**Journal Name: *World Journal of Clinical Cases***

**Manuscript No: 51085**

**Manuscript Type: ORIGINAL ARTICLE**

***Observational Study***

**Pathogens causing diarrhoea among Bangladeshi children with malignancy: Results from two pilot studies**

Karim S *et al*. Diarrhoeal pathogens in children with malignancy

**Sabina Karim, Ferdousi Begum, Afiqul Islam, Monowar Ahmad Tarafdar, Mamtaz Begum, Md Johirul Islam, Bushra Malik, Md Shamim Ahsan, Ameneh Khatami, Harunor Rashid**

**Sabina Karim, Ferdousi Begum, Mamtaz Begum,** Department of Paediatric Haematology and Oncology, National Institute of Cancer Research and Hospital, Mohakhali, Dhaka 1212, Bangladesh

**Afiqul Islam,** Department of Pediatric Hematology and Oncology, Bangabandhu Sheikh Mujib Medical University, Dhaka 1212, Bangladesh

**Monowar Ahmad Tarafdar,** Department of Community Medicine, Z. H. Sikder Women’s Medical College, Dhaka 1212, Bangladesh

**Md Johirul Islam,** Department of Cancer Epidemiology, National Institute of Cancer Research and Hospital, Mohakhali, Dhaka 1212, Bangladesh

**Bushra Malik, Harunor Rashid,**National Centre for Immunisation Research and Surveillance, The Children’s Hospital at Westmead, Westmead, NSW 2145, Australia

**Md Shamim Ahsan,** Medical Services, Rangpur Cantonment, Rangpur 5400, Bangladesh

**Ameneh Khatami,** Department of Infectious Diseases and Microbiology, The Children’s Hospital at Westmead, NSW 2145, Australia

**Ameneh Khatami, Harunor Rashid,**Discipline of Child and Adolescent Health, Faculty of Medicine and Health, University of Sydney, NSW 2145, Australia

**Author contributions:** Karim S, Begum F, Begum M, and Islam A contributed to the study conception and design; Karim S, Begum F, Tarafdar MA, Islam MJ, and Ahsan MS contributed to data acquisition, collation, and curation; Rashid H, Malik B, and Khatami A contributed to the data analysis and interpretation; All authors contributed to the drafting, editing, reviewing, and final approval of the article.

**Corresponding author: Harunor Rashid, MD, Associate Professor, Senior Researcher,** National Centre for Immunisation Research and Surveillance, Kids Research Institute at The Children’s Hospital at Westmead, Cnr Hawkesbury Road and Hainsworth Street, Locked Bag 4001, Westmead, NSW 2145, Australia. harunor.rashid@health.nsw.gov.au

**Received:** August 28, 2019

**Revised:** November 27, 2019

**Accepted:** December 13, 2019

**Published online:** January 26, 2020

**Abstract**

BACKGROUND

Diarrhoea is a frequent symptom in children with cancer, and occurs due to a composite effect of underlying disease and immunosuppression consequent to therapy, malnutrition, and non-infective aetiologies such as mucositis. In a large proportion of cases, the aetiology of diarrhoea remains unknown but is often attributed to multiple pathogens including parasites.

AIM

To identify and describe the pathogens causing diarrhoea in Bangladeshi children with cancer.

METHODS

Two cross-sectional pilot studies were conducted involving paediatric oncology patients with diarrhoea. Stool samples were collected from children who were hospitalised with or without being treated with chemotherapy during the study period, and had diarrhoea at any stage during their admission. In the first study, stool samples were tested by conventional microbiological methods and by polymerase chain reaction for parasites, and by immunoassays for Clostridium difficile. In the second study, conventional microbiology was conducted for bacteria and parasites including an enzyme-linked immunosorbent assay for *Cryptosporidium* antigen, and in a subset, immunoassays for *C. difficile*.

RESULTS

In the first study *Giardia lamblia* was detected in 68.5% of samples, *Entamoeba histolytica* in 13%, *Cryptosporidium* in 5.6%, non-toxigenic *C. difficile* in 22.4%, and other bacteria in 5.2%. In the second study, *E. histolytica* was detected in 10% of samples, *Cryptosporidium* in4.3%, *G. lamblia* in 1.4%, *C. difficile* in 5.1%, and other bacteria in 5.7% of samples.

CONCLUSION

These pilot data suggest that parasites are important aetiologies of diarrhoea in Bangladeshi children with malignancy. While molecular diagnostic tools detect an array of stool pathogens with greater sensitivity, conventional diagnostic methods are also useful.

**Key words:** Bangladesh; Cancer; Child; *Cryptosporidium*; Gastroenteritis; Parasite

**Citation:** Karim S, Begum F, Islam A, Tarafdar MA, Begum M, Islam MJ, Malik B, Ahsan MS, Khatami A, Rashid H.Pathogens causing diarrhoea among Bangladeshi children with malignancy: Results from two pilot studies. *World J Clin Cases* 2020; 8(2): 276-283

**URL:** https://www.wjgnet.com/2307-8960/full/v8/i2/276.htm

**DOI:** https://dx.doi.org/10.12998/wjcc.v8.i2.276

**Core tip**: In these two pilot studies, pathogens responsible for causing diarrhoea in Bangladeshi children with cancer were explored. In both studies, there were an abundance of parasites including *Giardia lamblia*, *Entamoeba histolytica*, and C*ryptosporidium*, as well as some bacteria, notably non-toxigenic *Clostridium difficile*.

**INTRODUCTION**

Diarrhoea is a frequent symptom in children with cancer[1], and occurs due to a composite effect of underlying disease and immunosuppression consequent to therapy, malnutrition, and non-infective aetiologies such as mucositis[2]. In a large proportion of cases, the aetiology of diarrhoea remains unknown but is often attributed to multiple pathogens including parasites[3,4].

In immunocompromised individuals, intestinal parasitic infections may run a severe course, at times leading to fatality[5]. However despite this, there are limited data on the epidemiology of such infections among children with malignancy in South Asia. In urban slums of Bangladesh, about five diarrhoeal episodes per year are reported among otherwise healthy infants[6], and in a typical year, a tertiary hospital admits more than 3600 children for diarrhoea, a significant proportion of which are caused by intestinal protozoa[7,8]. As the leading cause, *Giardia lamblia* has been shown to account for about 15% of identified pathogens causing diarrhoea in young children in urban slums of Bangladesh, while *Cryptosporidium* and *Entamoeba histolytica* each account for about 4%[6]. However, the profile of pathogens causing diarrhoea among Bangladeshi children with malignancy is not yet described.

To this end, we presented the results of two pilot studies describing the frequency of pathogens identified during episodes of diarrhoea among paediatric oncology patients admitted to a tertiary referral hospital in Bangladesh. The role of cheaper and more widely available conventional microbiological tests (as opposed to molecular diagnostics) in detecting those pathogens was also investigated.

**MATERIALS AND METHODS**

***Participants and data collection***

Two pilot cross-sectional studies were conducted at Bangabandhu Sheikh Mujib Medical University Hospital (Dhaka, Bangladesh): the first one from April 2012 to March 2013, and the second from March 2016 to February 2017. Both studies involved hospitalised children with malignancies who developed diarrhoea, defined as an alteration in normal bowel pattern with the passage of three or more consecutive unformed stools within a 24 h period, during their admission. The two study designs differed slightly as summarised in Figure 1. Children with cancer who were hospitalised with or without being treated with chemotherapy during the study period and had diarrhoea at any stage during admission and whose parents/guardian provided consent to participate were eligible for inclusion. For the included children, a separate data form was used each year for collecting demographic and clinical data including age, gender, type and stage of cancer, phase of treatment, and hydration and circulatory status.

In the first study, following recruitment, a fresh stool sample was collected into a pre-labelled container for microscopy for parasites, cysts, and ova and aerobic culture on selective media for enteric bacterial pathogens using standard protocols. In addition, multiplexed, real time, polymerase chain reaction (PCR) for *Cryptosporidium* spp, *E. histolytica*, and *G. lamblia* was conducted on 54 of the total 58 samples using a commercial assay as described elsewhere[9]. A second stool sample was collected for identification of Clostridium difficile toxin and glutamate dehydrogenase by enzyme immunoassays (EIAs) using TOX A/B IITM and C. DIFF CHEKTM-60 (TechLab®, Blacksburg, VA, United States). Some methodological details were presented at the 46th Congress of the International Society of Paediatric Oncology in Toronto, Canada 22nd–25th October, 2014, and the results of this study have been published in brief as conference proceedings[10].

In the second study, a single stool sample was collected in a pre-labelled container for microscopy for parasites, cysts, and ova and aerobic culture on selective media for enteric bacterial pathogens using standard protocols, as well as an enzyme-linked immunosorbent assay (ELISA) for *Cryptosporidium* using the *Cryptosporidium* Ag ELISA kit (DRG Diagnostics GmbH, Marburg, Germany). In a random subset (*n* = 39), *C. difficile* antigen and toxin were also investigated using TOX A/B IITM and C. DIFF CHEKTM-60 immunoassays.

On the first day of diarrhoea, blood samples were obtained for complete blood count and serum creatinine and electrolytes, as part of the routine diagnostic workup. In both studies, blood tests and stool ELISA were conducted at the Microbiology Department of Bangabandhu Sheikh Mujib Medical University; while stool microbiology, ELISA, and molecular tests were carried out at the microbiology laboratory of the International Centre for Diarrhoeal Disease Research (Dhaka, Bangladesh).

***Data analysis***

Data were collated on a master Excel spread sheet before importing to Statistical Package for Social Sciences software (IBM SPSS Statistics for Windows, version 25.0; IBM Corp., Armonk, NY, United States). Categorical data were expressed as number and proportion while continuous data were expressed as range with measures of central tendency and/or dispersion. Some patients had more than one episode of diarrhoea and hospitalisation, and each presentation was counted separately towards the final denominator.

**RESULTS**

***First study***

During a 12-mo period from April 2012 to March 2013, a total of 58 diarrhoeal episodes were experienced by 51 patients. The demographic characteristics of children included in the study are outlined in Table 1. Of note, more than 50% of the children with diarrhoea included in the study were aged < 60 mo. Pathogens detected are listed in Table 1. There was an abundance of *G. lamblia* (68.5%), and non-toxigenic *C. difficile* was detected in 13 episodes (22.4%).

In all but two episodes (96.6%), the children had a history of receiving antibiotic therapy or prophylaxis, on average 3.9 d (range 1-16) prior to or during the episode of diarrhoea. Antibiotics received included prophylaxis with oral trimethoprim-sulfamethoxazole (25.9%) or levofloxacin (19%), and treatment with cefepime plus amikacin (19%) or meropenem plus vancomycin (13.8%).

All three children with *Cryptosporidium* infection were male, aged 3.5, 4.5, and 6 years; two of them had acute lymphoblastic leukaemia (ALL) and the other had non-Hodgkin’s lymphoma. All three had severe neutropenia, with absolute neutrophil counts (ANCs) of 150, 20, and 180 per µL. Two patients had multiple parasitic co-infections: one with all three tested parasites and the other with *G. lamblia* and *Cryptosporidium* (Table 2). One of these children had severe dehydration.

***Second study***

During a 12-mo period from March 2016 to February 2017, a total of 70 diarrhoeal episodes were experienced by 66 patients. The demographic characteristics of children included in the study and the pathogens detected are outlined in Table 1. Of note, about 60% of children with diarrhoea included in the study were aged < 60 mo and the majority of pathogens detected were parasites.

Two out of three children with *Cryptosporidium* infection were male, aged 2.5 and 4 years, and the other was female, aged 5 years. One had rhabdomyosarcoma, another had a primitive neuroectodermal tumour, and the third patient had ALL. Two had severe neutropenia with ANCs of 20 and 40, and the other had ANC of 790 per µL (Table 2).

**DISCUSSION**

These two pilot studies show that parasites, notably *G. lamblia*, are responsible for a large proportion of diarrhoeal aetiologies among children with malignancy in Bangladesh. A greater number of potential pathogens were detected with PCR compared to ELISA and conventional microbiological methods, as demonstrated in other studies[11]; however, the latter is still found to be useful.

Apart from an exceptionally high detection rate of giardiasis in the first study, the epidemiological profile of parasites was similar to that found among otherwise healthy Bangladeshi children with diarrhoea[7]. *G. lamblia* was detected at a significantly higher rate than among otherwise healthy Bangladeshi children 15.2%[6], and in children with cancer in other countries with a similar socioeconomic profile such as Mexico (28.7%)[12]. These differences may be attributed to both the study population (children with malignancy *vs* otherwise healthy children) as well as study methodologies (use of PCR in the current study, compared to conventional microscopic detection in the Mexican study). This could also be because of selection bias, as some children with diarrhoea or episodes of diarrhoea may have been missed.

Interestingly, the *Cryptosporidium* burden reported in these pilot studies (4%-5%) is similar to what has been reported in children with cancer in neighbouring countries; *e.g.,* 3.8% in Iran, 4% in Turkey, 2% in Malaysia, 1.3% in India, and 9.6% in Egypt[4,13-16]. The slight variation in these rates is likely because of disparities in testing practice, diagnostic methods used, age groups included, and study designs[1,11].Conversely, an Australian study that investigated 149 stool samples from 60 paediatric oncology patients with diarrhoea found none to be positive for *Cryptosporidium*. Contamination of drinking water may be the source of many *Cryptosporidium* infections in Bangladesh, whereas in Australia exposure to contaminated recreational water (*e.g.,* swimming pools) is the most common source of infection[17]. A comparative study involving Jordanian children demonstrated that compared to children without cancer, paediatric oncology patients had higher prevalence of *Cryptosporidium* infection (5.1% *vs* 14.4%, *p* ≤ 0.05)[18]. These data suggest that the aetiological role of *Cryptosporidium* is dependent on cancer as an underlying co-morbidity, as well socio-economic and geographic variables among others.

In our setting, in the first dedicated pilot study, 22.4% children were found to be positive for *C. difficile* in their stool with an absence of toxin positivity based on EIA; while in the second study 5.1% (only in 39 subjects tested) were positive for *C. difficile* (none were toxin positive). In comparison, among Dutch immunocompromised children admitted to a tertiary hospital, the prevalence of *C. difficile* detected by culture and cytotoxin tissue culture assay was 27.4%, with over half toxin-positive[19]. In contrast, the prevalence of toxigenic *C. difficile* among symptomatic paediatric oncology patients was found to be 8.7% in a prospective Australian study (based on culture and EIA for toxin A and cytopathic assay for toxin B), with an additional 4% with non-toxigenic *C. difficile*[20]. Interestingly, in this study, the prevalence of toxigenic and non-toxigenic *C. difficile* was higher among asymptomatic children (19% and 6.7% respectively) indicating that toxigenic *C. difficile* may be part of children’s indigenous gastrointestinal flora, particularly in young infants, as observed in other studies[20,21]. The prevalence of toxigenic *C. difficile* colonisation may also be higher in children with underlying malignancy. The colonisation rate of *C. difficile* among asymptomatic Iranian children with cancer was 25% by stool culture, 92% of which were toxicogenic based on cytopathic effect on HeLa cells[22]. Although no studies of Bangladeshi children with malignancy exist, among otherwise healthy Bangladeshi children hospitalised with diarrhoea, 1.6% were infected with *C. difficile* diagnosed by cell cytotoxin assay in 1993-1994[23].

Despite high rates of colonisation, with even toxigenic strains of *C. difficile* among asymptomatic children with malignancy, it is important to have an accurate estimate of the prevalence in our population since it has been shown that colonisation with a toxigenic strain is predictive of subsequent *C. difficile* infection[24]. Further studies using PCR to detect presence of *C. difficile* toxins would be useful given the limited sensitivity of EIAs used in the current studies.

There were several limitations to these studies. First, the sample sizes were small, the study methodologies were different across the two studies, diagnostic tools used were not uniform, the age groups differed, and in the second study *C. difficile* was tested in only a small subset of patients; hence the findings are not generalisable. However, despite these shortfalls, these two are the first ever studies in Bangladeshi children with cancer to provide data on the infectious aetiologies of diarrhoea in this population and inspire further research. In conclusion, this study confirms that parasites constitute a significant burden in Bangladeshi children with malignancy who present with diarrhoea. While molecular diagnostic tools detect an array of stool pathogens with greater sensitivity, conventional laboratory diagnostic methods are also useful.

**ARTICLE HIGHLIGHTS**

***Research background***

Diarrhoea is a frequently occurring symptom among children with cancer. In a large proportion of cases, the aetiology of diarrhoea remains unknown but often multiple pathogens are attributed.

***Research motivation***

There is little or no information about pathogens responsible for diarrhoea among children with cancer in Bangladesh, a country where diarrhoeal diseases are endemic.

***Research objectives***

To describe pathogens causing diarrhoea in Bangladeshi children with cancer.

***Research methods***

Two cross-sectional pilot studies were carried out involving hospitalised paediatric oncology patients with diarrhoea. Stool samples were tested by conventional microscopy and culture techniques and by polymerase chain reaction for parasites and bacteria, as well as immunoassays for *Clostridium difficile*, and enzyme-linked immunosorbent assay for *Cryptosporidium* antigen.

***Research results***

In the first study *Giardia lamblia* was detected in around 69% of samples, *Entamoeba histolytica* in 13%, *Cryptosporidium* in 6%, non-toxigenic *C. difficile* in 22% and other bacteria in 5%. In the second study, *Entamoeba histolytica* was detected in 10% of samples, *Cryptosporidium* in4%, *G. lamblia* in 1%, non-toxigenic *C. difficile* in 5% and other bacteria in 6% of samples.

***Research conclusions***

These pilot data suggest that parasites are important aetiologies of diarrhoea among Bangladeshi children with malignancy.

***Research perspectives***

In a resource poor setting such as Bangladesh, while molecular diagnostic tools allow detection of an array of stool pathogens with greater frequency, conventional laboratory diagnostic methods are still useful.

**ACKNOWLEDGEMENTS**

The authors would like to thank Professor (Brigadier General) Md. Nizam Uddin, Principal, Rangpur Army Medical College, Bangladesh for his helpful comments on the manuscript.

**REFERENCES**

1 **O'Connor O**, Cooke RP, Cunliffe NA, Pizer B. Clinical value of stool culture in paediatric oncology patients: hospital evaluation and UK survey of practice. *J Hosp Infect* 2017; **95**: 123-125 [PMID: 27825673 DOI: 10.1016/j.jhin.2016.10.005]

2 **Davila M**, Bresalier RS. Gastrointestinal complications of oncologic therapy. *Nat Clin Pract Gastroenterol Hepatol* 2008; **5**: 682-696 [PMID: 18941434 DOI: 10.1038/ncpgasthep1277]

3 **Esteghamati A**, Khanaliha K, Bokharaei-Salim F, Sayyahfar S, Ghaderipour M. Prevalence of Intestinal Parasitic Infection in Cancer, Organ Transplant and Primary Immunodeficiency Patients in Tehran, Iran *Asian Pac J Cancer Prev* 2019; **20**: 495-501 [PMID: 30803212 DOI: 10.31557/APJCP.2019.20.2.495]

4 **El-Mahallawy HA**, El-Din NH, Salah F, El-Arousy M, El-Naga SA. Epidemiologic profile of symptomatic gastroenteritis in pediatric oncology patients receiving chemotherapy. *Pediatr Blood Cancer* 2004; **42**: 338-342 [PMID: 14966830 DOI: 10.1002/pbc.10394]

5 **Hunter PR**, Nichols G. Epidemiology and clinical features of Cryptosporidium infection in immunocompromised patients. *Clin Microbiol Rev* 2002; **15**: 145-154 [PMID: 11781272 DOI: 10.1128/cmr.15.1.145-154.2002]

6 **Mondal D**, Minak J, Alam M, Liu Y, Dai J, Korpe P, Liu L, Haque R, Petri WA Jr. Contribution of enteric infection, altered intestinal barrier function, and maternal malnutrition to infant malnutrition in Bangladesh. *Clin Infect Dis* 2012; **54**: 185-192 [PMID: 22109945 DOI: 10.1093/cid/cir807]

7 **Haque R**, Mondal D, Karim A, Molla IH, Rahim A, Faruque AS, Ahmad N, Kirkpatrick BD, Houpt E, Snider C, Petri WA Jr. Prospective case-control study of the association between common enteric protozoal parasites and diarrhea in Bangladesh. *Clin Infect Dis* 2009; **48**: 1191-1197 [PMID: 19323634 DOI: 10.1086/597580]

8 **Korpe PS**, Haque R, Gilchrist C, Valencia C, Niu F, Lu M, Ma JZ, Petri SE, Reichman D, Kabir M, Duggal P, Petri WA Jr. Natural History of Cryptosporidiosis in a Longitudinal Study of Slum-Dwelling Bangladeshi Children: Association with Severe Malnutrition. *PLoS Negl Trop Dis* 2016; **10**: e0004564 [PMID: 27144404 DOI: 10.1371/journal.pntd.0004564]

9 **Haque R**, Roy S, Siddique A, Mondal U, Rahman SM, Mondal D, Houpt E, Petri WA Jr. Multiplex real-time PCR assay for detection of Entamoeba histolytica, Giardia intestinalis, and Cryptosporidium spp. *Am J Trop Med Hyg* 2007; **76**: 713-717 [PMID: 17426176 DOI: 10.4269/ajtmh.2007.76.713]

10 **Begum F,** Islam A, Haque R, Chowdhury Y, Mia A, Yasmin F. Clostridium difficile-associated diarrhea in children with haematological malignancy (EP 402). In: 46th Congress of The International Society of Paediatric Oncology (SIOP) 2014 Toronto, Canada, 22nd -25th October, 2014 SIOP Abstracts. *Pediatr Blood Cancer* 2014; **61 Suppl 2**: S343 [DOI: 10.1002/pbc.25314]

11 **de Boer RF**, Ott A, Kesztyüs B, Kooistra-Smid AM. Improved detection of five major gastrointestinal pathogens by use of a molecular screening approach. *J Clin Microbiol* 2010; **48**: 4140-4146 [PMID: 20861334 DOI: 10.1128/JCM.01124-10]

12 **Martínez Pérez A**, Justiniani Cedeño NE. [incidence of intestinal parasites in pediatric patients with hematologic neoplasms from 1 to 15 years of age]. *Rev Alerg Mex* 1999; **46**: 26-29 [PMID: 10232025]

13 **Berahmat R**, Mahami-Oskouei M, Rezamand A, Spotin A, Aminisani N, Ghoyounchi R, Madadi S. Cryptosporidium infection in children with cancer undergoing chemotherapy: how important is the prevention of opportunistic parasitic infections in patients with malignancies? *Parasitol Res* 2017; **116**: 2507-2515 [PMID: 28730516 DOI: 10.1007/s00436-017-5560-5]

14 **Aksoy U**, Erbay A, Akisu C, Apa H, Ozkoç S, Oztürk S. Intestinal parasites in children with neoplasms. *Turk J Pediatr* 2003; **45**: 129-132 [PMID: 12921299]

15 **Menon BS**, Abdullah MS, Mahamud F, Singh B. Intestinal parasites in Malaysian children with cancer. *J Trop Pediatr* 1999; **45**: 241-242 [PMID: 10467838 DOI: 10.1093/tropej/45.4.241]

16 **Sreedharan A**, Jayshree RS, Sridhar H. Cryptosporidiosis among cancer patients: an observation. *J Diarrhoeal Dis Res* 1996; **14**: 211-213 [PMID: 9019017]

17 **Burgner D**, Pikos N, Eagles G, McCarthy A, Stevens M. Epidemiology of Cryptosporidium parvum in symptomatic paediatric oncology patients. *J Paediatr Child Health* 1999; **35**: 300-302 [PMID: 10404455]

18 **Hijjawi N**, Zahedi A, Kazaleh M, Ryan U. Prevalence of Cryptosporidium species and subtypes in paediatric oncology and non-oncology patients with diarrhoea in Jordan. *Infect Genet Evol* 2017; **55**: 127-130 [PMID: 28867592 DOI: 10.1016/j.meegid.2017.08.033]

19 **Wolfhagen MJ**, Meijer K, Fluit AC, Torensma R, Bruinsma RA, Fleer A, Verhoef J. Clinical significance of Clostridium difficile and its toxins in faeces of immunocompromised children. *Gut* 1994; **35**: 1608-1612 [PMID: 7828982 DOI: 10.1136/gut.35.11.1608]

20 **Burgner D**, Siarakas S, Eagles G, McCarthy A, Bradbury R, Stevens M. A prospective study of Clostridium difficile infection and colonization in pediatric oncology patients. *Pediatr Infect Dis J* 1997; **16**: 1131-1134 [PMID: 9427457]

21 **Jangi S,** Lamont JT. Asymptomatic colonization by Clostridium difficile in infants: implications for disease in later life. *J Pediatr Gastroenterol Nutr* 2010; **51**: 2-7 [PMID: 20512057 DOI: 10.1097/MPG.0b013e3181d29767]

22 **Armin S**, Shamsian S, Drakhshanfar H. Colonization with Clostridium difficile in Children with Cancer. *Iran J Pediatr* 2013; **23**: 473-476 [PMID: 24427503]

23 **Albert MJ**, Faruque AS, Faruque SM, Sack RB, Mahalanabis D. Case-control study of enteropathogens associated with childhood diarrhea in Dhaka, Bangladesh. *J Clin Microbiol* 1999; **37**: 3458-3464 [PMID: 10523534]

24 **Al-Rawahi GN**, Al-Najjar A, McDonald R, Deyell RJ, Golding GR, Brant R, Tilley P, Thomas E, Rassekh SR, O'Gorman A, Wong P, Turnham L, Dobson S. Pediatric oncology and stem cell transplant patients with healthcare-associated Clostridium difficile infection were already colonized on admission. *Pediatr Blood Cancer* 2019; **66**: e27604 [PMID: 30666782 DOI: 10.1002/pbc.27604]

**Footnotes**

**Institutional review board statement:** This study was reviewed and approved by the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh (Study 1 Ref: BSMMU/2012/11867, Study 2 Ref: BSMMU/ 2016/4711).

**Informed consent statement:** All study participants, or their legal guardian, provided informed written consent prior to study enrolment.

**Conflict of interest statement:** There are no conflicts of interest to disclose in relation to this manuscript.

**Data sharing statement:** No additional data are available. These data, in part, were presented at the 46th Congress of the International Society of Paediatric Oncology Toronto, Canada on 22nd–25th October, 2014, and at the 50th Congress of the International Society of Paediatric Oncology Kyoto, Japan on November 16-19, 2018.

**STROBE statement**: The guidelines of the STROBE Statement have been adopted.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

**Manuscript source:** Invited manuscript

**Peer-review started:** August 28, 2019

**First decision:** November 19, 2019

**Article in press:**

**Specialty type:** Medicine, Research and Experimental

**Country of origin:** Bangladesh

**Peer-review report classification**

Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Kai K **S-Editor:** Zhang L **L-Editor:** Filipodia **E-Editor:** Ma YJ

**Figure 1 Summary of study methods.** PCR: Polymerase chain reaction; ELISA: Enzyme-linked immunosorbent assay.

**Table 1 Patient demographics and laboratory results of hospitalised paediatric oncology patients with diarrhoea at Bangabandhu Sheikh Mujib Medical University hospital, *n* (%)**

|  |  |  |
| --- | --- | --- |
| Particulars | Study 11 | Study 22 |
| Male:Female | 32:19 | 47:19 |
| Age in mo, range (mean) | 13-180 (70.8) | 11-216 (73.2) |
| Age group |
| ≤ 60 mo | 32 (55.2) | 41 (58.6) |
| 61-120 mo | 16 (27.6) | 15 (21.4) |
| > 120 mo | 10 (17.2) | 14 (20) |
| Diagnosis |
| ALL | 37 (63.8) | 40 (57.1) |
| NHL | 17 (29.4) | 10 (14.3) |
| AML | 4 (7.9) | 7 (10) |
| Others |  | 1 (1.4) |
| Solid tumours |  | 12 (17.1) |
| Phase of treatment  |
| Induction | 37 (63.8) | 43 (61.4) |
| Consolidation | 14 (24.1) | 10 (14.3) |
| Maintenance | 6 (10.3) | 12 (17.1) |
| Not applicable | 1 (1.7) | 5 (7.1) |
| ANC category |
| < 500/mm3 | 47 (81) | 42 (60) |
| ≥ 500/mm3 | 11 (19) | 28 (40) |
| Number of bowel motions/d |
| ≥ 10 | 29 (50) | 10 (14.2)  |
| 6-9 | 19 (32.8)  | 40 (57.1) |
| ≤ 5 | 10 (17.2) | 20 (28.6) |
| Pathogens detected in stool samples |
| *Giardia lamblia* | 37 (68.5)2 | 1 (1.4) |
| *Entamoeba histolytica* | 7 (13)2 | 7 (10) |
| *Cryptosporidium* | 3 (5.6)b | 3 (4.3) |
| *Clostridium difficile* | 13 (22.4) | 2 (5.1)b |
| *Campylobacter jejuni* | 2 (3.4) | 1 (1.4) |
| *Salmonella spp.*  | 1 (1.7)  | 1 (1.4) |
| *Shigella sonnei* | 0 (0) | 1 (1.4) |
| *Vibrio cholerae* | 0 (0) | 1 (1.4) |

1Each episode of diarrhoea was included as a separate event counting towards the denominator used for each characteristic, with the exception of gender (where each child was counted only once irrespective of the number of episodes of diarrheal experienced); 2In the first study, only 54 of the total 58 samples were processed by polymerase chain reaction for parasites, and in the second study *Clostridium difficile* was investigated in only 39 randomly selected samples out of the total 70 samples, of which 2 were positive, none were toxin-positive. ALL: Acute lymphoblastic leukaemia; AML: Acute myeloblastic leukaemia; ANC: Absolute neutrophil count per µL; NHL: Non-Hodgkin’s lymphoma.

**Table 2 Summary of paediatric oncology patients with diarrhoea from whose stool samples *Cryptosporidium* was detected**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Patients**  | **Age in yr** | **Gender** | **Primary Diagnosis** | **Phase of Treatment** | **Preceding hospital stay in d1**  | **Frequency of bowel motions/d** | **Fever** | **Mucositis** | **Stool microscopy** | **ANC** |
| Study 1 |
| Patient 1 | 4.5 | Male | NHL | Induction | 15 | 16 | Present | Present | 11-20 pus cells per HPF | 150 |
| Patient 2 | 3.5 | Male | ALL | Maintenance | 0 | 6-9 | Present | Absent | > 50 pus cells per HPF | 20 |
| Patient 3 | 6 | Male | ALL | Maintenance | 0 | 3 | Present | Absent | > 10 per HPF | 180 |
| Study 2 |
| Patient 1 | 4 | Male | RMS | Induction | 7 | > 10  | Absent | Absent | Normal | 790 |
| Patient 2 | 5 | Female | PNET | Induction | 0 | 6-9  | Present | Present | Pus cells | 20 |
| Patient 3 | 2.5 | Male | ALL | Induction | 22 | 6-9  | Present | Absent | Normal | 40 |

1Days in hospital prior to the onset of diarrhoea. ALL: Acute lymphoblastic leukaemia; ANC: Absolute neutrophil count per µL; HPF: High power field; NHL: Non-Hodgkin’s lymphoma; PNET: Primitive neuroectodermal tumour; RMS: Rhabdomyosarcoma.