QUALITY ASSURANCE PROJECT

Measuring the Cost of Inefficient Use of Laboratory Resources: Ecuador

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Abstract

The Quality Assurance Project (QAP) investigated strategies for increasing efficiency in hospital laboratory services, an area of hospital operations that is frequently identified as high cost. The study developed measurement methodologies for seven separate sources of economic waste in hospital laboratories (unneeded tests, unclaimed tests, resource use inefficiency, staffing inefficiency, expired reagents, poor quality control, and inefficient procurement) and tested them in three public hospitals in Ecuador. The methodologies were intended to provide rapid assessments of the economic waste in each source and so relied on data from existing hospital records and relatively short turnaround surveys. Estimates of economic waste were made for each source by comparing actual measured costs to what the costs would have been if standards were met.

The application found that the measurement methodologies were useable, in the sense that they could be applied and the requested data obtained. We found that economic waste from unneeded tests and staffing inefficiency may be very large. Findings on a sample of unneeded tests in six disease categories (acute diarrhea in children and adults, pneumonia in children and adults, appendicitis, cholecistitis) indicated that roughly half were unneeded and may represent economic waste. This result

Continued on page ii

Table of Contents

Abstract *Continued*

is based on clinical standards for lab tests developed through consensus by each hospital and may not apply to other disease categories. The economic waste of staffing inefficiency was estimated to range from 15% to 25% of the total laboratory budget across the three hospitals. However, these figures probably overstate the actual economic waste due to overstaffing because they do not account for staff time spent on indirect and other productive tasks. Economic waste from inefficient procurement of reagents and materials was estimated to be very high at one of the three hospitals due to lack of systematic competitive bidding.

Additional refinement of the measurement methodologies is needed to obtain information that is valid and useful. This report identifies the areas that need to be strengthened in each methodology. Some examples: the need to develop clinical standards for lab tests was not originally envisioned, and the successful development of standards for six disease categories needs to be extended to other categories to ensure a representative selection that can be generalized to all tests. Poor record keeping and erratic discard practices for unclaimed tests and expired reagents suggest that improved ongoing monitoring and reporting of these problems may be necessary to acquire valid data. Information on the cost of benefits and other payroll costs should be incorporated into the staffing inefficiency methodology, along with information on all productive tasks carried out by laboratory staff. These and other refinements would improve the validity of the methodologies. Finally the issue of double counting needs to be addressed as such information is incorporated into management decision making.

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Measuring the Cost of Inefficient Use of Laboratory Resources: Ecuador

Hany Abdallah and Patricio Ayabaca

Abbreviations

AMR	Antimicrobial resistance
MOH	Ministry of Health
OR	Operations research
QAP	Quality Assurance Project
USAID	United States Agency for International Development

I. Introduction

A. Rationale

The challenge for healthcare systems worldwide continues to be providing quality healthcare services while containing costs. In developing countries especially, where available funds for health services are thin and/or decreasing despite growing demands for services, providers need strategies for "doing more with less." Yet the existence of inefficiency in health systems has long been recognized (Parker and Newbrander 1994). One of the opportunities for meeting the cost-quality challenge lies in increasing the efficiency with which services are provided; that is, maximizing the allocation and use of limited resources.

In this operations research (OR) study, the Quality Assurance Project (QAP) investigated strategies for increasing efficiency in hospital laboratory services, an area of hospital operations frequently identified as a high-cost area (Parrish 1997). Many factors have been identified as drivers of the high cost of lab services, including the wasteful practices of health providers in using lab exams in the delivery of care (Moore 2000). The management and control of costs improves efficiency and effectiveness in using resources (Butros 1997; Parrish 1997; Lewis et al. 1996; Barnard et al. 1978). This study aims to contribute to the development of methodologies for identifying and measuring economic waste in hospital laboratories in developing countries.

B. Objective of the Study

Seeking to contribute to the development of tools for measuring economic waste in hospital laboratories in developing countries, this study developed and tested methods for measuring seven sources of economic waste in hospital laboratories. The intent is for the measurement methodologies to be applied in a relatively short period (a few days or weeks) so that system managers can use the results for decision making. Each method is assessed here with regard to its usability (the extent to which the data collection and analysis procedures can be successfully implemented), validity (Do the data reflect all the actual costs associated with the source?), and usefulness in identifying important areas of waste and guiding the design of solutions.

II. Methods

A. Sources of Economic Waste in Laboratories

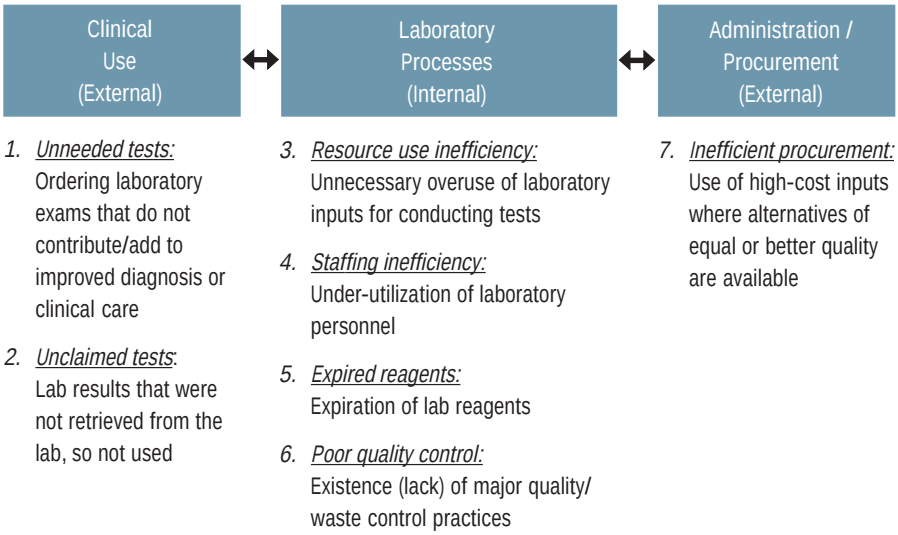
There are several causes of waste related to hospital laboratories. According to published literature (van Walraven and Naylor 1998; Wu

1998; Travers 1996; Steiner et al. 1991; Portugal 1989; HCDS 1999) and consultations with laboratory management experts,[1] two types of factors are related to the management of resources and costs in laboratories: 1) rational and appropriate use of lab tests in clinical care (external factors) and 2) cost control in the use of lab resources (internal factors). External events that contribute to waste include ordering unneeded tests and failure to claim and use completed tests. Internal waste is generated by inefficient organization of work, over-staffing, and poor procurement decisions, among others.

This study focused on seven sources of economic waste in hospital laboratories, namely, unneeded tests, unclaimed tests, resource use inefficiency, staffing inefficiency, expired reagents, poor quality control, and inefficient procurement (Figure 1). Inefficient procurement is considered an external factor here because it is performed outside the laboratory (by hospital administration) in the three study hospitals, although it could be performed under the aegis of the laboratory, which would have rendered it an internal factor.

Other factors may affect the efficient and effective use of resources, but were not measured in this study: 1) the "flight" (theft) of lab resources, 2) the quality of the lab tests, 3) the long-term cost of poor quality (impact on cost and quality of patient care), 4) the cost of prolonged inefficiency, and 5) the effectiveness/ineffectiveness of the lab's organizational structure and design.

Figure 1
Sources of Waste Investigated in This Study



B. Develop and Test Methodologies

Separate measurement methodologies were developed for each of the seven sources of waste and then pilot tested in the hospitals. The pilot tested the usability, validity, and reliability of the data collection instruments. Results revealed some useful insights about the need to tailor tools to the size and conditions of the laboratory and hospital. For instance, some indicators that were in the initial list of possible indicators were dropped during the pilot phase, primarily because they rarely applied to typical hospital laboratories in the country. One such indicator was for the cost of poor economies of scale due to inadequate use of test batching or of machines and equipment. In fact, very few laboratories in Ecuador are automated. The pilot test also underscored the need for an iterative process for developing tools (i.e., tools customized based on what information is locally available).

The general approach used to estimate economic waste for each source of waste was to compare the cost of standard practice to the cost of actual practice. If the cost of actual practice exceeded that of standard practice, then we assumed the excess was potential economic waste. Alternatively, if the cost of actual practice was less than standard, we assumed a savings. Quality should be similar in both actual and standard practice. An example: for the staffing inefficiency methodology we obtained standard staff times (in minutes) required to perform each type of test, and knowing the number of tests performed in a hospital, calculated

[1] Communication with Carolann Liszewski, consultant with the Johns Hopkins Reference Laboratory, Laboratory Management Consultation Services.

the total standard time required to perform all the tests in that hospital. We multiplied the total standard time for all tests (in hours) by the average cost per hour of laboratory staff in the hospital to obtain the total cost according to the standard. We compared this to the actual cost of laboratory staff during the period. In some cases the standard was zero (e.g., unclaimed tests and expired reagents where the standard was to have no costs: no unclaimed tests or expired reagents).

The pilot test and subsequent application of the measurement methodologies were carried out in three hospitals in Ecuador. The participating hospitals were selected, for convenience, based on hospital type, location, and willingness to participate. All three were representative of a typical provincial hospital, although of varying size, and all three were near the capital city, Quito, where the study team was centered. To maintain confidentiality, the hospital names are not used in this report.

Data collection was conducted by an external team of investigators, including the investigators and a local Ecuadorian consultant with laboratory management skills. Data collectors were not affiliated with the hospitals or labs. Data collection occurred in early 2001; most of the data from records reflected events and conditions from 2000.

C. Data Sources

Four different data sources were used to obtain information about all sources of waste: (1) various existing records, (2) direct observation in the lab, (3) staff interviews, and (4) expert clinical opinion. All data sources were selected because they could be examined in a relatively short period.

1. Existing records:

This entailed reviewing several sources of information related to the type and volume of tests performed by a lab, the cost of the tests, the staffing profile of labs, and the general clinical profile of the hospital patient population. In applying the measurement methodology, we evaluated information for a one-year period (2000). Information not available through records was garnered from interviews with knowledgeable persons able to provide the information or direct us to it. The following were sources for relevant information:

a) *Records from the Ministry of Health (MOH):* for reports on the types and volumes of tests performed (distinguished by whether tests were for in- or outpatients)

b) *Hospital financial and administrative records:* obtained primarily through the hospital's administrative department. They provided information on the cost of lab tests based on the cost of test inputs (e.g., reagents), the amount and cost of staff time, the cost of equipment and other charges directly applicable to labs (e.g., cost of maintenance for any equipment, etc.).

c) *Hospital medical statistics:* provided clinical profiles of inpatient and outpatient populations. This information was used to estimate the expected type and number of tests that the hospital laboratory would have needed to perform, based on the population seen at the hospital.

d) *Sample of medical records:* used to obtain information on the inappropriate use of lab tests ("unneeded tests") in clinical care for selected disease categories. Criteria used to select the disease categories included the volume of tests, whether a significant level of waste (inappropriate overuse of tests) was expected, and whether the disease was of national concern. The categories selected were pneumonia (in children and adults), acute diarrhea (in children and adults), appendicitis, and cholecistitis. In most cases, all records of patients presenting with these conditions were reviewed and in cases where the number of patients exceeded 300, a random sample was selected (every third medical record with the condition listed as a primary cause of illness). See Text Box 1 for a description of how the standard for determining the appropriate use of lab tests for the six disease categories was determined.

2. Direct observations in lab:

Direct observations of the production of "tracer tests" contributed information used to estimate costs of the different major categories of tests. Tracer tests are specific subtests in each major lab test category that tend to be most frequently ordered and/or have a cost that is average for that category. For example, a "white blood cells count" was selected as a tracer test for all hematology tests. Tracer tests were identified and selected for costing purposes in order to simplify the calculation of cost of major types of tests.

Text Box 1

Assessing the Appropriate Use of Lab Tests in Clinical Care through Medical Records Review

We initially intended that the analysis of economic waste in the use of tests in clinical care could rely on standards against which abnormal levels of test use could be analyzed. However, international reference standards for the use of tests in clinical care are generally inadequate or nonexistent. While some national standards for the use of lab tests were found (e.g., related to appropriate prenatal care testing for healthy motherhood), standards for test use that were applicable to the management of major health conditions were more difficult to find. A complicating factor was that, very often, practitioners had diverse training and backgrounds and so did not use the same standard. In addition, use of certain lab tests in different hospitals was often contingent on what test was feasible locally, which in turn depended on the available technology and resources.

These circumstances underscored the importance of using standards for test use that practitioners at each hospital accepted. We found little guidance from published literature about how to establish "appropriate" standards for lab test use. While alternative possibilities exist (e.g., standards defined by external experts, selection of one standard from those used by practitioners), the study team used a consensus-driven approach to define explicit criteria of appropriate test use for certain clinical areas at each hospital. Clinical (medical and nursing) staff and laboratory experts met in each study hospital and agreed on which tests were necessary for the diagnosis, treatment, and monitoring of four major conditions: acute diarrhea, pneumonia, appendicitis, and cholecistitis. Participants discussed the frequency of testing and the specific tests that would be required for different types of patients (e.g., patients in different age groups). It had been pre-decided that if consensus was not achieved, more than one criterion would be developed and tested, though this proved to be unnecessary because consensus was always achieved. Annex A summarizes the defined standards. These standards were not analyzed to determine whether they reflect evidence-based or international standards.

The study team also discussed the possibility of finding underuse of lab tests for some conditions. The difficult economic times drove underuse, which may initially appear to save costs (i.e., expected expenditures for the clinical management of a certain condition are not incurred). However, the potential effect on the patient's health and subsequent cost of care may be significant. Though not the focus of the study, in instances where underuse of tests was an important phenomenon, simple approaches could have been explored to measure the cost of not using tests; for example, estimates on the cost of treating complications could be obtained from a literature or medical record review.

Owing to capacity and time constraints, the study observed lab tests performed in only one randomly selected day in each study site (typically between 7:30 am and 5:00 pm). Where possible, at least one observation was made of a complete process for completing tracer tests, from the time when the order for the test was received to the time when the results were recorded for statistical purposes or sent to the ordering provider. We measured: a) turnaround time of tests, i.e., the length of time taken to complete the series of major activities in a process, and b) the concurrence of lab procedures with acceptable standards, including special observations regarding whether the test was repeated, how many times, and briefly why.

3. Interviews:

Interviews with heads of laboratory service units were used to evaluate aspects of lab management practices that play a major role in promoting or controlling the level of waste. Information from these interviews was not used to measure costs of waste but to provide information for assessing causes of waste. The information from the interviews was mostly in a "yes or no" format.

4. Clinical opinion:

Clinicians and lab specialists assembled in each study hospital to agree on standards for lab test usage for the disease categories selected for study. As described in Text Box 1, data from medical and administrative records from each hospital were given to the clinicians to inform their decision making about acceptable standards.

Twelve different data collection instruments were developed to assess the sources and levels of waste in the use of lab resources. Annex B provides a list of the data that were required.

D. Analysis

Data analysis was conducted using Excel and SPSS software, the latter to analyze data obtained through medical records. Using Excel, data analysis worksheets were constructed to reflect the design of data collection instruments to facilitate both data entry and analysis. All information that could potentially identify a patient was concealed to ensure confidentiality.

The usability and usefulness of the approaches were evaluated in two ways: (1) an evaluation by the researchers, and (2) presentations of findings to lab and hospitals managers to obtain their feedback. Guidelines for using data collection instruments were documented in a draft manual; they highlight specific steps for implementing the tools and caveats to consider in the process.

III. Study Limitations

The design of the study was limited to achieving the study's main objective of developing and testing tools and approaches for measuring the level of waste in hospital laboratories, i.e., a beta-test study. The study was not, in this sense, a test or evaluation of an intervention. The selected hospitals participating as test sites were not expected to act on the study's findings, though their feedback on the findings' value for managerial decision making was assessed. In other words, the test of waste assessment approaches was not based on any improvement or waste reduction that may result from having applied the approaches.

As a beta-test, the study may have had the following limitations in addition to that stated above:

- In keeping with the objective of developing a relatively simple approach, the study relied heavily on available sources of information to analyze economic waste. Where relevant, the study evaluated the reliability of necessary information sources (e.g., the reports of production numbers) and discussed adjustments to the information as appropriate. However, the study did not systematically test the reliability or validate the information obtained (for instance, through observations or tests of sensitivity). Such testing may be advisable in future applications.
- This study was limited to seven sources of waste (Figure 1). It is possible that other major sources of economic waste exist. For example, in labs that are automated (not the case of a typical public lab in Ecuador), a major source of waste may be poor calibration of equipment or poor planning of test batching, leading to production of poor quality tests or higher than average test costs. The study relied on the pilot test of the tools and approaches to make a determination of the types of waste to measure and analyze.
- The study did not combine the seven sources of waste into a single indicator that would tell the hospital the total magnitude of laboratory waste nor did it compare which sources were largest. Although annual cost of waste is conceptually such an indicator, it proved to be more difficult to achieve than originally thought. The reliability and validity of the estimates of the seven different sources of waste proved to be very different, making comparisons unreliable; and double-counting issues made the problem of combining the estimates problematic.
- The study relied on estimates rather than exact measures of the costs of lab services and in some cases may have systematically underestimated activity costs, particularly when the hospital received donated supplies and materials. The study did not try to determine the value of donated items, since in most cases (as revealed by observation of supply inventories) donated items were neither the standard product used by the lab (e.g., material for equipment) nor the major source of supplies or materials.
- The study analyzed costs for a one-year period (2000), though it is plausible that reagents and materials purchased earlier may have been used to produce tests in the year studied. If so, our test cost may be underestimated. The study tried to control for this as far as possible (e.g., by comparing to other, production-based approaches for measuring the unit cost of tests). As far as we could tell, our findings were not significantly affected by the one-year restriction, but analysis of multi-year data may be useful from a management perspective.

IV. Findings and Discussion

This section reports two sets of findings by the separate measurement methodologies. The findings that focus on the usability, validity, and usefulness of each methodology are integrated with the discussion about that methodology. The estimated values of the economic waste in the three study hospitals are also reported and integrated into the methodology discussion.

A. Budgets and Cost-per-Test

The three hospital laboratories differed widely in number of tests performed, annual budget, and average cost-per-test, as shown in Table 1. In 2000, hospital A had the largest lab budget, hospital B performed the most tests, and hospital C was by far the smallest both in budget and number of tests. The average cost-per-test was much lower in hospital B ($0.51) than in hospital A ($1.10) or C ($1.07). Although this large difference in the average cost-per-test could be largely due to less economic waste in hospital B, it is important to note that differences in cost-per-test can be caused by factors other than economic waste, including different types of tests and different salary structures. Also note that cost-per-test does not reflect certain types of economic waste, such as unneeded or unclaimed tests. Nevertheless, this large difference in average cost-per-test points up the need for a more detailed analysis that identifies the specific sources of economic waste that contribute to this difference.

Table 1
Number of Tests, Budgets, and Cost-per-Test in Three Hospital Laboratories

	Hospital		
	A	B	C
Tests performed	55,052	66,568	12,025
Annual lab budget	$ 60,699	$ 33,938	$ 12,894
Average cost-per-test	$ 1.10	$ 0.51	$ 1.07

Notes: (1) Data from year 2000. (2) Cost-per-test = Annual budget divided by tests performed.

B. Usability, Validity, and Usefulness of Methods by Source of Waste

Unneeded tests: In the absence of pre-existing nationally or locally recognized standards for the use of lab tests in clinical care, we identified unneeded tests by three different methods: external expert judgement, explicit criteria, and statistical analysis. The first two methods (expert judgement, explicit criteria) required local laboratory test standards for the same six disease categories for each hospital. These standards were developed through consensus by expert clinical staff from that hospital, in light of local, national, and international evidence. (See Text Box 1.) The standards had two parts: *what types* of tests were appropriate for each disease category and *how many* appropriate tests should be given in each disease category (see Annex A).

To apply the standards, the first method (expert judgement) used the expert's opinion of whether the tests ordered for the six disease categories met the standards established for that hospital. This method was applied in hospitals B and C. The second method (explicit criteria) established simple, explicit decision criteria to determine if the local standards had been met for the sample of cases in the six disease categories, and then used a computer-assisted protocol to judge if each test met the criteria, and by implication the standard. The third method (statistical analysis) based its definition of unneeded tests on the expected number of tests per patient for each disease category, rather than on locally developed standards. The statistical analysis method defined unneeded tests as those in excess of two standard deviations of the average number of tests per patient in each category.

Table 2 shows the number of patient records reviewed and lab tests ordered for each of the six disease categories at each study hospital. In total, 1,098 patient records and 7,214 tests were reviewed.

Table 3 gives the number of unneeded tests and their cost for each hospital as estimated by the three methods. Clearly, the statistical analysis method produces estimates far below the other two methods. The expert judgement method yielded the highest estimates of unneeded tests, approximately double the estimates produced by the explicit criteria method. Most of this difference is due to the fact that the explicit criteria method is concerned with whether the test is appropriate (meets the standard) for a particular disease category but not

Table 2
Number of Patient Records and Lab Tests Reviewed by Disease Category and Hospital

Disease Category	Number of Patient Records				Number of Tests			
	A	B	C	Total	A	B	C	Total
Acute diarrhea, children	106	117	19	242	571	896	123	1,590
Acute diarrhea, adults	27	19	5	51	194	165	24	383
Pneumonia, children	93	133	17	243	417	688	81	1,186
Pneumonia, adults	38	37	19	94	283	394	149	826
Appendicitis	109	141	4	254	338	938	33	1,309
Cholecistitis	88	121	5	214	614	1,251	55	1,920
Total	461	568	69	1,098	2,417	4,332	465	7,214

Table 3
Unneeded Tests by Estimation Method

Estimation Method	Number of Unneeded Tests			Unneeded Tests as Percentage of Total			Cost of Unneeded Tests ($US)		
	A	B	C	A	B	C	A	B	C
Expert judgement	NA	2,622	314	NA	60%	67%	NA	$1,336	$ 201
Explicit criteria	1,074	1,185	179	44%	27%	38%	$ 691	$ 604	$ 114
Statistical analysis	36	42	2	1%	1%	0.5%	$ 23	$ 21	$ 1

Notes: [1] The cost calculations for this table assume that the unit cost of all lab tests for the six disease categories in a particular hospital equaled the actual average unit cost of all lab tests for those six categories in that hospital in 2000. [2] All figures in this table, including the costs, refer to the sample of tests defined in Table 4, and not to all cases of the six disease categories or to all disease categories. [3] NA = not available.

with whether an appropriate test is ordered too many times. It did not include a criterion about the appropriate frequency of a test (e.g., a urine test that should be given only once every 24 hours). The expert judgement method accounted for test frequency (e.g., judged a urine test to be unneeded if performed more than once in a 24-hour period), and as a result identified many more unneeded tests than the explicit criteria method.

Table 4 looks closely at the number of tests of each type given to a patient. On average, patients are likely to receive at least one more test than their hospital standard stipulates. In several cases, the average number of tests received was double the standard or more (acute diarrhea in adults in hospitals A and B, pneumonia in adults in hospitals B and C, cholecistitis in hospital A). This analysis would be enriched by accounting for length of stay and investigating which tests in particular are being prescribed too frequently. Table 4 also shows frequency standards, and in general, the standards of hospital A recommend using fewer tests per patient than hospitals B and C. The more stringent standards for hospital A are at least part of the reason why hospital A has a higher percentage of its tests not to standard. (This is an example of why it is not always meaningful to compare hospitals.)

The expert judgement method indicates that 60 and 67% of the sample tests in hospitals B and C, respectively, were unneeded, while the explicit criteria method estimates 44, 27, and 38% for hospitals A, B, and C (Table 3), respectively. Thus, for the six disease categories studied, our evidence suggests that roughly half of all tests performed were unneeded.

Comments: The finding that roughly half of the tests in our sample were unneeded is extremely high, and a major cause for concern. However, we believe it is dangerous to extrapolate this result to the entire production of the laboratories for several reasons. First, the disease categories were chosen in part because we suspected that high levels of unneeded tests would occur in those disease categories. Second, we also suspected that relatively more evidence existed for these disease categories on appropriate standards. It may be that other disease categories with less evidence would generate

Table 4
Expected versus Actual Average Tests per Patient by Disease Category

Disease Category	Expected Number of Tests [1]		Actual Average Number of Tests in 2000 [2]		
	A	B & C	A	B	C
Acute diarrhea, children	4	6	5	8	6
Acute diarrhea, adults	3	4	7	8	5
Pneumonia, children	2	3	4	5	5
Pneumonia, adults	6	5	7	11	8
Appendicitis	2	6	3	7	5
Cholecistitis	3	8	7	10	11

Notes: [1] Expected number of tests-per-patient based on standards established by clinicians at each hospital. Standards for tests-per-patient by disease category were the same in hospitals B and C. [2] Actual number of tests obtained from a sample of patient records.

broader and less stringent standards that would therefore yield fewer unneeded tests. With regard to the three estimation methods, we believe that the statistical analysis method is not valid and should not be used. But the expert judgement and explicit criteria methods appear to hold substantial promise as practical methods for estimating unneeded tests in hospitals and for disease categories, when consensus on standards can be achieved. Revising the explicit criteria method to incorporate frequency standards would result in a reliable method that would be less costly than the expert judgement method.

Unclaimed tests: What did the laboratories do with test results that were not retrieved? After varying periods of time, they either filed the results in the patient record, threw them away, or left them unarchived. The practice of discarding unclaimed test results was common in all three study hospitals, but policies and practices for the amount of time to allow before discarding differed substantially. In our initial development of a methodology to measure the cost of unclaimed tests, we discovered few systematic aspects of the process related to unclaimed tests. For example, hospitals A and B had no unclaimed results for the first two months of 2001 but many from the last three months of 2000. Hospital C had discarded nearly all unclaimed tests.

Finding no systematic process for discarding unclaimed test results, we could not develop a systematic and reliable method for measuring costs related to unclaimed tests. The data that we did obtain are opportunistic, in the sense it was what we were able to find. Nevertheless, they do provide some initial insights, as shown in Table 5. In hospital A, fewer unclaimed tests were identified for emergency patients than for regular inpatients or outpatients, whereas in hospital B most unclaimed tests were for emergency patients. Table 5 also indicates that, contrary to expectations, more expensive tests are more likely to go unclaimed than less expensive tests.

Comments: In light of the erratic nature of current practices regarding unclaimed tests, we believe that the

Table 5
Number and Cost of Unclaimed Test Results

	Hospital A	Hospital B
Number (%) from outpatient service	218 (44%)	16 (31%)
Number (%) from hospitalization	265 (53%)	6 (12%)
Number (%) from emergency	15 (3%)	29 (57%)
Total	498 (100%)	51 (100%)
Total cost estimate #1 – one overall unit cost	$ 549	$ 26
Total cost estimate #2 – unit cost for each test	$ 733	$ 55

Notes: [1] The figures in this table are based on an opportunistic sample of unclaimed tests that were not yet discarded and thus do not represent all the unclaimed tests during any particular time period. [2] Cost estimate #1 uses a unit cost-per-test equal to the average cost-per-test of all tests in the hospital during 2000. Cost estimate #2 uses different unit costs for each type of test, equal to the average cost-per-test for that type in the hospital in 2000. The difference between estimates #1 and #2 suggests that more expensive tests go unclaimed more often than less expensive tests.

magnitude and cost of unclaimed tests can best be measured as part of a more comprehensive effort to identify and measure economic waste in a hospital laboratory within an ongoing monitoring system. Also, the estimation of the economic waste associated with unclaimed tests needs to be done in combination with unneeded tests because many of the unclaimed tests may also be unneeded. If the two measurements are not linked, tests that are both unneeded and unclaimed could be double-counted.

Resource use inefficiency: This source of waste includes the use of laboratory resources other than number of staff (staff are addressed in staffing inefficiency). The ratio of the *actual* unit cost-per-test to a *standard* unit cost-per-test was defined as the indicator of resource use inefficiency: the higher the actual unit cost in relation to the standard, the more the inefficiency. The actual cost-per-test was based on the direct cost of materials and reagents only. The costs of equipment and staff time were not included in the actual costs. Both batch-processed and individually processed tests were observed when appropriate. The standard cost-per-test was estimated based on low-tech standards for producing tracer tests in five different categories of tests (hematology, biochemical, urinalysis, microbiology, parasitology).

The measured actual cost-per-test was lower than the standard cost-per-test in almost all test categories and hospitals (Table 6). The reasons

Table 6

Actual versus Standard Direct Costs for Producing Tests (Resource Use Inefficiency), by Test Category ($US)

Hospital		Test Category					
		Hematology	Biochemical	Urinalysis	Microbiology	Parasitology	TOTAL
A	Volume in 2000	9,232	29,027	8,416	2,802	4,460	53,937
	Standard direct cost-per-test	0.85	0.98	0.51	0.41	0.13	
	Actual direct cost-per-test	0.80	0.87	0.38	0.55	0.13	
	Standard minus actual	0.05	0.11	0.12	(0.14)	0.00	
	Projected savings (waste) of actual over standard cost	435	3,118	1,023	(392)	0	4,184
B	Volume in 2000	8,667	24,523	1,922	9,081	-	44,193
	Standard direct cost-per-test	0.88	0.81	0.49	0.11	-	
	Actual direct cost-per-test	0.82	0.70	0.37	0.11	-	
	Standard minus actual	0.07	0.11	0.13	0.00	-	
	Projected savings (waste) of actual over standard cost	569	2,642	240	0	-	3,451
C	Volume in 2000	2,507	4,198	2,334	-	2,381	11,420
	Standard direct cost-per-test	0.85	0.76	0.45	-	0.13	
	Actual direct cost-per-test	0.79	0.66	0.45	-	0.13	
	Standard minus actual	0.06	0.10	0.00	-	0.00	
	Projected savings (waste) of actual over standard cost	140	414	0	-	0	554

Note: Direct cost-per-test includes costs for materials and reagents only, and excludes cost of amortized equipment or staff time.

are several: the study hospitals often used less expensive materials than called for in the standard; sometimes they produced two tests on the same slide; and frequently they did more batch processing than the standard assumed. When actual costs exceeded the standard, it was usually because a larger quantity of a solution was used than the standard assumed.

Comments: The accuracy of the standard, particularly with regard to the treatment of batch and individual processing, is an issue that should be addressed more closely. The reliability of the measurement methodology is an issue because data were collected during one day only, which meant that some tracer tests were not observed at all or only once. Furthermore, observer effect may have generated frugality by some lab technicians. These practices may compromise the quality of the tests and should be corrected.

Staffing inefficiency: The measurement methodology for staffing inefficiency is based on observations of the amount of staff time used to perform a sample of tests during one day. (This is the same sample of tests used to estimate resource use inefficiency.) Actual average times were obtained for batch-processed and individually processed tests for five categories of tests based on the observations. These observed average times were multiplied by the number of tests performed annually in each category and summed to obtain the total estimated required staff time needed to perform the tests for one year. This was compared to the total amount of paid staff time for the year. The value of the excess time (total time paid minus estimated time to do all tests) was obtained by multiplying the excess time by the weighted average salary. Benefits and other payroll costs were not included in the calculation. Nor was any allowance made for functions that the lab staff may have done during the excess time. See Table 7 for a summary of the measurement methodology.

Table 7
Description of Staffing Inefficiency Measurement Methodology

Type of Data	Comments
Number of tests produced annually, by category of test, and emergency tests reported separately	■ Data obtained from hospital statistical records, but needed adjustment in hospitals A and B; laboratory staff indicated that a relatively arbitrary multiplier is used when reporting tests in specific categories to the statistical department (e.g., five tests are reported in the hematology test category in hospital A for every sub-type of hematology exams produced in the lab). ■ Hospital C does not report emergency tests separately. ■ Sensitivity analysis would be beneficial to analyze the effect of the multiplier used in each test category on the overall level of waste calculated in this area.
Estimate of the actual time required to produce each category of tests	■ Estimates of time were measured based on observations of the time taken to produce "tracer" tests during one day of observations in labs; separate time estimates were calculated for producing one test in a batch versus individually (e.g., in emergency department). ■ It is possible that the measurements obtained during that one day of observations were not representative of the average or typical time it takes to produce a test. ■ Production of some "tracer" tests was not observed in a given hospital, so time estimates may be incorrect. ■ For hospital C, overall estimates of waste were calculated using estimates of time required for batch and for emergency production.
Amount of paid staff time available during the year, by test category	■ Data were obtained from the Human Resources Department on the number of staff assigned to produce different categories of tests each month, including number of hours worked during the month (i.e., not covering leave time); data were aggregated for the year. ■ Data on personnel time distribution by test category were not available for hospital C.
Cost of personnel time	■ Monthly salary by personnel type (level of training and expertise) was used; weighted average salary was calculated and used to estimate the cost of staff time per test category; benefits and other payroll costs were excluded.

The potential economic waste due to staffing inefficiency (the value of excess staff time as calculated above) was significant for all three hospitals, representing 75%, 31%, and 65% of all staff time, and 25%, 15%, and 19% of the entire annual lab budget in hospitals A, B, and C, respectively. It is important to keep in mind that these high figures are "potential" waste, not real waste. While some of the excess time not currently being used to perform lab tests may indeed be due to over-staffing, much of it may be devoted to other useful tasks (such as completing overhead functions, or in the case of hospital A, performing its teaching function) or to coverage during low-demand periods such as nights and weekends. Such coverage time may have the potential to be filled with other productive tasks. In addition, it is important to make proper allowance for personal time and variability in demand for services.

Comments: The sizeable potential waste due to staffing inefficiency requires that the measurement methodology perform to higher standards of reliability and validity than less significant sources of potential waste. One source of reliability problems is the low volume of tests observed in the one day allotted for observations. More time is probably needed. The cost of benefits and other payroll costs should be included if possible. Most important, more careful measurement and analysis of use of the "excess" time should be incorporated into the methodology.

Expired reagents: The measurement methodology for expired reagents started with an audit of each hospital's inventory of reagents in April 2001 to determine which were expired. All reagents that had expired or would expire in the next three months (by the end of July) were counted as expired. The three-month period is based on the "three-month lead time rule" in inventory management, which assumes that it takes three months to receive an order once it is placed. Note that although the expired reagents in theory spanned a 19-month period (January 2000 through July 2001), in fact most expirations occurred in 2001 and only a few in 2000. We believe that most of the reagents that expired in 2000 had been discarded before our April 2001 audit. The economic value of expired reagents was assumed to equal their procurement cost.

Expired reagents were a significant source of economic waste in the study hospitals. Figure 2 displays the value of expired reagents as a percentage of all reagents; it varied from 38% in hospital B to 5% in hospital C. Table 8 shows that the monetary value of the identified expired agents represented a small but still significant portion of the 2000 lab budgets in the hospitals.

Comments: None of the hospitals appeared to have a systematic process for checking and disposing of expired reagents, although hoarding of reagents was typical. For example, hospitals A and B had reagents on their shelves in April 2001 that had expired between 1997 and 1999, and a few even earlier. The pre-2000 reagents in these hospitals were valued at $868 and $777, respectively. It is difficult to achieve accurate estimates of the value of expired reagents given the haphazard process then operating. We believe that the most fruitful

Figure 2
Value of Expired as Percentage of All Reagents

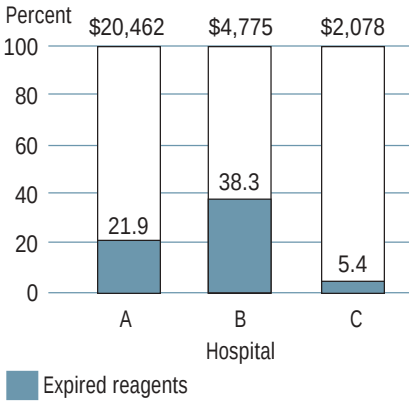


Table 8
The Value of Expired Reagents as a Percentage of Lab Budget

Hospital	Number of Expired Reagents[1]	Expired Reagents as a Fraction of All Tests in 2000[2]	Annual Budget for All Reagents in 2000	Estimated Value of Expired Reagents[3]	Total Lab Budget in 2000[4]	Expired Reagents as a % of Lab Budget
A	3,673	0.219	$20,462	$ 4,477	$ 60,699	7.4 %
B	1,831	0.383	4,775	1,831	33,938	5.4 %
C	107	0.054	113	113	12,894	0.9 %

Notes. [1] Number of expired reagents obtained from survey. [2] Number of all tests from Table 1. [3] The value of expired reagents assumed to equal average cost of all reagents purchased in 2000. [4] From Table 1.

approach will be to develop better management systems for checking, discarding, and recording expired reagents.

Poor quality control: Eight indicators of the laboratory quality control function were developed, with each indicator assigned a maximum score to reflect its relative importance. (Maximum scores ranged from two to five.) An expert external evaluator made a subjective assessment of the degree to which each indicator was achieved in each study hospital. The results are presented in Table 9. Out of a possible maximum score of 28, the total score ranged from 13 (46% of maximum) in hospital C to 18 (64% of maximum) in hospital A. The average score as a percentage of maximum across all eight indicators and hospitals was 55%. The workspace optimization indicator was very high in all three hospitals (averaging 92% of maximum), while several indicators scored well under 50% of maximum on average. Scores on two indicators were highly variable across hospitals: the assignment of personnel indicator was high in hospital B (three out of three) but zero in the other two, and the norms for eliminating physical waste was low in hospital B (one out of four) but high in the others.

Comments: The eight indicators may be broader than necessary to assess the quality control function, although this is addressed through the weighting achieved by the maximum scores. The results may be useful for management decisions, but the data as collected precluded quantitative estimations of the monetary value of economic waste due to poor quality control.

Table 9
Indicators and Scores for Qualitative Assessment of Quality Control Practices in Labs

	Max Score	A	B	C	Average Rating
1. Norms for biosecurity	4	2	3	2	58.3%
2. Norms for quality control in lab	5	3	2	1	40.0%
3. Norms for eliminating physical waste	4	3	1	4	66.7%
4. Workspace optimization	4	4	4	3	91.7%
5. Assignment of functions	3	0	3	0	33.3%
6. Prophylaxis for personnel	2	1	1	1	50.0%
7. Training	3	2	1	1	44.4%
8. Coverage of lab services	3	3	1	1	55.6%
Average rating		62.7%	57.1%	45.2%	55.0%

Notes: [1] The rating for each cell was the calculated by dividing the score in each cell by the maximum (max.) score for that row. [2] Max score was assigned by study team; an external evaluator assigned scores for indicators in each hospital.

Inefficient procurement: Purchasing decisions for reagents and materials were not based solely on price, but price was probably the most important consideration. Still, only two out of the three hospitals (B and C) used pro-formas[2] to make purchasing decisions. Possibly as a result, reagents and materials accounted for 43% of total annual lab costs in the hospital that did not use pro-formas (A), compared to 18% in the two hospitals that did (B and C). (See Annex C.) Hospitals B and C used pro-formas for 57% of their purchases of reagents and 89% of their materials. When pro-formas were used, hospitals B and C nearly always selected the vendor with the lowest price. The actual cost paid for reagents and materials that could have been obtained at a lower cost if pro-formas had been used and the lowest bid accepted was not very significant, only about 7% of total cost of reagents and materials.

Pro-formas seemed to be a potentially important tool for minimizing waste, especially in hospital A. Our analysis indicates that if hospital A had selected the lowest price alternative using pro-formas, it could have cut the average price of reagents and materials by a third ($8,663), or 14.3% of the total lab budget in 2000. The analysis used the lowest prices paid by the other two hospitals to establish the lowest price that could have been achieved using pro-formas. Price comparisons were based on the price of reagents and materials from the other two hospitals that had similar presenta-

[2] "Pro-formas" refers to bid statements obtained by hospitals from various vendors (usually at least three vendors) to competitively select suppliers for reagents and materials.

tion (e.g., dosage and quantity per packet) and were purchased about a month from the purchase date of hospital A's reagents and materials. A similar analysis for the other two hospitals suggested that even lower-priced alternatives might have slightly reduced the annual cost of reagents and materials for hospitals B ($68 reduction) and C ($13 reduction).

Comments: A potential weakness of this analysis is that it relied primarily on information available from the three hospitals for comparative price information, rather than a more comprehensive survey of market prices. It remains to be determined what types of competitive bids would actually be available in the general marketplace and how much could be saved by using them. The figures above represent potential savings because we have assumed that the lowest bid is always selected, when in fact price is not the only valid factor and sometimes a higher bidder should be selected.

C. Data Sources

Investigators assessed whether the required information to implement the approaches was obtainable and whether the information obtained was a good measure of the required data. Findings were mixed and depended on the type of information that was being collected. The following is a summary of findings by data source.

Medical records: In all three hospitals, medical records that satisfied the investigation's criteria for inclusion were relatively easy to identify and obtain. All three hospitals maintained a daily log of records that were filed in the hospital's statistical department (where records were kept). The log contains a summary of the medical history of patients who were seen as outpatients or discharged on a given day, including their date of admission and discharge where appropriate and a brief list of primary and secondary conditions for which they received treatment. The log, also used to compile hospital statistics, was used to identify patient records and randomly select from a group of patients where appropriate.

The reviewer relied entirely on information that was filed in the patient's records to obtain information on the type and quantity of tests that were performed for the patient. In the best-case scenario, lab reports were used when available to abstract data on tests performed. In addition to lab reports, the reviewer examined specific forms and physician notes made in the medical record to identify references. Though some information on tests may have been missed (because of improper filing of lab reports or no specific requirements for physicians to record all tests), the study did not investigate whether this was the case.

Generally, the fairly standardized structure of medical forms and records facilitated the abstraction of relevant information. Specific forms within the records were designed and used for summarizing patient diagnoses and treatment (including tests, drugs, and procedures). However, not all records followed the standard structure (e.g., not all forms were fully completed) or organized in an easily understandable manner (e.g., some records were very large and complex and required careful perusal). These complexities underscore the need to have clinical personnel review and abstract records.

Financial records: Financial information was generally available, though not always in a format that facilitated collection or analysis. Different types of information, e.g., on reagents and materials purchased, on personnel, on lab-related overhead expenses (electricity, other utilities, land, equipment) were obtained with varying degrees of difficulty, primarily because it was not organized by cost center in a consolidated, centralized way. Some information required more intensive review of records than expected. For example, the total cost of reagents was obtained by abstracting information from individual purchases of reagents using receipts and purchase agreements kept by the finance department. Similarly, indirect costs related to administration and overhead were not consolidated in any single statement. Estimates of these costs were determined for purposes of calculating costs of lab services.

The management of financial information was not uniform over the three study hospitals, so we obtained data from more than one source to the extent possible. For example, in the two larger hospitals, information on reagents and materials obtained from the records in the finance department was checked against receipts in the warehouse.

Statistical records: Information from statistical records on the number of tests performed was not reliable in the two larger hospitals (A and B). Observations of the test production process revealed overreporting of the number of tests performed in certain test categories. For instance, in hospital A, the number of hematology tests *reported* to the statistical department was five times the number of

sub-tests actually performed in that category. In addition, information obtained from MOH sources on test production levels (as well as on particular health statistics) did not always reconcile with information from hospital statistical records, although there is no clear reason why. Finally, differences in reporting criteria among the hospitals complicated matters. Criteria for categorizing different sub-tests were subjectively and at times erroneously determined in each hospital. For example, hospital B reported all tests performed in the emergency lab unit in one category called "Emergency," while the other two hospitals reported emergency tests separately by test category. As a rule, the study team relied on data available from the hospital and on interviews with the heads of each laboratory to determine the factor used for multiplying the number of tests.

Still, except for a few items, most of the statistical information needed to implement the measurement approaches seemed obtainable. Certain information on the type and number of tests by department or service area (e.g., pediatric versus ob/gyn) was not available and is not expected to be available in other hospitals.

Observations: Owing to limited time and resources, we relied on data from observations that were conducted on only one day by two investigators and that covered all aspects of the lab production process. While the particular day was selected at random, collecting data for more days would have made the data more representative of typical production processes (time and procedures used to produce tests). Still, the fact that some types of tests were observed more than once provided increased confidence in the findings. Also, analysis of information on resources consumed to produce a specific type of test suggested that there was little if any variation in the procedures applied to produce a test (i.e., the sequence of steps for completing a test). This minimized some of the concern about having an insufficient sample of observations. Finally, our analysis tried to carefully identify and separate those findings that were highly situation dependent (e.g., estimates of time when tests were performed in batches). A sensitivity analysis could be performed to evaluate the effect of variations in how the observation data were obtained on estimates of economic waste, but we did not do so.

Interviews: From a methodological point of view, interviewing was probably the weakest source of data. Limited time and resources prevented us from conducting in-depth interviews that could have shed light on unusual patterns in the data and on causal relationships. Interview data were used as a supplement to other data. For example, in assessing the adequacy of the quality control process, we relied primarily on an external consultant's assessment of each laboratory's policies and procedures related to maintaining quality, using a five-point scale, and used interview data as a check.

V. Conclusions

This study developed and tested measurement methodologies for seven separate sources of economic waste in hospital laboratories. While the concepts behind the methodologies were driven by review of the literature and expert advice based primarily on experience in industrial countries, the methodologies themselves were developed for application in developing countries and tested in three public hospitals in Ecuador.

While all the measurement methodologies were usable, most require further refinement to yield valid and useful information. The *unneeded tests methodology* needs ways to ensure that tracer disease categories are representative of all disease categories and also to incorporate frequency standards into the explicit criteria method. The *unclaimed tests and expired reagents methodologies* must overcome erratic record keeping and discard practices. *The resource use inefficiency methodology* may be reasonably valid, but the assumptions in the standard about the relative frequency of batch and individual tests need to be reviewed, especially in light of the large savings found in the area. The *staffing inefficiency methodology* must account for time spent on indirect lab functions (including coverage) and other tasks that are productive, and incorporate benefits and other payroll costs. *The poor quality control methodology* needs to develop ways of quantifying the effects of poor quality control on economic waste so that it can be compared to the other sources of waste. The *inefficient procurement methodology* is, we believe, among the more valid and useful measurement methodologies, and should improve as more hospitals in an area use it and share results. These needs and quantitative results are summarized in Table 10.

Table 10

Summary of Conclusions, Problems, and Quantitative Results by Source of Economic Waste

Source of Waste	Conclusions, Problems, and Requirements to Apply Measurement Methodology	Estimated Waste as % of Hospital Lab Budget[1]			
		General Result	A	B	C
1. Unneeded tests	Required: Locally acceptable test-ordering standards for tracer conditions Problem: Tracer conditions used may not be representative sample. Conclusions: Statistical analysis method is not valid; expert judgement and explicit criteria methods are valid, but explicit criteria method needs standards on frequency.	Large waste likely	44%–NM[2]	27–60%	38–67%
2. Unclaimed tests	Problem: Poor existing records and erratic discarding and archiving Conclusion: May require ongoing monitoring system	Small waste	1%	0%	NM
3. Resource use inefficiency[3]	Required: Production standards for representative tracer tests Problems: Standards don't account for efficiencies of batch processing; observer effect may have influenced lab worker behavior, compromising our data. Conclusion: Method can be valid if batch-processing standards are included.	Savings, not waste	(7%)	(10%)	(4%)
4. Staffing inefficiency	Required: Production standards for representative tracer tests Problems: Indirect and other productive staff activities not incorporated; sample too small: more days of observation are needed. Conclusion: Validity needs to be checked after incorporating additional staff activities and larger sample.	Potentially large waste	25%	15%	19%
5. Expired reagents	Problem: Poor existing records and erratic discarding and archiving Conclusion: May require ongoing monitoring system	Medium waste	7%	5%	1%
6. Poor quality control	Problem: Current method does not quantify value of economic waste. Conclusion: Current method is useful, but cannot be related to other results.	Unknown	NM	NM	NM
7. Inefficient procurement	Required: Comparison hospitals using competitive bidding procedures Conclusion: Method is reasonably valid.	Erratic; but significant	14%	0%	0%

Notes: [1] The estimates of economic waste as a percentage of the lab budget should not be summed to obtain a total potential waste because they are not all valid due to substantial double counting. [2] NM means not measured. [3] Note that the estimates for resource use inefficiency are savings and not waste.

Our experience suggests that the use of appropriate standards is even more important but more challenging than we originally thought. Standards for staff (time and skill level) and materials for the production of different types of tests were crucial for most of the standards. The lack of clinical standards for ordering lab tests by disease category forced the study to undertake a consensus approach to developing such standards for each study hospital. The success of this approach may be one of the most important achievements of the project. It not only created the foundation for the unneeded tests measurement methodology, but its application indicates that economic waste due to unneeded tests is very large indeed. Other approaches for assessing inappropriate test use and resulting economic waste could be explored, including more rigorous, evidence-based criteria of appropriateness (van Walraven and Naylor 1998) and case management evaluation techniques, such as critical pathway analysis. Even in the two areas that assumed zero-error standards (no unclaimed tests, no expired reagents), there is work to be done to find realistic levels of non-compliance that take into account off-setting costs.

In spite of the willingness of hospital staff to identify, provide access to, and interpret information sources, the study highlighted the weakness of existing records and rapid surveys as the only information sources. The strategy of reviewing multiple sources of data aimed at the same information was helpful but finally inadequate. Valid information about certain phenomena (e.g., unclaimed tests and expired reagents) probably requires improved ongoing management information and control systems. Organizing financial information around major cost centers such as the laboratory would be valuable not only to facilitate measuring economic waste but also to strengthen financial management. This underscores the potential benefit of evaluating the organization and use of major information sources in the hospitals.

Information regarding lab test production could also be strengthened. The usefulness of many of the findings relies on the reliability of this information. It would be in the interests of quality management practice and decision making to have information that accurately reflects actual production.

The estimates of economic waste for the different sources overlap one another, creating the potential for double counting. For example, unclaimed tests may include unneeded ones, and the per-item cost associated with the unclaimed tests may be high due to inefficient procurement. Such overlaps should be clarified before using the information for management decisions.

During presentation of findings, hospital managers, heads of labs, medical staff, and technicians in the three hospitals expressed appreciation for the potential usefulness of the approaches. The findings stimulated requests for more information that could further explain the causes of the apparent economic waste, a next step in making the tool useful for guiding quality improvement efforts. Hospital A administrators expressed their interest in conducting their own situational analysis, which could guide and justify the development of strategic and operational plans to address the major economic waste problems.

Finally, our findings underscore the need for further analysis to guide the development and use of waste reduction strategies, such as clinical standards for appropriate lab tests. Wider application of waste assessment methodologies and waste reduction efforts in more hospitals will generate a useful database to enable comparisons across hospitals. Better-performing hospitals may offer a benchmark for hospitals with more wasteful labs.

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Annex A

Internal Standards for the Appropriate Use of Laboratory Exams for Six Disease Categories by Study Hospital

	APENDICITIS *Children & Adults*		CHOLECISTITIS		Acute DIARRHEA *Adults*		Acute DIARRHEA *Children*		PNEUMONIA *Adults*		PNEUMONIA *Children*	
Hospital	B/C	A	B/C	A	B/C	A	B/C	A	B/C	A	B/C	A
DIAGNOSIS	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld	1 Bld
	1 Urin	1 Urin	1 SGOT-SGPT		1 O&P	1 O&P	1 Urin	1 Urin	1 G+	1 G+	1 PPD	
	1 Gluco		1 Creat	1 Creat.	1 PMN	1 PMN	1 O&P	1 O&P				
	1 Urea		1 Glyc	1 Glyc	1 Na-K>60		1 PMN	1 PMN		Potas		
	1 Creat		1 PT-PTT				1 Occult					
	1 Clot		1 Alk.Ph				1 Na-K			Eosin		
			1 Bili									
			1 Urea									
TREATMENT & FOLLOW-UP									1 PPD		1 Bld 72	1 Bld 48/72
									3 AFB	3 AFB		
									1 C&S	1 C&S		

Notes: AFB = Acid Fast Bacilli; Alk.Ph = Alkaline phosphate; Bili = Bilirubin; Bld = Blood count; Bld 72 = Blood count in 72 hours; Bld 48/72 = Blood count in 48–72 hours; C&S = Culture and sensitivity; Clot = clotting time; Creat = Creatinine; Eosin = Eosinophils; G+ = Gram + sputum; Gluco = Glucose; Glyc = Glycemia; Na-K = Sodium potassium, electrolytes; Na-K>60 = Na K for over 60 years of age; O&P = Ova and parasites; Occult = test for occult blood (stools); PMN = Polymorphonuclear (white blood cells); Potas = Potassium; PPD = Tuberculin skin test; Urin = Urinalysis; SGOT-SGPT = liver enzymes; PT-PTT = Prothrombin Time and Partial Thromboplastin Time (clotting tests).

Annex B

Data Required from Hospitals to Apply the Measurement Methodologies

- Number of outpatients, inpatients, and emergency patients by month and/or year, by department
- Average length-of-stay for hospitalized patients by department by month and/or year
- Average unit cost for different types of tests (can also be calculated using tools developed as part of approach)
- Standards for the appropriate tests for select pathologies for outpatient and hospitalized patients
- Number of different types of tests performed for (sample of) patients with the select pathologies
- Cost expended by the laboratory department by category for year (e.g., labor, supplies, material, equipment, overhead)
- Cost expended for different categories of tests
- Total number of tests by category of tests
- Unit purchase price and quantity (and presentation) of purchased of supplies and materials
- Expiration date and quantity in inventory of supplies and materials purchased
- Direct cost of reagents and materials used to produce a tracer test per category according to a standard protocol
- Actual direct cost of reagents and materials used to produce a tracer test per category
- Total number of tracer tests produced per month and/or year
- Number of persons working (i.e., person-days) per month and/or year and by test category
- Amount of staff time to produce one test based on standard protocol
- Actual amount of time to produce one test, as part of a batch and as a single test
- Number of unclaimed tests per month or year

Annex C

Financial Statements in 2000 for the Three Hospital Laboratories

Item	Annual Lab Cost in $US (%) by Hospital in 2000 A	B	C
Direct costs:			
Reagents	$ 20,462 (34%)	$ 4,775 (14%)	$ 2,078 (16%)
Materials	5,419 (9%)	1,299 (4%)	208 (2%)
Other	- - (0%)	498 (1%)	- - (0%)
Sub-Total	25,880 (43%)	6,572 (19%)	2,286 (18%)
Indirect costs:			
Salaries	27,080 (45%)	19,725 (58%)	5,699 (44%)
Equipment and maintenance	1,470 (2%)	2,966 (9%)	3,001 (23%)
Other (e.g., administration, utilities, etc.)	6,269 (10%)	4,676 (14%)	1,907 (15%)
Sub-Total	34,819 57%)	27,367 (81%)	10,608 (82%)
TOTAL	**$ 60,699** (100%)	**$ 33,938** (100%)	**$ 12,894** (100%)