

# Contemporary Testing for Enteric Pathogens: the Potential for Cost, Time, and Health Care Savings

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**We sent a questionnaire to 79 clinical microbiology laboratories seeking information on contemporary practices when investigating for bacterial and protozoan enteric pathogens. Data from the 67 respondents (response rate of 85%) showed that a minority of laboratories (40% for stool culture and 45% for ova and parasite [O&P] examinations) had restrictions for testing in place and that fewer laboratories (24% for stool culture and 19% for O&P examinations) rejected specimens from patients who had been in the hospital for >3 days. Using two estimates, 15 and 40%, for the proportion of all specimens received from patients in the hospital for >3 days, we calculated savings for the average hospital in this survey. Reagent savings of \$4,000 to \$10,000 and time savings of 274 to 731 h per year might have been realized. Moreover, between \$26,000 and \$71,000 in patient charges could have been prevented. On the basis of this survey, wider application of rejection criteria when testing for enteric pathogens appears possible. If implemented, savings to the nation's health care system could be between \$27 and \$73 million a year.**

In the past few years, we and others have investigated the yields of stool culture and ova and parasite (O&P) examinations for patients who have been hospitalized for more than 3 days (3, 5, 7, 11, 18, 20, 22). The yield from such testing is minimal, yet recent data indicate that approximately 40% of requests for both types of test for enteric pathogens came for such patients (20). Some laboratories have a 3-day rule, whereby stool specimens from patients who have been in the hospital for more than 3 days are not tested for traditional bacterial or protozoan pathogens unless special reasons exist. We surveyed a group of clinical microbiology laboratories to see how many invoke the 3-day rule and to estimate the potential savings available to hospitals and the health care system if this approach became more widely utilized.

## MATERIALS AND METHODS

**Survey.** We sent a questionnaire to 79 clinical microbiologists asking for details on their laboratory's practices to detect enteric pathogens. The information sought included the following: position of the individual completing the questionnaire; type of hospital and its number of beds; whether testing for fecal leukocytes was performed; range of bacterial pathogens tested for routinely, selectively, or on special request; testing methods for *Clostridium difficile*; the number of specimens tested for bacterial pathogens and examined for ova and parasites; whether there were any restrictions on testing for bacteria or parasites; whether it was known what proportion of specimens came from patients who had been in the hospital for more than 3 days; and whether it was known what proportion of specimens contained bacterial pathogens or parasites depending on duration of hospitalization ( $\leq$  or  $>3$  days).

**Cost and time saved.** For stool culture, cost and time calculations included setup, reading, reporting negative results, and reagents and time saved on evaluating possible pathogens. For 100 consecutive negative stool cultures for which we reported that no *Salmonella*, *Shigella*, or *Campylobacter* species was isolated, the computer work sheets, which record all work performed on specimens, were examined to see how many tests were performed to rule out a potential enteric pathogen. For the 100 negative reports, 55 isolates were screened with a urea

agar slant, a triple-sugar-iron agar slant, and a motility-indole-lysine semisolid agar test (15); 10 isolates were tested with *Salmonella* polyantisera, 6 of which were boiled; 4 API 20 E strips were set up; and 118 oxidase tests were performed. This amounted to almost \$2.50 in reagent costs and just over 4 min in technologist time for each negative stool culture reported. For O&P examinations, cost and time calculations included preparation and reading of concentrates and smears. The estimate did not include the cost of the transport packs and preservatives. For each stool culture not performed, \$9.15 in supply costs and 19 min of technologist time were saved. For each O&P examination not performed, \$2.43 in supply costs and 30 min of technologist time were saved.

## RESULTS

**Respondents.** Sixty-seven of the 79 (85%) questionnaires were returned. Most of those completing the form were either the laboratory director (70%) or laboratory supervisor or section head of bacteriology (18%). Most (79%) had either an M.D. or Ph.D. degree or both. Most of the institutions were tertiary care or medical school hospitals (73%), with community hospitals (9%), children's hospitals (6%), and reference laboratories (7%) making up most of the remainder. Large hospitals were common: 201 to 350 beds, 15%; 351 to 500 beds, 25%; 501 to 750 beds, 21%; and  $>750$  beds, 28%.

**Fecal leukocyte testing.** Sixty hospitals (90%) tested for fecal leukocytes. This test was performed in the microbiology laboratory 73% of the time. Most (70%) performed it only on request, while 10% looked for leukocytes in all stools. Most (74%) quantified the number of leukocytes, although several commented that this was only an estimate.

**Routine bacterial pathogens.** The proportion of laboratories routinely culturing for bacterial pathogens were as follows: *Salmonella* and *Shigella* spp., 97%; *Campylobacter* spp., 93%; *Yersinia* spp., 54%; *Aeromonas* spp., 58%; *Plesiomonas* spp., 53%; *Vibrio* spp., 12%; and *Escherichia coli* O157:H7, 24%. An additional 3% looked for *Vibrio* spp. seasonally, and an additional 16% looked for *E. coli* O157:H7 when the stool was bloody. A minority of laboratories reported pure or predominant growth of the following: *Staphylococcus aureus*, 22%; yeast, 16%; and *Pseudomonas aeruginosa*, 13%.

**Number of stools tested.** The mean, median, and range of

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TABLE 1. Number of tests performed for enteric pathogens in a year and estimation of cost and time savings for the average hospital in this 67-hospital survey

Parameter	Result of:	
	Bacterial culture	O&P examination
No. of tests		
Median	1,700	1,500
Range	150–16,000	250–16,000
Mean	2,256	2,229
Proportion (%) of requests for patients in the hospital for >3 days	15	15
Estimate of no. of specimens potentially rejected each yr	338	334
Reagent cost savings possible	\$3,092	\$812
Technologist time savings possible (h)	107	167
Avoidable patient charges (based on \$40 a test)	\$13,520	\$13,360

numbers of tests performed per year for bacterial culture and O&P examination are shown in Table 1.

**Restrictions on testing.** Forty (60%) laboratories had no restrictions for bacterial cultures. Five laboratories allowed no more than one culture a day, and three stated that they did not culture "rocks" or solid stool specimens. Sixteen (24%) laboratories used duration of hospitalization to determine if a culture was done; 14 and 2 laboratories did not culture specimens if the patient had been in the hospital for more than 3 and 7 days, respectively. Of the 13 hospitals having this 3-day rule that had both adult and pediatric patients, 11 applied the rule to both age groups. Exceptions to the 3-day rule included human immunodeficiency virus (HIV)-infected patients and stools containing erythrocytes or leukocytes or both. Thirty-seven (55%) laboratories had no restrictions on performing O&P examinations. Eight laboratories allowed no more than one specimen a day; two allowed no more than three specimens per patient; and four mentioned volume, use of preservatives, and time from collection to receipt as factors that determined if an examination was performed. Thirteen (19%) laboratories used the 3-day rule. Of the 10 hospitals with adult and pediatric patients, 9 applied the rule to all ages. Patients with HIV infection were mentioned as being exceptions to this criterion. One laboratory performed only a *Giardia lamblia* antigen test on specimens sent for O&P examination, reported this result, and asked the clinician to contact the laboratory if other parasites were being sought.

**Estimation of potential savings.** Of the hospitals without the 3-day rule, 12 and 13 had data on the proportion of all requests for bacterial culture and O&P examination, respectively, that came for patients who had been hospitalized for more than 3 days. The ranges were 1 to 45%, and the median proportions were 15% for both tests.

The potential cost and time savings are shown in Table 1. Total savings were calculated by multiplying the mean number of specimens per year by the median proportion from patients who had been in the hospital for more than 3 days (15%). For the average hospital in this survey, the total reagent savings would be about \$4,000 and the savings in technologist time would be about 274 h, i.e., almost 7 40-h weeks.

A recent survey of mostly smaller hospitals (<300 beds) that processed less than 1,000 stool cultures or O&P examinations a year showed that 40% of both types of requests came for patients hospitalized for >3 days (20). Because this proportion may approximate more closely the ordering practices in the United States, it was used to calculate the upper limit of possible savings. In this situation, total reagent savings, hours saved, and charges prevented per hospital would be \$10,424, 731 h, and \$71,760, respectively.

Using 15% as a low estimate and 40% as the high estimate for the proportion of specimens recovered from patients in the hospital for more than 3 days, the total savings for all 67 responding hospitals would be on the order of \$261,000 to \$698,000 for reagent costs, 18,000 to 49,000 h for technologist time, and \$1,800,000 to \$4,800,000 for hospital charges. Extrapolation of these calculations to the approximately 6,000 hospitals nationally is shown in Table 2. Total savings in reagent costs not incurred and charges prevented range between \$27 to \$73 million. Additionally, about 100 to 300 years of technologist time, based on 52 40-h weeks, would be available for other more useful diagnostic pursuits.

## DISCUSSION

Stool cultures and O&P examinations are among the most expensive investigations in routine clinical microbiology. Potential pathogens are numerous, methods are almost exclusively manual, reagents are diverse and expensive, and appreciable interpretative skills are required. Moreover, indiscriminate ordering patterns prevail (20). The net result is great expense that escalates rapidly in the costly quest for diagnostic certainty (20).

This survey focused on a single rejection criterion of not processing stools for isolation of *Campylobacter*, *Salmonella*, or *Shigella* spp. or for O&P examination for patients in the hospital for more than 3 days that, if applied more widely, could

TABLE 2. Nationwide extrapolation of potential savings from rejection of stool specimens from patients in the hospital for >3 days<sup>a</sup>

Test	Potential specimens rejected (%)	Reagent cost <sup>b</sup> (\$) (10 <sup>6</sup> )	Time (yr) <sup>c</sup>	Charges <sup>d</sup> (\$) (10 <sup>6</sup> )
Stool culture	15	2.7	45	12
	40	7.3	121	32
O&P examination	15	0.7	72	12
	40	1.9	192	32

<sup>a</sup> Based on estimate of 6,000 hospitals processing two million stool cultures and performing two million O&P examinations a year (18). The 15 and 40% rejection rates are low and high estimates, respectively, of the number of stools received from patients in the hospital for more than 3 days based on this survey and the American College of Pathologists Q-Probes study (20), respectively.

<sup>b</sup> These values were calculated by using costs of \$9.15 for stool culture and \$2.43 for O&P examination.

<sup>c</sup> The number of years of technologist time saved based on 52 40-h weeks worked. These values were calculated by using 19 min of technologist time per stool culture and 30 min per O&P examination.

<sup>d</sup> Hospital charges prevented based on a charge of \$40 a test.

result in remarkable savings in health care. Extrapolation of savings from this survey to the more than 6,000 hospitals in the United States that together process about two million specimens for isolation of enteric pathogens and O&P examination could result in total savings in the range of \$27 to \$73 million annually for society (Table 2). Our estimate is close to that of Siegel et al., who estimated that up to \$30 million a year could be saved (18). Moreover, the 3-day criterion for stools is relatively easy to implement, because it is based on the date of admission and the yield is nearly nil. Rejection criteria, however, should be coupled with consultative back-up for diagnostic microbiology (5, 11, 12). Nosocomial outbreaks of diarrhea do occur, and testing for enteric pathogens is justified in this situation (19). While inappropriate for bacterial and O&P testing, rejected specimens are appropriate for *Clostridium difficile* toxin testing (2, 4, 5, 18, 20, 22).

Additional savings could be achieved by scrutiny of other aspects of enteric microbiology. The need for all currently accepted isolation media and procedures has been questioned (13). Multiple specimens escalate cost dramatically. For example, the incremental cost (not charge) for finding a previously undetected pathogen can exceed \$25,000 in bacteriology and \$8,000 in parasitology by the third specimen (20). Fecal leukocyte examinations may be more costly than useful for routine screening (5, 8). Also, pathogens routinely sought can be circumscribed (6). For parasitology testing, there are potential savings by looking only for *Giardia lamblia* rather than performing examination for all parasites. This may be accomplished not only by antigen detection assays but also by limiting the number of stools tested or by pooling specimens (1, 9–11, 14, 17, 21). The greatest savings, however, for the least effort would be achieved by the consistent nationwide application of rejection of stool specimens from patients hospitalized for more than 3 days coupled with consultation based on epidemiological considerations. This approach is in accord with the duty of laboratory medicine to provide quality results in a cost-effective way (2, 16).

#### REFERENCES

- Aldeen, W. E., J. Whisenant, D. Hale, J. Matsen, and K. Carroll. 1993. Comparison of pooled formalin-preserved fecal specimens with three individual samples for detection of intestinal parasites. *J. Clin. Microbiol.* **31**: 144–145.
- Bartlett, R. C., M. Mazens-Sullivan, J. Z. Tetreault, S. Lobel, and J. Nivard. 1994. Evolving approaches to management of quality in clinical microbiology. *Clin. Microbiol. Rev.* **7**:55–88.
- Bowman, R. A., J. M. Bowman, S. A. Arrow, and T. V. Riley. 1992. Selective criteria for the microbiological examination of faecal specimens. *J. Clin. Pathol.* **45**:838–839.
- Brady, M. T., D. L. Pacini, C. T. Budde, and M. J. Connell. 1989. Diagnostic studies of nosocomial diarrhea in children: assessing their use and value. *Am. J. Infect. Control* **17**:77–82.
- Fan, K., A. J. Morris, and L. B. Reller. 1993. Application of rejection criteria for stool cultures for bacterial enteric pathogens. *J. Clin. Microbiol.* **31**:2233–2235.
- Kachoris, M., K. L. Ruoff, K. Welch, W. Kallas, and M. J. Ferraro. 1988. Routine culture of stool specimens for *Yersinia enterocolitica* is not a cost-effective procedure. *J. Clin. Microbiol.* **26**:582–583.
- Koplan, J. P., H. C. Fineberg, M. J. B. Ferraro, and M. L. Rosenberg. 1980. Value of stool cultures. *Lancet* **ii**:413–416.
- Marx, C. E., A. Morris, M. L. Wilson, and L. B. Reller. 1993. Fecal leukocytes in stool specimens submitted for *Clostridium difficile* toxin assay. *Diagn. Microbiol. Infect. Dis.* **16**:313–315.
- McLaughlin, J. C., S. K. Rasmussen, L. J. Nims, D. A. Dador, and C. R. Yazzie. 1993. Evaluation of reliability of pooling stool specimens from different patients and detection of *Giardia lamblia* antigen by microtiter enzyme-linked immunosorbent assay. *J. Clin. Microbiol.* **31**:2807–2808.
- Montessoni, G., and L. Bischoff. 1987. Searching for parasites in stool: once is usually enough. *Can. Med. Assoc. J.* **137**:702.
- Morris, A. J., M. L. Wilson, and L. B. Reller. 1992. Application of rejection criteria for stool ovum and parasite examinations. *J. Clin. Microbiol.* **30**: 3213–3216.
- Pappas, A. A., M. J. Drew, J. Flick, L. Fink, G. L. Fuller, and A. J. Hough. 1994. An introductory orientation to clinical pathology care and on-call responsibilities. *Arch. Pathol. Lab. Med.* **118**:578–583.
- Persaud, C. A., and S. J. Eykyn. 1994. Stool culture: are you getting value for money? *J. Clin. Pathol.* **47**:790–792.
- Peters, C. S., L. Hernandez, N. Sheffield, A. L. Chiffon-Swiatlo, and F. E. Kocka. 1988. Cost containment of formalin-preserved stool specimens for ova and parasites from outpatients. *J. Clin. Microbiol.* **26**:1584–1585.
- Reller, L. B., and S. Mirrett. 1975. Motility-indole-lysine medium for presumptive identification of enteric pathogens of *Enterobacteriaceae*. *J. Clin. Microbiol.* **2**:247–252.
- Robinson, A. 1994. Rationale for cost-effective laboratory medicine. *Clin. Microbiol. Rev.* **7**:185–199.
- Rosenblatt, J. E., L. M. Sloan, and S. K. Schneider. 1993. Evaluation of an enzyme-linked immunosorbent assay for the detection of *Giardia lamblia* in stool specimens. *Diagn. Microbiol. Infect. Dis.* **16**:337–341.
- Siegel, D. L., P. M. Edelstein, and I. Nachamkin. 1990. Inappropriate testing for diarrheal diseases in the hospital. *JAMA* **263**:979–982.
- Telzak, E. E., L. D. Budnick, M. S. Z. Greenberg, S. Blum, M. Shayegani, C. E. Benson, and S. Schultz. 1990. A nosocomial outbreak of *Salmonella enteritidis* infection due to the consumption of raw eggs. *N. Engl. J. Med.* **323**:394–397.
- Valenstein, P., M. Pfaller, and M. Yungbluth. 1996. The use and abuse of routine stool microbiology. *Arch. Pathol. Lab. Med.* **120**:206–211.
- Wahlquist, S. P., R. M. Williams, H. Bishop, D. G. Addiss, J. M. Stewart, R. J. Finton, D. D. Juraneck, and J. J. Sullivan. 1991. Use of pooled formalin-preserved fecal specimens to detect *Giardia lamblia*. *J. Clin. Microbiol.* **29**:1725–1726.
- Yannelli, B., I. Gurevich, P. E. Schoch, and B. A. Cunha. 1988. Yield of stool cultures, ova and parasite tests, and *Clostridium difficile* determinations in nosocomial diarrheas. *Am. J. Infect. Control* **16**:246–249.