Physician Use of Parasite Tests in the United States from 1997 to 2006 and in a Utah *Cryptosporidium* Outbreak in 2007[▽]

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Parasitic infection is uncommon in the United States, but surveys suggest that physicians test when the presence of parasites is unlikely and fail to order appropriate testing when suspicion is high. Numerous studies confirm that immunoassays are more sensitive for *Giardia* and *Cryptosporidium* detection, but our experience was that physicians preferentially used ovum and parasite examination (O&P). We conducted a retrospective study of fecal parasite testing at a referral laboratory nationally (1997 to 2006) and during a *Cryptosporidium* outbreak (Utah, 2007) to correlate physician use of O&P and enzyme immunoassays (EIAs) with the yield of parasites detected. Nationally, of 170,671 episodes, 76.0% ($n = 129,732$) included O&P, 27.9% ($n = 47,666$) included *Giardia* EIA, and 5.7% ($n = 9,754$) included *Cryptosporidium* EIA. Most pathogens were *Giardia* or *Cryptosporidium*. More episodes were positive when EIA was performed ($n = 1,860/54,483$ [3.4%]) than when O&P only was performed ($n = 1,667/116,188$ [1.4%]; $P < 0.001$), and EIA was more sensitive than O&P. However, more O&P results were positive among patients with both O&P and EIA performed (2.5%) than among those with O&P only performed (1.4%; $P < 0.001$), suggesting that patients tested by O&P only may have been at lower risk. During the first 10 weeks of the outbreak, physicians also preferentially used O&P over EIA, but no *Cryptosporidium* cases were detected by O&P. We conclude that clinicians frequently use O&P testing when test performance and epidemiology support the use of immunoassays or no testing. We recommend that stool O&P be limited to patients with negative immunoassay results and persistent symptoms or individuals at increased risk for non-*Giardia*, non-*Cryptosporidium* infection. An evidence-based algorithm for the evaluation of patients with suspected intestinal parasitic infection is proposed.

Gastrointestinal illness is one of the most common reasons for adults and children to seek medical care in the United States, but parasitic infection without specific risk factors is uncommon (8, 10, 25). Paradoxically, laboratory and physician surveys suggest that physicians often test for parasites when the likelihood of infection is low and fail to use essential tests when suspicion is high (11, 12, 16, 18, 21, 27). Such practices have the potential to increase laboratory workload and costs while contributing to diagnostic delay and underreporting of transmissible illness (e.g., cryptosporidiosis) (11, 16–18, 21).

Microscopic ovum and parasite examination (O&P) is the traditional test for fecal parasites, but because it is labor-intensive and often has a low yield, a number of proposals have been made to limit testing by this method (3, 8, 18). O&P is necessary when less common parasites are suspected but is insensitive for the detection of *Giardia lamblia* (66 to 79%) and *Cryptosporidium* spp. (<5% without a special stain), two of the most common parasites in the United States (1, 9). Immunoassays (e.g., enzyme immunoassay [EIA] and direct fluorescent-antibody [DFA] assay) are easier to perform and more sensitive for the detection of *Giardia* (94 to 99%) and *Crypto-*

sporidium (93 to 100%), but other parasites are not detected (1, 9, 11, 16).

Not surprisingly, many physicians are uncertain about when to use these tests (11, 16). In a survey of both generalists and specialists in Connecticut, >75% of physicians did not order the necessary testing for cryptosporidiosis even when they suspected the diagnosis (16). In a separate multistate survey of diagnostic practices for acute diarrhea, the majority of physicians assumed that testing for *Cryptosporidium* was included with O&P. Other physicians tested for parasites even when the patient presentation was most consistent with a viral or bacterial cause (11).

From 2001 to 2007, Associated Regional and University Pathologists (ARUP) Laboratories experienced a 379% increase in O&P requests without a concomitant change in the rate of positivity. We also observed that most positive results yielded parasites that were either nonpathogenic or better detected by EIA (e.g., *Giardia*). Concerned that these observations did not reflect optimal medical practice, we performed a review to analyze physicians' use of stool O&P and EIA. Our goals were to define the distribution of test use among patients from facilities referring samples for both tests to ARUP Laboratories and to correlate individual strategies (e.g., O&P only, O&P and EIA, and EIA only) with the yield and type of parasites detected. Subsequently, when a *Cryptosporidium* outbreak occurred in Utah in 2007, we extended our study to include regional data from this outbreak for comparison.

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MATERIALS AND METHODS

Laboratory assessment. Results for stool samples submitted for O&P and *Giardia* and *Cryptosporidium* EIAs to ARUP Laboratories between July 1997 and December 2006 were reviewed. Data from facilities that repeatedly referred samples for O&P and EIA during the study period were included in the study. For the outbreak analysis, results from April to December 2006 and 2007 in Utah were obtained by the same approach. Specimens were submitted for O&P in commercial two-vial collection kits (Para-Pak; Meridian Bioscience, Cincinnati, OH). For local patients, specimens collected after the third hospital day or multiple specimens from same-day collections were rejected. All ovum and parasite specimens were examined macroscopically and microscopically with an iodine wet mount of formalin concentrate and modified trichrome stain of polyvinyl alcohol-preserved stool. *Giardia* and *Cryptosporidium* EIAs were performed by one of several kit-based assays (the ProSpecT microplate [Alexon, Inc., Sunnyvale, CA]; Premier [Meridian Bioscience, Inc., Cincinnati, OH]; and ProSpecT microplate [Remel, Inc., Lenexa, KS] assays), as recommended in the manufacturers' package inserts. Because modified acid-fast staining was performed upon request only and much less frequently than EIA, results for this test were not examined.

Case definitions. Results of O&P and EIA for individual patients were divided into 90-day test episodes to minimize classification of initial diagnostic testing and follow-up testing as separate test episodes. Episodes were categorized by test composition and yield of pathogenic parasite. Episodes in which a recognized pathogen (e.g., *Giardia lamblia*, *Entamoeba histolytica*/E. *dispar*, *Dientamoeba fragilis*, *Cryptosporidium*, and other coccidia, microsporidia, and helminths) was detected were considered positive. Episodes in which no parasites, nonpathogenic parasites only, or parasites widely accepted to be nonpathogenic (e.g., *Blastocystis hominis*) were detected were considered negative. For the *Cryptosporidium* outbreak (4), testing was divided into four time periods on the basis of Utah Department of Health (UDH) investigations (R. Rolfs): preoutbreak (1 April to 22 May 2007), early outbreak (23 May to 1 August 2007), peak outbreak (2 August to 31 August 2007), and late outbreak (1 September to 16 December 2007). The early-outbreak period was defined as the period between the time of detection of the index case (23 May 2007) and the first public and physician notification of the outbreak (2 August 2007). The peak-outbreak period (August 2007) corresponded to the period when the majority of *Cryptosporidium* cases and public health announcements occurred. Data from Utah during the same period in 2006 were analyzed for comparison.

Statistical analysis. O&P and EIA results were considered equally likely to represent true positives, consistent with clinical practice and surveillance definitions. For comparisons involving independent groups (see Table 1), the chi-square test or Fisher's exact test was used. For EIA and O&P comparisons within groups (see Table 3), the proportion of positive episodes was expressed as a test positive ratio (TPR), and a random-intercept negative binomial regression was used to account for the within-subject correlation. As patient data were not available, no other variables were used in the model. The Wilcoxon-Mann-Whitney test was used to compare the number of tests per episode between groups. Differences were considered to be significant if $P \leq 0.05$. No adjustment was made for multiple comparisons, but this did not affect our conclusions.

RESULTS

National data. (i) Distribution of O&P and EIA tests and parasites detected. From 1997 to 2006, there were 170,671 test episodes representing 162,937 patients and 229,997 tests referred from facilities submitting samples for both O&P and EIA during the study period. The majority of episodes included ≥ 1 O&P test ($n = 129,732$; 76.0%). Only 27.9% ($n = 47,666$) and 5.7% ($n = 9,754$) of episodes included EIA for *Giardia* and *Cryptosporidium*, respectively (Table 1). When grouped by test composition, the majority of episodes included O&P only ($n = 116,188$; 68.1%) and fewer episodes included EIA only ($n = 40,939$; 24.0%) or O&P and EIA ($n = 13,544$; 7.9%) (Table 1). Overall, 2.1% ($n = 3,527/170,671$) of episodes were positive for a recognized pathogen, and the majority of episodes were positive for *Giardia* or *Cryptosporidium* (Tables 1 and 2). Only 0.6% of the episodes with O&P ($n = 750/129,732$) and 33.2% of the positive O&P episodes ($n = 750/$

TABLE 1. Episodes grouped by test composition and yield of *Giardia*, *Cryptosporidium*, and other pathogenic parasites

Parasite(s)	O&P only ($n = 116,188$; 68.1%)			O&P and/or EIA ($n = 13,544^a$; 7.9%)			EIA only ($n = 40,939^b$; 24.0%)		
	O&P			EIA			O&P and EIA		
	No. of episodes positive/total no. tested by O&P (%) (A)	95% CI (%)	No. of episodes positive/total no. tested (%) (B)	95% CI (%)	No. of episodes positive/total no. tested (%) (C)	95% CI (%)	No. of episodes positive/total no. tested (%) (D)	95% CI (%)	No. of episodes positive/total no. tested (%) (E)
<i>Giardia lamblia</i> ^c	1,039/116,188 (0.9)	0.8–1.0	209/12,206 (1.7)	1.4–2.0	376/12,206 (3.1)	2.8–3.4	389/12,206 (3.2)	2.9–3.5	1,007/35,460 (2.8)
<i>Cryptosporidium</i> ^d	25/116,188 (0.02)	0.01–0.03	7/2,408 (0.3)	0.1–0.6	94/2,408 (3.9)	3.2–4.8	96/2,408 (4.0)	3.2–4.8	262/7,346 (3.6)
Other parasites ^e	642/116,188 (0.6)	0.5–0.6	108/13,544 (0.8)	0.7–1.0	NA ^f	0.7–1.0	108/13,544 (0.8)	0.7–1.0	NA
Total positive episodes ^g	1,667/116,188 (1.4)	1.4–1.5	335/13,544 (2.5)	2.2–2.7	467/13,544 (3.5)	3.1–3.8	594/13,544 (4.4)	4.1–4.7	1,266/40,939 (3.1)
									2.9–3.3

^a O&P, $n = 13,544$; *Giardia* EIA, $n = 12,206$; *Cryptosporidium* EIA, $n = 2,408$.

^b *Giardia* EIA, $n = 35,460$; *Cryptosporidium* EIA, $n = 7,346$.

^c Group comparisons for *Giardia lamblia*: column A versus column B, $P < 0.001$; column C versus column E, $P = 0.17$.

^d Group comparisons for *Cryptosporidium* spp.: column A versus column B, $P < 0.001$; column C versus column E, $P = 0.44$.

^e Group comparisons for other parasites: column A versus column B, $P < 0.001$.

^f Group comparisons for total positive episodes: column A versus column D, $P < 0.001$; column D versus column E, $P < 0.001$.

^g NA, not applicable.

TABLE 2. Distribution of parasites in 129,732 episodes with O&P

Parasite composition ^a	Parasite(s)	No. of episodes detected by O&P or EIA
<i>Giardia</i> or <i>Cryptosporidium</i> only (<i>n</i> = 1,511; 66.8%)	<i>Giardia lamblia</i>	1,398
	<i>Cryptosporidium</i> spp.	120
<i>Giardia</i> or <i>Cryptosporidium</i> plus non- <i>Giardia</i> , non- <i>Cryptosporidium</i> parasites (<i>n</i> = 49; 2.2%)	<i>Giardia lamblia</i>	46
	<i>Cryptosporidium</i> spp.	3
	<i>Dientamoeba fragilis</i>	28
	<i>Entamoeba histolytica/dispar</i>	16
	<i>Ascaris lumbricoides</i>	1
	<i>Hymenolepis</i> spp.	6
Non- <i>Giardia</i> , non- <i>Cryptosporidium</i> parasite only (<i>n</i> = 701; 31.0%)	<i>Dientamoeba fragilis</i>	488
	<i>Entamoeba histolytica/dispar</i>	96
	<i>Cyclospora</i> spp.	2
	<i>Cystoisospora</i> spp.	7
	<i>Ascaris lumbricoides</i>	29
	<i>Strongyloides stercoralis</i>	23
	Hookworm	2
	<i>Taenia</i> spp.	6
	<i>Hymenolepis</i> spp.	10
	<i>Diphyllobothrium latum</i>	3
	<i>Dipylidium caninum</i>	2
	<i>Enterobius vermicularis</i>	35
	<i>Schistosoma mansoni</i>	1
	<i>Trichuris</i> spp.	5
Total		2,327

^a *n* = 2,261 (1.7%) positive episodes among a total of 129,732 episodes. Data for specimens with negative results or a nonpathogen parasite only (*n* = 127,471 episodes; 98.3%) are not shown.

2,261) yielded a non-*Giardia*, non-*Cryptosporidium* pathogenic parasite (Tables 1 and 2).

(ii) **Correlation of episode test composition with yield of parasite testing.** The proportion of positive episodes differed between the three testing strategies (Table 1). The positivity rate was the lowest in the patients tested by O&P only (*n* = 1,667/116,188; 1.4%) and higher in those tested by EIA only (*n* = 1,266/40,939; 3.1%) or O&P and EIA (*n* = 594/13,544; 4.4%) (*P* < 0.001 for all comparisons). We examined three potential causes for these differences: (i) prevalence of parasitic infection (e.g., as a surrogate for pretest probability of parasites), (ii) relative test performance (e.g., EIA versus O&P), and (iii) number of tests per episode (Tables 1 and 3).

First, to evaluate for differences in parasite prevalence between groups, the positivity rate by like test methods was compared with the assumption that test performance was uniform during the study period (Table 1). For example, comparison of the yield from ≥ 1 O&P in the O&P-only group versus ≥ 1 O&P in the O&P and EIA group showed a higher frequency of *Giardia lamblia* (*P* < 0.001), *Cryptosporidium* (*P* < 0.001), and non-*Giardia*, non-*Cryptosporidium* parasites (e.g., *Dientamoeba fragilis* and helminths) (*P* < 0.001) detected by O&P in the O&P and EIA group. Using the same approach, the proportion of episodes positive for *Giardia* and *Cryptosporidium* by EIA was not statistically different between the EIA-only and O&P and EIA groups (e.g., *Giardia* EIA, *P* = 0.17; *Cryptosporidium* EIA, *P* = 0.44). Taken together, these results indicate that the patients for whom physicians ordered O&P only (*n* = 116,188; 68.1%) likely had a lower pretest risk for parasitic infection than those evaluated by EIA with or without O&P. Second, to determine if differences in test performance (e.g., sensitivity) between O&P and EIA also contributed to the prevalence differences between groups, the number of positive results detected by each test method was compared for the subset of episodes for which both tests were performed (Table 3). The data are presented as a ratio of the number of positive results by EIA/number of positive results by O&P, referred to as the TPR. These ratios are consistent with findings in previous reports showing that EIA detects more cases of *Giardia lamblia* and, in particular, *Cryptosporidium* than O&P (Table 3). Interestingly, as a reflection of the enhanced sensitivity of EIA and the predominance of *Giardia* and *Cryptosporidium* in the data set, more positive episodes were detected by EIA even when non-*Giardia*, non-*Cryptosporidium* parasites were included among episodes positive by O&P (Table 3). Third, the number of O&Ps or EIAs performed per episode was compared between groups. From this, we observed that multiple O&Ps per episode were more common in the O&P and EIA group (*n* = 3,920/13,544; 28.9%) than the O&P-only group (*n* = 19,673/116,188; 16.9% [*P* < 0.001]), while the proportion of episodes with multiple EIAs was similar between the O&P and EIA and EIA-only groups (*Giardia* EIA, 6.9% versus 4.4%; *Cryptosporidium* EIA, 8.6% versus 5.6% [*P* < 0.001 for both comparisons]). To account for the potential impact of multiple O&Ps on the rate of detection and the detected parasite prevalence, we reexamined the number of episodes that were positive in the O&P-only and O&P and EIA groups using the first O&P performed. With this approach, 1.3% (*n* =

TABLE 3. Comparison of EIA and O&P test performance by proportion of episodes yielding positive test results

Comparison	Parasite(s) detected	No. of episodes positive by EIA/no. positive by O&P (TPR ^a)	95% CI	<i>P</i> value
<i>Giardia</i> EIA versus O&P (<i>n</i> = 12,206)	<i>Giardia lamblia</i> (<i>n</i> = 389)	376/209 (1.80 ^b)	1.63, 1.98	<0.001
	Any pathogenic parasite (<i>n</i> = 484)	376/306 (1.23)	1.12, 1.36	<0.001
<i>Cryptosporidium</i> EIA versus O&P (<i>n</i> = 2,408)	<i>Cryptosporidium</i> spp. (<i>n</i> = 96)	94/7 (13.43 ^c)	6.48, 27.83	<0.001
	Any pathogenic parasite (<i>n</i> = 147)	94/64 (1.47)	1.09, 1.97	0.011

^a TPR = ratio of number of positive results detected by EIA to number of positive results detected by O&P (EIA/O&P).

^b Thirteen episodes were O&P positive and EIA negative. For 4 of the 13 episodes, EIA and O&P were performed together (false-negative EIA). For 9 of the 13 episodes, EIA testing was delayed (test of cure).

^c Two episodes were O&P positive and EIA negative, for both of which EIA was delayed (test of cure).

1,528/116,188; 95% confidence interval [CI], 1.3% to 1.4%) of first O&Ps were positive in the O&P-only group, where the rate is 2.3% ($n = 311/13,544$; [95% CI, 2.1%–2.6%]) in the O&P and EIA group ($P < 0.001$), supporting a genuine difference in parasite prevalence between these groups. In summary, we observed that even though the majority of episodes ($n = 116,188/170,671$; 68.1%) included O&P only, more parasites were detected in the episodes which included EIA as a result of the predominance of *Giardia* and *Cryptosporidium* in the data set, the superior performance of EIA over that of O&P for these parasites, and the higher prevalence of parasitic infection in patients tested by EIA.

Utah *Cryptosporidium* outbreak. A *Cryptosporidium* outbreak occurred in Utah between 23 May and 16 December 2007, with UDH retrospectively identifying the index case to have occurred on 23 May (4). Due to the location of ARUP Laboratories in Salt Lake City, a large proportion of testing for this outbreak, including 2,558 test episodes and 1,109/1,902 (58.3%) laboratory-confirmed *Cryptosporidium* cases identified during the outbreak, was performed at those laboratories. In this setting, we infer that the pretest probability of parasitic infection was likely to have been increased for most patients and that the majority of testing was being performed to evaluate patients for a cause of infectious diarrhea. Yet, the pattern of O&P and *Cryptosporidium* EIA use observed during the first 10 weeks of the outbreak (23 May to 1 August 2007) was similar to that observed during the preoutbreak period (1 April to 22 May 2007), during the previous year in Utah (1 April to 16 December 2006), and nationally from 1997 to 2006 (data not shown). In Utah during these periods, the majority of patient episodes ($\geq 68\%$) included O&P only, with $<30\%$ of episodes including *Cryptosporidium* EIA. Following recognition of the outbreak by UDH and its subsequent recommendations to health care providers to order *Cryptosporidium* EIA (2 August 2007), the testing pattern shifted such that O&P use declined and most patients were tested by *Cryptosporidium* EIA. For this 19-week period (2 August to 16 December 2007), only 28.2% of episodes included O&P, whereas 76.5% included *Cryptosporidium* EIA. Importantly, no cryptosporidiosis cases were detected by O&P at ARUP Laboratories during the outbreak. Overall, a pathogenic parasite was detected in only 1.7% ($n = 16/969$) of patients with O&P performed (14 *Giardia*, 2 *D. fragilis*, 1 *Hymenolepis nana*). For the 178 patients with *Cryptosporidium* EIA and O&P, 30 patients (16.8%) were positive for *Cryptosporidium* by EIA and 2 patients (1.1%) were positive for *Giardia* by O&P.

DISCUSSION

Microscopic examination of stool for ova and parasites is commonly performed for clinical contexts such as gastrointestinal complaints or investigation of eosinophilia or liver abscess or as part of evaluation for travelers, immigrants, or patients prior to transplantation. Often, such testing is conducted without adequate physician knowledge of the frequency of infection, expected parasites, or test performance (11, 16). In this large retrospective study, 170,671 fecal parasite test episodes from patients across the United States and 2,558 test episodes from a *Cryptosporidium* outbreak in Utah were evaluated to assess physicians' utilization of stool O&P and EIA and the

associated yield of diagnostic testing. Nationally, physicians utilized O&P without EIA as a predominant test strategy and ordered EIA infrequently, especially for *Cryptosporidium*. The yield of O&P was low overall ($\sim 1.5\%$), and O&P detected a non-*Giardia*, non-*Cryptosporidium* pathogen in $\leq 0.6\%$ episodes including O&P (33% of O&P-positive episodes). However, more O&P specimens were positive among patients tested by both O&P and EIA (2.5%) than by O&P only (1.4%; $P < 0.001$), implying that patients tested by O&P only may have been at lower risk of parasite infection. Compared with O&P, EIA detected more patients with *Giardia* and *Cryptosporidium* infection and, because these were common relative to the frequency of other parasites, more positive results overall. During the first 10 weeks of the outbreak in Utah, physicians also preferentially used O&P, and the frequency of positive results was low, similar to the national data set. After the outbreak was declared and testing recommendations were made, physicians shifted toward *Cryptosporidium* EIA. No cryptosporidiosis cases were detected by O&P during the outbreak. We conclude that physicians inappropriately favor O&P as a screening method for intestinal parasites, even in patients at low risk for disease or settings where *Cryptosporidium* should be considered. At the same time, physicians underutilize immunoassays for *Giardia* and *Cryptosporidium*, despite their epidemiologic and performance superiority among patients at low risk for other parasites (e.g., helminths and *E. histolytica*). These findings suggest a critical need for more specific practice guidelines to assist physicians with identifying patients at risk for intestinal parasites and inform their test selection when testing is performed.

Most previous studies have focused on the yield of O&P from outpatients versus inpatients (18) and the number of O&Ps that are necessary to exclude parasitic infection (3, 8, 18). Few studies have examined testing practices for stool parasites on a large scale or attempted to correlate these with the yield of positive results. Valenstein et al. analyzed parasitology data and survey responses from 585 laboratories to assess implementation of policies recommended to target testing and improve quality (27). Among the laboratories surveyed, the frequency of positive specimens ranged from $<1\%$ to $>6\%$ (median = 2%), but the presence of ≥ 1 policy to limit testing by O&P was associated with a higher rate of positive examinations. This suggests that the rate of positive O&P results that we observed is not atypical for a sample representing specimens from multiple institutions and diverse populations and raises the possibility that a lack of policies to limit requests for O&P among institutions referring to ARUP Laboratories may have contributed to the low positivity rate that we experienced. In a separate multistate survey of diagnostic practices conducted by the Centers for Disease Control and Prevention (CDC) and members of the FoodNet Working Group, a subset of physicians presented with a hypothetical case of acute diarrhea for which a parasitic cause was considered unlikely indicated that they would still test for parasites (11). These studies support our observation that a significant proportion of patients tested by O&P were at low risk overall.

Numerous publications have documented the increased sensitivity of immunoassay methods (e.g., EIA or direct fluorescent-antibody assay) versus O&P for detection of *Giardia lamblia* and *Cryptosporidium* spp. (1, 9), but most laboratories do

FIG. 1. Proposed test algorithm for parasitic evaluation of patients with persistent diarrhea or gastrointestinal complaints. Other patient subgroups (e.g., patients with persistent eosinophilia, elevated IgE levels, urticaria, or other skin manifestations suggestive of parasitic infestation) may benefit from additional testing or referral to a specialist for complete evaluation. ^a, evaluation of patients for stool parasites is generally not recommended for illnesses of <7 days' duration (10, 23); ^b, may rarely include O&P or PCR for potential parasitic pathogens; ^c, prior residence or extensive travel in regions endemic for *E. histolytica* or *Strongyloides stercoralis*. Most cases of *E. histolytica*/*E. dispar* infection reported in the United States and Canada are due to nonpathogenic species (26). Outdated reports describe *Strongyloides* infection acquired in rural areas of Appalachia and the southeastern United States (21).

not perform these without a physician request (12, 21). It has also been suggested that testing for parasites is often conducted without adequate physician knowledge of the frequency of infection, the expected parasites, or test performance (11, 16, 21). As a result, specific testing for *Giardia* and, in particular, *Cryptosporidium* is underutilized, despite the performance superiority (12, 16, 21). In a 1999 survey of 455 laboratories in nine U.S. states, only 28% of fecal specimens were examined for *Cryptosporidium* by any method (12). Earlier, following the 1993 *Cryptosporidium* outbreak in Milwaukee, WI, Roberts et al. reported that only 5.3% of stool O&P specimens containing were tested for *Cryptosporidium* over 9 months at 33 Connecticut laboratories (21). These authors identified the failure of laboratories to routinely test for *Cryptosporidium* and a lack of physician awareness of the need for specific testing as barriers to utilization and expressed concern that undertesting had the potential to result in false-negative results and underreporting to public health authorities. The same authors surveyed Connecticut physicians, finding that <25% ordered specific testing for *Cryptosporidium*, even when they suspected the diagnosis (16). We show that underutilization of *Cryptosporidium* testing persists nearly a decade later and may have contributed to delayed recognition in the Utah outbreak.

We believe that our data are representative of practice on a national level and are unlikely to be due to referral bias. The data set includes samples originating from academic hospitals, group practices, and private clinics from all 50 U.S. states and was limited to samples from facilities referring for both O&P and EIA during the study periods. Still, there are limitations. As a referral laboratory, we were unable to correlate physicians' ordering practices with clinical contexts. We also note that the frequency of positive results that we report is less than that reported by some single centers (3) and centers serving high-prevalence populations. Our experience is consistent with those described in reports of several prior studies from diverse U.S. and Canadian laboratories (13, 18, 27), and the distribution of parasites that we observed is similar to that found in previous studies from the United States (3, 13, 27). Our case definition for a positive result excluded *Blastocystis hominis* and parasites that are accepted as being nonpathogenic, although detection of these parasites may be clinically useful in selected cases. Finally, we did not examine serology or alternative methods (e.g., PCR and antigen detection from non-stool sources) that may contribute to the diagnosis of specific infectious syndromes (e.g., strongyloidiasis and amoebic liver abscess) (14, 22–24).

In summary, our experience offers striking evidence that routine testing by O&P is diagnostically low yield in the United States, with clinicians commonly testing patients at low risk of parasitic infection and inappropriately utilizing O&P when the risk of non-*Giardia*, non-*Cryptosporidium* parasites is small. Stool O&P has repeatedly been targeted for laboratory and health care cost savings (3, 6, 17, 27), but a lack of consensus on optimal diagnostic approaches has made it difficult to limit testing by O&P. Previous clinical investigations (22), reviews (15, 25, 26), and reports from the CDC, Infectious Diseases Society of America, and American College of Gastroenterology (5, 7, 10) do not provide comprehensive testing algorithms that are stratified by patient risk factors, clinical contexts, or type of parasite. On the basis of our laboratory experience and literature review (1–3, 5–8, 10, 14, 15, 19, 22–26), we propose a diagnostic algorithm for the main clinical contexts for which clinicians evaluate patients for gastrointestinal parasitic infection (Fig. 1). We believe that O&P should be limited to patients at increased risk of non-*Giardia*, non-*Cryptosporidium* parasites and/or severe disease due to immunocompromising condition. The risk of non-*Giardia*, non-*Cryptosporidium* parasites is related to the likelihood of exposure. Immigrants from regions where such parasites remain endemic (e.g., Southeast Asia, Africa, India, Central and South America, and the Caribbean) are at higher risk (2, 22). Travelers visiting family and friends in regions of endemicity have a higher risk than individuals born in industrialized countries traveling to high-prevalence areas as tourists or for business (2, 15, 26). For U.S.-born persons with no history of foreign travel, *Giardia lamblia* and *Cryptosporidium* spp. are the most common pathogenic parasites and the risk of helminth or true *E. histolytica* infection is very low (8, 19). For these patients, in the absence of other risk factors, immunoassay methods are superior to O&P and are probably sufficient. Such an approach has been reported and implemented at some institutions but has yet to achieve widespread acceptance (6). If immunoassays are repeatedly negative and symptoms persist, O&P may be indicated to detect *D. fragilis* and rule out other parasites. We also acknowledge the importance of special stains (e.g., modified acid-fast stain for *Cyclospora* and *Cystoisospora* spp.), serology, and nucleic acid amplification testing for certain clinical syndromes and parasites. On the basis of this work, we have implemented a computerized order entry approach to improve utilization by incorporating risk factors for non-*Giardia*, non-*Cryptosporidium* parasites and defaulting to immunoassays (20). More targeted and effective evidence-based clinical guidelines that provide specific recommendations for testing strategies to diagnose intestinal parasite infections in patients are needed.

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