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The Epidemiology of *Blastocystis hominis* in the United States

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Abstract: This is the first large scale investigation of the epidemiology of *Blastocystis hominis* in the United States. Trends in annual, seasonal, geographical and host distribution and symptomology by age, sex and season are reported in 48 states and the District of Columbia in 2002-2004. Sixteen percent of 10,582 fecal specimens from 5,291 patients tested positive. Annual prevalence rate declined from 23% in 2000 to 11% in 2004. Infections were most prevalent in September and October and in coastal states. About one fifth of the infections were concurrent with 10 other parasitic species the most common of which was *Cryptosporidium parvum*. Females submitted about twice as many specimens as males and were markedly more frequently infected at the 40-49 years age group. Children (age 0-9 years) were the least frequently infected but the prevalence rate in male and female children was 15 and 6%, respectively. About two thirds of infected patients were symptomatic with highest frequency of symptoms observed between July and September. Intestinal symptoms were considerably more common than extra-intestinal symptoms especially in females. Diarrhea and fatigue were the most common symptoms in both male and females.

Key words: Epidemiology, *Blastocystis hominis*, USA

Introduction

Blastocystis hominis is the most common human parasite in the United States. It remains inadequately researched. Significant epidemiological information remained wanting but is herein addressed for the first time in the United States and any other part of the world by this investigation. The objective was to study the annual and seasonal prevalence of *B. hominis* over a period of years, its host, sex, age and geographical distribution by state and region and its symptomology. This objective was met by this detailed study and analysis of a total of 10, 582 fecal specimens from 5,291 Parasitology Center, Inc. (PCI) patients examined between 2002 and 2004. Related reports include those of Amin (1997) on the prevalence and symptomology of *B. hominis* in a small summer population of 644 patients and Amin (2002) on its seasonal prevalence in a larger population of 2,896 patients examined during 2000. Few relevant studies of a different scope and nature have been reported in smaller patient populations in the United States (Kappus *et al.*, 1994; Garcia *et al.*, 1984) or in more geographically limited populations, e.g., California (Conteas *et al.*, 1998) or Ontario, Canada (Senay and MacPherson, 1990).

Materials and Methods

A total of 10,582 fecal specimens from 5,291 patients (two specimens per patient) were collected and transported to PCI (Tempe, AZ) in Proto-Fix™ in plastic vials provided in mailable kits by

Alpha-Tec Systems, Inc. (Vancouver, WA). Specimens were collected throughout the United States between January 2002 and December 2004 following physicians' orders. Tests were ordered either as part of routine medical examinations or when patients experience changes in bowel habits, energy level, or normalcy after a foreign trip, bad meal, or other exposures. Specimens were processed and stained in CONSED™ according to manufacture's (Alpha-Tec Systems, Inc.) directions and Amin (2000). This procedure was previously used in 10,358 specimens by 1998 and was described, fully evaluated and compared with other methods (Amin, 2000). The number of specimens found positive (number of individuals and of species of parasites) was significantly higher than in other methods compared, e.g., formalin-ethyl acetate or trichrome stain (Amin, 2000). These observations were supported by findings of other observers (Allen and Frankel, 1997; Keply *et al.*, 2000). The Proto-Fix™ CONSED™ system involves filtering of fixed specimens, mixing with CONSED™ and ethyl acetate, vortexing, centrifugation, decanting all but the fecal plug and mixing with CONSED™ diluting reagent. The plug, in part, is then transferred to and mounted on a slide for examination (Amin, 2000). All microscopic evaluations and identification were made by the same observer (OMA) blinded to patient information, e.g., symptoms, travel, etc. Positive results were quantified (number of organisms per high-power field on a scale of 1 to 4) from duplicate samples from the same patient.

Results

Prevalence

The annual and seasonal prevalence of *B. hominis* in the years 2002-2004 was compared with those of 2000 (Amin, 2000) for a total of 8,187 patients (16,374 fecal specimens) of whom 1,486 patients (18%) were infected with *B. hominis* (Table 1), the most common human parasite in the United States. The annual prevalence rates showed a gradual and consistent decline from 23% in 2000 to 11% in 2004.

The overall prevalence was lowest (13%) in February and highest between July and October (20-23%). The February decline was more evident in 2002 and 2004. The summer/autumn increase was highest in 2000.

Single and Multiple Infections

Of 5,291 patients examined in 2002-2004, 661 (12%) were singly infected with *B. hominis* and 163 (3%) were infected with *B. hominis* concurrently with 10 other species of parasites

Table 1: Seasonal prevalence of *Blastocystis hominis* infections in United States patients in 2000 (Amin, 2002) and in 2002-2004

Month	No. specimens examined, No. infected (% prevalence)				Total
	2000	2002	2003	2004	
January	155, 27 (17)	210, 38 (18)	120, 25 (21)	113, 17 (15)	598, 107 (18)
February	283, 43 (15)	195, 18 (09)	126, 19 (15)	149, 17 (11)	753, 97 (13)
March	254, 53 (21)	183, 37 (20)	157, 26 (17)	152, 22 (14)	746, 138 (18)
April	228, 41 (18)	173, 37 (21)	182, 22 (12)	133, 20 (15)	716, 120 (17)
May	326, 43 (13)	176, 37 (21)	139, 21 (15)	143, 11 (08)	784, 112 (14)
June	268, 51 (19)	167, 29 (17)	117, 13 (11)	169, 14 (08)	721, 107 (15)
July	198, 50 (25)	171, 33 (19)	131, 26 (20)	119, 16 (13)	619, 125 (20)
August	304, 88 (29)	134, 25 (19)	128, 28 (22)	134, 7 (05)	700, 148 (21)
September	227, 81 (36)	137, 29 (21)	103, 13 (13)	149, 20 (13)	616, 143 (23)
October	295, 91 (31)	169, 44 (26)	149, 22 (15)	177, 17 (10)	790, 174 (22)
November	181, 51 (28)	130, 30 (23)	113, 8 (07)	137, 17 (12)	561, 106 (19)
December	177, 43 (24)	149, 33 (22)	133, 19 (14)	124, 14 (11)	583, 109 (19)
Total	2,896, 662 (23)	1,994, 390 (20)	1,598, 242 (15)	1,699, 192 (11)	8,187, 1486 (18)

Table 2: Seasonal prevalence of single and multiple (two or more species of parasites) infection with *Blastocystis hominis* in the United States in 2002-2004

Month	Specimens examined	Specimens Infected (%)		No. (% Prevalence) of other parasites in multiple infections*									
		Single	Multiple	AL	CM	CC	CP	DF	EN	EC	EH/ED	GL	IB
Jan.	443	67 (15)	13 (3)	0	0	0	2 (15)	2 (15)	4 (31)	3 (23)	2 (15)	0	0
Feb.	470	46 (10)	8 (2)	0	0	0	3 (38)	0	3 (38)	1 (12)	1 (12)	0	0
March	492	61 (12)	24 (5)	1 (4)	1 (4)	2 (8)	6 (26)	0	7 (29)	2 (8)	2 (8)	1 (4)	2 (8)
April	488	60 (12)	19 (4)	0	2 (10)	0	8 (42)	0	3 (16)	0	3 (16)	0	3 (16)
May	458	53 (12)	16 (3)	1 (6)	1 (6)	2 (12)	5 (31)	0	2 (12)	1 (6)	4 (25)	0	0
June	453	47 (10)	9 (2)	0	1 (11)	0	4 (44)	0	0	0	2 (22)	0	2 (22)
July	421	63 (15)	12 (3)	0	0	2 (17)	6 (50)	0	3 (25)	0	0	1 (8)	0
Aug	396	46 (12)	14 (3)	0	0	1 (7)	6 (43)	0	4 (29)	3 (21)	0	0	0
Sept.	389	52 (13)	10 (3)	0	0	0	3 (30)	0	1 (10)	2 (20)	3 (30)	1 (10)	0
Oct.	495	67 (13)	16 (3)	0	0	0	4 (25)	1 (6)	3 (19)	1 (6)	5 (31)	2 (12)	0
Nov.	380	44 (12)	11 (3)	0	1 (9)	1 (9)	3 (27)	0	2 (18)	2 (18)	1 (9)	0	1 (9)
Dec.	406	55 (13)	11 (3)	0	4 (36)	0	5 (45)	0	0	0	1 (9)	0	1 (9)
Total	5,291	661 (12)	163 (3)	2 (1)	10 (6)	8 (5)	55 (34)	3 (2)	32 (20)	15 (9)	24 (15)	5 (3)	9 (5)

*AL = *Ascaris lumbricoides*; CM = *Chilomastix mesnili*; CC = *Cyclospora cayetanensis*; CP = *Cryptosporidium parvum*; DF = *Dientamoeba fragilis*; EN = *Endolimax nana*; EC = *Entamoeba coli*; EH/ED = *Entamoeba histolytica/Entamoeba dispar*; GL = *Giardia lamblia*; IB = *Iodamoeba butchlii*

Table 3: Sex and age distribution of *Blastocystis hominis* cases in the United States in 2002-2004

Age	Males			Female			Total		
	Examined	Infected	Prevalence (%)	Examined	Infected	Prevalence (%)	Examined	Infected	Prevalence (%)
0-9	304	37	15	108	7	6	412	44	11
10-19	125	21	17	109	10	9	234	31	13
20-29	142	24	17	279	44	16	421	68	16
30-39	221	34	15	639	96	15	860	130	15
40-49	386	67	17	998	181	18	1,384	248	17
50+	519	103	20	1,461	200	14	1,980	303	15
Total	1,697	286	17	3,594	538	15	5,291	824	16

(Table 2). *Cryptosporidium parvum* was the most frequent parasite observed concurrently with *B. hominis*. *Endolimax nana* and *Entamoeba histolytica/E. dispar* ranked second and third. The overall prevalence of single vs. multiple infections did not show marked seasonality.

Sex and Age Distribution

About twice as many women (3,594) as men (1,697) submitted stool specimens for parasite testing between 2002 and 2004. They, however, had slightly less frequent infections with *B. hominis* (15%) than men (17%). Prevalence of infection increased by age in males and in females up to age 40-49. The youngest age group was the least frequently infected. Youngest males were more than twice as frequently infected (15%) as females (6%) (Table 3).

Geographical Distribution

The geographical distribution of *B. hominis* in 48 states and District of Columbia by patient sex for 2002-2004 is shown in (Table 4). More patients from California and Arizona were tested for parasites than from any other state. In most states where an adequate sample size (more than 100 patients) of both sexes was examined, infection prevalence were comparable between males and females. Patients from coastal states were more frequently infected with *B. hominis* than patients from land-locked states (Table 4).

Table 4: Nationwide prevalence of *Blastocystis hominis* infection by state and patient sex 2002-2004*

	Males			Females			Total		
	Examined	Infected	Prevalence (%)	Examined	Infected	Prevalence (%)	Examined	Infected	Prevalence(%)
Alabama	2	0	0	14	2	14	16	2	13
Alaska	2	0	0	14	2	14	16	2	13
Arizona	274	36	13	476	61	13	750	97	13
Arkansas	10	1	10	25	3	12	35	4	11
California	531	112	21	797	151	19	1,328	263	20
Colorado	41	8	20	91	16	18	132	24	18
Connecticut	7	1	14	25	2	8	32	3	9
Delware	0	0	0	0	0	0	0	0	0
Dist of Columbia	1	0	0	5	0	0	6	0	0
Florida	40	12	30	106	13	12	146	25	17
Georgia	7	2	29	31	4	13	38	6	16
Hawaii	12	4	33	22	3	14	34	7	21
Idaho	7	0	0	10	3	30	17	3	18
Illinois	69	6	9	327	15	5	396	21	5
Indiana	72	4	6	132	18	13	204	22	11
Iowa	33	7	21	97	14	14	130	21	16
Kansas	3	0	0	8	0	0	11	0	0
Kentucky	9	2	22	8	2	29	17	4	24
Louisiana	4	1	25	8	0	0	12	1	8
Maine	8	3	38	272	54	20	280	57	20
Maryland	15	3	20	38	7	18	53	10	19
Massachusetts	16	2	13	56	4	7	72	6	8
Michigan	21	1	50	48	5	10	69	6	9
Minnesota	9	1	11	14	1	7	23	2	9
Mississippi	3	0	0	2	0	0	5	0	0
Missouri	2	0	0	13	1	8	15	1	7
Montana	11	1	9	14	3	21	25	4	16
Nebraska	5	1	20	4	1	25	9	2	22
Nevada	15	3	20	28	4	14	43	7	16
New Hampshire	2	1	50	22	6	27	24	7	29
New Jersey	19	2	11	42	8	19	61	10	16
New Mexico	57	16	28	107	20	19	164	36	22
New York	81	16	20	170	46	27	251	62	25
North Carolina	3	2	67	11	2	18	14	4	29
North Dakota	0	0	0	0	0	0	0	0	0
Ohio	11	1	9	38	9	24	49	10	20
Oklahoma	3	1	33	3	0	0	6	1	17
Oregon	140	21	15	141	27	19	181	48	27
Pennsylvania	27	2	7	81	12	15	108	14	13
Rhode Island	0	0	0	9	1	11	9	1	11
South Carolina	1	0	0	9	2	22	10	2	20
South Dakota	3	0	0	4	0	0	7	0	0
Tennessee	0	0	0	24	0	0	24	0	0
Texas	55	4	7	126	9	7	181	13	7
Utah	2	0	0	10	2	20	12	2	17
Vermont	1	0	0	3	0	0	4	0	0
Virginia	7	2	29	36	1	3	43	3	7
Washington	39	4	10	45	3	7	84	7	8
West Virginia	0	0	1	0	0	2	0	0	
Wisconsin	15	3	20	25	1	4	40	4	10
Wyoming	1	0	0	2	0	0	3	0	0
Total	1,697	286	17	3,594	538	15	5,291	824	16

*No specimens were examined from the states of Delaware and North Dakota

Table 5: Seasonal distribution of symptoms in 824 patients infected with *Blastocystis hominis* in the United States in 2002-2004

Month	Infected patients	Asymptomatic patients (%)	Symptomatic patients (%)	Types of symptoms (%)*		
				GI	Non-GI	Both
January	80	21 (26)	59 (74)	46 (78)	16 (27)	10 (17)
February	54	17 (31)	37 (69)	33 (89)	13 (35)	11 (30)
March	85	24 (28)	61 (72)	49 (80)	26 (43)	19 (31)
April	79	25 (32)	54 (68)	43 (80)	22 (41)	12 (22)
May	69	19 (28)	50 (72)	40 (80)	23 (46)	16 (32)
June	56	18 (32)	38 (68)	32 (84)	19 (50)	13 (34)
July	75	19 (25)	56 (75)	40 (71)	21 (37)	13 (23)
August	60	10 (17)	50 (83)	38 (76)	27 (54)	13 (26)
September	62	14 (23)	48 (77)	34 (71)	22 (46)	9 (18)
October	83	28 (34)	55 (66)	41 (75)	19 (35)	10 (18)
November	55	17 (31)	38 (69)	23 (61)	12 (32)	7 (18)
December	66	16 (24)	50 (76)	34 (68)	17 (34)	13 (26)
Total	824	228 (28)	596 (72)	453 (76)	237 (40)	146 (24)

*Prevalence rates are higher than 100% because symptomatic patients often have more than one symptom (Table 6 and 7)

Table 6: Frequency of reported intestinal symptoms associated with single infections of *Blastocystis hominis* in 596 symptomatic patients, 2002-2004

Symptoms	Occurrences (% of total occurrences)*		
	Males	Females	Total
Bleeding	2 (1)	12 (1)	14 (1)
Bloating	23 (17)	131 (16)	154 (16)
Constipation	13 (10)	86 (10)	99 (10)
Cramping	8 (6)	47 (6)	55 (6)
Diarrhea	24 (18)	173 (21)	197 (20)
Flatulence	22 (16)	129 (15)	151 (16)
Foul Order	1 (1)	10 (1)	11 (1)
IBS	1 (1)	15 (2)	16 (2)
Indigestion	4 (3)	13 (2)	17 (2)
Irregularity	6 (14)	25 (3)	31 (3)
Leaky gut	0 (0)	1 (0)	1 (0)
Malabsorption	9 (7)	33 (4)	42 (4)
Mucus	3 (2)	10 (1)	13 (1)
Rectal itching	7 (5)	56 (7)	63 (6)
Stomach Ache	14 (10)	90 (11)	104 (11)
Vomiting	0 (0)	6 (1)	6 (1)
Total	137 (100)	837 (100)	974 (100)

*The actual number of patients involved can not be shown because of the multiplicity of symptoms often reported by individual symptomatic patients

Symptoms

A symptom is herein defined as any change in normal body function due to direct parasite action (invasiveness and tissue damage due to parasite feeding or migration) or indirect action (from parasite metabolic byproducts and toxic secretions). Of a total of 824 patients infected with *B. hominis* during 2002-2004, 596 (72%) were symptomatic (Table 5). The relative frequency of symptomatic cases was highest in August and low in February, April, June, October and November. The prevalence of gastro-intestinal symptoms was higher (76%) than extra-intestinal symptoms (40%) and was highest in spring and early summer than during the rest of the year (Table 5).

The most common intestinal symptom was diarrhea with bloating and flatulence ranking second and third. Women reported intestinal symptoms much more frequently (837 times) than men (137 times) far exceeding the ratio of men: women tested of 1: 2 (Table 6). The most common

Table 7: Frequency of reported extra-intestinal symptoms associated with single infections of *Blastocystis hominis* in 596 symptomatic patients, 2002-2004

Symptoms	Occurences (% total occurences)*		
	Males	Females	Total
Abnormal skin	11 (12)	34 (9)	45 (9)
Allergies	6 (7)	29 (7)	35 (7)
Brain fog	6 (7)	21 (5)	27 (6)
Chills/sweat	0 (0)	5 (1)	5 (1)
Depression	6 (7)	15 (4)	21 (4)
Dizziness	1 (1)	10 (3)	11 (2)
Fatigue	26 (29)	126 (32)	152 (32)
Fever/headache	5 (6)	38 (10)	43 (9)
Fibromyalgia	1 (1)	5 (1)	6 (1)
Hunger	1 (1)	2 (0)	3 (1)
Insomnia	1 (1)	6 (1)	7 (1)
Joint pain	3 (3)	27 (7)	30 (6)
Muscle pain	5 (6)	5 (1)	10 (2)
Nausea	9 (10)	28 (7)	37 (8)
Sinus problems	1 (1)	7 (2)	8 (2)
Swelling	3 (3)	13 (3)	16 (3)
Weight change	3 (3)	18 (5)	21 (4)
Total	88 (100)	389 (100)	477 (100)

*The actual number of patients involved can be shown because of the multiplicity of symptoms often reported by individual symptomatic patients

extra-intestinal symptom reported was fatigue with fever/headache and skin abnormalities (allergic dermatitis) ranking a distant second and third (Table 7). Women reported extra-intestinal symptoms considerably more frequently (389 times) than men (88 times).

Discussion

The reported decreasing annual prevalence rate of *B. hominis* from 23% in 2000 to 11% in 2004 (Table 1) appears to reflect a genuine national trend of decreasing prevalence of the most common intestinal parasite in the United States (Amin, 2002). This is the first such a report in the United States. During that period, 16,374 fecal specimens from 8,187 patients were examined using the same methods of collecting, processing and evaluation of specimens. A comparison with other reference points in time can not be made as no other comparable large scale studies using the same procedures exist. For example, results reported by nation wide state diagnostic laboratories in 1987 show a 2.6% *B. hominis* prevalence (Kappas *et al.*, 1994) while a large laboratory in North Carolina reported a 15% prevalence in 1995 (Lee, 1995). Both prevalence rates, especially the first, represent a serious underestimate because the formalin-ethyl acetate (FEA) or trichrome (T) methods were commonly used. These two methods were shown to be considerably less efficient in detecting and identifying parasites in fecal specimens (Amin, 2000). That the 2.6% prevalence in the 1987 reports by state diagnostic laboratories (Amin, 2000) represents a gross under estimate is confirmed by a large 1982-1984 retrospective study, also using the same FEA and T methods, which reported a *B. hominis* prevalence of 12.2% (Garcia *et al.*, 1984).

The observed seasonal prevalence rates over a period of four years is reported herein for the first time thus no comparisons can be made. The increased overall rates of 20-23% between July and October (Table 1) possibly reflect increased transmission during warm and wet summers. These dates do not essentially negate possible spring/summer peaks. Exposure, experiencing symptoms, seeking

medical help and testing would probably explain this time lag. This observation is supported by the fact that the highest prevalence of patients with symptoms was observed between July and September (Table 5). High prevalence rates were also observed in other months in individual years, e.g., in October-December (2000, 2002) (Table 1).

The seasonality of single *B. hominis* infections vs. multiple infections involving 10 other species of parasites is reported herein for the first time. Single or multiple infections did not show any marked seasonality. A relatively higher prevalence of patients with single infections was noted in January and July and of patients with multiple infections in March. The prevalence of *C. parvum*, the most frequent concurrent parasite, was highest in April and June-August (Table 2). An increase in spring prevalence of *C. parvum* was previously observed and attributed to warm wet spring weather (Amin, 2002; Inunga *et al.*, 2000; Current and Garcia, 1991). The next two most frequent concurrent parasites, *E. nana* and *E. histolytica/E. dispar* also showed relatively higher prevalence in spring and summer despite their recovery in small numbers. These concurrent infections are reported here for the first time.

The sex and age distribution of *B. hominis* cases (Table 3) is reported here for the first time in the United States. Only Garcia *et al.* (1984) briefly stated that “the sex age... and symptoms in family members were no different in the *B. hominis* group.” The considerably larger number of females (3,594) than males (1,697) submitting specimens for testing may reflect the fact that females appear to experience and/or report symptoms relatively more often than males (Table 6 and 7). On the average, however, females had relatively lower infections prevalence than males. This difference is clearly attributed to the considerably lower prevalence rates in 0-9, 10-19 and 50+ year old females compared to males in the same age groups. Youngest and oldest females show the lowest prevalence of *B. hominis* infections than females of other age groups and than males of the same age. The overall prevalence rate in both sexes shows a gradual increase by age up to age 40-49 then a decline after age 50 attributed to the female-specific rate.

The geographical distribution of *B. hominis*, by state and patient sex, is reported herein for the first time in the United States. Among states with more than 100 patients tested, the coastal states of California, Oregon and New York and Maine had the highest prevalence rates (Table 4). Land-locked mid-western states such as Illinois, Indiana and Iowa, however, show considerably low prevalence rates. The moderating effect of the ocean on the weather in coastal states compared to the Midwestern states appears to be involved in the above differences in prevalence.

This proposed interpretation is supported by the fact that *B. hominis* has fecal-oral waterborne and zoonotic transmission routes (Leelayoova *et al.*, 2004; Garcia, 2001) requiring favorable environmental condition for the external transmission of the thick-walled cysts (Singh *et al.*, 1995). Patients from the adjacent states of Arizona, New Mexico and Texas with comparable landscape and weather conditions, however, had prevalence rates of 13, 22 and 7%, respectively (Table 4). It is not certain what other variables are at play here.

The seasonal distribution of symptoms reported by patients singly infected with *B. hominis* is reported here for the first time (Table 5). Symptomatic patients were most prevalent in July-September and patients reporting GI symptoms only were most prevalent in February-June corresponding to the warmer months of year. About one third of singly infected patients were asymptomatic. The prevalence of asymptomatic cases appears to be common (Amin, 1997; Garcia *et al.*, 1984; Senay and MacPherson, 1990; Leelayoova *et al.*, 2004; Udkow and Markell, 1993; Hussain Qadri *et al.*, 1989) and varied between 30% (Amin, 2002; Garcia *et al.*, 1984) and most cases (Senay and MacPherson, 1990; Leelayoova *et al.*, 2004). This report and others (Amin, 1997; Garcia *et al.*,

1984; Lee, 1995; Leelayoova *et al.*, 2004; Garcia, 2001; Hussain *et al.*, 1989; Russo *et al.*, 1988) also demonstrate that *B. hominis* can cause a variety of gastrointestinal and other diseases. The expressed different outcomes of *B. hominis* can be plausibly explained by its genetic diversity. Up to five genetic subgroups of *B. hominis* associated with corresponding pathogenicity have been isolated from symptomatic and asymptomatic patients (Boreham *et al.*, 1992; Mueller, 1994; Böhm *et al.*, 1997; Clark, 1997; Hoevers *et al.*, 2000). Environmental factors such as geography, seasonal factors and weather (this study) and genetic diversity (Senay and MacPherson, 1990; Bohm *et al.*, 1997; Clark, 1997; Hoevers *et al.*, 2000) may be associated with prevalence rates and with the pathogenicity and symptomology of *B. hominis* infections. Canadian “strains” appear to be non-pathogenic (Senay and MacPherson, 1990). *Blastocystis hominis* may well be a species complex (Amin, 1997). While subgroups of *B. hominis* in their vacuolar, granular and amoeboid forms (Zierdt, 1988) appear to be morphologically indistinguishable in diagnostic testing, cysts of two forms, one with an outer fibrillar coat and one without it, were observed with electron microscopy (Zaman *et al.*, 1997).

Females experienced and/or reported considerably more intestinal symptoms than males. The most commonly reported intestinal symptom in both sexes was diarrhea with bloating and flatulence ranking second and third (Table 6). These three symptoms and others related to dysentery, e.g., colitis, cramping, stomachache and constipation, were often reported in association with *B. hominis* infections (Amin, 1997) but not quantified (Garcia *et al.*, 1984; Conteas *et al.*, 1998; Lee, 1995; Leelayoova *et al.*, 2004; Russo *et al.*, 1988). The relationship with irritable bowel syndrome (IBS) was well established (Yakoob *et al.*, 2004; Giacometti *et al.*, 1999; Collins, 1994) even though it was poorly reported in our study. IBS patients were shown to have high levels of specific IgG antibodies against *B. hominis* and of cytokines that include interleukin-1 which inhibits the absorption of sodium and water and may thus cause diarrhea (Collins, 1994).

Fatigue was the most commonly reported extra-intestinal symptom by both males and females (Table 7) and its prominence among the non-specific symptoms associated with *B. hominis* infections has been rarely reported (Amin, 1997). Other non-specific symptoms were also infrequently reported (Garcia *et al.*, 1984; Leelayoova *et al.*, 2004; Garcia, 2001; Yakoob *et al.*, 2004). The second most frequently reported extra-intestinal symptom by both males and females in our study was skin abnormalities (allergic skin dermatitis). A statistically significant association between *B. hominis* infection and cutaneous allergies and disease has been established (Moqbel and Pritchard, 1990). In this PCI experience, skin abnormalities in most patients infected with *B. hominis* have resolved upon the successful treatment of the parasite. This relationship with skin condition is probably due to the toxic allergenic nature to the parasite’s metabolic byproducts. Other species of intestinal parasites may also cause similar skin pathology (Moqbel and Pritchard, 1990).

Other symptoms associated with *B. hominis* infections that were not reported in this study included chronic HBV infection (Chen *et al.*, 2003), infectious arthritis (*B. hominis* found in synovial fluid of arthritic patients) (Krueguer *et al.*, 1994), unspecific vaginitis (*B. hominis* found in patient’s vagina) (Wolynska and Soroczan, 1972) and patients immune compromised with various disorders such as acquired immunodeficiency syndrome, poorly controlled diabetes and leukemia (Llibre *et al.*, 1989; Sheehan and Ulchaker, 1990; Garavelli *et al.*, 1991; Cirioni *et al.*, 1999).

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