Impact of Ramadan on Clinical and Microbiologic Parameters of Patients Seen at a Diarrheal Hospital in Urban Dhaka, Bangladesh, 1996–2012

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Abstract. Ramadan is a month in the Islamic calendar when Muslims fast during daylight hours. We used data from the surveillance system of the International Centre for Diarrhoeal Disease Research, Bangladesh, Dhaka Hospital in Dhaka, Bangladesh, a predominantly Muslim country, to compare the etiology and clinical presentation of patients who presented with diarrhea during Ramadan to that of control periods, defined as the 30 days immediately before Ramadan. The proportion of infecting pathogens was largely the same, although *Shigella* spp. were less likely to be identified during Ramadan. Clinical presentations during Ramadan among adult Muslim diarrheal patients were also comparable to those admitted during control periods. A subgroup of cholera patients who presented after sunset during Ramadan had a shorter duration of diarrhea and higher prevalence of severe thirst, drowsiness, and severe dehydration. Our findings suggest that Ramadan has few effects on the profile of enteric pathogens and clinical features of adults seeking medical care for diarrhea.

INTRODUCTION

There are an estimated 1.6 billion Muslims, or 23.4% of the world's population.[1] Ramadan is a lunar month of the Islamic calendar in which adult Muslims abstain from food and drink (including water) between dawn and dusk. Ramadan fasting is accompanied by changes in patterns of food consumption and physical activity levels. Meals occur only at night and less frequently, food is prepared closer to meal times, and there is an increase in large gatherings for meals, especially for Iftar, the daily breaking of fast at sunset. Strenuous physical activity during daytime is reduced, replaced by an increase in night-time activity, and throughout the day there is an increase in adherence to prayer times and associated washing practices. Increased gastric acidity has been documented,[2] and although total caloric intake appears to be minimally affected,[3] those who fast experience significant reductions of fluid intake,[4] resulting in increases in serum urea and creatinine levels.[5]

Diarrheal diseases are a cause of substantial morbidity and mortality.[6] The effect of religious fasting on the clinical presentation of diarrheal disease has not been studied. We hypothesize that Ramadan may affect the etiology and clinical presentation of acute diarrheal diseases in a country where most residents observe the fast. Our objectives were to 1) determine the impact of the Ramadan month on the identity of enteric pathogens isolated from patients presenting to a diarrheal hospital in Dhaka, Bangladesh; and 2) determine the effect of Ramadan on the clinical presentation and outcomes of patients presenting to a diarrheal hospital in Bangladesh, especially those presenting with cholera, an acutely dehydrating diarrheal disease endemic to Bangladesh.

METHODS

Surveillance and setting. Bangladesh is a country with a population of approximately 160 million persons, approximately 90% of whom are Muslims.[1] Dhaka, a densely populated city of 15 million inhabitants, is the capital of Bangladesh. The Dhaka Hospital of the International Centre for Diarrhoeal Disease Research, Bangladesh, is a diarrheal treatment center that provides treatment at no cost to patients. The Diarrheal Disease Surveillance System of the hospital prospectively collects demographic, clinical, and enteric pathogen data from every 50th diarrheal patient. Details of the surveillance questionnaire have been described.[7]

Microbiologic methods. Stool samples from each surveillance patient underwent standard isolation techniques for enteric pathogens as described.[8] For analysis, pathogens were grouped by species, including *Salmonella*, *Shigella*, *Vibrio*, *Aeromonas*, and *Campylobacter* spp. Stool specimens were analyzed to detect enterotoxigenic *Escherichia coli* by molecular methods and enzyme-linked immunosorbent assay,[9] and rotavirus by enzyme-linked immunosorbent assay.[10] Stool samples also underwent direct microscopic examination for detection of parasites, including *Entamoeba histolytica*, *Giardia*, *Ascaris*, *Trichuris*, and hookworm.

Clinical presentation of diarrheal patients. Because the practice of fasting during the Ramadan period is usually adopted after puberty (commonly after 12 years of age but with no specified age cutoff), to determine differences in clinical presentation of patients with diarrhea, we focused our primary analysis on adult (≥ 18 years of age) Muslim patients who presented for care during Ramadan versus adult Muslims presenting for care during control periods. To determine whether any differences might be caused by fasting, we also compared the Muslim adults' clinical presentation with that of children ≤ 12 years of age, most of whom do not fast, as well as that of non-Muslim adults. We collected and compared the following patient characteristics on presentation: duration of diarrhea, history of abdominal pain, history of frequent vomiting (> 10 times in past 24 hours), history of severe thirst, and presence of drowsiness and severe dehydration on physical examination. We also collected the following outcome variables: use of intravenous rehydration, duration of hospitalization, and death.

Ramadan and control periods. We obtained dates of Ramadan periods for 1996–2012 from records of local religious

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TABLE 1
Dates of Ramadan periods with median sunrise/sunset times for Dhaka, Bangladesh, 1996–2012

	Ramadan period				Control period (30 days before Ramadan)			
Year	Start date	End date	Sunrise (AM)	Sunset (PM)	Start date	End date	Sunrise (AM)	Sunset (PM)
1996	Jan 22	Feb 20	6:38	5:47	Dec 23, 1995	Jan 21	6:42	5:27
1997	Jan 10	Feb 7	6:42	5:40	Dec 11, 1996	Jan 9	6:39	5:19
1997	Dec 31	Jan 18, 1998	6:43	5:31	Dec 1	Dec 30	6:33	5:14
1998	Dec 20	Jan 18, 1999	6:41	5:24	Nov 20	Dec 19	6:26	5:11
1999	Dec 9	Jan 7, 2000	6:37	5:17	Nov 9	Dec 8	6:19	5:11
2000	Nov 27	Dec 26	6:31	5:13	Oct 30	Nov 26	6:10	5:15
2001	Nov 16	Dec 15	6:24	5:11	Oct 17	Nov 15	6:04	5:20
2002	Nov 6	Dec 4	6:17	5:11	Oct 7	Nov 5	5:59	5:27
2003	Oct 27	Nov 24	6:09	5:15	Sep 27	Oct 26	5:54	5:37
2004	Oct 16	Nov 13	6:23	5:11	Sep 16	Oct 15	5:50	5:46
2005	Oct 5	Nov 4	5:58	5:28	Sep 5	Oct 4	5:46	5:57
2006	Sep 23	Oct 22	5:52	5:40	Aug 24	Sep 22	5:42	6:11
2007	Sep 13	Oct 11	5:49	5:49	Aug 14	Sep 12	5:39	6:20
2008	Sep 1	Sep 30	5:45	6:01	Aug 2	Aug 31	5:35	6:30
2009*	Aug 21	Sep 19	6:41	7:12	Jul 22	Aug 20	6:30	7:38
2010	Aug 11	Sep 8	5:38	6:22	Jul 12	Aug 10	5:26	6:44
2011	Jul 31	Aug 29	5:33	6:33	Jul 1	Jul 30	5:21	6:48
2012	Jul 20	Aug 18	5:29	6:40	Jun 20	Jul 19	5:16	6:49

*Daylights savings time was implemented in 2009 only.

institutions (Table 1). The control period for each year was the 30-day period immediately before the Ramadan period. We obtained sunset and sunrise times of Dhaka from timeanddate.com. A Ramadan or control period's sunrise and sunset times were determined as the sunrise and sunset times of the middle date of that time period. We defined night time as the period between sunset and sunrise, and daytime as the period between sunrise and sunset.

Statistical analysis. For comparisons between Ramadan and control periods, we used the Mann-Whitney U test for continuous variables and the Fisher exact test for categorical variables. We performed statistical analysis by using SPSS 17.0 (SPSS Inc., Chicago, IL). Statistical significance was defined as a two-tailed P value < 0.05.

RESULTS

During 1996–2012, we surveyed 3,485 diarrheal patients who were admitted during Ramadan, and 3,705 patients who presented during control periods (Table 2). We found no differences in overall numbers, sex, religion, age group, or time of arrival between groups.

Diarrheal pathogens. We did not find any significant differences in frequency of isolation of diarrheal pathogens between Ramadan and control periods (Table 3). We found

TABLE 2
Demographics of patients admitted during Ramadan and control periods, Dhaka, Bangladesh, 1996–2012*

Variable	Ramadan (n = 3,479) no. (%)	Control period (n = 3,702) no. (%)	P
Age group, years			NS
≥ 18	1,364 (39)	1,482 (40)	
13–17	135 (4)	152 (4)	
≤ 12	1,986 (57)	2,071 (56)	
Female sex (%)	1,447 (42)	1,563 (42)	NS
Muslim religion (%)	3,342 (96)	3,559 (96)	NS
Daytime arrival (%)	2,370 (68)	2,482 (69)	NS

*NS = not significant ($P > 0.10$).

a lower likelihood of identifying *Shigella* spp. during Ramadan. Sub-analysis of pathogens identified in children ≤ 12 years of age and among non-Muslims did not show any differences.

Clinical presentation. We compared the demographics, clinical presentation, and outcomes of adult (age ≥ 18 years of age) Muslim patients who presented during Ramadan (n = 1,305) and control (n = 1,423) periods. We found that adult Muslim diarrheal patients who presented during Ramadan had a higher prevalence of severe thirst ($P = 0.02$) and a longer duration of hospitalization ($P = 0.02$) than those who presented during control periods (Table 4). We did not find these differences when focusing our analysis on children ≤ 12 years of age or among non-Muslims. Rates of other variables, including duration of diarrhea, drowsiness, severe dehydration, and use of intravenous rehydration, were not significantly different among adult Muslim patients.

Because cholera is a severe acutely dehydrating diarrheal illness endemic to the region, we also performed an *a priori* comparison of culture-confirmed *Vibrio cholerae* O1 infection among those who presented during Ramadan (n = 445) and control (n = 408) periods (Table 5). We found that adult Muslim cholera patients presenting during Ramadan were older ($P = 0.04$) and were more likely to complain of severe thirst ($P = 0.04$). Among Muslims ≤ 12 years of age, there was also a trend to have more severe thirst during Ramadan ($P = 0.06$).

In addition, given that cholera is an acutely dehydrating disease, and that fasting occurs between sunrise and sunset, we then performed a planned sub-analysis comparing the clinical presentation of adult Muslim cholera patients who arrived after sunset during Ramadan and those who arrived after sunset during control periods (Table 6). We did not find any differences in percentage of patients presenting during night time during Ramadan than during control periods. We found that patients arriving at night during Ramadan (n = 148) had a shorter duration of diarrhea (median = 11 hours, interquartile range = 14 hours) than patients arriving at night during control periods (n = 114, median = 15 hours, interquartile range = 20 hours;

TABLE 3

Pathogens isolated from stool or rectal swab specimens for all patients presenting to a diarrheal hospital during Ramadan and control periods, Dhaka, Bangladesh, 1996–2012*

Pathogen	All, Ramadan (n = 3,394) no. (%)	All, control period (n = 3,616) no. (%)	P	non-Muslims Ramadan (n = 125) no. (%)	non-Muslims control period (n = 131) no. (%)	P	≤ 12 years of age, Ramadan (n = 1,986) no. (%)	≤ 12 years of age, control period (n = 2,071) no. (%)	P
Salmonella spp.	62 (2)	67 (2)	NS	2 (2)	1 (0.8)	NS	30 (2)	33 (2)	NS
Shigella spp.	150 (4)	196 (5)	0.05	4 (3)	12 (9)	NS	96 (5)	114 (6)	NS
Vibrio cholerae O1 or O139	896 (26)	939 (26)	NS	28 (22)	37 (28)	NS	349 (18)	384 (19)	NS
Aeromonas spp.	104 (3)	127 (4)	NS	3 (2)	3 (2)	NS	70 (4)	75 (4)	NS
Campylobacter spp.	148 (4)	152 (4)	NS	5 (4)	6 (5)	NS	107 (5)	106 (5)	NS
Other bacteria†	53 (2)	63 (2)	NS	5 (4)	2 (2)	NS	25 (1)	29 (1)	NS
ETEC	217 (6)	246 (7)	NS	4 (3)	13 (10)	NS	135 (7)	142 (7)	NS
Rotavirus	797 (23)	785 (22)	NS	33 (26)	29 (22)	NS	749 (38)	716 (35)	NS
Entamoeba histolytica	25 (0.7)	25 (0.7)	NS	1 (0.8)	0 (0)	NS	3 (0.2)	5 (0.2)	NS
Giardia	53 (2)	58 (2)	NS	2 (2)	2 (2)	NS	23 (1)	24 (1)	NS
Ascaris	81 (2)	88 (2)	NS	0 (0)	3 (2)	NS	40 (2)	45 (2)	NS
Trichuris	100 (3)	96 (3)	NS	1 (1)	1 (1)	NS	21 (1)	25 (1)	NS
Hookworm	38 (1)	28 (1)	NS	1 (1)	0 (0)	NS	7 (0.4)	4 (0.2)	NS
Any pathogen	2,164 (64)	2,261 (63)	NS	84 (67)	84 (64)	NS	1,326 (67)	1,363 (66)	NS

*NS = not significant (*P* > 0.10); ETEC = enterotoxigenic *Escherichia coli*.
†*Hafnia alvei*, non-O1/O139 *Vibrios*, *Plesiomonas*, and *Shigelloides*.

P = 0.02). Ramadan night time arrivals also had a higher prevalence of severe thirst (*P* = 0.005), and a near significantly higher prevalence of drowsiness (*P* = 0.07) and severe dehydration (*P* = 0.06). Such differences were not seen when cholera patients who presented during the daytime during Ramadan (n = 297) were compared with those who presented during the daytime during control periods (n = 292). Notably, among daytime arrivals, the Ramadan group had a longer duration of diarrhea before presentation than the control group (*P* = 0.02).

To ascertain whether the aforementioned differences were caused by fasting, we performed the same comparison with Muslim cholera patients ≤ 12 years of age, most of whom do not fast. Although children arriving at night during Ramadan also had a shorter duration of diarrhea than children who arrived at night during control periods, we did not find any differences in prevalence of severe thirst, drowsiness, or severe dehydration.

DISCUSSION

Acute diarrheal illnesses are an important cause of morbidity and mortality in low-income and middle-income countries worldwide,[6] and in many of these countries, most residents fast during Ramadan. In this study based at a diarrheal hospital in Bangladesh, we found only minor differences between Ramadan and control periods with regard to the identity of infecting pathogens and the clinical presentation and outcomes of patients admitted.

Specifically, we detected a slightly decreased recovery of *Shigella* spp. during Ramadan periods. A lower *Shigella* spp. burden during Ramadan might be caused by differences in food preparation and hygienic practices during the fasting period, such as the preparation of foods closer to scheduled mealtimes, resulting in consumption of foods with a higher temperature, as well as an increase in adherence to prescribed and special prayers, which might translate to an increase in the frequency of hand and foot washing. We hypothesize that differences are most notable for *Shigella* spp. because of their low inoculum requirements for infection compared with that required for other organisms.[11] Nevertheless, such relatively minor differences are unlikely to have major clinical or public health implications.

Practices adopted for the Ramadan fast might affect health-seeking behavior for those who are ill. We found that adult

TABLE 4

Clinical presentation and outcomes of adult Muslim patients admitted during Ramadan and control periods, Dhaka, Bangladesh, 1996–2012*

Clinical variable	Muslims ≥ 18 years of age, Ramadan (n = 1,305) no. (%)	Muslims ≥ 18 years of age, control period (n = 1,423) no. (%)	P	Muslims ≤ 12 years of age, Ramadan (n = 1,907) no. (%)	Muslims ≤ 12 years of age, control period (n = 1,990) no. (%)	P	Non-Muslims ≥ 18 years of age, Ramadan (n = 53) no. (%)	Non-Muslims ≥ 18 years of age, control period (n = 52) no. (%)	P
Age, years, median (IQR)	30 (20)	30 (21)	NS	1 (2)	1 (2)	NS	35 (24)	30 (22)	NS
Female sex, no. (%)	583 (45)	648 (46)	NS	747 (39)	810 (41)	NS	21 (39)	20 (38)	NS
History									
Abdominal pain, no. (%)	754 (58)	837 (59)	NS	503 (26)	508 (26)	NS	35 (66)	31 (60)	NS
Vomiting > 10 times in 24 h, no. (%)	158 (12)	189 (13)	NS	160 (8)	140 (7)	NS	2 (4)	4 (8)	NS
Thirst, severe (%)	718 (56)	722 (51)	0.02	251 (13)	239 (12)	NS	23 (43)	26 (50)	NS
Duration of diarrhea before arrival, h, mean (SD)	16 (26)	16 (24)	NS	42 (58)	42 (61)	NS	12 (23)	25 (31)	0.03
Examination									
Drowsy, no. (%)	672 (52)	713 (51)	NS	255 (13)	236 (12)	NS	23 (43)	22 (42)	NS
Severe dehydration, no. (%)	721 (56)	765 (54)	NS	271 (14)	259 (13)	NS	24 (45)	27 (52)	NS
Outcome									
Duration of hospital stay, h, mean (SD)	15 (17)	14 (16)	0.02	18 (33)	18 (35)	NS	25 (48)	28 (54)	NS
IV rehydration used no. (%)	834 (65)	894 (64)	NS	373 (20)	414 (21)	NS	14 (21)	14 (17)	NS

*IQR = interquartile range; NS = not significant (*P* > 0.10); IV = intravenous.

TABLE 5

Clinical presentation and outcomes of adult Muslim patients with culture-confirmed *Vibrio cholerae* O1 infection admitted during Ramadan and control periods, Dhaka, Bangladesh, 1996–2012*

Clinical variable	Muslims ≥ 18 years of age, Ramadan (no. = 445) no. (%)	Muslims ≥ 18 years of age control period (n = 408) no. (%)	P	Muslims ≤ 12 years of age, Ramadan (n = 331) no. (%)	Muslims ≤ 12 years of age, control period (n = 342) no. (%)	P	Non-Muslims ≥ 18 years of age, Ramadan (n = 17) no. (%)	Non-Muslims ≥ 18 years of age, control period (n = 14) no. (%)	P
Age, years, median (IQR)	30 (18)	27.5 (16)	0.04	4 (6)	3 (5)	NS	35 (23)	27 (21)	NS
Female sex, no.	217 (49)	181 (44)	NS	147 (44)	157 (46)	NS	5 (29)	3 (21)	NS
History									
Abdominal pain, no. (%)	231 (52)	202 (50)	NS	110 (33)	122 (36)	NS	11 (65)	9 (64)	NS
Vomiting > 10 times in 24 h, no. (%)	77 (17)	75 (18)	NS	48 (15)	56 (16)	NS	0 (0)	2 (14)	NS
Severe thirst, no. (%)	352 (79)	299 (73)	0.04	150 (45)	130 (38)	0.06	12 (71)	9 (64)	NS
Duration of diarrhea before arrival, h, mean (SD)	14 (19)	13 (16)	NS	20 (37)	22 (37)	NS	12 (11)	21 (15)	NS
Examination									
Drowsy, no. (%)	330 (74)	300 (74)	NS	151 (46)	127 (37)	0.03	13 (76)	9 (64)	NS
Severe dehydration, no. (%)	358 (81)	319 (78)	NS	157 (47)	146 (43)	NS	14 (82)	10 (59)	NS
Outcome									
Duration of hospital stay, h, mean (SD)	20 (18)	19 (17)	NS	20 (30)	23 (32)	NS	14 (88)	11 (79)	NS
IV rehydration used, no. (%)	392 (89)	357 (88)	NS	192 (56)	206 (60)	NS	10 (31)	17 (20)	NS

*IQR = interquartile range; NS = not significant (*P* > 0.10); IV = intravenous.

Muslims presenting with diarrhea during the Ramadan month in large part had comparable clinical presentations and outcomes as those presenting during control months. Although they were significantly more likely to complain of severe thirst, and to have a longer hospitalization, we did not find differences in prevalence of severe dehydration, duration of diarrhea before presentation, intravenous (IV) fluid use, or death. We hypothesize that the decreased intake of fluids during the Ramadan fast might cause patients with diarrhea to experience increased thirst at time of admission, but not enough to cause significant increases in rates of severe dehydration or need for IV fluids.

Cholera is an acute watery diarrheal disease that can cause a rapid loss of fluids and severe dehydration.[12] In the absence of prompt treatment with rehydration therapy, it can lead to hypotensive shock and death. As with the comparison among diarrheal patients regardless of etiology, we did not find any major differences between adult Muslim cholera patients admitted during Ramadan and those admitted in the control periods. Although patients presenting during Ramadan were older and experienced more severe thirst, the rates of severe dehydration, IV fluid use, and duration of diarrhea were comparable between groups. Notably, when we looked at the

smaller subset of cholera patients arriving after sunset, the difference in prevalence of severe thirst was amplified, and the prevalence of severe dehydration and drowsiness were higher (nearing statistical significance) among those in the Ramadan group, which occurred despite a shorter duration of diarrhea before presentation. Such differences in disease severity were not seen when comparing cholera patients arriving during the day. Notably, daytime arrivals during Ramadan had a longer time interval between onset of symptoms and presentation than controls, perhaps because of a reluctance to travel before sunset, including the reduced availability of accompanying caregivers. We hypothesize that among those arriving at night, the rapid dehydrating effects of cholera is compounded by the relative dehydrated state brought on by fasting. These findings might help to inform healthcare providers of the potential for higher severity of illness among those presenting after sunset during Ramadan.

This study has a number of limitations. First, we did not collect information on the actual fasting practices of each patient, and thus cannot confirm that the patient was observing the fast prior to start of diarrheal symptoms. However, when we looked at cholera patients ≤ 12 years of age (most of whom do not fast), the differences in clinical characteristics

TABLE 6

Clinical presentation and outcomes of adult Muslim patients with culture-confirmed *Vibrio* cholerae O1 infection, by time of arrival, Ramadan and control periods, Dhaka, Bangladesh, 1996–2012*

Clinical variable	Ramadan, night (n = 148) no. (%)	Control period, night (n = 114) no. (%)	P	Ramadan, day (n = 297) no. (%)	Control period, day (n = 292) no. (%)	P
Age, years, median (IQR)	30 (23)	26 (20)	NS	30 (18)	28 (13)	NS
Female sex, no. (%)	68 (46)	50 (44)	NS	149 (50)	129 (44)	NS
History						
Abdominal pain, no. (%)	76 (51)	56 (49)	NS	155 (52)	144 (49)	NS
Vomiting, > 10 times in 24 h, no. (%)	22 (15)	23 (20)	NS	55 (19)	52 (18)	NS
Severe thirst, no. (%)	123 (83)	77 (68)	0.005	214 (72)	221 (76)	NS
Duration of diarrhea before arrival, h, mean (SD)	11 (14)	15 (18)	0.02	15 (19.5)	13 (16)	0.02
Examination						
Drowsy, no. (%)	116 (78)	77 (68)	0.07	214 (72)	221 (76)	NS
Severe dehydration, no. (%)	124 (84)	84 (74)	0.06	234 (78)	233 (80)	NS
Outcome						
Duration of hospital stay, h, median (IQR)	17 (17)	14.5 (19)	NS	21 (19)	20 (18)	NS
IV rehydration used, no. (%)	138 (94)	104 (92)	NS	247 (84)	241 (83)	NS

*IQR = interquartile range; NS = not significant (*P* > 0.10); IV = intravenous.

seen in adult patients were lost, suggesting that the effects seen may have been because of fasting. Second, infecting pathogens were identified using only conventional culture and microscopic methods. Thus, our ability to define a true pathogen profile was limited to the most commonly identified pathogens. Third, our study was hospital-based. Thus, our findings are generalizable only to those in the population who seek medical care. Fourth, the periods of Ramadan during 1996–2012 only covers half of the Gregorian calendar year. Thus, potential seasonal effects might be present and not fully considered. Fifth, the number of non-Muslims in our analysis was small and likely limited our ability to detect differences between Ramadan and control periods in this group.

In conclusion, we show that the Ramadan month has minimal impact on the profile of enteric pathogens among those presenting to a diarrheal hospital, and has little effect on the prevalence of dehydration seen at presentation, except for patients with cholera arriving after sunset.

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