ORIGINAL ARTICLE

Paediatrician and Caregiver Awareness of Cryptosporidiosis and Giardiasis in Children: US Survey Responses

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Impacts

- Currently, there appears to be no published information concerning the awareness and knowledge on diarrhoea caused by *Cryptosporidium* spp. or *Giardia* among US paediatricians and caregivers of young children.
- Our survey results indicate that there are gaps in awareness and knowledge concerning childhood diarrhoea caused by these parasites in both of these groups, in particular with respect to some important aspects related to parasite control and transmission.
- A key to minimizing the burden and impact of these parasitic infections in the community may lie in the improvement of awareness among paediatricians, given their pivotal position in communicating best practice to caregivers of the children affected by parasitic-induced diarrhoea, as well as directly to caregivers, using appropriate educational methods.

Keywords:
Giardiasis; cryptosporidiosis; paediatrician; caregiver; survey

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Summary

There appears to be no published information concerning the awareness and knowledge about diarrhoea caused by *Cryptosporidium* spp. or *Giardia lamblia* among US paediatricians and caregivers of young children. Two concurrent, separate surveys were conducted among paediatricians and caregivers (~1000 respondents in each survey) of children ages 1–12 years concerning their knowledge, perceptions and attitudes in the diagnosis and treatment of parasitic diarrhoea. Awareness of parasite-induced diarrhoea was low for specific aspects among both paediatricians and caregivers. Educational efforts to improve awareness on the appropriate clinical presentation, management and treatment of cryptosporidiosis and giardiasis in children with persistent diarrhoea should be undertaken.

Introduction

Giardia lamblia (also called *Giardia intestinalis* or *duodenalis; herein after referred to as Giardia*) and *Cryptosporidium* spp. (C. *parvum* and *C. hominis* being the most common in humans) are leading causes of parasite-induced persistent diarrhoeal disease in children (Thompson, 2000; Chen et al., 2002; Fletcher et al., 2012) and are important diseases according to the World Health Organization (Savioli et al., 2006). In the United States, *Giardia* is the leading cause of human intestinal parasitic infections (Kappus et al., 1994) and, although less frequently encountered than *Giardia*, *Cryptosporidium* spp. is also a major cause of parasite-induced diarrhoea (Chen et al., 2002; Fletcher et al., 2012). Paediatric infections with intestinal parasites such as *Giardia* and *Cryptosporidium* spp. occur more frequently in the US than commonly perceived and may therefore have been understudied in the past (Barry et al., 2013). It is therefore believed that general awareness of these persistent parasitic infections among healthcare professionals and patients may be low. A recent Centers for Disease Control and Prevention (CDC) survey of obstetrician-gynaecologists on their clinical and epidemiologic knowledge of cryptosporidiosis in pregnancy found a low level of knowledge with respect to all aspects of cryptosporidiosis, particularly with respect to diagnosis,

treatment and prevention strategies (Domjahn et al., 2014). We are not aware of any similar survey data that assesses the general awareness of *Giardia* and/or *Cryptosporidium* spp. in any other physician group, in particular paediatricians, or among caregivers of paediatric patients.

Two concurrent, separate surveys were conducted among US paediatricians and caregivers, respectively, for children ages 1–12 years concerning knowledge, perceptions and attitudes in the diagnosis and treatment of parasitic diarrhoea. The aim of this publication is to report those aspects of these surveys related to public health awareness among these target groups and identify areas that might be potentially improved.

Materials and Methods

Two online surveys were conducted during July 1–15, 2014, one for paediatricians and one for caregivers of children 1 to 12 years of age. The surveys were commissioned by Atom Strategic Consulting, LLC and Harris Poll was responsible for the conduct and completion of the surveys, their submission to potential participants, data collection, result tabulation, statistical analysis and final reporting to the sponsor (Lupin Pharmaceuticals Inc., Baltimore, MD, USA).

The surveys were designed by Atom Strategic Consulting, LLC (Randolph, NJ, USA) and Harris Poll in collaboration with academic physicians of diverse specialty focus including paediatric infectious disease, paediatric gastroenterology and epidemiology (The Persistent Diarrhea Working Group). Input on survey creation was also provided by staff from the CDC (see Acknowledgements).

Paediatrician survey

Potential survey participants were identified from Harris Poll's national general paediatrician database (N = ~12 000) and 3286 were randomly invited via computer algorithm to participate via direct e-mail to achieve a target of 1000 respondents. Soft quotas were set for paediatric infectious diseases specialists (n = 30) and paediatric gastroenterologists (n = 30) and the majority as general paediatricians (n = 940) [to a maximum of 1000]. If the soft quota was met for one or both of the specific subspecialties, no additional responses would be accepted for that subspecialty. Likewise, the total target response of 1000 would be allowed to be met even if the subspecialty soft quota was below target. Survey enrolment was competitive. Once the target sample was achieved, all others were excluded even though they might have been willing to complete the survey. Respondents were included based on screening questions and the following criteria: they had to be practicing in one of the target specialties (paediatrics, paediatric gastroenterology or paediatric infectious diseases), see at least one paediatric patient (age 1–12 years) per week with diarrhoea and been practicing clinical medicine for at least 2 years. Those who completed the survey were offered a modest honorarium for their time.

Survey questions were organized such that, after the screening questions, general questions about causes of diarrhoea and treatment approach were asked first, followed by specific questions about parasite awareness. Questions specific to familiarity with and barriers to using the antiparasitic agent nitazoxanide (Lupin Pharmaceuticals, Inc., Baltimore, MD) were asked, as well as general knowledge on parasite treatment guidelines. The survey concluded with a demographic assessment. There were a maximum of 44 survey questions that included four screening questions, five demographic questions and 35 questions concerning diarrhoea (on causes, definition, treatment and parasite awareness), of which five had follow-up questions that would only require completion based on the response of the originating question.

Caregiver survey

Potential survey participants were identified from Harris Poll's national general population database, who were invited to take part via direct e-mail to achieve a target of 1000 respondents. A total of 141 300 contacts were sent until the survey target maximum was met. As with the paediatrician survey, enrolment was competitive. Once the target sample was achieved, all others were excluded even though they might have been willing to complete the survey. Respondents were included based on screening questions and had to be US residents and to have a child or children living in the home who were 1–12 years of age. Eligible respondents had to be the primary caregiver for the child/children living in their home, the person primarily responsible for taking the child/children to the doctor and the person responsible for making medical decisions for the child/children. To be included in the survey, children within the age specified had to be under the care of the caregiver and had to have suffered from at least one episode of diarrhoea. Those who completed the survey were awarded panel points which they can exchange for items of modest value, in exchange for their time.

After the screening questions, survey questions were organized in the following order: general questions about diarrhoea experience, treatment approach, persistent diarrhoea care and persistent diarrhoea prevention. This was followed specific questions concerning general knowledge on parasites, the caregivers approach to management of diarrhoea and receptivity to treatment options. There were a maximum of 42 survey questions that included eight

screening questions, five demographic questions, five calibration questions for respondent validation and 24 questions concerning paediatric diarrhoea (causes, definition, treatment and parasite awareness).

Data analysis

Data were described descriptively as *n* (%) or mean ± SD for the total respondent cohort for each survey and for pre-selected respondent subgroups. Pre-selected subgroups among paediatricians were defined by their response to survey questions: practice type (solo/group/multispecialty); practice setting (urban/suburban/rural); duration in practice (2–10/11–20/21–30 years); cases of diarrhoea seen weekly (<10–49/50–100/>100); persistent diarrhoea changes suspicion of cause (yes/no); caring for patients with recurrent/prolonged diarrhoea (never or rarely/sometimes/often or frequently); and familiarity with nitazoxanide (never heard of or never prescribed/prescribed in past or currently prescribe).

Pre-selected subgroups among caregivers were defined by their response to survey questions: number of children in home (1/≥2); relationship to child (mother/father/other); heard of *Giardia* (yes/no) heard of *Cryptosporidium* spp. (yes/no); children with diarrhoea should be allowed to swim, attend school, etc. (yes/no); number of times children had diarrhoea ≥3 days (0/1/≥2); receptivity to a 3-day course of treatment (very or somewhat unreceptive/neither receptive nor unreceptive/somewhat or very receptive); and education level (high school or less/college or associate's degree/college graduate/postgraduate). Statistical testing (IBM SPSS software, Armonk, NY, USA) across subgroups only was performed using the *t*-test with $P < 0.05$ considered as statistically significant. There are no specific *P* values to report in the attached tables as subgroup data were not included.

Results

Paediatrician survey

Respondent demographics

Demographics for the 1000 paediatrician respondents are summarized in Table 1. In accord with the initial target survey population, the majority were general paediatricians (95.8%). A small number of paediatric gastroenterologists (2.7%) and paediatric infectious disease specialists (1.4%) were also included, although the target quotas were not met for these groups, and there was one paediatric surgeon. As a result, no subspecialty analysis was attempted and all responders were assessed as a group. Gender distribution was equally balanced. Most were in group practice (64.4%) in a suburban location (60.9%). Their mean duration in practice was 16.7 ± 8.14 years.

Table 1. Paediatrician demographics (*N* = 1000)

Characteristic	*N*	%
Medical specialty		
General paediatrics	958	95.8
Paediatric gastroenterology	27	2.7
Paediatric infectious diseases	14	1.4
Paediatric surgeon	1	0.1
Paediatric patients seen per week		
>100	295	29.5
50–100	521	52.1
10–49	167	16.7
<10	17	1.7
Cases of diarrhoea seen per week		
>25	109	10.9
15–25	282	28.2
5–14	499	49.9
<5	110	11.0
Gender		
Male	506	50.6
Female	494	49.4
Practice type		
Group	644	64.4
Multispecialty	211	21.1
Solo	120	12.0
Other	25	2.5
Practice location		
Suburban	609	60.9
Urban	299	29.9
Rural	91	9.1
Other	1	0.1
Years in practice		
21–30	340	34.0
11–20	393	39.3
2–10	167	16.7

Survey analyses

The survey results for selected primary questions with a public health focus are summarized in Tables 2 and 3. The denominator for per cent calculations is for the total number of respondents (*N* = 1000).

Only one in 10 paediatricians consider parasites as the cause of diarrhoea and this is only after diarrhoea is determined to be persistent by the paediatrician's definition. Once parasites are top of mind in the differential, the majority (83.0%) of paediatricians would consider testing for parasites in children when diarrhoea was persistent and nearly all the remainder (13.9%) would only consider parasite testing after their initial treatment was ineffective. If they considered parasites as the cause of diarrhoea, paediatricians would most commonly test for both *Cryptosporidium spp.* and *Giardia* (70.9%) or *Giardia* alone (12.1%) and then initiate therapy after confirmation. Almost without exception (98.7%), respondents had tested a child with diarrhoea for parasites.

Table 2. Paediatrician survey – parasite testing

Questions/answers	*N*	%
When a young patient presents with diarrhoea, what in your experience is the most likely cause? (*N* = 1000)		
Viruses	950	95.0
Bacteria	8	0.8
Parasites	0	0
Food intolerance	34	3.4
Chemical exposure	0	0
Medication adverse event	6	0.6
Metabolic disorder such as coeliac disease	0	0
Other	2	0.2
When you encounter persistent diarrhoea in a young patient and your suspicion about what may be causing the diarrhoea changes, what do you think of first that may be causing the diarrhoea? (*N* = 940)		
Viruses	83	8.8
Bacteria	371	39.5
Parasites	106	11.3
Food intolerance	259	27.6
Chemical exposure	1	0.1
Medication adverse event	21	2.2
Metabolic disorder such as coeliac disease	56	6.0
Other	43	4.6
When would you consider testing for parasites? (*N* = 1000)		
When diarrhoea is persistent by my definition	830	83.0
When my initial treatment is not effective	139	13.9
I never test for parasite	3	0.3
All other answers specified verbally by respondents combined	28	2.8
If you are considering parasites as the cause of diarrhoea, how do you approach treatment and diagnosis? (*N* = 1000)		
I watch and wait as parasite caused diarrhoea usually clears on its own	17	1.7
I treat empirically with antibiotics without testing for parasites	6	0.6
I test for *Cryptosporidium* and then initiate drug therapy after confirmation	14	1.4
I test for *Giardia* and then initiate drug therapy after confirmation	121	12.1
I test for both *Cryptosporidium* and *Giardia* and initiate drug therapy after confirmation	709	70.9
I test for both *Cryptosporidium* and *Giardia* and initiate empiric drug therapy right away	37	3.7
I test for both *Cryptosporidium* and *Giardia* but do not initiate treatment after confirmation (watch and wait)	96	9.6
Have you ever tested a child with diarrhoea for parasites? (*N* = 1000)		
Yes	987	98.7
No	13	1.3
Which tests have you requested for diagnosing patients with cryptosporidiosis in the past? (*N* = 1000)[a]		
Immunochromatographic card/rapid card test (<30 min)	60	6.0
Routine faecal O&P test	892	89.2
Specific cryptosporidiosis testing such as PCR or other DNA-based testing	309	30.9
Not applicable – I have not ordered patient testing for cryptosporidiosis in the past	26	2.6
In your experience is a negative test for *Cryptosporidium* always 100% accurate? (*N* = 1000)		
Yes	77	7.7
No	543	54.3
I don't know	380	38.0
Is cryptosporidiosis a reportable disease in your state? (*N* = 1000)		
Yes	330	33.0
No	119	11.9
I don't know	551	55.1
Which tests have you requested for diagnosing patients with *Giardia* in the past? (*N* = 1000)[a]		
Antigen testing for *Giardia*	435	43.5
Specific *Giardia* testing such as PCR or other DNA-based testing	269	26.9
Routine faecal O&P test	823	82.3
Not applicable – I have not ordered testing for *Giardia* in the past year	16	1.6
Is giardiasis a reportable disease in your state? (*N* = 1000)		
Yes	280	28.0
No	253	25.3
I don't know	467	46.7

O&P, ova and parasite; PCR, polymerase chain reaction.
Some percentages do not add up to 100% exactly due to rounding.
[a]Multiple choice response.

Table 3. Paediatrician survey – parasite awareness

Questions/answers	*N*	%
Which of the following would you consider to be a valid concern with regard to parasite-induced infection in a child? (*N* = 1000)[a]		
It can lead to delayed recognition and treatment	655	65.5
It can result in prolonged morbidity for the child	735	73.5
It can lead to lost productivity and general inconvenience for caregivers	702	70.2
It can result in transmission to others due to delayed or lack of treatment	833	83.3
Other (specify)	4	0.4
Does the burden of caring for a patient with persistent diarrhoea factor into your decision to treat? (*N* = 1000)		
Yes	547	54.7
No	321	32.1
I do not think about this issue	132	13.2
In your opinion, typically how distressed would you say children are when they experience persistent diarrhoea? (*N* = 1000)		
Not at all distressed	32	3.2
Somewhat distressed	511	51.1
Distressed or fairly distressed	329	32.9
Very distressed	113	11.3
Extremely distressed	15	1.5
Do you feel that transmission of parasites is of concern for…? (*N* = 1000)[a]		
Patient to caregiver or other family member transmission	893	89.3
Patient to pet transmission	160	16.0
Pet to patient transmission	365	36.5
I feel such transmission risk is low and do not worry about it	58	5.8
Alcohol-based hand gels and sanitizers effectively inactivate? (*N* = 1000)		
Cryptosporidium	10	1.0
Giardia	45	4.5
Both	232	23.2
Neither	333	33.3
I do not know	380	38.0
The CDC and AAP recommend that patients diagnosed with cryptosporidiosis abstain from swimming until when? (*N* = 1000)		
Until they complete a 3-day treatment course of nitazoxanide (Alinia)	96	9.6
Until their diarrhoea has completely resolved	432	43.2
Until 2 weeks after their diarrhoea has completely resolved	430	43.0

CDC, centers for disease control and prevention; AAP, American Academy of Pediatrics.
[a]Multiple choice response.

With respect to suspected cryptosporidiosis testing, most paediatricians (89.2%) had requested routine faecal ova and parasite (O&P) testing in the past and a significant proportion had requested specific cryptosporidiosis testing such as polymerase chain reaction (PCR) or other DNA-based testing (30.9%) or immunochromatographic card/rapid card testing (6.0%). Only 7.7% of paediatricians believed that a negative *Cryptosporidium* spp. test is always 100% accurate. Just over half (55.1%) of respondents did not know whether cryptosporidiosis was a reportable disease in their state. With respect to testing for suspected giardiasis, most paediatricians (82.3%) had requested routine faecal O&P testing in the past and significant proportions had requested *Giardia* antigen testing (43.5%) and specific PCR or other DNA-based testing (26.9%). Just under half (46.7%) of respondents did not know whether giardiasis was a reportable disease in their state. Subgroup analysis showed that paediatricians who never or rarely care for patients with recurrent/prolonged diarrhoea were significantly ($P < 0.05$) more likely than those caring for these patients more frequently to not know if testing was accurate or if the disease was reportable in their state for both cryptosporidiosis and giardiasis, respectively.

A high proportion of paediatricians (83.3%) considered transmission to others due to delayed or lack of treatment as a valid concern with regard to parasite-induced infection in a child: this was followed by prolonged morbidity for the child (73.5%), lost productivity and general inconvenience for caregivers (70.2%) and delayed recognition and treatment (65.5%). About half (54.7%) of paediatricians stated that the burden of caring for a patient with persistent diarrhoea factored into their decision to treat. Most paediatricians (84.0%) considered children were somewhat to fairly distressed by their experience with persistent diarrhoea. Paediatricians practicing for >20 years were significantly ($P < 0.05$) more likely to say children with persistent diarrhoea are very/extremely distressed than those in practicing for 11–20 or 2–10 years (17.6% versus 11.2% versus 9.0%,

Table 4. Caregiver demographics (N = 1048)

Characteristic	N	%
Gender		
Male	432	41.2
Female	616	58.8
No. of children in household		
1	536	51.2
2	357	34.0
≥3	155	14.8
Residential setting		
Suburban	540	51.6
Urban	297	28.3
Rural	208	19.9
Other	2	0.2
Relationship to child		
Mother	581	55.4
Father	401	38.3
Grandparent	49	4.7
Other	17	1.6
Marital status		
Married	734	70.0
Single, never married	145	13.8
Living with partner	90	8.6
Divorced	52	5.0
Separated	18	1.7
Widowed	9	0.9
Employment status		
Employed	741	70.7
Not employed	307	29.3
Education		
Some college/associate's degree	330	31.5
High school or less	323	30.8
College graduate	251	24.0
Postgraduate	144	13.7
Ethnicity[a]		
White	681	64.9
Hispanic	155	14.8
African American	133	12.7
Other	76	7.3
Declined to answer	3	0.3

[a]Ethnicity was characterized by Nielsen. The authors acknowledge that this is a mix of both race and ethnicity identifiers.

respectively). Also, paediatricians in a solo practice were significantly ($P < 0.05$) more likely to say children with persistent diarrhoea are very/extremely distressed than those in a group or multispecialty setting (20.8% versus 12.4% versus 9.5%). The majority of paediatricians (89.3%) considered that transmission from patient to caregiver or their family member was a concern followed by transmission from pet to patient (36.5%) and patient to pet (16.0%), whereas 5.8% felt the risk of transmission was low and do not worry about it.

About 1% of paediatricians were aware that alcohol-based hand gels and sanitizers did not inactivate *Cryptosporidium*: 38.0% did not know and 33% thought they did inactivate both parasites. Just under half of paediatricians (43.0%) were aware that the CDC/AAP recommends that children diagnosed with cryptosporidiosis should not swim until 2 weeks after their diarrhoea had completely resolved.

Caregiver survey

Respondent demographics

Demographics for the 1048 caregiver respondents are summarized in Table 4. Caregivers were more frequently female (58.8%) and the mother (55.4%). Ethnicity (as characterized by Nielsen) was White (64.9%) followed by Hispanic (14.8%) and African American (12.7%). The authors acknowledge that this is a mix of both race and ethnicity identifiers. About half had one child in the household (51.6%) with the remainder had two (34.0%) or three or more (14.8%) children. Mean caregiver age was 38.4 ± 9.18 years and their mean income was USD 77 570 ± 53 550.

Survey analyses

The survey results for selected primary questions are summarized in Table 5. The denominator for per cent calculations is for the total respondents (N = 1048) unless specified otherwise.

The major sources or resources used by caregivers to learn about best care for children with diarrhoea were the internet (68.8%) and asking a relative (54.0%) with 9.5% specifying no sources/resources: when openly asked to specify verbally any other sources or resources to learn best care, only few respondents specified their child's physician (5.6%) or nurse (3.6%). Almost two-thirds (64.9%) of caregivers stated that they had to stay at home to care for a child with persistent diarrhoea until they were able to return to normal activity, 17.3% had a sitter or other person who could stay with the child at home, and 9.2% were still able to take their child to day care or school where they were able to be cared for. With respect to preventative advice or techniques when a child has persistent diarrhoea, about two-thirds of respondents reported washing their own (75.4%) or child's (72.1%) hands prior to or after risk activities (e.g. food handling, diaper changing, toilet use), just over half kept their child away from child-care settings (57.1%) or did not let their child swim or attend a water park (55.2%), 17.2% reported that their child had never had persistent diarrhoea, and as few as 1.1% did not follow any preventative advice or techniques. Subgroup analysis showed that caregivers who had heard of *Cryptosporidium* were significantly ($P < 0.05$) more likely than those who have not to wash their own or their child's hands, and those who have heard of *Giardia* were significantly ($P < 0.05$)

Table 5. Caregiver survey

Questions/answers	*N*	%
What sources or resources do you use for information to learn how best to care for your child with diarrhoea? (*N* = 1048)[a]		
I look up information on the internet (World Wide Web)	721	68.8
I ask a relative (mother, father, aunt, others) for advice on how to care for my child	566	54.0
I ask a friend or neighbour for advice on how to care for my child	299	21.8
I use information and articles from health magazines	193	18.4
I don't use other sources or resources	100	9.5
All other answers specified verbally by respondents combined	116	11.1
How do you typically arrange care for a child who has persistent diarrhoea? (*N* = 1047[b])		
I have a sitter or other that stays with my child in my home	181	17.3
I am able to leave my child at day care where they are cared for	71	6.8
I am able to take my child to school (pre-school, elementary) where they are cared for	25	2.4
I have to stay at home with my child until they are able to return to normal activity	679	64.9
Other	91	8.7
What prevention advice or techniques have you used when your child has had persistent diarrhoea? (*N* = 1048)[a]		
Wash my hands with soap and water (e.g. before handling food)	790	75.4
Wash my child's hands with soap and water (e.g. after they have diaper changed or use toilet)	755	72.1
Keep my child away from child-care settings (e.g. day care) until diarrhoea has resolved	602	57.1
Do not let my child swim or attend a water park while they still have diarrhoea	578	55.2
I have not used any prevention advice or techniques	12	1.1
My child has never had persistent diarrhoea	180	17.2
All other answers specified verbally by respondents combined	24	2.3
Do you think that children with diarrhoea should be allowed to swim, go to a water park or attend school? (*N* = 1048)		
Yes	60	5.8
No	888	84.7
I don't know	100	9.5
Which of the following activities can lead to *Cryptosporidium* or *Giardia* infection? (*N* = 1048)[a]		
Drinking unfiltered, untreated water from a lake, river or stream	182	17.3
Swallowing recreational water while swimming or playing in a pool, water park, spray ground/splash park, river, lake, ocean	154	14.7
Having contact with persons ill with diarrhoea, particularly those in diapers	141	13.5
By putting something in your mouth or accidentally swallowing something that has come into contact with stool of a person or animal infected with *Cryptosporidium* or *Giardia*	187	17.8
By eating uncooked food contaminated with *Cryptosporidium* or *Giardia*	174	16.6
All of the above	392	37.4
None of the above	11	1.0
I don't know	372	35.5
If you have heard of *Giardia* and/or *Cryptosporidium*, do you believe that alcohol-based hand gels and sanitizers effectively inactivate *Cryptosporidium* and/or *Giardia*? (*N* = 430)		
Yes	176	40.9
No	103	24.0
I don't know	151	35.1
If you have heard of *Giardia* and/or *Cryptosporidium*, the CDC and AAP recommend that patients diagnosed with cryptosporidiosis should not swim until when? (*N* = 430)		
Until they complete a 3-day treatment course of nitazoxanide (Alinia)	72	16.8
Until their diarrhoea has completely resolved	110	25.5
Until 2 weeks after their diarrhoea has completely resolved	116	26.9
None of the above	1	0.2
I don't know	132	30.6
If you have pets in your home, are you concerned about the possibility of your child being infected by a family pet with diarrhoea and/or infecting your pet when you child has diarrhoea? (*N* = 730)		
Yes	204	28.0
No	199	27.2
I don't know	327	44.8

CDC, Centers for Disease Control and Prevention; AAP, American Academy of Pediatrics.
Some percentages do not add up to 100% exactly due to rounding.
[a]Multiple choice response.
[b]Response by one caregiver not recorded.

more likely than those who have not to follow all preventative measures. The majority of caregivers (84.7%) did not believe that children with diarrhoea should be allowed to swim, go to a water park or attend school. Approximately one-third (35.5%) of caregivers did not know which of the activities presented in the survey could lead to *Giardia* or *Cryptosporidium* spp. infection and a similar proportion (37.4%) were aware of all five of the main routes of infection presented in the survey. Subgroup analysis showed that caregivers with some college education or less were significantly ($P < 0.05$) more likely than those with a college degree or postgraduate education to not know which activities lead to infection, and those who had heard of *Cryptosporidium* spp. or *Giardia* were significantly ($P < 0.05$) more likely than those who have not to agree that all five activities can lead to infection.

Among caregivers who had heard of *Giardia* and/or *Cryptosporidium* spp. ($n = 430$), approximately a quarter were aware that alcohol-based hand gels and sanitizers did not inactivate *Giardia* or *Cryptosporidium* spp. (24.0%) or that the CDC/AAP recommend that children diagnosed with cryptosporidiosis should not swim until 2 weeks after their diarrhoea had completely resolved (26.9%).

Among caregivers who had pets in their home ($n = 730$), just over a quarter (28.0%) were concerned about the possibility of cross-infection between pets and children (or *vice versa*) during episodes of diarrhoea in either children or pets compared to a quarter (27.2%) who were not concerned: the remaining respondents (44.8%) did not know. Subgroup analysis showed that caregivers who had heard of *Cryptosporidium* spp. or *Giardia* were significantly more likely than those who have not to be concerned about cross-infection between pets and children (or *vice versa*).

Discussion

The number of respondents in each survey (~1000) was sufficiently large to provide representative samples. The paediatrician survey in particular, with 1000 responders, was over twice as large as any other physician survey we uncovered. The survey analysis of obstetrician-gynaecologists on their clinical and epidemiologic knowledge of cryptosporidiosis in pregnancy included 431 usable responses (Domjahn et al., 2014). There may be a potential for responder bias in both surveys as only about one-third of paediatricians and less than 1% of caregivers contacted were included in the surveys. This was further confounded by the competitive nature of inclusion in the survey and may also have contributed to not meeting the paediatric subspecialty soft quota targets for the paediatrician survey.

While virtually all paediatricians had tested a child with diarrhoea for parasites, the majority (83.0%) would test for parasites when the diarrhoea was persistent but that same majority would not initiate any kind of pharmacotherapy to ameliorate the burden of diarrhoea. Routine faecal O&P testing for *Giardia* (82.3%) and *Cryptosporidium* spp. (89.2%) was the most common test used for diagnosis yet this test has suggested limitations with an important false negative potential; especially if only one stool sample is tested (Branda et al., 2006). It was of some comfort to find that a substantial proportion of paediatrician responders had additionally used other more specific test procedures.

Approximately half of paediatricians (55.1% for cryptosporidiosis and 46.7% for giardiasis) did not know whether these parasitic infections were a reportable disease in their state, which indicates a potential educational opportunity and relative lack of knowledge by paediatricians given that both parasitic infections are nationally notifiable diseases (CDC, 2010a, 2012a). Paediatricians also showed an important gap in their knowledge concerning awareness that alcohol-based hand gels and sanitizers do not effectively inactivate *Cryptosporidium* spp. (CDC, 2014): only 1% of paediatricians were aware that *Cryptosporidium* was inactivated by this infectious disease control method.

In addition, only 43.0% of paediatricians were aware of the CDC/American Academy of Pediatrics recommendation that patients with cryptosporidiosis should abstain from swimming until 2 weeks after their diarrhoea had completely resolved (American Academy of Pediatrics, 2006; CDC, 2015): this compared to an even lower proportion (26.9%) of caregivers aware of this recommendation. The 2-week restriction on swimming also applies to children who have been treated with a 3-day course of nitazoxanide for diarrhoea induced by *Cryptosporidium* spp. (CDC, 2010c), of which about 10% of paediatricians were not aware. With respect to preventative measures when their child had persistent diarrhoea, approximately three-quarters of caregivers were aware of the importance of hand washing with soap and water when performing risk activities such as food handing or toileting, while just over one-half of caregivers would keep their child away from child-care settings or stop allowing them to swim or attend a water park while they still had diarrhoea. It should be better recognized that rigorous hand washing with soap and hot water is a pivotal measure in the control of parasitic infections among contacts of children with diarrhoea (CDC, 2010b, 2012b). With respect to the five main routes of parasite transmission (drinking unfiltered or untreated water, swallowing recreational water, contact with a person with diarrhoea, accidentally putting something in the mouth and eating contaminated food), about one-third (35.5%) of caregivers did not know any of these, while a similar proportion (37.4%) knew all five (CDC, 2010b, 2012b). Both paediatricians and caregivers have a relatively

low awareness of the potential for parasite transmission from patient to pet and *vice versa*.

Giardia infection results from ingestion of faecally contaminated food or water or contact with infected persons or less so with infected animals (CDC 2012c). Faecal-oral transmission can occur in child-care centres and within households (CDC, 2011). Child-care centre outbreaks have been associated with toddler wading pools where diapered children share the same water. Similar transmission can potentially occur at any water park where contact with contaminated water occurs (CDC, 2015). Like other enteric infections, rates of giardiasis increase during warmer months (Barry et al., 2013), likely because of more frequent exposure to contaminated water through swimming or camping. Similarly, *Cryptosporidium* spp. infection also results following ingestion of faecally contaminated food or water or contact with infected persons or animals (CDC, 2011). *Cryptosporidium* spp. is extremely chlorine tolerant and so can survive in a properly chlorinated pool or other treated recreational water venues for more than 10 days (Betancourt and Rose, 2004; Shields et al., 2008; Cantey et al., 2012). This creates a special challenge for outbreaks linked to recreational water such as swimming pools. Like *Giardia*, *Cryptosporidium* spp. transmission can therefore occur at any water park where contact with contaminated water occurs (Dziuban E. J. et al., 2006; CDC, 2015).

Regarding treatment, metronidazole is usually used in routine practice to treat giardiasis, although the tablet formulation can be difficult to administer in children because of paediatric dose requirements, its unpalatable metallic taste when crushed and re-suspended, its association with adverse effects such as nausea, and the need to be administered three times daily for 5–7 days (Gardner and Hill, 2001; Lalle, 2010). Apart from nitazoxanide, there are no other commonly recommended specific treatments for cryptosporidiosis. Nitazoxanide is clinically effective when administered twice daily in a 3-day course in both children (>1 year old) and adults who are otherwise healthy (Anderson and Curran, 2007): it is the only agent approved by the Food and Drug Administration (FDA) for the treatment of both giardiasis and cryptosporidiosis and is available in oral suspension that does not leave an after taste.

In conclusion, general awareness of parasite-induced diarrhoea is low for caregivers and some specific aspects of awareness are low for paediatricians, particularly as it relates to transmission. While specific education initiatives are not the focus of this report, educational efforts to improve awareness should be undertaken for both groups; paediatricians and caregivers. This should also include efforts to improve appropriate management and treatment of cryptosporidiosis and giardiasis in children with persistent diarrhoea.

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Conflict of Interest

The design, data generation, and analysis of both surveys used for this manuscript were supported financially by Lupin Pharmaceuticals, Inc. The authors have no other conflict of interest to disclose that pertains to this manuscript.

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