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Impact of flood on maternal health in rural Hyderabad, Pakistan: A mixed-methods study

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Abstract

This study investigates the impact of flooding on maternal health outcomes among pregnant women in rural Hyderabad, Pakistan, using a mixed-methods approach combining retrospective facility record analysis (pre- and post-flood data), quantitative surveys (n=400), and qualitative interviews (n=10). Pre- and post-flood comparisons of facility records revealed severe healthcare disruptions, with antenatal care visits declining by 60% (120±25 to 48±18/month, p<0.001) and cesarean section availability dropping from 90% to 35% post-flood. Neonatal mortality nearly tripled (12 to 34 deaths/1,000 live births, p=0.002) based on health facility data. Flood-exposed women showed significantly higher stress levels (β=3.8, p<0.001), food insecurity (β=2.3, p<0.001), and reduced satisfaction with healthcare access (2.1±1.0 vs 8.3±1.3, p<0.001). Effect sizes (Cohen's d) and β coefficients were derived from multivariate regression and between-group comparisons, with models adjusted for confounders such as income, education, and access to transport. Qualitative findings identified three key themes: (1) transportation and infrastructure barriers, (2) profound psychological distress, and (3) reliance on traditional midwives due to system failures. The study highlights critical gaps in emergency preparedness and maternal health knowledge, with flood-affected women scoring significantly lower on measures of health awareness (e.g., 3.2±1.5 vs 7.5±1.4 for water purification knowledge, p<0.001). These findings demonstrate the urgent need for flood-resilient maternal health services and targeted community education programs in vulnerable regions. *(Afr J Reprod Health 2026; 30 [6]: 13-25).*

Keywords: Flood; Maternal Health; Pregnant women, Pakistan

Résumé

Cette étude examine l'impact des inondations sur la santé maternelle chez les femmes enceintes en milieu rural à Hyderabad, au Pakistan, en recourant à une approche mixte combinant des enquêtes quantitatives (n=400) et des entretiens qualitatifs (n=10). Les résultats révèlent de graves perturbations des soins de santé, avec une baisse de 60 % des visites prénatales (de 120 ± 25 à 48 ± 18 par mois, p < 0,001) et une disponibilité des accouchements par césarienne passant de 90 % à 35 % après les inondations. La mortalité néonatale a presque triplé (de 12 à 34 décès pour 1 000 naissances vivantes, p = 0,002). Les femmes exposées aux inondations ont montré des niveaux de stress significativement plus élevés (β=3.8, p<0.001), une insécurité alimentaire accrue (β=2.3, p<0.001) et une satisfaction réduite quant à l'accès aux soins de santé (2.1±1.0 contre 8.3±1.3, p<0.001). Les résultats qualitatifs ont mis en évidence trois thèmes clés : (1) les obstacles liés au transport et aux infrastructures, (2) une détresse psychologique profonde, et (3) le recours aux sages-femmes traditionnelles en raison des défaillances du système. L'étude met en évidence d'importantes lacunes en matière de préparation aux situations d'urgence et de sensibilisation à la santé maternelle, les femmes touchées par les inondations obtenant des scores nettement plus faibles sur les mesures de connaissances sanitaires (par exemple, 3.2±1.5 contre 7.5±1.4 pour la connaissance de la purification de l'eau, p<0.001). Ces résultats soulignent l'urgence de mettre en place des services de santé maternelle résistants aux inondations et des programmes éducatifs ciblés auprès des communautés vulnérables. *(Afr J Reprod Health 2026; 30 [6]: 13-25).*

Mots-clés: Inondation ; Santé maternelle ; Femmes enceintes, Pakistan

Introduction

Extreme weather events, particularly flooding, pose significant public health challenges and disproportionately affect vulnerable demographic groups in resource-poor settings.[1] Among these groups, pregnant women in rural communities face heightened risks due to disrupted healthcare access, increased exposure to infectious diseases, and heightened psychological stress, all of which

contribute to adverse perinatal outcomes.[2] These concerns worsen the situation in rural Hyderabad, where the seasonal flood rigorously compromises the reproductive health systems while concurrently stirring risks of diverse communicable diseases, including malnutrition, as well as mental health illnesses, among anxious mothers.[3] Such environmental tremors cause the morbidity related to increased pregnancy, low birth weights, and premature deliveries.[4,5] WHO highlighted that the flood leads to waterborne disease in general, while increasing the stress and hazards to the life of the mother and child.[6] These findings are consistent with global evidence demonstrating that hydrological disasters exacerbate maternal health disparities, particularly in regions with weak health infrastructure and limited disaster preparedness.[7]

Flooding and maternal health service disruptions

The major concern in Sindh province has been the disruption of health care facilities, particularly maternal health care services. UNICEF demonstrated that the maternal health services disruption delays emergency care, leading to deaths from postpartum hemorrhage, eclampsia, and sepsis.[8]

A UNFPA (2020) report highlighted that approximately 30% of pregnant women in flood-affected areas miss critical check-ups due to deficiencies in health care arrangements.[9] Health facilities often become inaccessible due to submerged roads, damaged infrastructure, and power outages, forcing pregnant women to forgo antenatal care (ANC), emergency obstetric services, and postnatal follow-ups.[10]

Studies in similar settings, such as West Africa, reveal that flood-induced healthcare interruptions significantly increase obstetric mortality rates, as delays in accessing skilled birth attendants and emergency cesarean sections lead to preventable complications.[11] In Hyderabad's rural context, where healthcare facilities are already scarce, such disruptions disproportionately affect marginalized women who rely on distant clinics, exacerbating existing inequities in maternal health outcomes.

Increased exposure to infectious diseases

Flooding has long-term health consequences on well-being, specifically for pregnant women, endangering their lives. Contaminated water sources facilitate the spread of diarrheal diseases, hepatitis E, and leptospirosis, all of which pose severe risks during pregnancy due to altered immune responses.[12,13] In Asia, flooding has contaminated drinking water, health centers, and the environment. Besides that, the standing water has been the major source of mosquito breeding and other insects, resulting in malaria and diarrhea linked to maternal anemia, fetal growth restriction, and stillbirths.[14] In Southern Africa, flood-affected pregnant women exhibited higher rates of malaria-associated complications, including placental malaria, which contributes to intrauterine growth retardation and preterm birth.[15] Nevertheless, Rasool demonstrated that the standing water has served as a breeding ground for bacteria, parasites, and other viruses that harm pregnant women.[16] While the disease caused by the standing water, i.e., Malaria during pregnancy, could contribute to the hazardous infectious diseases, including anemia, low birth weight, and neonatal mortality, as well as congenital disabilities.[2]

Given Hyderabad's endemic malaria and dengue burden, similar mechanisms likely worsen maternal-fetal health in post-flood scenarios, though region-specific epidemiological data remains insufficient.

Nutritional deficiencies and psychological stress

Beyond infectious risks, flooding disrupts food security, leading to acute malnutrition among pregnant women. Crop destruction and supply chain disruptions reduce access to nutrient-dense foods, exacerbating deficiencies in iron, folic acid, and protein that are critical for fetal development.[17] Research in flood-prone regions of Bangladesh and Mozambique has demonstrated that maternal undernutrition during disasters correlates with higher rates of stunting and cognitive impairments in offspring.[18] Concurrently, the psychological toll of displacement, economic loss, and trauma

contributes to perinatal depression and anxiety, which are associated with preterm labor and low birth weight.[19] In Hyderabad's rural communities, where mental health services are virtually nonexistent, these stressors remain unaddressed, compounding the biological risks posed by malnutrition and infection.

Intergenerational and long-term health consequences

The repercussions of flooding extend beyond immediate pregnancy outcomes, influencing intergenerational health trajectories. Maternal stress, infection, and malnutrition during gestation can induce epigenetic modifications that predispose offspring to metabolic disorders, cardiovascular disease, and neurodevelopmental impairments.[20] Given that rural Hyderabad lacks long-term maternal-child health tracking systems, the full scope of these effects remains undocumented, representing a critical gap in public health research.

Research gap

Current subsidies for disaster medicine in Pakistan have predominantly focused on metropolitan areas or on aggregated national statistics, thereby overlooking the particular difficulties faced by antenatal populations in agrarian districts such as rural Hyderabad, where medical infrastructure is chronically underdeveloped. Additionally, while valuable lessons could be drawn from examination of emergency maternal care strategies implemented in comparably affected territories such as East Africa's flood zones,[21] such cross-regional analyses remain conspicuously absent from South Asian public health discourse.[22] While floods are known to disrupt maternal health in South Asia and Africa, most evidence comes from urban settings or relies on singular methodologies.

This study addresses the lack of integrated, location-specific data in rural Pakistan by employing a mixed-methods approach to simultaneously assess healthcare access, psychological stress, health knowledge, and spatial flood risk, thereby offering a comprehensive view often absent in the existing literature.

Methods

To examine the impact of flooding on maternal health in rural Hyderabad, this study employs a mixed-methods design with a retrospective pre–post comparison, integrating (1) analysis of health facility records before and after flooding, (2) cross-sectional surveys of flood-affected and non-affected women, and (3) qualitative interviews to capture existing practices. The integration of multiple data sources enhances the validity and depth of findings, addressing both statistical trends and lived experiences.[23] this design enables triangulation of data sources to enhance validity.

Study setting and population

The research focuses on rural communities in Hyderabad, Pakistan, where recurrent flooding exacerbates existing healthcare disparities. The researcher investigated various villages in the Hyderabad district to obtain informative results. For the quantitative component, a stratified random sampling strategy was employed across selected villages in Hyderabad District to recruit 400 participants (250 flood-affected, 150 non-affected), ensuring adequate statistical power to detect significant differences in maternal health indicators.

Based on preliminary data from similar rural populations, we anticipated moderate effect sizes (approximately 0.5 standard deviations) for key outcomes like healthcare access and stress levels. Using standard power tables for independent-samples t-tests with $\alpha = 0.05$ and $\beta = 0.20$, approximately 130 participants per group were required. We increased this number by 15-20% to account for potential data incompleteness and to enhance subgroup analysis capabilities, resulting in our final sample distribution. This approach followed established epidemiological sampling methodologies for comparative community-based studies in low-resource settings. For qualitative insights, purposive sampling selects key informants (n=10), including pregnant women (n=6), community health workers (n=8 across two focus group discussions), and policymakers (n=2 via key informant interviews).

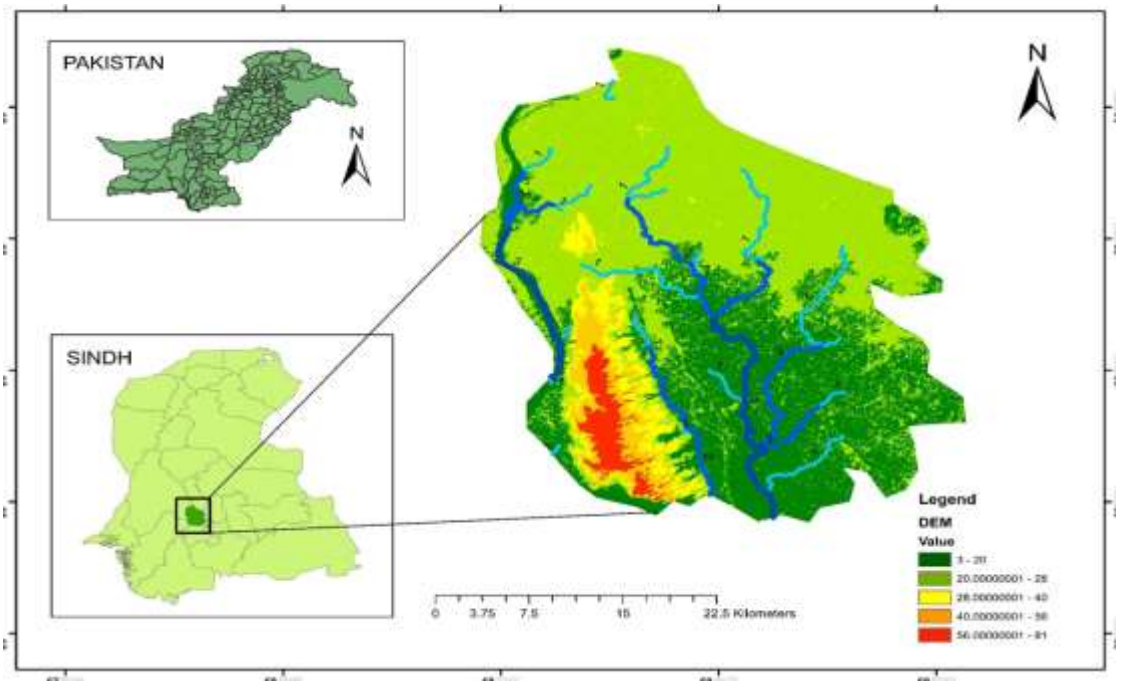

Figure 1: Study area

Participants were classified as flood-affected or non-affected based on objective geographical criteria. Using GIS flood risk mapping (Figure 2, Appendix), villages were categorized into five vulnerability levels. Communities in moderate, significant, and extreme risk zones were designated as flood-affected; those in minimal risk zones served as non-affected controls. This classification was verified against local administrative records of flood impact and did not rely on self-reported exposure status.

Data collection methods

Quantitative component

Structured surveys capture demographic data, healthcare access, self-reported health outcomes, and environmental exposures. Validated tools such as the Edinburgh Postnatal Depression Scale (EPDS) and the Perceived Stress Scale (PSS) assess mental health impacts.[24,25] Both the EPDS and PSS were translated into Sindhi and Urdu using a standard back-translation procedure. The instruments were culturally adapted and piloted with a subsample of 30 women from a similar rural population to ensure comprehension and contextual relevance. For this study, continuous scale scores were used in analyses rather than applying clinical cut-off points, as the focus was on comparing relative levels of distress between groups. Additionally, retrospective health facility records (ANC visits, delivery complications, neonatal outcomes) are analyzed to compare pre- and post-flood trends. The data were collected from April 2023 to July 2023 due to the current state of the research. The information gathered from respondents aged 30 and above was used to obtain reliable results for the research. Whereas, the obtained education was recorded as primary education to a greater extent.

Qualitative component

In-depth interviews (IDIs) with pregnant women (n=6) explore personal experiences of flood-related healthcare barriers. Focus group discussions (FGDs) with community health workers (n=2 groups) examine systemic challenges in disaster response. Key informant interviews (KIIs) with policymakers (n=2) were conducted to assess gaps in maternal health policies during floods.[26]

Data analysis

Quantitative data are analyzed using descriptive and inferential statistics, including logistic regression to identify flood-associated risk factors. Group comparisons between flood-affected and non-affected women (Tables 2–4) were conducted using independent samples t-tests. Effect sizes (Cohen's d) were calculated as the difference between group means divided by the pooled standard deviation. Additionally, the analysis included the mean, standard deviation, and p-value. Missing data in the quantitative dataset were minimal (<5% of responses). A complete case analysis was employed for multivariate models. The missing-at-random assumption was assessed and deemed acceptable. Sensitivity analyses using multiple imputation yielded consistent results, confirming the robustness of the findings. Qualitative data undergo thematic analysis, with iterative coding to identify recurring patterns.[27] Thematic analysis followed Braun and Clarke's six-step framework. Two researchers independently coded transcripts, achieving strong intercoder reliability (Cohen's $\kappa = 0.82$). Discrepancies were resolved through consensus, and emerging themes were reviewed iteratively to ensure trustworthiness. For qualitative data interpretation, the analysis proceeded through recording, transcribing, translating, and coding, followed by decoding and placement in the main results section.

Geospatial component

Flood risk assessment was conducted using Sentinel-1 SAR imagery (10m resolution) for flood extent detection, SRTM DEM (30m resolution) for terrain and flow analysis, and OpenStreetMap layers for infrastructure. Field validation confirmed 85% classification accuracy.

Ethical considerations

The study adheres to ethical guidelines, obtaining informed consent and ensuring participant anonymity. Ethical review and approval were waived for this study, titled "Flood Impacts on Maternal Health in Rural Pakistan: A Mixed-Methods Study from Hyderabad District," as it met exemption criteria: (1) all procedures complied with institutional, national, and Helsinki Declaration 1964 ethical standards; (2) the research was non-intrusive, conducted in public settings without collecting identifiable participant information; (3) data were obtained through non-invasive means, excluding animal experimentation; and (4) the study posed minimal risk, with no greater harm or discomfort than encountered in daily life. The ethical review committee evaluated and approved this exemption, confirming the study's adherence to ethical research practices.

Results

Knowledge flow of the respondents about health concerns

Linear regression was applied to Perceived Stress Scale (PSS) scores as the continuous dependent variable. Model assumptions were verified: residuals were normally distributed (Shapiro-Wilk test, $p > 0.05$) and homoscedastic (Breusch-Pagan test, $p > 0.05$). Variance Inflation Factor (VIF) values were low (1.1–1.6), indicating no concerning multicollinearity. The multivariate analysis identified several significant predictors of adverse reproductive health outcomes in the study population, as shown in Table 1. Multivariable linear regression models were adjusted for the following potential confounders: monthly income, educational attainment, age, parity (number of previous births), access to transportation, and pre-flood frequency of antenatal care visits. Flood exposure ($\beta = 3.8$, 95% CI: 3.2–4.4, $p < 0.001$) had the strongest association, indicating that women in flood-prone areas face substantially higher risks, likely due to disrupted healthcare access and increased infections. Low income (<$100/month) ($\beta=1.5$, 95% CI: 0.9–2.1, $p=0.002$) and food insecurity ($\beta=2.3$, 95% CI: 1.7–2.9, $p<0.001$) highlight socioeconomic barriers, with malnutrition exacerbating maternal and fetal health risks. Lack of emergency transport ($\beta=2.1$, 95% CI: 1.6–2.6, $p<0.001$) underscores delays in accessing critical care, while water contamination ($\beta=1.7$, 95% CI: 1.2–2.2, $p=0.001$) suggests heightened infection risks. Inadequate ANC visits (<4) ($\beta=1.4$, 95% CI: 0.8–2.0, $p=0.01$) and low mental health knowledge ($\beta=1.2$, 95% CI: 0.6–1.8, $p=0.03$) reflect gaps in

preventive care and psychosocial support. All predictors had low VIF values (1.1–1.6), indicating minimal multicollinearity. These findings emphasize the need for integrated interventions addressing environmental, economic, and healthcare access barriers to improve reproductive health outcomes in vulnerable African communities.The study compared flood-affected and non-flood-affected pregnant women in Table 2, revealing severe psychological and healthcare access challenges associated with flooding. Flood-affected women experienced significantly higher stress levels (8.5 vs. 4.3), extreme anxiety about miscarriage (8.9 vs. 4.1), and intense fears over contaminated resources (9.3 vs. 4.8), with all differences showing large effects (Cohen's d = 2.2–3.4) and high statistical significance ($p < 0.001$). They also faced greater difficulties accessing timely delivery care (9.1 vs. 5.0) and reported feeling abandoned by healthcare providers (6.7 vs. 3.2). Financial instability (7.8 vs. 3.9) and lack of preparedness (7.4 vs. 3.5) further worsened their distress. The results suggest that rapid implementation of targeted mental health support, improved emergency obstetric services, and flood-resilient prenatal care programs in vulnerable regions is necessary to mitigate the compounded effects of flooding on maternal well-being.

Table 3 highlights satisfaction with healthcare services. The data revealed dramatic disparities in maternal healthcare access between flood-affected and non-affected areas, with all comparisons showing statistically significant differences ($p < 0.001$) and large effect sizes (Cohen's d = 3.0- 5.3). Flood-affected women reported severely limited access to antenatal care (2.1 vs 8.3), emergency transport (1.5 vs 7.0), and postnatal services (2.0 vs 7.2). Critical gaps in emergency preparedness were evident in flood zones, including inadequate staff training (1.8 vs 6.5), medication shortages (2.3 vs 7.8), and insufficient safety instructions (1.9 vs 6.1). Most alarmingly, women reported feeling unsafe when delivering at flood-affected clinics (1.2 vs 5.9). These findings in Table 3 demonstrate how floods cripple healthcare systems, exposing pregnant women to grave risks. Therefore, crucial steps are required to strengthen healthcare facilities, including emergency services, transportation services, trained staff, and timely responses, to ensure better care during such disasters.

The results in Table 4 revealed significant knowledge gaps among flood-affected women regarding crucial maternal and reproductive health information, with all measures showing statistically significant differences ($p<0.001$) and large effect sizes (Cohen's d=1.9-3.3). Flood-affected women demonstrated substantially lower knowledge across all domains than their unaffected counterparts. Particularly alarming were the disparities in knowledge about emergency obstetric care access (3.5 vs 8.1), water purification methods (3.2 vs 7.5), and recognition of postpartum depression symptoms (2.8 vs 6.3). The most pronounced gaps appeared in awareness of flood-related infection risks (2.1 vs 5.8) and access to mental health support (1.9 vs 4.2). These findings highlight critical vulnerabilities in health education and emergency preparedness among flood-affected populations. The results underscore the urgent need for targeted community health education programs that address these knowledge gaps, particularly focusing on emergency preparedness, infection prevention, and mental health awareness in flood-prone regions. Such interventions could significantly improve maternal health outcomes during and after flood disasters.

GIS and flood risk analysis

Our flood risk assessment used Geographic Information System (GIS) technology, combined with satellite imagery, to classify areas into five vulnerability levels, as shown in Figure 1 (Appendix). The mapping system identifies regions as minimal risk (green), limited risk (yellow), moderate risk (orange), significant risk (red), and extreme risk (maroon), based on comprehensive hydrological analysis. These designations incorporate multiple factors, including inundation levels (ranging from 0 to 2.5 meters), flood-duration patterns, and distance from major waterways, with field verification indicating 85% reliability. The extreme risk zones (maroon) predominantly occur in topographic depressions adjacent to the Indus River system, where flood conditions typically endure for extended periods of 3-4 weeks.

Table 1: Multivariate linear regression – predictors of pss scores

Predictor	β (95% CI)	p-value	VIF
Flood exposure	3.8 (3.2–4.4)	<0.001	1.2
Income (<$100/month)	1.5 (0.9–2.1)	0.002	1.4
Lack of emergency transport	2.1 (1.6–2.6)	<0.001	1.3
Water contamination	1.7 (1.2–2.2)	0.001	1.1
ANC visits (<4)	1.4 (0.8–2.0)	0.01	1.5
Food insecurity	2.3 (1.7–2.9)	<0.001	1.6
Mental health knowledge (Low)	1.2 (0.6–1.8)	0.03	1.3

Dependent variable: Perceived stress score

Table 2: Pregnancy-related stressors between flood-affected and non-flood-affected women

Item	Flood-affected (Mean ± SD)	Non-flood-affected (Mean ± SD)	p-value	Effect size (Cohen's d)
Felt overwhelmed by stress during pregnancy.	8.5 ± 1.2	4.3 ± 1.7	<0.001	2.8 (Large)
Worried about reaching a health facility in time for delivery.	9.1 ± 0.9	5.0 ± 1.8	<0.001	3.0 (Large)
Lost sleep due to financial concerns after floods.	7.8 ± 1.5	3.9 ± 1.6	<0.001	2.5 (Large)
Felt unsupported by healthcare providers during floods.	6.7 ± 1.8	3.2 ± 1.4	<0.001	2.2 (Large)
Fear of miscarriage/stillbirth due to flood conditions.	8.9 ± 1.1	4.1 ± 1.9	<0.001	3.1 (Large)
Anxiety about contaminated water/food affecting the baby.	9.3 ± 0.7	4.8 ± 1.7	<0.001	3.4 (Large)
Felt unprepared to cope with flood-related health risks.	7.4 ± 1.6	3.5 ± 1.5	<0.001	2.6 (Large)

Table 3: Healthcare access satisfaction

Item	Flood-affected (Mean ± SD)	Non-flood-affected (Mean ± SD)	p-value	Effect size (Cohen's d)
Could access ANC services when needed.	2.1 ± 1.0	8.3 ± 1.3	<0.001	5.3 (Large)
Emergency transport was available during floods.	1.5 ± 0.6	7.0 ± 1.7	<0.001	4.2 (Large)
Health staff were adequately trained for flood emergencies.	1.8 ± 0.8	6.5 ± 1.6	<0.001	3.7 (Large)
Medications/supplies were available post-flood.	2.3 ± 1.1	7.8 ± 1.4	<0.001	4.5 (Large)
Received clear instructions on flood-safe delivery practices.	1.9 ± 0.9	6.1 ± 1.8	<0.001	3.0 (Large)
Felt safe delivering at flood-affected clinics.	1.2 ± 0.4	5.9 ± 1.7	<0.001	3.6 (Large)
Postnatal care was accessible despite floods.	2.0 ± 1.2	7.2 ± 1.5	<0.001	4.0 (Large)

Table 4: Maternal health knowledge

Item	Flood-affected (Mean ± SD)	Non-flood-affected (Mean ± SD)	p-value	Effect size (Cohen's d)
Knew how to purify water during floods.	3.2 ± 1.5	7.5 ± 1.4	<0.001	3.0 (Large)
Understood signs of preterm labor.	4.1 ± 1.7	7.9 ± 1.2	<0.001	2.6 (Large)
Recognized symptoms of postpartum depression.	2.8 ± 1.3	6.3 ± 1.6	<0.001	2.4 (Large)
Knew where to seek emergency obstetric care.	3.5 ± 1.6	8.1 ± 1.3	<0.001	3.3 (Large)
Aware of flood-related infection risks (e.g., leptospirosis).	2.1 ± 1.0	5.8 ± 1.7	<0.001	2.7 (Large)
Understood the importance of iron/folic acid post-flood.	4.3 ± 1.8	7.7 ± 1.4	<0.001	2.2 (Large)
Knew how to access mental health support.	1.9 ± 0.8	4.2 ± 1.5	<0.001	1.9 (Large)

Our analysis found that nearly three-quarters of medical facilities in these high-vulnerability areas become non-functional during flood events. Adjacent regions classified as moderate- and high-risk, located within a 10-kilometer radius of primary water channels, experience periodic flooding that severely impairs road access to healthcare services. These geographical barriers directly contribute to the dramatic reduction in prenatal care utilization documented in our research. Furthermore, the spatial evaluation reveals that communities located beyond the immediate river floodplain, particularly those in low-risk areas (yellow), remain susceptible to secondary health threats. These include vector-borne illnesses associated with residual water accumulation, which create additional hazards for pregnant women in these locations. The 20-kilometer assessment range effectively captures both direct and indirect flood impacts across the study region.

Qualitative findings on maternal healthcare access and psychological well-being in disaster-affected settings

(Focus: Lived Experiences of Flood Impacts on Maternal Health)

This study explored the lived experiences of women navigating pregnancy and childbirth during environmental disasters, revealing three interconnected themes: (1) systemic barriers to healthcare access, (2) profound psychological distress, and (3) adaptive coping mechanisms.

Barriers to healthcare access

Women faced severe logistical and infrastructural challenges, exacerbating obstetric risks. Transport disruption emerged as a critical issue, with participants describing how floods or landslides rendered roads impassable, preventing ambulances from reaching remote villages. One respondent recounted, "The ambulance couldn't reach us; my husband carried me on a cot for 3 hours to the clinic" (IDI-01). Such delays are life-threatening in obstetric emergencies, aligning with global evidence that geographic inaccessibility increases maternal mortality in low-resource settings.[28] Additionally, the damage that occurred with healthcare facilities, including infrastructure, as well as the availability of the staff, further creates barriers for healthcare. Another respondent noted that, when we visited the delivery room during the flood, it was flooded. They asked us to stay away and couldn't provide the basic facilities" (IDI-03), underscoring the lack of disaster-resilient facilities. This mirrors findings from sub-Saharan Africa, where climate-related damage to clinics disrupts essential services like emergency deliveries and

neonatal care.[29] Such systemic catastrophes demonstrate the crucial importance of the urgent requirement for portable units regarding maternal health in flood-prone areas for better facilities.

Psychological distress

The intersection of disaster-induced deprivation and perinatal mental health emerged as a key concern. Women expressed terror over their infants' survival due to disrupted care, with one stating, "I kept thinking, what if the baby dies because I couldn't get medicine?" (IDI-02). Such narratives reflect the trauma of "deprivation guilt" observed in humanitarian crises, where mothers perceive themselves as failing to protect their children. Economic instability compounded this distress, particularly for agrarian communities. A participant lamented, "No crops, no money, how will I feed my child?" (IDI-06), illustrating how climate shocks amplify perinatal anxiety through livelihood loss. This aligns with studies linking food insecurity to postpartum depression in sub-Saharan Africa,[29] emphasizing the need for integrated mental health and economic support in maternal programs.

Coping mechanisms

In the absence of formal healthcare, women relied on informal networks. Traditional midwives (dais) often served as first responders, with one participant noting, "The dai came every day when doctors didn't" (IDI-05). While these networks provided vital immediate support, their limitations, such as inadequate emergency obstetric skills, raise ethical concerns about equity in crisis response. Similar findings in rural Uganda suggest that empowering community health workers with training and supplies could bridge gaps while formal systems are restored.[30]

(Focus: Systemic Challenges in Service Delivery During Floods)

This qualitative study, comprising two focus group discussions (FGDs) with eight health workers each, reveals critical systemic challenges in providing maternal healthcare during flood disasters in resource-constrained settings. The findings highlight three major themes: (1) severe resource scarcity, (2) erosion of community trust, and (3) critical training deficits in emergency preparedness.

Resource scarcity

Health workers reported severe shortages of essential medical supplies, forcing them to resort to risky ad hoc solutions. One participant stated, "No IV fluids or oxytocin, we used herbal concoctions for postpartum hemorrhage" (FGD-2), illustrating how the absence of life-saving medications compromises maternal survival. Such improvisations align with studies documenting increased maternal mortality in sub-Saharan Africa due to stockouts of uterotonics during emergencies.[31] Additionally, extreme staff shortages exacerbated ethical dilemmas, as captured in the quote, "One nurse for 50 deliveries, we prioritized who might survive" (FGD-1). This reflects the "triage paradox" in humanitarian crises, where overburdened providers must make impossible decisions, often leading to preventable deaths.

Community trust gaps

The floods exacerbated pre-existing distrust of health services, particularly antenatal care (ANC). Health workers noted, "Women believed vaccines caused infertility, so ANC dropped further" (FGD-2), demonstrating how disasters amplify misinformation. Similar trends have been observed in post-disaster settings in Nigeria[32] and Kenya 33, where rumors about vaccines and family planning persist due to weak community engagement. This underscores the need for culturally sensitive risk communication strategies to rebuild trust during crises.

Training deficits in emergency preparedness

A critical gap in disaster readiness was evident, with participants revealing, "We had no flood drills; everyone panicked when water entered" (FGD-2). The lack of institutional protocols mirrors findings from Malawi and Mozambique, where health facilities remain unprepared for climate-related disasters despite high flood risks.[34] Investing in simulation training and flood-resilient

infrastructure is essential to prevent service breakdowns.This qualitative study, based on 2 key informant interviews (KIIs) with doctors, reveals systemic failures in health infrastructure, data management, and disaster policymaking that critically undermine maternal and neonatal health outcomes during floods. The findings expose three fundamental gaps: (1) climate-vulnerable health infrastructure, (2) fragmented health information systems, and (3) short-term, reactive policy approaches that fail to address long-term resilience.

Infrastructure deficiencies: Flood-unsafe facilities

Doctors highlighted how poor urban planning and infrastructure design exacerbate health system fragility during disasters. One participant stated, "Our hospital is in a depression; every monsoon, the ICU floods" (KII-01), illustrating how geographic location and construction flaws render critical care units non-functional precisely when they are most needed. This aligns with research from flood-prone regions such as Nigeria and Bangladesh, where health facilities located in low-lying areas become inaccessible during heavy rains, necessitating emergency deliveries in unsafe conditions. Such infrastructure failures contravene WHO guidelines for climate-resilient health systems, which emphasize elevation, flood barriers, and backup power as essential for continuity of care.

Data fragmentation: Invisible mortality due to reporting flaws

A critical governance gap emerged in maternal and perinatal death surveillance. Doctors reported, "We don't track flood-related stillbirths, they're coded as 'normal' deaths" (KII-02), indicating how flawed data systems obscure the true mortality burden of disasters. This "statistical invisibility" of flood-attributable deaths has been documented in Malawi and Mozambique, where inadequate ICD coding prevents accurate risk assessment and resource allocation.[34] Without real-time surveillance, policymakers cannot identify hotspots or evaluate interventions, perpetuating cycles of preventable loss.

Policy paralysis: Short-termism in governance

Doctors criticized the reactive nature of disaster response, with one noting, "After floods, they send tents, not permanent clinics" (KII-01). This reflects a broader pattern across sub-Saharan Africa, in which post-disaster measures prioritize temporary relief over long-term infrastructure investment. Such approaches fail to address the root causes of vulnerability, leaving health systems perpetually unprepared for recurring climate shocks.

Discussion

The study highlights the severe impact of flooding on maternal health in rural Hyderabad, Pakistan, with parallels to challenges observed in flood-prone regions of Africa. In Hyderabad, flooding led to a 60% decline in antenatal care visits and a drop in cesarean section availability from 90% to 35%, accompanied by a near-tripling of neonatal mortality rates. Similar disruptions were documented in Mozambique, where floods caused 30% of health facilities to close, reducing skilled birth attendance by 50% and increasing maternal mortality by 40%.[35] In Nigeria, damaged infrastructure forced pregnant women to travel long distances, often resorting to unsafe deliveries.[36] Exposure to waterborne and vector-borne diseases in Hyderabad mirrored conditions in Ghana and Kenya, where cholera and malaria outbreaks post-flood were linked to adverse birth outcomes.[29] In Uganda, it was reported that the rise of malaria among pregnant women during floods was observed 35%, further contributing to the higher rate of low birth weight.[30] Nutritional deficiencies and psychological stress were prevalent in Hyderabad, as seen in Mozambique and Bangladesh, where crop destruction led to acute malnutrition in 40% of pregnant women,[37,] and in Malawi, where perinatal depression rates doubled post-flood.[38] Systemic gaps in disaster preparedness, such as inadequate staff training and fragmented data systems in Hyderabad, were echoed in Nigeria, where the lack of real-time surveillance obscured flood-related maternal deaths,[39] and in Kenya, where temporary clinics

failed to address long-term infrastructure needs.[40] These findings underscore the need for integrated interventions, including flood-resilient health infrastructure, community education, and proactive policies, drawing on lessons from Africa to mitigate maternal health risks in disaster-prone regions.

The Discussion section draws heavily on comparisons with African countries (e.g., Mozambique, Nigeria, Ghana, Kenya, Uganda, Malawi) but does not adequately contextualize the findings within South Asia or Pakistan. While global parallels are valuable, readers may expect more region-specific comparisons with neighboring countries sharing similar climatic, cultural, and health system contexts, such as India, Bangladesh, or Nepal, or with national studies from Pakistan. This would strengthen the relevance and applicability of the findings.

Limitations

This research acknowledges several constraints that may affect the interpretation of its findings. Furthermore, the large Cohen's d values reported (e.g., >3) reflect the extreme disparity in service access and knowledge between flood-affected and non-affected groups in a disaster setting. While these large magnitudes are plausible given the near-total collapse of services in affected areas, they should be interpreted within this specific catastrophic context. Effect sizes were calculated as $d = \frac{M1-M2}{SD\ pooled}$, where SD_{pooled} is the combined standard deviation of both groups.

The reliance on self-reported data introduces the possibility of recall bias, particularly for sensitive topics like stress levels and healthcare experiences. The sampling approach may not fully represent displaced populations, potentially skewing results. While the mixed-methods design provides robust insights, the observational nature of the study precludes definitive causal conclusions regarding the impacts of floods. Data collection in post-disaster settings encountered practical challenges, including potential gaps in health facility records resulting from flood damage. The focus on a single district, while providing depth, may limit direct applicability to other regions with different geographic or healthcare contexts. These limitations are partially mitigated by methodological triangulation and careful interpretation of results within the study's specific setting.

Conclusion and recommendations

The research highlights maternal health concerns associated with flooding in rural areas of the Hyderabad district, Pakistan. The findings reveal how hydrological disasters exacerbate existing healthcare inequities, creating cascading risks for pregnant women through service disruptions, environmental hazards, and psychological trauma. The documented collapse of essential obstetric care during floods represents both a public health emergency and a failure of disaster preparedness systems. The intersection of infrastructure fragility, knowledge gaps, and psychosocial stressors creates a perfect storm of risk for maternal and neonatal health. Traditional coping mechanisms, while valuable, cannot compensate for systemic failures in emergency response. These realities demand a fundamental rethinking of how maternal health services are designed and delivered in flood-prone regions. Moving forward, resilience must be built into every level of the maternal healthcare continuum, from flood-proof facilities to community-based early warning systems. The study calls for urgent investment in adaptive infrastructure, emergency training for health workers, and targeted education programs to empower at-risk women. Beyond immediate interventions, these findings highlight the need to mainstream climate adaptation into maternal health policy, recognizing flooding as a growing determinant of reproductive health outcomes in Pakistan and similar settings worldwide. Ultimately, protecting maternal health in an era of climate change requires transforming reactive crisis response into proactive, women-centered systems of care. This study provides the evidence base to guide that transformation while amplifying the voices of women whose experiences must shape future interventions.

Conflicts of Interest

Authors declare no conflicts of interest.

Contribution of authors

All authors contributed equally from writing the draft to final submission. S.B (writing Original draft, Questionnaires) G.J (Writing, reviewing and editing, Supervision, Funding) A.R.K (Data Collection, Data Analysis, Writing reviewing Editing) W.S (Methodology, Data Analysis). However, all the authors mentioned in the article approved the manuscript for submission in the Journal.

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