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Exploring the Association Between Floods and Diarrhea among Under-five Children in Rural India

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Abstract

Objective: Flood is one of the major public health concerns increasing the risk of childhood diarrhea. This study aims to explore the association of floods with diarrhea among under-five children in rural India.
Methods: A cross-sectional study was carried out using large-scale nationally representative data from the National Family Health Survey-5. The Central Water Commission reports between the years 2018 and 2020 were used to group all the districts as non-flood-affected districts or flood-affected districts. Bivariate and multivariate logistic regression models were employed to assess the association of floods with childhood diarrhea.
Results: The prevalence of diarrhea was higher among children exposed to three consecutive floods during the year 2019-21 than those children not exposed to flood. Children exposed to flood three times between the year 2018-19 to 2020-21 were associated with a 34% higher likelihood of developing diarrhea than those children exposed to flood one or two times.
Conclusions: Our study suggests that community health workers should target mothers belonging to the poor wealth quintile, young mothers, and mothers with young infants and more children to receive child health related counseling in flood-prone areas.

Natural catastrophes have a profound impact on the health of children, particularly in low and middle-income countries such as South and Southeast Asia.[1,2] Floods are one of the most common natural hazards in the world, posing a significant threat to the health of children.[3,4] It is predicted that the magnitude and frequency of floods will gradually increase in the future as a result of global warming.[5-7] By the end of this century, approximately 1.2% of the global population is expected to be affected by floods. [8] In India, about 23 million people were affected by floods in 2018.[9]

In addition to the financial loss and infrastructure and property damage, floods have wide-ranging negative impacts on various aspects of human well-being, including crop production, economic activities, livelihood, and mental health.[2] Furthermore, floods can contribute to the incidence of infectious diseases, including diarrhea, leptospirosis, and cholera.[4,10-13] The post-flood period may also lead to an increase in vector-borne diseases such as malaria, dengue, hemorrhagic fever, and West Nile Fever due to the proliferation of mosquitoes in stagnant water.[14-16] Bacterial causes of diarrhea are more common in the summer season, whereas viral diarrhea is more prevalent during the winter season.[17-20] In lower and middle income countries, infectious diseases remain a significant cause of death, and floods can pose a serious hazard to public health, with a substantial impact on childhood diarrhea.[21]

In India, the leading causes of mortality among children under the age of five remain a critical issue. Pneumonia, a respiratory infection (in 2015, there were an estimated 192,000 pneumonia deaths in children younger than 5 years), and diarrheal diseases, linked to inadequate clean water and sanitation, are significant contributors.[22,23] Malnutrition weakens children's immune systems, heightening susceptibility to various diseases, accounting for 68.2% of the total deaths among children below five years of age.[24] Preterm birth complications, occurring before 37 weeks of gestation, and childbirth-related issues like birth asphyxia and trauma, also contribute to health complications and under-five mortality.[25]

Diarrhea remains a significant public health challenge in low- and middle-income countries, contributing to increased morbidity and mortality rates among children.[22] It ranks as the second leading cause of illness and death among children under the age of five.[22] Each year, approximately 17 million children are affected by diarrhea, and an estimated 52,500 children die from the disease, with the majority of cases occurring in children under the age of two.[26] According to the World Health Organization (WHO), diarrheal disease is characterized by three or more loose or liquid stools per day. [27] It is primarily caused by waterborne bacteria, protozoa, and viruses. Poor sanitation, unhygienic food practices, and unfavorable environmental conditions further contribute to the burden of childhood diarrhea.[28] Various studies have indicated that socio-economic, demographic, environmental conditions and household characteristics play a significant role in the occurrence of childhood diarrhea.[29,30,31] Moreover, geographical factors have been found to influence the spatial distribution of diarrheal diseases, including factors such as geographical location, place of residence, and the rural-urban composition.[29,30,33-36] Sanitation facilities and hygiene conditions have a significant impact on childhood diarrhea, including factors such as the absence of toilet facilities, poor household conditions, improper child stool disposal, and lack of access to improved drinking water.[30] Additionally, behavioral factors such as breastfeeding practices, eating habits, food consumption patterns, and hand-washing practices are also closely associated with childhood diarrhea.[37-39] In lower-income countries, sanitation facilities, water quality, and the causative agents of diarrhea (such as bacteria and pathogens) differ from those in higher-income countries, leading to poor health outcomes following floods, including cholera, rotavirus diarrhea, cryptosporidiosis, and non-specific diarrhea. [40-45] A rigorous study conducted in Bangladesh revealed that a flood-induced diarrheal epidemic was primarily driven by cholera.[46] Furthermore, climatic and weather variations also play a significant role in influencing the occurrence of childhood diarrhea. The seasonal variation of climatic events can have a direct impact on the prevalence and incidence childhood diarrhea, which remains a major concern for the overall well-being of children.[45, 47] While many studies have focused on micro-level or regional perspectives, there is a limited amount of large-scale research on flood and childhood diarrhea in rural India. Therefore, this study sought to explore the association of floods with diarrhea among under-five children in rural India. This study aims to contribute to the scarce existing evidence on the association between childhood diarrhea and flood exposure in rural India.

Methods

Data Source

The study utilized data from the latest round of the National Family Health Survey (NFHS-5), conducted in 2019-21. The NFHS-5 is a nationally representative large-scale sample survey that collected data from 636,699 households, 724,115 ever-married women aged 15-49 years, and 101,839 men aged 15-54 years. The survey was carried out across all 28 states and 8 union territories in the country. A stratified two-stage sampling design was used for the selection of samples. The purpose of this survey was to gather updated and reliable information on a wide range of population and health indicators such as maternal and child health, fertility, childhood morbidity and mortality, family planning, immunization services, nutritional status of women and children, family planning, non-communicable diseases, disability, access to a toilet facility, etc. up to the district level. A detailed description of the sampling design and procedures of the survey is provided in the national report NFHS-5.[48]

Study Design

To assess the relationship between childhood diarrhea and floods, a cross-sectional study design was employed using data from the fifth round of the National Family Health Survey (NFHS-5) data. The study focused on children under the age of five residing in rural areas, with a total of 178,334 children whose information were collected in the NFHS-5 survey. These children were included as study subjects to explore the association between childhood diarrhea and flood occurrences.

Outcome variable

The outcome variable of this study is diarrheal disease among children under five years of age. Diarrhea is defined as having three or more loose or watery stools in 24 hours as reported by the mother or caregiver of the children in the last two weeks of the survey.[29] In the NFHS survey, data on children's experiences with diarrhea were gathered by interviewing mothers of children under the age of five in the selected households. Mothers were asked whether her child/children had suffered from diarrheal diseases in the last two weeks preceding the survey, and their responses were recorded as '0' for 'no' and '1' for 'yes.'

Predictor variable

In this study, non-flood-affected areas and flood-affected areas were considered as the explanatory variable. At first, we categorized the districts into flood and non-flood-affected districts using the Central Water Commission annual reports of 2018-19, 2019-20, and 2020-21. This study included only those districts severely affected by floods. Those districts affected by floods for three consecutive years (2018-20) were termed as “three times affected” and if a flood occurred one or two times between the years 2018 and 2020, they were assigned as “one and two times”. To conduct this study, only participants residing in rural areas were included. Of the total, 39 districts were included in the flood-affected area and 659 districts were included in the non-flood-affected area.

Confounders

Apart from the main predictor variable, several socio-demographic and environmental characteristics of households were incorporated into the analysis as confounding factors that could significantly influence the prevalence of childhood diarrhea. The selected variables included the age of the children (0-11, 12-23, 24-35, 36-47, 48-59 months), sex of child (male and female), birth order (1, 2-3, and 4+), birth weight (< 2.5 kg [low birth weight] and ≥ 2.5 kg [normal]), maternal age (15-24, 25-34, and 35-49 years), maternal education (no education, primary, secondary, and higher), caste (Scheduled Castes [SC], Scheduled Tribes [ST], Other Backward Classes [OBC], and none of them [forward caste]), religion (Hindu, Muslim, and other religions), household size (0-4, 5-6, and 6+), wealth quintile (poorest, poorer, middle, richer, and richest), the availability of toilet facility (no/yes), type of house (*kutcha* and *pucca*), child stool disposal (not safe and safe), sources of drinking water (unimproved and improved), and perceived distance to the health facility (no problem, not a big problem, and big problem).

The caste system in India is a hierarchical social structure traditionally based on the division of labor and hereditary occupations, with individuals categorized into distinct groups known as castes. Despite efforts to address economic and social deprivation, the caste system has persisted, influencing social interactions and opportunities for individuals within the Indian society. According to the 2011 census, about 16.6% of India's population belongs to the Scheduled Castes (SCs), often residing in rural areas and working as landless agricultural laborers. Another marginalized group, the Scheduled Tribes (STs) or Adivasis, makes up around 8.6% of the population, having faced historical discrimination. In contrast,

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Other Backward Classes (OBCs) and general castes together make up 71% of India's total population.[49] It is important to mention that the wealth quintile is used as a proxy measure of standard of living which is calculated using the household's ownership of selected assets (e.g., television, bicycle, types of access to water and sanitation facilities, etc.). Likewise, we grouped the type of house into two categories i.e., houses made from mud, thatch, sand, dung, or other low-quality materials are termed as *kutcha* houses, and houses made with bricks, cement, wood, or high-quality materials throughout, including floor, roof, and exterior walls, are termed as *pucca* houses. Availability of toilet facilities was dichotomized into two groups "yes" (improved, unimproved, and shared latrine facility) and "no" (households using open defecation). The children's stools were considered to be disposed of safely if the child used a toilet or latrine, or rinsed into a toilet or latrine, or the stools were buried. Sources of drinking water were classified as improved and unimproved sources. Improved sources of drinking water comprised piped water, public taps, standpipes, tube wells, boreholes, protected dug wells and springs, rainwater, tanker truck, cart with a small tanks, bottled water, and community reverse osmosis (RO) plants, whereas unimproved sources of drinking water included unprotected dug well, unprotected spring, tanker/cart with a small tank, and surface water. The perceived distance to health facility was assessed by asking women regarding the difficulty they faced in travelling a certain distance to the health facility when they were sick and seeking medical advice or treatment.

Data Analysis

Descriptive statistical analyses were carried out to describe the distribution of study subjects. To assess the prevalence of the diarrheal disease among children, bivariate percentage distribution was estimated using selected predictors and confounding variables. Pearson's chi-square statistic was later tested and variables with $P < 0.05$ were considered statistically significant. Bivariate and multivariate logistic regression models were employed to examine the associations between exposure to flood and diarrhea among children. The regression results were presented by unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) and the results were considered to be statistically significant at $P < 0.05$. All statistical analyses were performed using STATA version 16.0 (StataCorp LP, College Station, TX, USA).

Ethics Declarations

This study used secondary data drawn from the National Family Health Survey 2019-21, which is available in the public domain. The ethical approval for NFHS-5 (2019–21) was obtained from the International Institute for Population Sciences (IIPS) in Mumbai. Furthermore, the ICF International Review Board (IRB) conducted a review of the survey and granted ethical approval. The datasets are publicly available with no identifiable information about the survey participants and the datasets are freely available from the Demographic Health Survey (DHS) program at https://dhsprogram.com/data/. Therefore, no separate ethical approval was required for conducting this study.

Results

A total of 177,978 samples from children under the age of five were included in the analysis. In non-flood affected areas, of the total number of children, 9,690 were reported to have experienced diarrhea. In regions affected by floods once or twice, 1,335 children were found to have suffered from diarrhea. Additionally, in areas affected by floods three times, 1,472 children were reported to have experienced diarrhea. These findings are summarized in Table 1, which outlines the characteristics of the study sample.

Prevalence of Diarrheal Disease by Background Characteristics of Under-five Children in India

The occurrence of diarrhea was higher in children aged 12-23 months (9.78%), 0-11 months (9.6%), and male children (7.27%). A significantly higher proportion of diarrheal diseases were found among children affiliated to the Muslim religion (7.25%). The prevalence of diarrheal diseases was substantially higher among children with low birth weight (8.09 %) and birth order above three (7.45 %). Furthermore, the prevalence of diarrheal diseases was higher among children of mothers aged 15-24 years (8.47%) than those children of mothers aged 35-49 years (6.02%). Mother's education was found to be significantly correlated with the occurrence of diarrhea among children. Childhood diarrhea was comparatively higher among those participants whose mothers had the primary level of education (7.63 %) as compared to those mothers who had a higher level of education (6.01%). Similarly, the occurrence of diarrheal diseases in children decreases from the poorest to the richest wealth quintile. The proportion of children experiencing diarrheal diseases were found to be significantly higher in children living in households without a toilet facility (8.02%) compared to those whose households had a toilet facility. The occurrences of diarrheal diseases were higher when the stool was not disposed of safely (7.25%). The prevalence of diarrhea is higher among the children living in *kutcha* house (7.31%) as compared to those living in *pucca* house (6.46%).

Table 2 also presents the association of under-five children experiencing diarrhea with the background characteristics across "non-flood affected area", "one and two times flood affected area," and "three times flood affected area." The results show that except caste and sources of drinking water of children, other variables were significantly associated with childhood diarrhea. Birth weight, household size, and child stool disposal were found to be significantly associated with diarrhea in the non-flood affected area and one and two times flood affected area but not significantly associated with under-five children experiencing diarrhea in the three times flood affected area.

Figure 1 depicts the close correlation between the flood occurrence patterns and the prevalence of diarrhea among under-five children. The distribution of flood occurrences in India reveals that regions experiencing one to two instances and three instances of flooding are concentrated in the Ganga and Brahmaputra River basins, primarily across northern districts of Bihar, some parts of West Bengal, and select areas of Assam. Coastal districts of Orissa have also reported occurrences of one to two floods (Figure 1A). Furthermore, regions experiencing a heightened frequency of severe flooding exceeding two instances in the past three years align with high prevalence rates of childhood diarrhea (Figure 1B). Thus, it is evident that floods are directly associated with an increased prevalence of childhood diarrhea.

Association Between Recurrent Floods on Diarrheal Diseases among Under-five Children in Flood-prone Areas

Table 3 illustrates the results of crude and adjusted logistic regression models for assessing the impact of floods on childhood diarrhea. The crude logistic regression model revealed that children

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Table 1. Background characteristics of living children aged 0-59 months in rural India, NFHS-5 (2019-21)

Variables	Non-flood affected area		One and two times flood affected		Three times flood affected		Total	
	Diarrhea= No (n=138,873)	Diarrhea= Yes (n=9,690)	Diarrhea= No (n=14,518)	Diarrhea= Yes (n= 1,335)	Diarrhea= No (n=12,090)	Diarrhea= Yes (n=1,472)	Diarrhea= No (n=165,481)	Diarrhea= Yes (n= 12,497)
Age of child in months								
0–11	27,374 (19.71)	2,747 (28.35)	2,853 (19.65)	357 (26.74)	2,417 (19.99)	362 (24.59)	32,644 (19.73)	3,466 (27.73)
12–23	26,170 (18.84)	2,619 (27.03)	2,731 (18.81)	350 (26.22)	2,217 (18.34)	403 (27.38)	31,118 (18.80)	3,372 (26.98)
24–35	27,415 (19.74)	1,682 (17.36)	2,895 (19.94)	254 (19.03)	2,420 (20.02)	282 (19.16)	32,730 (19.78)	2,218 (17.75)
36–47	28,117 (20.25)	1,431 (14.77)	2,879 (19.83)	194 (14.53)	2,510 (20.76)	214 (14.54)	33,506 (20.25)	1,839 (14.72)
48–59	29,797 (21.46)	1,211 (12.5)	3,160 (21.77)	180 (13.48)	2,526 (20.89)	211 (14.33)	35,483 (21.44)	1,602 (12.82)
Sex of child								
Male	71,544 (51.52)	5,148 (53.13)	7,470 (51.45)	742 (55.58)	6,184 (51.15)	793 (53.87)	85,198 (51.49)	6,683 (53.48)
Female	67,329 (48.48)	4,542 (46.87)	7,048 (48.55)	593 (44.42)	5,906 (48.85)	679 (46.13)	80,283 (48.51)	5,814 (46.52)
Birth order								
1	52,138 (37.54)	3,655 (37.72)	5,134 (35.36)	443 (33.18)	4,302 (35.58)	471 (32.00)	61,574 (37.21)	4,569 (36.56)
2–3	67,643 (48.71)	4,725 (48.76)	7,067 (48.68)	621 (46.52)	5,705 (47.19)	690 (46.88)	80 ,415 (48.59)	6,036 (48.30)
4+	19,092 (13.75)	1,310 (13.52)	2,317 (15.96)	271 (20.30)	2,083 (17.23)	311 (21.13)	23,492 (14.2)	1,892 (15.14)
Birth weight								
Low birth weight	21,175 (15,25)	1,755 (18.11)	2,099 (14.46)	230 (17.23)	1,718 (14.21)	215 (14.61)	24,992 (15.10)	2,200 (17.60)
Normal	117,698 (84.75)	7,935 (81.89)	12,419 (85.54)	1,105 (82.77)	10,372 (85.79)	1,257 (85.39)	140,489 (84.90)	10,297 (82.40)
Maternal age in years								
15–24	44,179 (31.81)	3,793 (39.14)	4,398 (30.29)	491 (39.78)	4,260 (35.24)	604 (41.03)	52,837 (31.93)	4,888 (39.11)
25–34	81,456 (58.66)	5,122 (52.86)	8,770 (60.41)	721 (54.01)	6,611 (54.68)	754 (51.22)	96,837 (58.52)	6,597 (52.79)
35–49	13,238 (9.53)	775 (8.00)	1,350 (9.30)	123 (9.21)	1,219 (10.08)	114 (7.74)	15,807 (9.55)	1,012 (8.10)
Level of mother education								
No education	32,213 (23.20)	2,053 (21.19)	4,112 (28.32)	410 (30.71)	3,986 (32.97)	541 (36.75)	40,311 (24.36)	3,004 (24.04)
Primary	19,018 (13.69)	1,457 (15.04)	1,939 (13.36)	197 (14.76)	1,705 (14.10)	219 (14.88)	22,662 (13.69)	1,873 (14.99)
Secondary	72,774 (52.40)	5,265 (54.33)	6,678 (46.00)	612 (45.84)	5,627 (46.54)	629 (42.73)	85,079 (51.41)	6,506 (52.06)
Higher	14,868 (10.71)	915 (9.44)	1,789 (12.32)	116 (8.69)	772 (6.39)	83 (5.64)	17,429 (10.53)	1,114 (8.91)
Caste								
Scheduled Castes	28,290 (21.12)	2,049 (21.85)	3,549 (25.37)	324 (24.83)	2,454 (24.65)	316 (24.14)	34,293 (21.72)	2,689 (22.42)
Scheduled Tribes	35,083 (26.19)	2,509 (26.75)	1,390 (9.93)	129 (9.89)	1,069 (10.74)	133 (10.16)	37,542 (23.78)	2,771 (23.11)
Other Backward Classes	50,614 (37.79)	3,445 (36.73)	6,691 (47.82)	610 (46.74)	4,723 (47.43)	651(49.73)	62,028 (39.29)	4,706 (39.24)
Others	19,956 (14.90)	1,375 (14.66)	2,361 (16.88)	242 (18.54)	1,711 (17.18)	209 (15.97)	24,028 (15.22)	1,826 (15.23)
Religion								
Hindu	103,304 (74.39)	7,304 (75.38)	11,669 (80.38)	1,038 (77.75)	8,049 (66.58)	1,071 (72.76)	123,022 (74.34)	9,413 (75.32)
Muslim	15,015 (10.81)	997 (10.29)	2,535 (17.46)	285 (21.35)	3,641 (30.12)	374 (25.41)	21,191 (12.81)	1,656 (13.25)
Other	20,554 (14.80)	1,389 (14.33)	314 (2.16)	12 (0.90)	400 (3.31)	27 (1.83)	21,268 (12.85)	1,428 (11.43)
Household size								
1–3	9,901 (7.13)	834 (8.61)	984 (6.78)	128 (9.59)	1,071 (8.86)	145 (9.85)	11,956 (7.22)	1,107 (8.86)
4–5	76,925 (55.39)	5,263 (54.31)	7,787 (53.64)	756 (56.63)	6,824 (56.44)	835 (56.73)	91,536 (55.32)	6,854 (54.85)
>6	52,047 (37.48)	3,593 (37.08)	5,747 (39.59)	451 (33.78)	4,195 (34.70)	492 (33.42)	61,989 (37.46)	4,536 (36.3)

(*Continued*)

Table 1. (*Continued*)

Variables	Non-flood affected area		One and two times flood affected		Three times flood affected		Total	
	Diarrhea= No (n=138,873)	Diarrhea= Yes (n=9,690)	Diarrhea= No (n=14,518)	Diarrhea= Yes (n= 1,335)	Diarrhea= No (n=12,090)	Diarrhea= Yes (n=1,472)	Diarrhea= No (n=165,481)	Diarrhea= Yes (n= 12,497)
Wealth quintile								
Poorest	42,483 (30.59)	3,085 (31.84)	5,069 (34.92)	563 (42.17)	5,958 (49.28)	833 (56.59)	53,510 (32.34)	4,481 (35.86)
Poorer	36,736 (26.45)	2,696 (27.82)	3,990 (27.48)	362 (27.12)	3,620 (29.94)	405 (27.51)	44,346 (26.80)	3,463 (27.71)
Middle	28,493 (20.52)	1,997 (20.61)	2,742 (18.89)	234 (17.53)	1,572 (13.00)	150 (10.19)	32,807 (19.83)	2,381 (19.05)
Richer	20,247 (14.58)	1,344 (13.87)	1,799 (12.39)	128 (9.59)	717 (5.93)	62 (4.21)	22,763 (13.76)	1,534 (12.27)
Richest	10,914 (7.86)	568 (5.86)	918 (6.32)	48 (3.60)	223 (1.84)	22 (1.49)	12,055 (7.28)	638 (5.11)
Type of house								
Kutcha	80,880 (61.51)	5,752 (62.98)	8,579 (63.20)	881 (70.26)	8,657 (75.57)	1,107 (79.70)	98,116 (62.68)	7,740 (65.73)
Pucca	50,617 (38.49)	3,381 (37.02)	4,995 (36.80)	373 (29.74)	2,799 (24.43)	282 (20.30)	58,411 (37.32)	4,036 (34.27)
Availability of toilet facility								
No	32,727 (24.75)	2,547 (27.71)	4,155 (30.54)	428 (34.02)	3,145 (27.28)	516 (37.02)	40,027 (25.43)	3,491 (29.48)
Yes	99,517 (75.25)	6,644 (72.29)	9,452 (69.46)	830 (65.98)	8,382 (72.72)	878 (62.98)	117,351 (74.57)	8,352 (70.52)
Sources of drinking water								
Unimproved	10,803 (8.63)	779 (8.95)	475 (3.56)	39 (3.18)	951 (8.37)	63 (4.60)	12,229 (8.15)	881 (7.79)
Improved	114,448 (91.37)	7,926 (91.05)	12,885 (96.44)	1,189 (96.82)	10.408 (91.63)	1308 (95.40)	137,741 (91.85)	10,423 (92.21)
Child stool disposal								
Not safe	50,801 (65.64)	4,228 (68.08)	5,764 (69.01)	609 (73.11)	5,394 (79.80)	745 (80.45)	61,959 (66.98)	5,582 (70.05)
Safe	26,588 (34.36)	1,982 (31.92)	2,589 (30.99)	224 (26.89)	1,365 (20.20)	181 (19.55)	30,542 (33.02)	2,387 (29.95)
Distance to health facility								
No problem	44,481 (32.03)	2859 (29.50)	5,325 (36.68)	448 (33.56)	3,334 (27.58)	354 (24.05)	53,140 (32.11)	3,661 (29.30)
Not a big problem	51,227 (36.89)	3,370 (34.78)	5,117 (35.25)	472 (35.36)	4,849 (40.11)	602 (40.90)	61,193 (36.98)	4,444 (35.56)
Big Problem	43,165 (31.08)	3,461 (35.72)	4,076 (28.08)	415 (31.09)	3,907 (32.32)	516 (35.05)	51,148 (30.91)	4,392 (35.14)

exposed to flood three times between the years 2018-19 to 2020-21 were associated with a 32% higher likelihood of experiencing diarrhea among children (COR: 1.32, 95% CI: 1.22-1.43) than those children exposed to flood one or two times.

In the adjusted analyses we found that children exposed to flood three times between the years 2018-19 to 2020-21 were associated with a 34% higher likelihood of developing diarrhea among children (AOR: 1.34, 95% CI: 1.20-1.50) than those children exposed to flood one or two times. The present study identified several sociodemographic characteristics of households significantly associated with diarrhea. It is observed that the children aged 12-23 months (AOR: 1.09, 95% CI: 0.97-1.23) had a higher likelihood of experiencing diarrhea as compared to children aged 0-11 months. However, children aged 24-35 months (AOR: 0.64, 95% CI: 0.51-0.79), 36-47 months (AOR: 0.38, 95% CI: 0.30-0.48), and 48-59 months (AOR: 0.36, 95% CI: 0.28-0.46) were less likely to experience diarrhea compared to children aged 0-11 months. Female children had a lower risk of the experiencing diarrhea compared to male children (AOR: 0.89, 95% CI: 0.80-1.00). Children suffering from diarrhea were more common among those in fourth or higher birth order (AOR: 1.31, CI: 1.07-1.60) compared to first-born children. Additionally, children with a normal birth weight had a slightly lower risk of diarrhea compared to those with a low birth weight (AOR: 0.86, 95% CI: 0.74-0.99). The likelihood of childhood diarrhea decreases with an increase in maternal age. Children of mothers aged 35-49 years were associated with a 36% decreased odds of diarrhea (AOR: 0.64, 95% CI: 0.49-0.85) compared to those whose mothers were aged 15-24 years. Children belonging to religions other than Hindu and Muslim (AOR: 0.41, 95% CI: 0.25-0.67) were less likely to experience diarrhea as compared to Hindu children. Household size was found to be significantly associated with childhood diarrhea, with a lower likelihood among children in houses with more than five persons (AOR: 0.77, 95% CI: 0.62-0.95) than those with 1-3 household members. The results revealed that the odds of experiencing diarrhea among children in the richer wealth quintile decreased by 26% (AOR: 0.74, 95% CI: 0.56-0.98) compared to those in the poorest wealth quintile. Surprisingly, there was an increased likelihood of childhood diarrhea observed among children with an improved source of drinking water (AOR: 1.58, 95% CI:.16-2.15).

Discussion

It is the first study conducted in India that examines the association between flood and diarrhea among under-five children and flood using a large-scale representative dataset. The study findings reveal

Table 2. Prevalence of diarrhea among under-five children by background characteristics of respondents in rural India, NFHS-5 (2019-21)

Variables	Non-flood affected area (n=148,563) Prevalence (%)	P-value	One and two times flood affected area (n= 15,853) Prevalence (%)	P-value	Three times flood affected area (n=13,562) Prevalence (%)	P-value	Total (n=177,978) Prevalence (%)	P-value
Age of child in months								
0–11	9.12	<0.001	11.12	< 0.001	13.03	< 0.001	9.60	<0.001
12–23	9.1		11.36		15.38		9.78	
24–35	5.78		8.07		10.44		6.35	
36–47	4.84		6.31		7.86		5.20	
48–59	3.91		5.39		7.71		4.32	
Sex of child								
Male	6.71	0.002	9.04	0.004	11.37	0.048	7.27	<0.001
Female	6.32		7.76		10.31		6.75	
Birth order								
1	6.55	0.809	7.94	<0.001	9.87	< 0.001	6.91	0.012
2–3	6.53		8.08		10.79		6.98	
4+	6.42		10.47		12.99		7.45	
Birth weight								
Low birth weight	7.65	< 0.001	9.88	0.006	11.12	0.682	8.09	<0.001
Normal	6.32		8.17		10.81		6.83	
Maternal age in years								
15–24	7.91	<0.001	10.04	<0.001	12.42	<0.001	8.47	<0.001
25–34	5.92		7.6		10.24		6.38	
35–49	5.53		8.35		8.55		6.02	
Level of mother education								
No education	5.99	<0.001	9.07	0.001	11.95	0.009	6.94	<0.001
Primary	7.12		9.22		11.38		7.63	
Secondary	6.75		8.4		10.05		7.1	
Higher	5.8		6.09		9.71		6.01	
Caste								
Scheduled Castes	6.75	0.104	8.37	0.496	11.41	0.429	7.27	0.199
Scheduled Tribes	6.67		8.49		11.06		6.87	
Other Backward Classes	6.37		8.36		12.11		7.05	
Others	6.45		9.3		10.89		7.06	
Religion								
Hindu	6.6	0.090	8.17	<0.001	11.74	<0.001	7.11	< 0.001
Muslim	6.23		10.11		9.32		7.25	
Other	6.33		3.68		6.32		6.29	
Household size								
1–3	7.77	< 0.001	11.51	< 0.001	11.92	0.354	8.47	< 0.001
4–5	6.4		8.85		10.9		6.97	
>6	6.46		7.28		10.5		6.82	

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Table 2. (*Continued*)

Variables	Non-flood affected area (n=148,563)		One and two times flood affected area (n= 15,853)		Three times flood affected area (n=13,562)		Total (n=177,978)	
	Prevalence (%)	P-value	Prevalence (%)	P-value	Prevalence (%)	P-value	Prevalence (%)	P-value
Wealth quintile								
Poorest	6.77	< 0.001	10	< 0.001	12.27	< 0.001	7.73	<0.001
Poorer	6.84		8.32		10.06		7.24	
Middle	6.55		7.86		8.71		6.77	
Richer	6.22		6.64		7.96		6.31	
Richest	4.95		4.97		8.98		5.03	
Type of house								
Kutcha	6.64	0.005	9.31	<0.001	11.34	<0.001	7.31	< 0.001
Pucca	6.26		6.95		9.15		6.46	
Availability of toilet facility								
No	7.22	<0.001	9.34	0.010	14.09	< 0.001	8.02	< 0.001
Yes	6.26		8.07		9.48		6.64	
Sources of drinking water								
Unimproved	6.73	0.299	7.59	0.490	6.21	< 0.001	6.72	0.176
Improved	6.48		8.45		11.16		7.03	
Child stool disposal								
Not safe	7.68	< 0.001	9.56	0.014	12.14	0.644	8.26	< 0.001
Safe	6.94		7.96		11.71		7.25	
Distance to health facility								
No problem	6.04	< 0.001	7.76	0.028	9.6	0.010	6.45	< 0.001
Not a big problem	6.17		8.45		11.04		6.77	
Big Problem	7.42		9.24		11.67		7.91	

Notes: P value: significance level of Pearson's chi-square statistic.

that the prevalence of diarrhea was significantly higher (10.85 %) among children who were exposed to three consecutive floods during the period of 2019-21 than among children who were not affected by floods. This finding is in line with a previous study conducted in Uttar Pradesh, which also reported a high prevalence of diarrhea among children exposed to floods.[32,45] This could be because floods create favorable environmental conditions that facilitate the proliferation of various pathogens, which can then be transmitted through contaminated food or water sources. Moreover, the damage inflicted upon sewage systems during flooding events can contribute to the spread of diarrheal diseases after sewage water mixes with floodwater and spills onto the ground surface.[50]

The results of the study reveal that children who are exposed to floods for three consecutive years have a higher likelihood of developing diarrhea compared to children who experience floods one or two times. This result is consistent with a study conducted in China.[50] Furthermore, the present study identifies several socio-demographic characteristics of households that are significantly associated with childhood diarrhea in addition to flood exposure. The risk of childhood diarrhea reduces with increasing age of the children. This finding is in line with other studies conducted in Uganda and Ethiopia.[51-54] This trend may be attributed to the fact that children in this age range begin to crawl and walk, exposing themselves to a wider range of environmental factors such as dirt or contaminated objects that they may put in their mouths, leading to an increased risk of diarrheal illnesses.[55] Another plausible reason could be that breastfeeding and complementary feeding practices for children were adversely affected during flooding.[56] Consequently, inadequate breastfeeding coupled with the provision of poor complementary feeding practices, whether in the form of cooked meals prepared with contaminated water or packaged food that is difficult for children to digest, may contribute to an increased likelihood of childhood diarrhea.[57] The study highlighted that female children were less likely to experience diarrhea compared to male children. This finding is in line with other studies.[58-60] The higher likelihood of diarrhea among young males compared to young females might be attributed to the tendency of young males to wander in unhygienic environments as opposed to their female counterparts. This tendency is particularly pronounced during periods of flood-induced damage to water supply and sewage systems, leading to compromised hygiene standards and poor

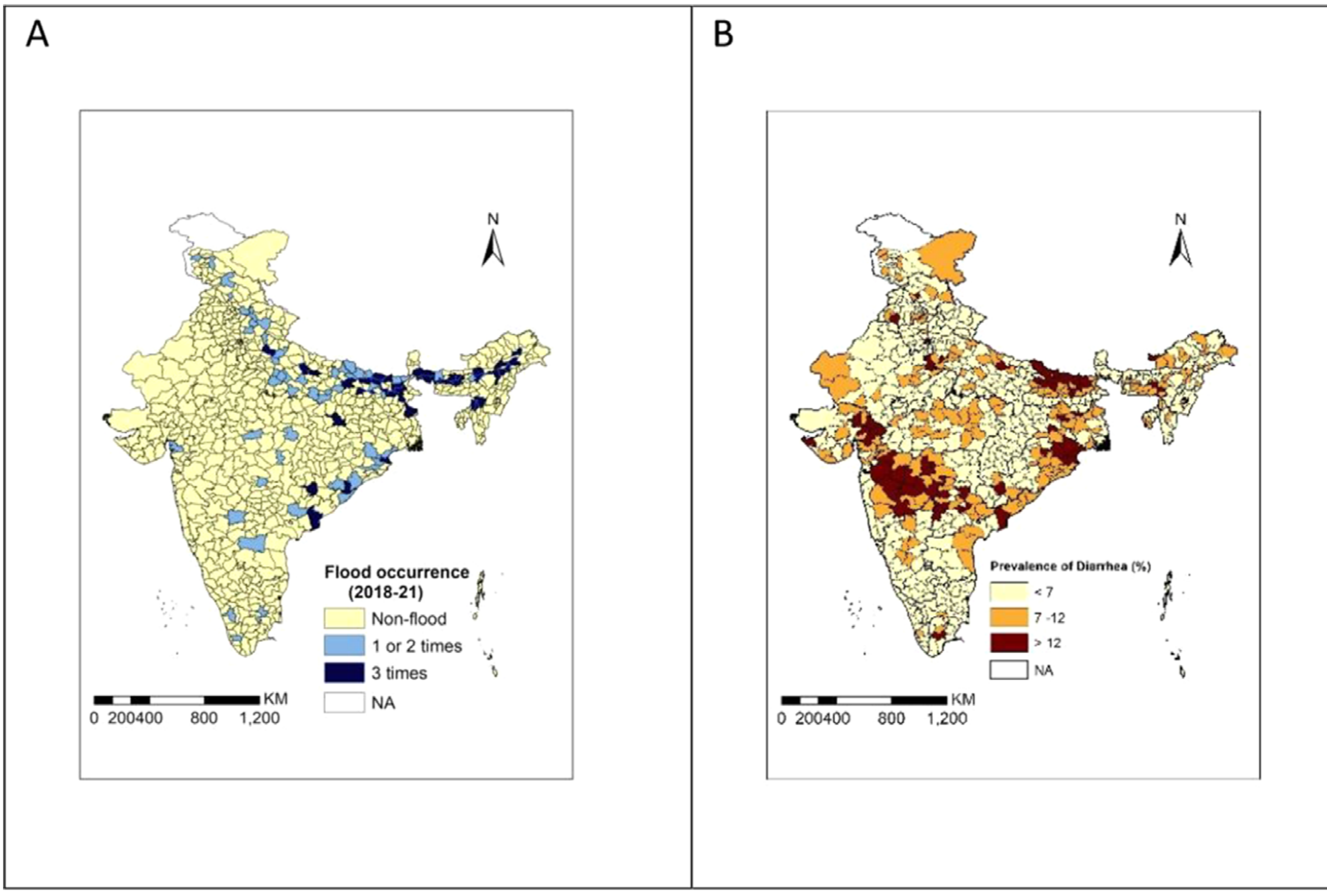

Figure 1 Spatial distribution of flood occurrence from 2018-21 (A) and prevalence of diarrhea among under five children from 2019-21 in rural India (B).

sanitation, thereby exacerbating the risk of diarrhea among males.[61] Additionally, children born with a normal birth weight exhibited a slightly reduced risk of diarrhea when compared to those with a low birth weight. The study is consistent with previous studies conducted in India and Brazil.[29,62] Moreover, the results indicate that children in the birth order of three or higher have a higher risk of developing diarrhea compared to those with birth orders below three. The odds of having diarrhea were 31% higher in children with a fourth or higher birth order. This finding is congruent with a study conducted in Ethiopia.[63] It suggests that the mothers' ability to pay attention and care for a larger number of children may be compromised, resulting in a potential risk of increased exposure to germs and infections, making these children more susceptible to diarrhea.[52,64] In consistent with previous studies conducted in Indonesia and Sub-Saharan Africa, the present study identified that children with relatively young mothers had a higher likelihood of experiencing diarrhea compared to older mothers.[65-68] It might be due to young mothers lacking skills and experience in childcare practices, unhygienic food practices, and poor knowledge of diarrheal disease transmission.[66] This finding of the current study is similar to studies conducted in Malawi, Bangladesh, and Ethiopia.[67,69,70] The result of this study finding demonstrated that children belonging to other religious communities were less likely to experience diarrhea as compared to Hindu children. However, a study by Joshi et al. (2011) conducted in a flood-affected area of Uttar Pradesh, India, found no significant association between diarrhea and religion.[32] The size of the household was also found to be a significant factor associated with childhood diarrhea. These results are consistent with studies conducted in Bangladesh and Ethiopia that have emphasized that households with fewer individuals face a notably higher risk of childhood diarrhea compared to those with six or more members.[61,71] One possible reason could be the larger size of households, which may include grandparents. Grandparents are often considered a source of knowledge and advice for parents of children, such as advising mothers to continue breastfeeding during diarrhea episodes and suggesting giving children plenty of fluids when they have diarrhea.[72] This study also revealed that under-five children from the middle wealth quintile had a lower chance of developing diarrhea compared to children from the poorest wealth quintile. The findings of the present study also confirmed the results found in different contexts.[73-75] It is a well-known fact that increasing household incomes are associated with decreased under-five mortality as well as a decrease in number of children. The improvement of socio-economic situation of the vulnerable population is the ultimate preventative measures in many communities. Repeating floods may deteriorate the household income and will increase the difficulties of accessing healthcare.[76] Another possible explanation is that access to basic water and sanitation services is intrinsically linked with household income. Thus, children in the poorest quintile are more prone to utilize unsafe water sources and have poor sanitation practices, making them more vulnerable to diseases like diarrhea. Nonetheless, numerous studies have emphasized that the intensity of floods can independently act as a risk factor, leading to an increased prevalence of diarrhea regardless of the presence of improved sanitation facilities.[21,77] The findings of this study align with this

Table 3. Bivariate and multivariate logistic regression analysis assessing the association between flood and diarrhea among under-five children in rural India, NFHS-5 (2019-21)

Variables	Crude OR	95% CI		Adjusted OR	95% CI	
Exposure to flood						
1 and 2 times affected (ref.)						
3 times affected	1.32**	1.22	1.43	1.34**	1.20	1.50
Age of child in months						
0–11 (ref.)						
12–23	1.12**	1.00	1.24	1.09**	0.97	1.23
24–35	0.74**	0.66	0.83	0.64**	0.51	0.79
36–47	0.55**	0.49	0.63	0.38**	0.30	0.48
48–59	0.50**	0.44	0.57	0.36**	0.28	0.46
Sex of child						
Male (ref.)						
Female	0.87**	0.81	0.94	0.89*	0.80	1.00
Birth order						
1 (ref.)						
2–3	1.06	0.97	1.16	0.96	0.84	1.10
4+	1.37**	1.22	1.52	1.31**	1.07	1.60
Birth weight						
Low birth weight (ref.)						
Normal	0.89*	0.8	0.99	0.86*	0.74	0.99
Maternal age in years						
15–24 (ref.)						
25–34	0.76**	0.70	0.82	0.79**	0.69	0.90
35–49	0.73**	0.63	0.85	0.64**	0.49	0.85
Level of mother education						
No education (ref.)						
Primary	0.97	0.86	1.1	0.99	0.83	1.18
Secondary	0.86**	0.79	0.94	1.02	0.89	1.18
Higher	0.66**	0.56	0.78	0.93	0.72	1.2
Caste						
Scheduled Castes (ref.)						
Scheduled Tribes	1.00	0.86	1.16	1.08	0.88	1.33
Other Backward Classes	1.04	0.94	1.15	1.04	0.91	1.2
Others	1.04	0.92	1.18	1.13	0.94	1.37
Religion						
Hindu (ref.)						
Muslim	1.00	0.91	1.09	1.12	0.96	1.31
Other	0.51**	0.37	0.71	0.41**	0.25	0.67
Household size						
1–3 (ref.)						
4–5	0.82**	0.72	0.94	0.87	0.72	1.07
>6	0.71**	0.62	0.82	0.77**	0.62	0.95

(*Continued*)

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Table 3. (*Continued*)

Variables	Crude OR	95% CI		Adjusted OR	95% CI	
Wealth quintile						
Poorest (ref.)						
Poorer	0.80**	0.73	0.87	0.86*	0.74	0.99
Middle	0.70**	0.62	0.79	067**	0.54	0.83
Richer	0.60**	0.51	0.70	0.74*	0.56	0.98
Richest	0.48**	0.38	0.62	0.67	0.45	1.00
Type of house						
Kutcha (ref.)						
Pucca	0.73**	0.66	0.80	1.04	0.88	1.23
Availability of toilet facility						
No (ref.)						
Yes	0.74**	0.68	0.81	0.99	0.87	1.13
Sources of drinking water						
Unimproved (ref.)						
Improved	1.50**	1.22	1.84	1.58**	1.16	2.15
Child stool disposal						
Not safe (ref.)						
Safe	0.84**	0.75	0.95	0.92	0.81	1.06
Distance to health facility						
No problem (ref.)						
Not a big problem	1.16**	1.06	1.28	1.05	0.92	1.20
Big Problem	1.26**	1.14	1.39	1.12	0.97	1.29

Notes: Significance level: **P < 0.01; **P < 0.05; ref.: reference category; COR: crude odds ratio; AOR: adjusted odds ratio; CI: confidence interval.

notion, indicating that a higher frequency of floods is correlated with an elevated risk of diarrhea, and improved sanitation may not necessarily contribute to the prevention of diarrhea. Moreover, our study suggests that in addition to focusing on increasing access to improved sources of drinking water to prevent diarrhea, it is necessary to ensure access to safe drinking water for all. Future strategies need to prioritize thorough monitoring and testing of water quality across all categories of water sources, including those classified as 'improved.' Moreover, it is imperative to integrate community engagement and educational campaigns aimed at increasing awareness about water quality indicators and effective treatment techniques in the flood affected area.

Notably, the present study did not find a significant association between childhood diarrhea, mother education, caste, type of house, availability of toilet facility, child stool disposal, and perceived distance to health facility. The results of the present study should be interpreted with caution due to some limitations. First, the dataset lacks information on the type, frequency, and intensity of floods, which are potential predictors of childhood diarrhea but were not included in the analysis. Second, the cross-sectional nature of our study design prevents us from establishing causality between predictor and outcome variables (i.e., childhood diarrhea). Third, our study relied on self-reported retrospective data, introducing the possibility of recall bias. Fourth, we have considered districts affected by floods, but due to the district-level data collection, it is not possible to determine whether individual households were affected. Fifth, the inclusion of some potentially mediating factors between exposure and outcome in the multivariate analysis might have led to over adjustment in the estimate of association. However, despite these limitations, our study holds significant implications for reducing diarrhea morbidity among children under the age of five residing in flood-prone areas. The findings offer valuable insights for policymakers to identify preventive measures, especially for the groups highlighted in this study as significantly associated with childhood diarrhea in flood-affected regions.

Conclusion

This study indicates that repeated experiences of floods have the adverse risk of diarrheal diseases among under-five children. Several other socio-demographic factors that were associated with diarrhea among children were the age of children, child sex, birth order, birth weight, maternal age, religion, household size, wealth quintile, and sources of drinking water. Based on the results of the present study, it is suggested that public health initiatives focus on areas affected by recurrent flooding with persistently high diarrhea prevalence, and necessary preventive steps should be undertaken to reduce both the frequency and severity of childhood diarrhea. The young infants were identified as more susceptible to childhood diarrhea, it is imperative to provide special support to lactating mothers. This support should include the provision of breastfeeding counseling to promote optimal breastfeeding practices, particularly during floods. Mothers belonging to the poor wealth quintile, young mothers, and mother with young infants and more children should be targeted to receive child health related counseling by community health workers like ASHA (Accredited Social Health Activist) and Anganwadi workers to mitigate childhood diarrhea in flood-affected areas. Additionally, emphasizing a study conducted by Debsarma (2022), we recommend that rural unqualified healthcare providers (RUHPs) in flood-prone areas of rural India or other low- and middle-income countries can be trained and upskilled in the prevention and management of childhood diarrhea at the household level.[78] If these strategies are implemented, there is possibility of preventing childhood diarrhea in the flood prone areas of India. Lastly, we recommend that there is the need to conduct a longitudinal study to understand the underlying factors contributing to the elevated risk of diarrhea in flood-affected areas.

Author contribution. Conception and design: JS, DH, and DD. Data management and analysis: JS. Interpretation of the results: JS. Drafting of the article: JS, DH, and DD. Review and editing: JS, DH, and DD. All authors read and approved the final version.

Competing interest. The authors have no conflicts of interest to declare.

Ethical standard. Secondary data available in the public domain were used; therefore, obtaining ethical approval was not required for conducting this study.

References

1. **Rodriguez J**, **Vos F**, **Below R**, et al. Annual disaster statistical review 2008: the numbers and trends. 2009. https://www.cred.be/sites/default/files/ADSR_2008.pdf
2. **Watts N**, **Amann M**, **Arnell N**, et al. The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet.* 2018; **392**(10163):2479–514. https://doi.org/10.1016/S0140-6736(18)32594-7
3. **Noji EK**. The public health consequences of disasters. *Prehosp Disaster Med.* 2000;**15**(4):21–31. https://doi.org/10.1017/S1049023X00025255
4. **Ahern M**, **Kovats RS**, **Wilkinson P**, et al. Global health impacts of floods: epidemiologic evidence. *Epidemiol Review.* 2005;**27**(1):36–46. https://doi.org/10.1093/epirev/mxi004
5. **Vitousek S**, **Barnard PL**, **Fletcher CH**, et al. Doubling of coastal flooding frequency within decades due to sea-level rise. *Scientific Reports.* 2017;**7**(1): 1–9. https://www.nature.com/articles/s41598-017-01362-7
6. **Knox JC**. Large increases in flood magnitude in response to modest changes in climate. *Nature.* 1993;**361**:430–2. https://www.nature.com/articles/361430a0
7. **Apurv T**, **Mehrotra R**, **Sharma A**, et al. Impact of climate change on floods in the Brahmaputra basin using CMIP5 decadal predictions. *J Hydrol.* 2015; **527**:281–291. https://doi.org/10.1016/j.jhydrol.2015.04.056
8. **Hirabayashi Y**, **Mahendran R**, **Koirala S**, et al. Global flood risk under climate change. *Nature Climate Change.* 2013;**3**(9):816-21. https://doi.org/10.1038/nclimate1911
9. **Dimitrova A**, **Bora JK**. Monsoon weather and early childhood health in India. *PLoS One.* 2020;**15**(4):e0231479. https://doi.org/10.1371/journal.pone.0231479.
10. **Ivers LC**, **Ryan ET**. Infectious diseases of severe weather-related and flood-related natural disasters. *Current opinion in infectious diseases.* 2006;**19**(5): 408–414. https://doi.org/10.1097/01.qco.0000244044.85393.9e
11. **Alderman, K**, **Turner LR**, **Tong S.** Floods and human health: a systematic review. *Environ International.* 2012;47:37–**47**. https://doi.org/10.1016/j.envint.2012.06.003
12. **Baqir M**, **Sobani ZA**, **Bhamani A**, et al. Infectious diseases in the aftermath of monsoon flooding in Pakistan. *Asian Pac J Trop Biomed.* 2012;**2**(1): 76–79. https://doi.org/10.1016/S2221-1691(11)60194-9
13. **Shokri A**, **Sabzevari S**, **Hashemi SA**. Impacts of flood on health of Iranian population: Infectious diseases with an emphasis on parasitic infections. *Parasite Epidemiol Control.* 2020;**9**:e00144. https://doi.org/10.1016/j.parepi.2020.e00144
14. **Garziera L**, **Pedrosa MC**, **de Souza FA**, et al. Effect of interruption of over-flooding releases of transgenic mosquitoes over wild population of A edesaegypti: two case studies in Brazil. *Entomologia Experimentalis et Applicata.* 2017;**164**(3):327–339. https://doi.org/10.1111/eea.12618
15. **Moya Quiroga Gomez V**, **Kure S**, **Udo K**, et al. Analysis of exposure to vector-borne diseases due to flood duration, for a more complete flood hazard assessment: Llanos de Moxos, Bolivia. *Ribagua.* 2018;2;**5**(1):48–62. https://doi.org/10.1080/23863781.2017.1332816
16. **Bhan S**, **Thomas TG**, **Singh R.** Post flood vector borne disease surveillance: an experience from Malappuram district of Kerala, India in 2018. *Int J Mosq Res.* 2020;**7**(5):1–6.
17. **Abuzerr S**, **Nasseri S**, **Yunesian M**, **Hadi M**, **Mahvi AH**, **Nabizadeh R**, **Mustafa AA**. Prevalence of diarrheal illness and healthcare-seeking behavior by agegroup and sex among the population of Gaza strip: A community-based cross-sectional study. *BMC Public Health.* 2019;**19**(1):704. https://doi.org/10.1186/s12889-019-7070-0
18. **Ahmed SF**, **Farheen A**, **Muzaffar A**, et al. Prevalence of diarrhoeal disease, its seasonal and age variation in under-fives in Kashmir, India. *Int J Health Sci.* 2008;**2**(2):126.
19. **Ameta P**, **Nayak VH**, **Goyal SC**. Prevalence and seasonal distribution of rotavirus diarrhea in hospitalized children less than 5 year old in South Rajasthan. *Int J Biomed Res.* 2015;**6**(03):214–218.
20. **Levy K**, **Hubbard AE**, **Eisenberg JN**. Seasonality of rotavirus disease in the tropics: a systematic review and meta-analysis. *Int J Epidemiol.* 2009;**38**(6): 1487–96. https://doi.org/10.1093/ije/dyn260
21. **Wang P**, **Asare EO**, **Pitzer VE**, et al. Floods and diarrhea risk in young children in low- and middle-income countries. *JAMA Pediatr.* 2023;**177**(11):1206–1214. doi: 10.1001/jamapediatrics.2023.3964.
22. **Walker CL**, **Rudan I**, **Liu L**, *et al.* Global burden of childhood pneumonia and diarrhoea. *The Lancet.* 2013;**381**(9875):1405–16. doi: 10.1016/S0140-6736(13)60222-6
23. **Wahl B**, **Knoll MD**, **Shet A**, et al. National, regional, and state-level pneumonia and severe pneumonia morbidity in children in India: modelled estimates for 2000 and 2015. *Lancet Chil Adolesc Health.* 2020;**4**(9):678–87. https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30129-2/fulltext
24. **India State-Level Disease Burden Initiative Malnutrition Collaborators**. The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. *Lancet Chil Adolesc Health.* 2019;**4642**(19). https://linkinghub.elsevier.com/retrieve/pii/S2352464219302731
25. **Beck S**, **Wojdyla D**, **Say L**, et al. The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity. *Bulletin of the World Health Organization.* 2010;**88**:31–8. https://www.scielosp.org/article/ssm/content/raw/?resource_ssm_path=/media/assets/bwho/v88n1/a12v88n1.pdf
26. **World Health Organization**. 2018. https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease (accessed April 4, 2023).
27. **World Health Organization**. WHO/UNICEF joint statement: management of pneumonia in community settings. 2004. https://apps.who.int/iris/bitstream/handle/10665/68926/WHO_FCH_CAH_04.06.pdf
28. **Hasan KZ**, **Pathela P**, **Alam K**, et al. Aetiology of diarrhoea in a birth cohort of children aged 0-2 year (s) in rural Mirzapur, Bangladesh. *J Health Popul Nutr.* 2006;Mar **1**:25–35.https://www.jstor.org/stable/23499263
29. **Paul P.** Socio-demographic and environmental factors associated with diarrhoeal disease among children under five in India. *BMC Public Health.* 2020;**20**(1):1–11. https://doi.org/10.1186/s12889-020-09981-y
30. **Ghosh K**, **Chakraborty AS**, **Mog M.** Prevalence of diarrhoea among under five children in India and its contextual determinants: a geo-spatial analysis. *Clin Epidemiol Glob Health.* 2021;**12**:100813. https://doi.org/10.1016/j.cegh.2021.100813
31. **Manun'ebo MN**, **Haggerty PA**, **Gaie MK**, et al. Influence of demographic, socio-economic and environmental variables on childhood diarrhea in a rural area of Zaire. *J Trop Med Hyg* 1994;**97**:31–38.
32. **Joshi PC**, **Kaushal S**, **Aribam BS**, et al. Recurrent floods and prevalence of diarrhea among under five children: observations from Bahraich district, Uttar Pradesh, India. *Glob Health Action.* 2011;**4**. https://doi.org/10.3402/gha.v4i0.6355

33. **Nilima, Kamath A**, **Shetty K**, **Unnikrishnan B**, et al. Prevalence, patterns, and predictors of diarrhea: a spatial-temporal comprehensive evaluation in India. *BMC Public Health.* 2018;**18**(1):1288. https://doi.org/10.1186/s12889-018-6213-z
34. **Bessong PO**, **Odiyo JO**, **Musekene JN**, et al. Spatial distribution of diarrhoea and microbial quality of domestic water during an outbreak of diarrhoea in the Tshikuwi community in Venda, South Africa. *J Health Popul Nutr* 2009;**27**(5):652–659. https://doi.org/10.3329/jhpn.v27i5.3642
35. **Bogale GG**, **Gelaye KA**, **Degefie DT**, et al. Spatial patterns of childhood diarrhea in Ethiopia: data from Ethiopian demographic and health surveys (2000, 2005, and 2011). *BMC Infect Dis.* 2017;**17**(1). https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-017-2504-8
36. **Chaurasia H**, **Srivastava S**, **Singh JK**. Does seasonal variation affect diarrhoea prevalence among children in India? An analysis based on spatial regression models. *Child Youth Serv Rev.* 2020;**118**:105453. https://doi.org/10.1016/j.childyouth.2020.105453
37. **Zedie FB**, **Kassa DH**. Socio-economic, behavioral and environmental factors associated with diarrhea among under five children in health development and non-health development army member mothers in Wondogenet, south Ethiopia. *Health Educ Care.* 2018;**3**(3):1–8. https://doi.org/10.15761/HEC.1000144
38. **Badowski N**, **Castro CM**, **Montgomery M**, et al. Understanding household behavioral risk factors for diarrheal disease in Dar Es Salaam: a photovoice community assessment. *J Environ Public Health.* 2011;**2011**(Article ID 130467):10. https://doi.org/10.1155/2011/130467
39. **Gupta A**, **Sarker G**, **Rout AJ**, et al. Risk correlates of diarrhea in children under 5 years of age in slums of Bankura, West Bengal. *J Glob Infect Dis.* 2015;**7**(1):23. https://doi.org/10.4103/0974-777x.150887
40. **Khan T**, **Abimbola S**, **Kyobutungi C**, et al. How we classify countries and people—and why it matters. *BMJ Global Health.* 2022;**7**(6). https://gh.bmj.com/content/bmjgh/7/6/e009704.full.pdf
41. **Katsumata T**, **Hosea D**, **Wasito EB**, et al. Cryptosporidiosis in Indonesia: a hospital-based study and a community-based survey. *Am J Trop Med Hyg.* 1998;**59**(4):628–632. https://doi.org/10.4269/ajtmh.1998.59.628
42. **Sur D**, **Dutta P**, **Nair GB**, et al. Severe cholera outbreak following floods in a northern disrict of West Bengal. *Indian Journal Med Res.* 2000;**112**:178.
43. **Woodruff BA**, **Toole MJ**, **Rodrigue DC**, et al. Disease surveillance and control after a flood: Khartoum, Sudan, 1988..*Disasters* 1990;**14**(2): 151–163. https://doi.org/10.1111/j.1467-7717.1990.tb01056.x
44. **Siddique AK**, **Baqui AH**, **Eusof A**, **Zaman K.** 1988 floods in Bangladesh: pattern of illness and causes of death. *J Diarrhoeal Diseases Res.* 1991;**9**(4): 310–314. https://www.jstor.org/stable/23497838
45. **Mondal NC**, **Biswas R**, **Manna A.** Risk factors of diarrhoea among flood victims: a controlled epidemiological study. *Indian J Public Health.* 2001; **45**(4):122–127.
46. **Schwartz BS**, **Harris JB**, **Khan AI**, et al. Diarrheal epidemics in Dhaka, Bangladesh, during three consecutive floods: 1988, 1998, and 2004. *Am J Trop Med Hyg.* 2006;**74**(6):1067–1073.
47. **Ballester F**, **Michelozzi P**, **Iñiguez C.** Weather, climate, and public health. *J Epidemiol Community Health.* 2003;**57**(10):759–760. http://doi.org/10.1136/jech.57.10.759
48. **IIPS: National Family Health Survey (NFHS-5)**, 2019–21: India. In. Mumbai: International Institute for Population Sciences.
49. **Bango M**, **Ghosh S.** Social and regional disparities in utilization of maternal and child healthcare services in India: a study of the post-National Health Mission period. *Front Pediatr.* 2022;**10**:895033. https://doi.org/10.3389/fped.2022.895033
50. **Ding G**, **Zhang Y**, **Gao L**, et al. Quantitative analysis of burden of infectious diarrhea associated with floods in northwest of anhui province, china: a mixed method evaluation. *PLoS One.* 2013; **6**(8): e65112. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0065112
51. **Bbaale E.** Determinants of diarrhea and acute respiratory infections among under fives in Uganda. *Australas Med J.* 2011;**4**(7):400–409. https://doi.org/10.4066/AMJ.2011.723
52. **Mihrete TS**, **Alemie GA**, **Teferra AS**. Determinants of childhood diarrhea among underfive children in BenishangulGumuz regional state, North West Ethiopia. *BMC Pediatr.* 2014;**14**(1):102. https://doi.org/10.1186/1471-2431-14-102
53. **Alambo KA**. The prevalence of diarrheal disease in under five children and associated risk factors in WolittaSoddo Town, Southern, Ethiopia. *ABC Research Alert.* 2015;**3**(2). https://doi.org/10.18034/abcra.v3i2.295
54. **Mosisa D**, **Aboma M**, **Girma T**, et al. Determinants of diarrheal diseases among under five children in JimmaGeneti District, Oromia region, Ethiopia, 2020: a case-control study. *BMC Pediatrics.* 2021;**21**(1):532. https://doi.org/10.1186/s12887-021-03022-2
55. **Kamal MM**, **Tewabe T**, **Tsheten T**, et al. Individual- and community-level factors associated with diarrhea in children younger than age 5 years in Bangladesh: evidence from the 2014 Bangladesh Demographic and Health Survey. *Current Therapeutic Research, Clinical and Experimental.* 2022;**97**: 100686. https://doi.org/10.1016/j.curtheres.2022.100686
56. **Goudet SM**, **Griffiths PL**, **Bogin BA**, et al. Impact of flooding on feeding practices of infants and young children in Dhaka, Bangladesh slums: what are the coping strategies? *Matern Child Nutr.* 2011;**7**(2):198–214. https://doi.org/10.1111/j.1740-8709.2010.00250.x
57. **Arikpo D**, **Edet ES**, **Chibuzor MT**, et al. Educational interventions for improving primary caregiver complementary feeding practices for children aged 24 months and under. *Cochrane Database Syst Rev.* 2018;**5**(5): CD011768. https://doi.org/10.1002/14651858.CD011768.pub2
58. **Kombat MY**, **Kushitor SB**, **Sutherland EK**, et al. Prevalence and predictors of diarrhea among children under five in Ghana. *BMC Public Health.* 2024; **24**(1):154. https://doi.org/10.1186/s12889-023-17575-7
59. **Sarker AR**, **Sultana M**, **Mahumud RA**, et al. Prevalence and health care-seeking behavior for childhood diarrheal disease in Bangladesh. *Glob Pediatr Health.* 2016;**3**:2333794X16680901. https://doi.org/10.1177/2333794X16680901
60. **Siziya S**, **Muula AS**, **Rudatsikira E.** Correlates of diarrhoea among children below the age of 5 years in Sudan. *Afr Health Sci.* 2013;**13**(2):376–383. https://doi.org/10.4314/ahs.v13i2.26
61. **Chowdhury F**, **Khan IA**, **Patel S**, et al. Diarrheal illness and healthcare seeking behavior among a population at high risk for diarrhea in Dhaka, Bangladesh. *PLoS One.* 2015;**10**(6):e0130105. https://doi.org/10.1371/journal.pone.0130105
62. **Lira PI**, **Ashworth A**, **Morris SS**. Low birth weight and morbidity from diarrhea and respiratory infection in northeast Brazil. *J Pediatr.* 1996; **128**(4):497–504. https://doi.org/10.1016/s0022-3476(96)70360-8
63. **Ali M**, **Asfaw T**, **Beyene H**, et al. A community based study of childhood morbidity in Tigray, Northern Ethiopia. *Ethiop J Health Dev.* 2001 **15**:165–172.
64. **Hashi A**, **Kumie A**, **Gasana J.** Prevalence of diarrhoea and associated factors among under five children in Jigjiga District, Somali Region, Eastern Ethiopia. *Open J Prev Med.* 2016;**6**(10):233–246. https://doi.org/10.4236/ojpm.2016.610022.
65. **Rohmawati N**, **Panza A**, **Lertmaharit S.** Factors associated with diarrhea among children under five years of age in Banten Province, Indonesia. *J Health Res.* 2017;**26**(1):31–34. https://he01.tcithaijo.org/index.php/jhealthres/article/view/84637
66. **Demissie GD**, **Yeshaw Y**, **Aleminew W**, et al. Diarrhea and associated factors among under five children in sub-Saharan Africa: evidence from demographic and health surveys of 34 sub-Saharan countries. *PLoS One.* 2021;**16**(9):e0257522. https://doi.org/10.1371/journal.pone.0257522
67. **Moon J**, **Choi J**, **Oh J**, et al. Risk factors of diarrhea of children under five in Malawi: based on Malawi Demographic and Health Survey 2015–2016. *J Glob Health Sci.* 2019;**1**(2):45. https://doi.org/10.35500/jghs.2019.1.e45
68. **Finlay JE**, **Özaltin E**, **Canning D.** The association of maternal age with infant mortality, child anthropometric failure, diarrhoea and anaemia for first births: evidence from 55 low- and middle-income countries. *BMJ Open.* 2011;**1**(2):e000226. https://doi.org/10.1136/bmjopen-2011-000226
69. **Ferede MM**. Socio-demographic, environmental and behavioural risk factors of diarrhoea among under-five children in rural Ethiopia: further analysis of the 2016 Ethiopian demographic and health survey. *BMC Pediatrics.* 2020;**20**(1):239. https://doi.org/10.1186/s12887-020-02141-6
70. **Rahman A**, **Hossain MM**. Prevalence and determinants of fever, ARI and diarrhea among children aged 6-59 months in Bangladesh. *BMC Pediatrics.* 2022;**22**(1):117. https://doi.org/10.1186/s12887-022-03166-9

71. **Getachew A**, **Guadu T**, **Tadie A**, et al. Diarrhea prevalence and socio-demographic factors among under-five children in rural areas of North Gondar Zone, Northwest Ethiopia. *Int J Pediatr*. 2018;**2018**:6031594. https://doi.org/10.1155/2018/6031594
72. **Jonasi, S.** What is the role of a Grandmother in a Malawian society and how can we as health care workers support her? *Malawi Med J.* 2007;**19**(3):126–7. https://doi.org/10.4314/mmj.v19i3.10940.
73. **Vijayan B**, **Ramanathan M.** Prevalence and clustering of diarrhoea within households in India: some evidence from NFHS-4, 2015-16. *J Biosoc Sci.* 2021;**53**(1):108–120. https://doi.org/10.1017/S0021932020000073
74. **Thiam S**, **Diène AN**, **Fuhrimann S**, et al. Prevalence of diarrhoea and risk factors among children under five years old in Mbour, Senegal: a cross-sectional study. *Infect Dis Poverty.* 2017;**6**(1):109. https://doi.org/10.1186/s40249-017-0323-1
75. **Mulatya DM**, **Ochieng C.** Disease burden and risk factors of diarrhoea in children under five years: evidence from Kenya's demographic health survey 2014. *Int J Infect Dis.* 2020;**93**:359–366. https://doi.org/10.1016/j.ijid.2020.02.003
76. **Saha J.** The pattern of morbidity and access to healthcare service in the riverine flood-prone villages of Assam, India. *The Open Public Health J.* 2023;**6**. https://openpublichealthjournal.com/contents/volumes/V16/e18749445269914/e18749445269914.pdf
77. **Kikuchi M.** Influence of sanitation facilities on diarrhea prevalence among children aged below 5 years in flood-prone areas of Bangladesh: a multilevel analysis. *Environ Sci Pollut Res Int.* 2023;**30**(43):97925–97935. https://doi.org/10.1007/s11356-023-29373-0
78. **Debsarma D**. Exploring the strategies for upgrading the rural unqualified health practitioners in West Bengal, India: a knowledge, attitude and practices assessment-based approach. *Health Policy OPEN*. 2022;**3**:100083.

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