Acute watery diarrhea surveillance during the Rohingya Crisis 2017-2019 in Cox’s Bazar, Bangladesh

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Abstract

Introduction
Forcibly Displaced Myanmar Nationals fled into Cox’s Bazar, Bangladesh due to internal conflict. Considering the public health situation, a surveillance network was established to identify the enteric pathogens and early detection of cholera epidemics. Purpose of this manuscript is to report the clinical, epidemiological determinants of cholera and other enteric pathogens among hospitalized diarrhoeal patients from FDMNs and host community.

Methodology
A total of 11 sentinel surveillance sites were established around the camps in Ukhia and Teknaf Upazila, Cox’s Bazar. Rapid diagnostic testing was conducted for immediate detection of cholera cases. Stool samples were transferred to the icddr,b laboratory for culture.

Result
A total of 8134 participants with diarrhea were enrolled from 2017-2019: 4881 were FDMNs and 3253 from the Bangladeshi host community. Among the FDMNs, the proportion of V. cholerae 0.7%, ETEC 4.9% and Shigella 1.5%. The distributions from host community were 1.2% V. cholerae, 1.8% ETEC and 1.1% Shigella. Similar risk factors have been identified for the diarrhoeal pathogens for both communities.

Conclusion
This surveillance helped to monitor the situation of diarrheal diseases including cholera in refugee camps as well as in the neighboring host community. These findings lead policy makers to take immediate preventive measures.

Keywords: Cholera surveillance, Rohingya refugee, Cox’s Bazar, Bangladesh
INTRODUCTION

Diarrhea is one of the leading causes of mortality across the globe. Cholera presents a substantial health burden in the developing world; it is endemic in Africa and Asia, and has recently spread to the America. An estimated 1.3 billion people worldwide are at risk of cholera; India and Bangladesh jointly constitute the largest share of this at-risk population [1]. Globally, 1.3 to 4.0 million cases and 21 000 to 143 000 deaths per year due to cholera have been estimated. The World Health Organization acknowledges that worldwide only 5%–10% of cholera cases are actually reported [2]. Experts suggest that approximately 66 million people are at risk and each year 109,052 cholera cases along with 3272 deaths occur in Bangladesh [3].

The conflict in the Rakhine province of Myanmar in 2017 resulted a large influx of approximately 700,000 Forcibly Displaced Myanmar Nationals (FDMNs) in Cox’s Bazar, Bangladesh. Currently, the number stands at over a million [4]. Among the newly arrived displaced people, 60% are women and children. Public health conditions of the settlements of these individuals are poor, and represent a risk for cholera outbreak [5]. In the recent past, e.g. in Yemen, South Sudan, Haiti, and other countries, lack of WaSH (Water, Sanitation and Hygiene) and public health facilities have facilitated large epidemics with high numbers of cholera cases along with deaths [6]. Myanmar is also considered as endemic to cholera and internally displaced person (IDP) camps of Rohingyas in Northern Rakhine have regularly reported cases of severe Acute Watery Diarrhea (AWD). As reported in the Weekly Epidemiological Report-2016, the number of cholera reported cases to WHO was 782 and 11 deaths and the case fatality rate (CFR) was 1.4% [7]. International Co-ordination Group (ICG) of WHO deployed 2,200,000 oral cholera vaccines (OCV) from the WHO emergency stockpile over the period of 2017 to 2019 in response to requests from government of Bangladesh.
People living in these settlements are vulnerable to outbreaks of diarrheal disease including cholera as well as other infectious diseases. The Bangladeshi host population also lives in close proximity to these settlements. The FDMNs especially women, children and elderly have a variety of health problems. In Myanmar women were deprived of reproductive health care and children suffered from malnutrition and their immunization coverage was very low. Now in Cox’s Bazar they live in densely populated conditions in the camps with limited sources of clean water and sanitation, conditions very favorable for outbreak of cholera and other enteric diseases [8]. A nationwide surveillance of cholera which has been carried out by the icddr,b in collaboration with Institute of Epidemiology Disease Control And Research (IEDCR) in 22 sites (including Cox’s Bazar) in Bangladesh since 2014 . The data showed that the proportion of cholera detection was 8.4% (among the tested samples) in Cox’s Bazar district even before the FDMNs arrived [9]. Soon after the influx of FDMNs, a diarrhea surveillance network was set up in and around the Rohingya camps at two sub-districts (Ukhiya and Teknaf) based on the procedures of the nationwide cholera surveillance. The surveillance was carried out for early detection of cholera epidemics. This paper describes the clinical and epidemiological characteristics of enteric pathogens Vibrio cholerae, ETEC and Shigella spp.among FDMNs and host population.

METHODS

Ethics Statement

Informed consent was obtained (prior the enrollment) from participants for collecting data and biological sample. For children younger than 18 years, informed consent was taken from participants/legal guardians. The surveillance protocol was approved by the Research Review Committee and Ethical Review Committee of International Centre for Diarrheal Disease Research, Bangladesh (icddr,b).
Surveillance sites

Surveillance was conducted in 9 sites in Ukhiya and 2 sites in Teknaf upazilla of Cox’s Bazar district, which is situated in Chattogram, Bangladesh. The areas include Kutupalong and Balukhali makeshift camps in Ukhia, and Leda, Nayapara and Shamlapur camps in Teknaf which comprise a total of 34 camps. The Bangladeshi host population also lives in close proximity to the FDMNs. In order to provide a comprehensive picture of the epidemiology of pathogen-specific diarrhea among the FDMNs and host community, different health facilities (both government and private) around the camps were selected for the surveillance. Health facilities comprise primary health care centers, International Organization for Migration (IOM) hospitals, Medecins Sans Frontieres (MSF) clinics, other non-governmental organization (NGO) hospitals and Upazila health complexes.

Operational definition of diarrhea

Any patient attending treatment facility with 3 or more loose or liquid stools within 24 hours or less than 3 loose/liquid stools causing dehydration was considered potentially eligible for the surveillance.

Surveillance

At each site trained staffs were assigned to select the participants for enrolment. Patients with diarrhea who met the case definition and had no other severe co-morbidity (e.g., severe acute respiratory illness, acute cardiovascular symptoms, or severe acute neurological disorder) were selected for enrolment. Upon receiving consent, patients’ sociodemographic characteristics such as age, gender, profession, medical history, sanitation and hygiene information were recorded through a structured questionnaire. A stool sample was collected from each enrolled participant for testing with rapid diagnostic test (RDT) for *V. cholerae*. 
RDT was carried out for immediate detection of cholera cases and reports were shared with the Early Warning and Alert Response System (EWARS) of WHO, a web-based system designed to enhance disease surveillance and outbreak detection in emergency settings for rapid response to control the disease. Samples were stored in the Cary-Blair transport media in the field office at Cox’s Bazar at ambient temperature. Stored samples (in the Cary-Blair transport media at ambient temperature) can be preserved for more than 20 days (Ref ). The stored samples were transported in Cary-Blair transport media to the Mucosal Immunology and Vaccinology Laboratory at the icddr,b Dhaka, in every week. Upon receiving the specimens at the icddr,b laboratory, the samples were immediately processed for detection of *V. cholerae* O1/O139, enterotoxigenic *Escherichia coli* (ETEC) and *Shigella* spp.

**Laboratory procedures**

For identification of *V. cholerae*, specimens were streaked onto taurocholate-tellurite gelatin agar (TTGA) and incubated overnight at 37°C. Specimens were also incubated in alkaline peptone water for enrichment and incubated for an additional 18–24 hours and plated on TTGA [10]. Suspected colonies were serotyped with monoclonal antibody specific to *V. cholerae* O1 (Ogawa and Inaba) and O139 serogroups [11, 12]. For detection of ETEC, stool specimens were spread on MacConkey agar and incubated overnight at 37°C. ETEC was confirmed by multiplex PCR targeting the gene targets for ETEC toxin LT and ST in lactose-fermenting colonies [13]. For detection of *Shigella* spp., specimens were streaked onto Salmonella-Shigella agar, and then incubated overnight at 37°C, followed by systematic biochemical and serological testing methods (Denka Seiken).
Statistical analysis

We analyzed the relationship between enteric pathogens (*Vibrio cholerae*, ETEC, *Shigella* spp.) detected in diarrheal patients among the FDMN and the host community populations and host socio-demographic factors. The demographic characteristics (age, gender, literacy status, household numbers, water and sanitation practices) and clinical history of patients were analyzed through descriptive statistics. We performed Pearson chi-square test to assess the statistical significance between categorical variables. To determine the independent factors associated with different enteric pathogens, we estimated crude odds ratio (OR) using logistic regression. The factors crudely associated (p value ≤0.10) with enteric pathogens were fitted as independent variables in multiple regression models to adjusted ORs. All tests were performed as 2-tailed and p value <0.05 considered as the margin of statistical significance. The analyses were carried out by the statistical software R (Version-3.6.1).

RESULTS

Between 2017 and 2019 a total of 8134 participants were recruited into this study. Of these, 4881 were FDMNs and 3253 were from the Bangladeshi host community. Gender distribution was similar in FDMN and host community. Among the study population, 2752 (56.4%) were under 5 in the FDMN children and 1988 (61.1%) were Bangladeshi host population children who visited health facilities during the study period. About 60% participants among FDMNs and 56% among Bangladeshi host population visited health facilities for diarrhea in the month of April-June/September-November in each year between 2017 and 2019.

Most of the diarrheal patients (FDMNs- 94.4% and Bangladeshi 95.5%) suffered from diarrhea with pre-presentation histories of 3 days or less. The FDMN participants were mostly illiterate [n=3171 (78.5%)] the rate was lower [n=1333(48.3%)] among the host
population participants. Among FDMNs participants, 87.9% used tube-well, 94.6% used latrine, and 90.1% used soap after defecation; whereas in the participants from host community 98.4% patients used tube-well and latrine, and 79.2% used soap after defecation. About 5.3% FDMN participants and 4.4% host population participants presented with severe dehydration. Around 58% FDMNs participants \([n=2827]\) and 66.5% participants from host population \([n=2164]\) visited health facilities with fever during diarrheal episodes. Among the tested samples 0.7% \(V.\) cholerae, 1.5% \(Shigella\) spp., and 4.9% ETEC were isolated from the FDMN participants whereas 1.2%, 1.1% and 1.8% were from the host community participants respectively (Table 1). There were no differences in the rates of isolation of \(Shigella\) between the participants of FDMNs and host population \((p>0.05)\) but significant differences were seen between the two communities in case of isolation rates of \(V.\) cholerae \((OR: 0.50, 95\% CI: 0.31,0.80, p =0.004)\) and ETEC \((OR: 2.85, 95\% CI: 2.12,3.83, p <0.001)\).

**Cholera**

Among the collected samples, 8077 were tested with RDT. The RDT test revealed 6.7% positivity \((n=328)\) from FDMNs participants and 5.6 \%(n= 183) from the host community participants. Microbiological culture was done for 8134 samples and a total of 73 (0.9%) \(V.\) cholerae were isolated by culture. About 93% cholera cases were identified in the FDMN population during the months of April-June/September-November. Presentation with fever was similar in both the communities (Supplementary Table 1). Among the FDMN participants cholera detection was about nine times higher in the period April-June/September-November in comparison to non-cholera cases \((OR: 8.77, 95\% CI: 2.63-54.42, p = 0.003)\). In case of the participants among host community, cholera detection rate was around five times higher during the period of April-June / September-November between 2017-2019 \((OR: 4.78, 95\% CI: 2.14.14, p = 0.001)\). Among the FDMN participants, confirmed cholera cases had odds of severe dehydration which was two times higher \((OR:
2.10, 95% CI: 0.61-5.49, \( p = 0.171 \)) and chance of vomiting was two times higher in comparison to non-cases (OR: 2.28, 95% CI: 1.07-5.26, \( p = 0.04 \)). On the other hand, among the host community participants, the chance of vomiting was three times higher (OR: 2.82, 95% CI: 1.32-6.72, \( p = 0.011 \)) in cholera cases. Age over 5 years was a significant (OR: 3.53, 95% CI: 1.72-7.78, \( p = 0.001 \)) risk factor for cholera in case of participants among the host community. Literacy was a protective factor for cholera in case of the FDMN participants (Table 2).

**Shigellosis**

Among all stool samples, 109 (1.3%) were found to be positive for *Shigella* by culture. Among the detected cases 84% were *Shigella flexneri*; and 7%, 5% and 2% were *Shigella sonnei*, *Shigella boydii* and *Shigella dysentery* respectively. Among the *Shigella* positive diarrheal patients about 82% cases in FDMN participants and 63% cases in host community participants occurred during the month of April-June/September-November. Among the *Shigella* in FDMN participants about 67% were female and 33% were male. The age distribution of the *Shigella* cases in FDMN participants was 35.8%, 14.9% and 49.3% for the under-5 children, adolescent (5-14 years) and other patients (15 and above) respectively. On other hand, use of soap after defecation in the host community participants was 64.7%, whereas the proportion was 95.2 % among FDMN participants. Majority of the shigellosis patient complained about fever in both the communities (Supplementary Table 2). The odds of occurrence of diarrhea due to *Shigella* among FDMN participants during April-June/September-November was two times higher (OR: 2.48, 95% CI: 1.35-4.94, \( p =.005 \)). The odds of isolation of *Shigella* cases was around eleven times (OR: 10.87, 95% CI: 4.88-22.99, \( p = 0 \)) higher when bloody stools were tested in FDMN population. On the other hand, *Shigella* detection rate was about twenty-six times higher in case of bloody stool among the participant of host population (OR: 25.71, 95% CI: 5.27-97.73, \( p = 0 \)). FDMN participants in
the over the 5-year age range were more prone to *Shigella* infection and the rate was around three times (OR: 2.54, 95% CI: 1.41-4.61, \( p = 0.002 \)) higher (Table 3).

**ETEC infection**

A total of 295 (3.6%) ETEC infection was detected from the 8134 enrolled patients. About 75% of ETEC cases of FDMN participants occurred during the month of April-June / September-November. Among all ETEC positive FDMN participants, 53.4% were under-5 children, 6.9% of children and adolescents (5-14 years) and 39.7% 15 years and above. On the other hand, from the host community participants 44.6% were under-5 children and 55.4% were 15 years and above, but there was no ETEC-diarrhea in 5 to 14 age group. (Supplementary Table 3). The surveillance shows that chances of ETEC confirmed cases was around two times higher (OR: 1.58, 95% CI: 1.16-2.18, \( p = 0.004 \)) during the months of April-June and September-November among FDMN participants. Among the host population, those over 5 years of age group were at higher chance for ETEC-diarrhea (OR: 2.39, 95% CI: 1.20-4.89, \( p = 0.013 \)) (Table 4).

**DISCUSSION**

The study describes the enteric disease surveillance carried out among FDMN participants and host community participants in Cox’s Bazar, with an emphasis on cholera, ETEC and *Shigella* spp. More than eight-thousand samples were collected from patients of whom 60% patients were from FDMN participants and 40% were from the host community participants. Isolation of ETEC was highest in both communities which includes FDMN participants (~70%) and host communities’ participants (~44%). The increased number of care seeking for diarrheal diseases was significantly associated with seasonality and more than half of all visits occurred in the month of April-June / September-November between 2017-2019 for
both communities. This seasonal variability demonstrates similar findings from a nationwide surveillance in Bangladesh carried out between 2014-2018 [9]. Moreover, system can pick up these changes and can be notified for early decision making. Participants with under-five children for both communities were highest (FDMN participants 56.4%; Host community participants 61.1%). Participants from host community were more aware ahead than the FDMN participants in terms of using tube-well and latrine, but lagging behind in soap-use after defecation. This may be the outcome of robust promotion of WaSH materials by different organization after the influx FDMNs in the makeshift camps [14]. Stool culture reports showed that, cholera was relatively higher among the host community patients, but Shigella- and ETEC-diarrhea were comparatively more among FDMN patients. More than two-thirds of the Shigella cases were female, and near half of the population were 15 years and above in age. Similar pattern was observed in a study on shigellosis conducted in Taiwan [15]. However, another study conducted in six Asian countries revealed that under five children were mostly affected by Shigella [16].

The major strength of the surveillance was that the team had strong expertise with long experience on enteric diseases surveillance in nationwide context including Cox’s Bazar from 2014 onwards. This has been going on in 10 district hospitals since 2014 and extended to 12 more district and subdistrict hospitals. All the surveillance sites were established within a 1-hour distance from the housings of the FDMNs and host community living in the camp areas. The surveillance was carried out in collaboration with government of Bangladesh, national and international non-government organizations (NGOs) hospitals. Moreover, the surveillance was monitored continuously by icddr,b and health care facility supervisors and based on the findings of the surveillance report the policy makers from government and non-government organizations took decisions about cholera vaccination among FDMN participants and later on host community to prevent sudden upsurge of cholera or disease.
outbreak. The surveillance results were also used for early warning alert and response systems (EWARS) of WHO to contain cholera in the highly densely populated area lacking proper water, sanitation and hygiene facilities.

The major limitation of the study was language barrier for communicating with the FDMNs. The hurdle was overcome by recruiting surveillance staff such as medical technologist, supervisors and medical officer from local community who were familiar with FDMNs’ mother tongue and local language. However, there were a huge number of OCV delivered among FDMN and host community but vaccination information could not be used in this analysis as the source of information (vaccination card) was not available during data collection.

In conclusion, the study provides critical insights for the control of diarrheal diseases due to specific enteric pathogens among FDMN as well as host community. Continuation and expansion of the surveillance will play a crucial role for early detection of the cases to identify any cholera epidemics or outbreaks among host community as well as FDMNs. Also alignment of the surveillance data with the EWARS will be a comprehensive strategy for diarrheal disease control in Bangladesh which can be replicated for similar settings over the globe.
Notes

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Potential conflicts of interest.

All No reported conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.
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| Risk factors          | Labels   | FDMN (%)     | Host population | p-value |
|----------------------|----------|--------------|-----------------|---------|
| Time (days)          | 0-180    | 1387 (28.4)  | 1004 (30.9)     |         |
|                      | 181-365  | 924 (18.9)   | 601 (18.5)      |         |
|                      | 366-545  | 774 (15.9)   | 600 (18.4)      |         |
|                      | 546-730  | 1111 (22.8)  | 542 (16.7)      |         |
|                      | 731-812  | 685 (14)     | 506 (15.6)      | < 0.001 |
| Duration of diarrhea (days) | 0-3     | 4610 (94.4)  | 3106 (95.5)     |         |
|                      | 4+       | 271 (5.6)    | 146 (4.5)       | 0.038   |
| Number of purging (times) | 0-10    | 2344 (48)    | 1456 (44.8)     |         |
|                      | 11-20    | 2355 (48.2)  | 1583 (48.7)     |         |
|                      | 21+      | 182 (3.7)    | 214 (6.6)       | < 0.001 |
| Nature of stool       | Watery   | 4823 (98.8)  | 3205 (98.5)     |         |
|                      | Bloody/semisolid/solid | 58 (1.2)        | 48 (1.5)         | NS      |
| Sex                  | Female   | 2556 (52.4)  | 1745 (53.6)     |         |
|                      | Male     | 2325 (47.6)  | 1508 (46.4)     | NS      |
| Age (years)          | 0-4,     | 2752 (56.4)  | 1988 (61.1)     |         |
|                      | 5+       | 2129 (43.6)  | 1265 (38.9)     | < 0.001 |
| Variable                  | Yes       | No       | Significance |
|--------------------------|-----------|----------|--------------|
| Literate                 | 870 (21.5)| 1429 (51.7)| < 0.001      |
| Family member            | 1-4       | 5+       |              |
|                          | 1665 (36.7)| 1163 (38.5)|              |
|                          | 2875 (63.3)| 1855 (61.5)| NS           |
| Tube-well use            | Yes       |          |              |
|                          | 3554 (87.9)| 2719 (98.4)| < 0.001      |
| Latrine use              | Yes       |          |              |
|                          | 3824 (94.6)| 2718 (98.4)| < 0.001      |
| Soap use                 | Yes       |          | < 0.001      |
|                          | 3639 (90.1)| 2188 (79.2)|              |
| Severe dehydration       | Yes       |          |              |
|                          | 259 (5.3)  | 144 (4.4) | NS           |
| Vomiting                 | Yes       |          |              |
|                          | 2385 (48.9)| 1633 (50.2)| NS           |
| Fever                    | Yes       |          |              |
|                          | 2827 (57.9)| 2164 (66.5)| < 0.001      |
| *Vibrio cholerae* +ve    | Yes       |          |              |
|                          | 33 (0.7)   | 40 (1.2)  | 0.013        |
| *Shigella* +ve           | Yes       |          |              |
|                          | 72 (1.5)   | 37 (1.1)  | NS           |
| *ETEC* +ve               | Yes       |          |              |
|                          | 237 (4.9)  | 58 (1.8)  | < 0.001      |

NS: Not significant at 5% level of size
Table 2: Risk factors associated with cholera in the entire study population

| Risk factors                        | COR          | p value | AOR          | p value |
|-------------------------------------|--------------|---------|--------------|---------|
|                                     |              |         |              |         |
| **FDMN**                            |              |         |              |         |
| Seasonal pattern (April-June/Sept-Nov) | 9.33 (2.22,39.21) | 0.002   | 8.77(2.63,54.42) | 0.003   |
| Duration of diarrhea: 4+ days       | 0.58(0.08,4.31) | 0.598   | NA           | NA      |
| Bloody/semisolid/solid              | 0(0, Inf)    | 0.987   | NA           | NA      |
| Age: 5+ yrs                         | 1.29(0.63,2.65) | 0.481   | NA           | NA      |
| Male                                | 0.96(0.47,1.97) | 0.915   | NA           | NA      |
| Literate                            | 0.36(0.08,1.55) | 0.472   | NA           | NA      |
| Family member 5+                    | 1.1(0.49,2.46) | 0.825   | NA           | NA      |
| Tube-well use                       | 0.87(0.26,2.94) | 0.82    | NA           | NA      |
| Latrine use                         | 1820492.860, Inf) | 0.984  | NA           | NA      |
| Soap use                            | 2.32(0.31,17.31) | 0.411   | NA           | NA      |
| Severe dehydration                 | 2.77(0.96,8) | 0.06    | 2.1(0.61,5.49) | 0.171   |
| Vomiting                            | 2.45(1.12,5.37) | 0.025   | 2.28(1.07,5.26) | 0.04    |
| Fever                               | 0.83(0.4,1.7) | 0.611   | NA           | NA      |
| **Host community**                  |              |         |              |         |
| Seasonal pattern (April-June/Sept-Nov) | 5.52(2.16,14.12) | 0       | 4.78(2,14.14) | 0.001   |
| Duration of diarrhea: 4+ days       | 1.74(0.53,5.71) | 0.361   | NA           | NA      |
| Bloody/semisolid/solid              | 0(0, Inf)    | 0.982   | NA           | NA      |
| Age: 5+ yrs                         | 2.96(1.54,5.69) | 0.001   | 3.53(1.72,7.78) | 0.001   |
| Male                                | 0.95(0.51,1.77) | 0.863   | NA           | NA      |
|                      | Odds Ratio | P-value | AOR | P-value |
|----------------------|------------|---------|-----|---------|
| Literate             | 1.34(0.67,2.66) | 0.407   | NA  | NA      |
| Family member 5+     | 1.15(0.57,2.34) | 0.696   | NA  | NA      |
| Tube-well use        | 538742.5 (0, Inf) | 0.983   | NA  | NA      |
| Latrine use          | 0.53(0.07,3.95)  | 0.534   | NA  | NA      |
| Soap use             | 2.74(0.83,8.98)  | 0.097   | 2.18(0.77,9.15)  | 0.202 |
| Severe dehydration   | 1.77(0.54,5.8)   | 0.348   | NA  | NA      |
| Vomiting             | 3.01(1.47,6.18)  | 0.003   | 2.82(1.32,6.72)  | 0.011 |
| Fever                | 0.61(0.33,1.14)  | 0.124   | NA  | NA      |

**Note:**
- **COR=** Crude Odds Ratio; **AOR=** Adjusted Odds Ratio
- **CORs, AORs and p values are generated using logistic regression**
- For the adjusted model, we selected variables only those had an association with cholera with p-value ≤0.10 in crude analysis.
Table 3: Risk factors associated with Shigellosis in the entire study population

| Risk factors                      | COR     | p-value | AOR     | p-value |
|-----------------------------------|---------|---------|---------|---------|
| **FDMN**                          |         |         |         |         |
| Season pattern (April-June/Sept-Nov) | 3.07(1.64,5.74) | 0       | 2.48(1.35,4.94) | 0.005   |
| Duration of diarrhea: 4+ days     | 1.69(0.72,3.94) | 0.227   | -       | -       |
| Bloody/semisolid/solid            | 22.59(11.35,44.98) | 0       | 10.87(4.88,22.99) | 0       |
| Age:5+ yrs                        | 2.34(1.42,3.87) | 0.001   | 2.54(1.41,4.61) | 0.002   |
| Male                              | 0.53(0.32,0.89) | 0.016   | 0.5(0.28,0.85)  | 0.012   |
| Literacy                          | 0.61(0.18,2.06) | 0.422   | NA      | NA      |
| Family members 5+                 | 1(0.53,1.9)    | 0.989   | NA      | NA      |
| Tube-well use                     | 1.3(0.35,6.2)  | 0.721   | NA      | NA      |
| Latrine use                       | 1.14(0.15,8.51) | 0.901  | NA      | NA      |
| Soap use                          | 2.21(0.3,16.52) | 0.439  | NA      | NA      |
| Severe dehydration                | 1.13(0.41,3.14) | 0.809  | NA      | NA      |
| Vomiting                          | 0.62(0.38,1.02) | 0.059  | 0.67(0.39,1.11) | 0.125   |
| Fever                             | 1.15(0.7,1.88)  | 0.585   | NA      | NA      |
| OCV Received                      | 0.41(0.24,0.69) | 0.001  | 0.29(0.16,0.52) | 0       |
| **Host community**                |         |         |         |         |
| Seasonal pattern (April-June/Sept-Nov) | 1.32(0.66,2.63) | 0.432  | NA      | NA      |
| Duration of diarrhea: 4+ days     | 2.01(0.61,6.66) | 0.251  | NA      | NA      |
| Bloody/semisolid/solid            | 24.14(10.32,56.46) | 0       | 25.71(5.27,97.73) | 0       |
| Age:5+ yrs                        | 2.38(1.21,4.71) | 0.012  | 2.11(0.74,6.38) | 0.164   |
| Male                              | 0.68(0.34,1.36) | 0.275  | NA      | NA      |
| Literacy                          | 0.39(0.14,1.1)  | 0.075  | 0.4(0.13,1.11) | 0.094   |
| Family members 5+                 | 0.58(0.27,1.24) | 0.159  | NA      | NA      |
| Tube-well use                     | 727889.49(0, Inf) | 0.989  | NA      | NA      |
| Latrine use                       | 728159.07(0, Inf) | 0.989  | NA      | NA      |
| Soap use                          | 0.48(0.18,1.3)  | 0.148  | NA      | NA      |
| Severe dehydration                | 2.04(0.62,6.76) | 0.241  | NA      | NA      |
| Vomiting                          | 0.66(0.33,1.3)  | 0.228  | NA      | NA      |
| Fever                             | 1.46(0.68,3.13) | 0.329  | NA      | NA      |

**Note:**
- **COR** = Crude Odds Ratio; **AOR** = Adjusted Odds Ratio
- **CORs, AORs and p values are generated using logistic regression**
- For the adjusted model, we selected variables only those had an association with shigellosis with *p*-value ≤0.10 in crude analysis
Table 4: Risk factors associated with ETEC infection in the entire study population

| Risk factors                              | COR        | P value | AOR        | P value |
|-------------------------------------------|------------|---------|------------|---------|
| **FDMN**                                  |            |         |            |         |
| Seasonal pattern (April-June/Sept-Nov)    | 2(1.48,2.7) | 0       | 1.58(1.16,2.18) | 0.004   |
| Duration of diarrhea: 4+ days             | 1.01(0.57,1.79) | 0.975   | NA         | NA      |
| Bloody/semisolid/solid                    | 0.35(0.05,2.53) | 0.297   | NA         | NA      |
| Age:5+ yrs                                | 1.13(0.87,1.48) | 0.357   | NA         | NA      |
| Male                                      | 0.81(0.62,1.06) | 0.124   | NA         | NA      |
| Literacy                                  | 0.88(0.61,1.3)  | 0.514   | NA         | NA      |
| Family member 5+,                         | 1.07(0.81,1.43) | 0.663   | NA         | NA      |
| Tube-well use                             | 1.54(0.89,2.69) | 0.126   | NA         | NA      |
| Latrine use                               | 0.81(0.43,1.51) | 0.505   | NA         | NA      |
| Soap use                                  | 1.79(0.94,3.42) | 0.079   | 1.63(0.92,3.28) | 0.129   |
| Severe dehydration                        | 1.64(1.01,2.66) | 0.047   | 1.52(0.77,2.67) | 0.181   |
| Vomiting                                  | 0.99(0.76,1.29) | 0.959   | NA         | NA      |
| Fever                                     | 0.91(0.71,1.18) | 0.469   | NA         | NA      |
| **Host community**                        |            |         |            |         |
| Seasonal pattern (April-June/Sept-Nov)    | 1.96(1.09,3.52) | 0.024   | 1.24(0.63,2.488) | 0.534   |
| Duration of diarrhea: 4+ days             | 0.38(0.05,2.78) | 0.342   | NA         | NA      |
| Bloody/semisolid/solid                    | 0(Inf)     | 0.981   | NA         | NA      |
| Age:5+ yrs                                | 1.98(1.16,3.36) | 0.012   | 2.38(1.20,4.869) | 0.013   |
| Male                                      | 0.8(0.47,1.37)  | 0.425   | NA         | NA      |
| Literacy                                  | 1.8(0.89,3.64)  | 0.1     | NA         | NA      |
| Family members 5+                         | 1.96(0.99,3.88) | 0.054   | 1.40(0.68,3.103) | 0.37    |
| Tube-well use                             | Inf*       | NA      | NA         | NA      |
| Latrine use                               | 0.26(0.06,1.11) | 0.069   | 0.21(0.06,1.363) | 0.041   |
| Soap use                                  | 1.27(0.53,3.08) | 0.593   | NA         | NA      |
| Severe dehydration                        | 1.23(0.38,3.97) | 0.734   | NA         | NA      |
| Vomiting                                  | 1.33(0.78,2.27) | 0.296   | NA         | NA      |
| Fever                                     | 1.06(0.61,1.87) | 0.829   | NA         | NA      |

* The estimate not stable due low sample size

**Note:**
- **COR** = Crude Odds Ratio; **AOR** = Adjusted Odds Ratio
- CORs, AORs and p values are generated using logistic regression
- ‡ For the adjusted model, we selected variables only those had an association ETEC infection with p-value ≤0.10 in crude analysis