternal and infant health is negative and show that the odds ratio on the number of antenatal visits, postnatal checks up, and size of children at birth in the flooded-affected area were lower than non-flooded areas. These results are justified in literature as the floods bring substantial damages and consequences to health facilities in the exposed areas. Nevertheless, I found surprising results in both the adjusted and unadjusted model of the paper on the assistance received during delivery and ANC visits by the providers. The study finds that the odds ratio for ANC visits by skilled providers and delivery assistance by the skilled provider are higher in flooded districts than in non-flooded districts. This result may be due to the massive interventions and humanitarian assistance provided to improve health conditions in the exposure period in Pakistan in the facility and non-facility-based systems in homes and communities. As a robustness check on the paper's main results, I used the changes-in-changes specification model, which loosens many assumptions of the considered DID model. I found significant and similar results to the paper's main results.

Based on the results of the paper, I would recommend the health NGOs to stay in more extended periods after a disaster, so they assist in the postnatal care through a more than two-month infant checkup and ANC visits during and after the pregnancy. In addition, medical protection should be enhanced for vulnerable groups, and extra effort should be considered to ensure access to maternal health care services to protect pregnant women's livelihoods in similar disaster settings.

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A Appendix

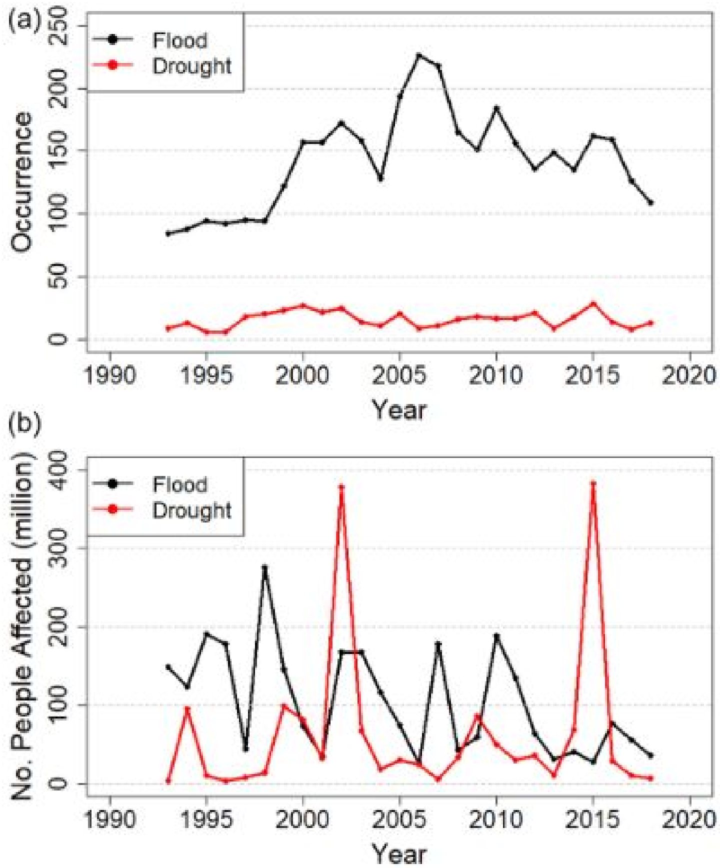

Figure A1: Global Occurrence (a) and number of affected people (b) due to floods and droughts, based on EM-DAT data (1993–2018). Source: (Lee et al. 2020)

Table A1: Floods in Pakistan during years, based on EM-DAT data.

Year	Cause	Area Affected	Life affected	Economic Damages
1955	Rainfall	Punjab		
1973	Rainfall	Punjab	474 Perished	$2.39 Billion
1976	Rainfall	Punjab / Sindh	425 Died/1.7 million affected $1.62 Billion	
1988	Rainfall	Punjab	500 Died	$400 Million
1992	Rainfall	Punjab/ Sindh	1000 Died, 4.8 million affected	$14 Billion
1994	Rainfall	Punjab/Sindh	386 Died	
2005-2006	Rainfall	Punjab	591 Died	
2010	Rainfall	Punjab/Sindh/ KPK	1985 Died, affected 21 million	$10 Billion

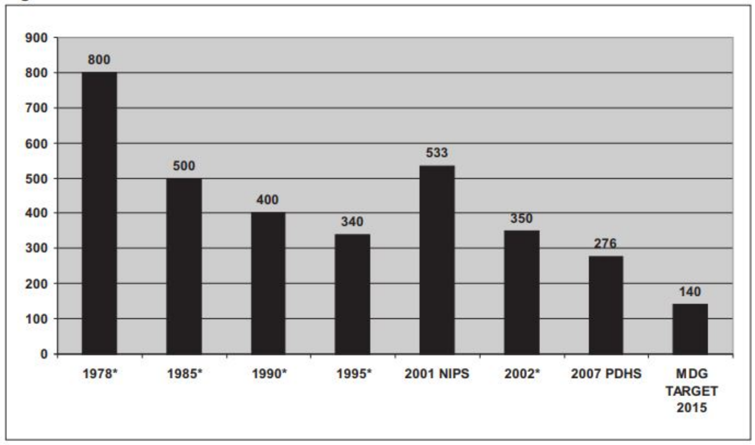

Figure B2: Trends of MMR in Pakistan Source: Khan et al. (2009)

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