LABORATORY USE IN GHANA: PHYSICIAN PERCEPTION AND PRACTICE

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Abstract. Clinical diagnosis of infectious diseases in Africa has been associated with increased misdiagnosis and mortality, but when laboratory testing is available, it remains underused. We retrospectively compared infectious diagnoses, test results, anti-microbial use, and patient cost with laboratory and physician surveys at a teaching hospital in Ghana to evaluate the potential barriers to laboratory use and financial impact for patients. Laboratory capacity was high, but physician survey results and objective data indicated a reliance on clinical judgment and empirical therapy. For the study period, 9–15% of malaria diagnoses, 34–43% of urinary tract infections (UTIs), and 62% of meningitis cases were supported by abnormal laboratory results. For the same period, 0.82–2.09 units of antibiotics were consumed per patient day, and patient cost for antibiotics was 4.8–21.6 times that of laboratory services. Physician perception regarding the value of diagnostic testing is potentially a major barrier to laboratory use, resulting in empiricism, disproportionate anti-microbial administration, and cost to patients.

INTRODUCTION

Diagnosis of infectious diseases without laboratory confirmation occurs routinely in sub-Saharan Africa, and often leads to misdiagnosis with subsequent increased morbidity and mortality. Many nations in sub-Saharan Africa have the smallest gross national products in the world, and not surprisingly, most investigators have identified inadequate laboratory capacity as the most common barrier to test use. Equally important, but underappreciated, barriers to test use are quality of laboratory testing, cultural beliefs of patients, attrition of health care workforce, physicians’ attitudes, and scarcity of consumables. To our knowledge, no study has comprehensively examined these barriers to laboratory use in West Africa by systematically evaluating laboratory capacity in comparison with physicians’ perceptions about patient management and actual medical practice.

Ghana, while economically similar to most sub-Saharan African nations, has made significant health-related advances in recent years including improvements in laboratory capacity, affording a unique setting for this study. We examined physician use of laboratory tests for the diagnosis and treatment of infectious diseases in a large teaching center in Kumasi, Ghana. We specifically chose a setting with a well-established laboratory facility enabling us to correlate laboratory capacity with objective indicators of actual practice and better define less recognized barriers to laboratory use. We also assessed the impact of test under-use on the administration of anti-microbial therapy and patient costs.

MATERIALS AND METHODS

The Komfo Anoye Teaching Hospital (KATH), located in Kumasi, serves as a referral center and teaching hospital for central Ghana. Medical and laboratory records were retrospectively reviewed for 2 months in 2005: January (dry season) and July (rainy season). The University of Utah Institutional Review Board and local KATH Ethics Committee approved the protocol and surveys before study.

Demographics. Data for adult medicine and pediatric patients were obtained by manual tabulation from outpatient clinic and inpatient logbooks and the Departments of Biostatistics, Medical Records, Medicine, and Child Health. When present, multiple discharge diagnoses were counted independently.

Laboratory. Results from blood, cerebrospinal fluid (CSF), urine, and stool culture; urinalysis; sputum smear for acid-fast bacilli (AFB); and peripheral blood smear for malaria microscopy were collected manually from laboratory logbooks. A fraction of malaria results in July were recorded in a logbook that was missing; these numbers were extrapolated. All patients ≤ 12 years old were considered children by a standard protocol at KATH. Samples received without clinic or ward designation were classified as medicine or pediatrics based on age alone. Blood and CSF specimens were tabulated with inpatient data; those received without age or location were included in the tabulations for both the medicine and pediatric inpatient services (counted twice). Cultures with typical contaminants (e.g., coagulase-negative Staphylococcus, Bacillus spp.) were excluded. Positive CSF cultures were defined as cell count ≥ 5 neutrophils/mL, positive Gram stain, or positive culture. Urine studies were considered positive when either microscopic cell count showed > 10 neutrophils or culture yielded a potential urinary pathogen. Isolation of Salmonella spp., Shigella spp., or other potential bacterial pathogen from stool was defined as a positive culture.

Surveys. Laboratory. Five KATH laboratories that performed tests related to infectious diseases were inspected and personnel interviewed. Reports of completed results from bacterial culture that had not been retrieved by health care personnel were tallied from January 1, 2005 to September 8, 2005.

Physician. An anonymous 10-question physician survey was administered randomly to housestaff and specialists without regard for specialty. Questions were designed to assess their perceived use of laboratory testing for the diagnosis and treatment of patients with infections.

Pharmacy. Anti-microbial data was collected for adult medicine and pediatric inpatient wards including the pediatric

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emergency unit for the same months. Anti-microbials were quantified in cost units that were not always dose equivalent (e.g., cefuroxime, oral suspension, 125 mg/5 mL, cost 75,000 Ghanaian Cedis). US Dollar (USD) values were calculated from Ghanaian Cedis at an exchange rate of 9,000 Cedis per USD, the average exchange rate at the time of study.

RESULTS

Potential barrier: availability of laboratory testing. Physician survey (N = 80). The majority of physicians expressed that malaria microscopy (68%), AFB smears (79%), and hemoglobin (Hb) measurement (98%) were either frequently or always available. Ninety-four percent of respondents indicated that they only rarely or sometimes did not order tests as the result of inadequate availability of specimen collection materials (e.g., vacutainers).

Objective practice measures. For the five laboratories evaluated, 20 full-time laboratorians and 6 laboratory technology students staffed the laboratories 7 d/wk. Two laboratories remained open to process specimens 24 h/d. Malaria microscopy and Hb measurements were available 24 h/d, whereas sputum AFB smears were processed 6 d/wk. Bacterial cultures were processed, and results were reported daily. Essential consumables (e.g., sterile blood collection materials, glass slides, staining reagents, culture media) were in adequate supply to meet clinical demand.

Potential barrier: quality of testing. Physician survey. Eighty-two percent of physicians frequently or always believed in the accuracy of laboratory test results.

Objective practice measures. Of the full-time laboratory staff, 11/20 (55%) had received at least degree level certification in laboratory technology and an additional 5/20 (25%) had at least 3 years of training qualifying them as laboratory technicians. Quality control measures were routinely used in four of five laboratories, and three of five laboratories were either currently receiving proficiency materials or had previously participated in external proficiency testing programs. The malaria research laboratory had participated in World Health Organization (WHO) clinical trials.

Potential barrier: delivery of laboratory results. Physician survey. Ninety-five percent of physicians said that they frequently or always received results for the tests that they order.

Objective practice measures. Laboratory results were reported to physicians on slips of paper and held for pick-up by staff. Times of specimen receipt and test completion were routinely recorded. On September 8, 2005, there were 268 reports of results from bacterial culture that had not been retrieved by health care personnel or placed in the patient’s medical record, including 204 blood cultures (25 positive); 23 CSF cultures (1 positive); and 10 sterile body fluid cultures (2 positive). The proportion of result slips remaining uncollected after date of sample collection was 0–7 days (6%); 8–14 days (24%); 15–21 days (4%); 22–180 days (64%); no recorded date of collection (2%). Of the 173 culture results not retrieved after 3 weeks, 16% were positive. Fifty-four percent and 18% of the uncollected reports originated from the medical and pediatric emergency units, respectively, and an additional 18% were without ward designation.

Potential barrier: sufficiency of the health care workforce. Physician survey. Ninety-eight percent of physicians stated that they only rarely or sometimes do not order tests as the result of “being too busy.”

Objective practice measures. The number of full-time physician staff, average daily census, official and actual bed capacity, and number of admissions for the Departments of Medicine and Pediatrics for the months of January 2005 and July 2005 are shown in Table 1. For these 2 months, both services maintained an average daily census near or above official bed capacity (range: medicine, 64–140%; pediatrics, 83–243%), with average housestaff to patient ratios of 3.1–4.8 (medicine) and 5.0–6.5 (pediatrics). The average patient length of stay ranged from 4.2 to 11.0 days.

Potential barrier: patients’ attitude to testing. Physician survey. Ninety-nine percent of physicians indicated that they rarely or sometimes elect not to order tests because patients refused testing.

Potential barrier: physicians’ attitudes and behaviors. Physician survey. When queried about their general degree of laboratory test use, 88% of physicians stated that they frequently or always rely on laboratory tests to diagnose infections in their patients. When asked specifically about malaria or tuberculosis, 64% of physicians said that they frequently or always diagnose malaria without the aid of malaria smear and 69%, 9%, and 1% said that they sometimes, frequently, or always diagnose tuberculosis without the help of a sputum AFB smear, respectively.

Objective practice measures: malaria smear. In January, 3,628 (39%) medicine and pediatric outpatients, 20 (3%) medical inpatients, and 571 (52%) pediatric inpatients were diagnosed with malaria. For the same month, 2,092 malaria smears were performed for the entire facility, with only 411 positive, supporting at most 9–11% of malaria diagnoses. In July, 4,126 (43%) medicine and pediatric outpatients, 16 (3%)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Service demographics and physician staff</th>
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<tbody>
<tr>
<td></td>
<td>Pediatrics</td>
</tr>
<tr>
<td></td>
<td>January</td>
</tr>
<tr>
<td>Number of admissions</td>
<td>1,101</td>
</tr>
<tr>
<td>Total patient days</td>
<td>6,940</td>
</tr>
<tr>
<td>Average length of stay</td>
<td>7.3 days</td>
</tr>
<tr>
<td>Official bed capacity</td>
<td>187</td>
</tr>
<tr>
<td>Average daily census (% capacity)</td>
<td>223.9 (119%)</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>112 (11.3%)</td>
</tr>
<tr>
<td>Housestaff (interns, officers, residents)</td>
<td>46</td>
</tr>
<tr>
<td>Specialists (attendings)</td>
<td>9</td>
</tr>
<tr>
<td>Average housestaff to patient ratio</td>
<td>5</td>
</tr>
</tbody>
</table>
medical inpatients, and 766 (57%) pediatric inpatients were diagnosed with malaria. For the same month, 2,610 malaria smears were performed for the entire facility, with only 626 positive supporting at most 13–15% of malaria diagnoses.

Sputum examination for AFB. In January, 54 medical and pediatric outpatients and 32 inpatients were diagnosed with tuberculosis. For the same month, 215 patients (11 children) had sputum examined for AFB diagnosis, and 38 were smear positive, supporting 44–70% of medicine and pediatric diagnoses. In July, 62 outpatients and 30 inpatients were diagnosed with tuberculosis. For the same month, 169 patients (6 children) had sputa examined, of which 50 were smear positive, supporting 54–80% of total diagnoses. Of the 296 smear-negative patients during these 2 months, 31% had fewer than three sputa submitted.

Urine culture. In January, 408 medical and pediatric outpatients and 50 inpatients were diagnosed with urinary tract infections (UTIs). This same month, 791 urine studies (urinalysis or urine culture) were obtained, and 155 were positive, supporting at most 34% of diagnoses. In July, 397 outpatients and 30 inpatients received UTI diagnoses. Of the 792 urine studies submitted, only 184 were positive, supporting at most 43% of patient diagnoses.

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Stool culture. In January, 411 outpatients and 87 inpatients were diagnosed with a gastroenteritis-like illness, whereas only 49 stool cultures were performed for the entire facility. None were positive. In July, 281 outpatients and 33 inpatients were diagnosed with gastroenteritis-like illness, 62 stool cultures were performed, and 1 was positive (Salmonella spp.). Overall, 9% (January) and 19% (July) of patients diagnosed with gastroenteritis were evaluated for bacterial causes.

Blood and CSF culture. In January, discharge diagnoses related to infectious disease for the 614 medical inpatients were sepsis (N = 21); endocarditis (N = 2); meningitis (N = 14); malaria (N = 20); pneumonia (N = 66); and HIV infection (N = 63). The same month, 28 (14.0%) of 200 blood and 12 (36.4%) of 33 CSF cultures submitted from these wards were positive. Of the 624 medical patients admitted in July, the infectious disease diagnoses were sepsis (N = 19); meningitis (N = 6); malaria (N = 16); pneumonia (N = 39); and HIV infection (N = 45). That month, 25 (10.7%) of 234 blood and 2 (8.7%) of 23 CSF cultures from these wards were positive. In pediatrics, of the 1,101 patients admitted in January, discharge diagnoses related to infectious disease were sepsis (N = 113); typhoid or typhoid-like illness (N = 7); meningitis (N = 21); febrile convulsions (N = 70); malaria (N = 571); and pneumonia or respiratory tract infection (N = 105). For the same month, 145 (20.2%) of 718 blood and 14 (7.2%) of 194 CSF cultures were positive. In July, of the 1,339 children admitted, discharge diagnoses included sepsis (N = 104); endocarditis (N = 1); meningitis (N = 41); febrile convulsions (N = 47); malaria (N = 766); and pneumonia or respiratory tract infection (N = 249). That month, 199 (19.4%) of 1,027 blood and 23 (8.5%) of 269 CSF cultures were positive.

Potential barrier: cost of laboratory testing. Physician survey. Ninety-five percent of physicians said that they rarely or sometimes do not order tests because “tests are too expensive.” Only 44% felt that laboratory test results changed their treatment or management of patients.

Objective practice measures. Representative patient charges are presented in Table 2. Patient charges for the antibiotics administered and laboratory tests performed are provided in Table 3. For January and July, an average of 2.09 and 1.59 units of antibiotics per patient day was dispensed for medical inpatients, with “billed to patient” antibiotic charges totaling 13.1 and 21.6 times that of all cultures and urinalyses performed. In pediatrics, an average of 0.82 and 1.45 units of antibiotics was given per patient day; antibiotic charges cost patients 4.8 and 6.3 times the cost of all cultures and urinalyses performed. While representing only 15.1% and 9.7% of

### Table 2
Representative health care charges

<table>
<thead>
<tr>
<th>Item</th>
<th>Representative patient charges (USD)</th>
<th>Item</th>
<th>Representative patient charges (USD)</th>
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<tbody>
<tr>
<td>Hospital accommodations/night</td>
<td>0.56</td>
<td>Blood transfusion</td>
<td>7.11</td>
</tr>
<tr>
<td>Food</td>
<td>0.33</td>
<td>HIV test (screening ELISA)</td>
<td>Subsidized</td>
</tr>
<tr>
<td>Syringe and needle</td>
<td>0.17</td>
<td>Malaria thick smear</td>
<td>0.67</td>
</tr>
<tr>
<td>Gloves/pair</td>
<td>0.13</td>
<td>Sputum for AFB</td>
<td>Subsidized</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>3.33</td>
<td>Blood culture (one bottle)</td>
<td>1.11</td>
</tr>
<tr>
<td>Ultrasound exam</td>
<td>5.00</td>
<td>CSF, urine, or stool culture</td>
<td>1.11</td>
</tr>
<tr>
<td>Computed scan</td>
<td>55.56</td>
<td>Urinalysis with microscopy</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated blood count</td>
<td>1.11–2.78</td>
</tr>
</tbody>
</table>

### Table 3
Cost of anti-microbial therapy vs. laboratory testing

<table>
<thead>
<tr>
<th></th>
<th>Antibiotics</th>
<th>Laboratory testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patient days</td>
<td>Units</td>
</tr>
<tr>
<td>Pediatrics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>6,940</td>
<td>6,733</td>
</tr>
<tr>
<td>July</td>
<td>6,899</td>
<td>10,025</td>
</tr>
<tr>
<td>Medicine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>3,657</td>
<td>7,655</td>
</tr>
<tr>
<td>July</td>
<td>5,772</td>
<td>9,182</td>
</tr>
</tbody>
</table>
DISCUSSION

Although syndromic diagnosis of infectious diseases has been an accepted standard of care in sub-Saharan Africa, there is accumulating evidence to support routine incorporation of laboratory testing into diagnostic algorithms when available. Clinical diagnoses have been repeatedly associated with increases in misdiagnosis, morbidity, and mortality. In this study, we provide evidence that lack of laboratory test use in this region may also be associated with disproportionate antibiotic use and increased empirical antibiotic administration and medication costs. Uniquely, we also explore potential mechanisms underlying physicians’ choice of test use and suggest that, when traditional barriers to laboratory testing (e.g., availability, quality) are minimized, physician perceptions and practice behaviors emerge as continued barriers to laboratory use. While we acknowledge that under-use of diagnostic tests and administration of empirical anti-microbial therapy also occur in developed nations, the impact of such practices may be more apparent when resources are limited. In sub-Saharan Africa, nearly one half the population lacks access to essential medications. Earn 45% earn < 1 USD/d, and patients are typically responsible for the bulk of medication costs. We show that, in Ghana, laboratory services were available routinely, quality controlled, and perceived as accurate by physicians. Our observations reflect prior efforts by Ghanaians to improve intra- and inter-laboratory accuracy and participate in international collaborations. Other studies from sub-Saharan Africa have suggested physicians’ perceived lack of consumables, inadequate test availability, and poor quality of testing as barriers to test use. These studies were performed in increasingly limited settings such that when laboratory capacity was assessed, physicians’ perceptions were supported. The majority of physicians in our survey indicated that essential tests were accurate, reliable, and consistently available. We conclude that neither physician’s mistrust of laboratory capacity nor inadequate laboratory capacity can be considered significant barriers to diagnostic testing at KATH.

We did identify evidence of ineffective delivery of laboratory results as a barrier, but this observation did not correlate with physician perceptions or workforce capacity. In sub-Saharan Africa, results are frequently held in the laboratory for collection by staff, and attrition of human capital has contributed to a shortage of skilled medical personnel. We explored why a significant number of bacterial culture results at KATH were not retrieved by health care workers. Patient census surpassed bed capacity during both months examined, but medical staff to patient ratio was acceptable, and physicians did not indicate workload as an impediment. An unpublished student thesis project performed at KATH in 2004 found inadequate numbers of ancillary personnel as one cause for inconsistent result collection (C. Opoku-Okrah and others, unpublished data), and numbers of ancillary staffs were increased. Despite these improvements, more than one half of the uncollected reports originated from the medical emergency unit, and ~20% of reports not retrieved had no designation of patient location. We conclude that a focused effort to improve documentation on specimen requisitions and a more systematic approach to collection of reports for the emergency units are necessary for more consistent reporting of laboratory results.

Perhaps the most significant barrier to laboratory use was physicians’ reliance on clinical judgment. When specifically asked about malaria and tuberculosis, physicians stated that they were more likely to rely on their clinical impression rather than tests to diagnose these infections. This attitude is not surprising in resource-limited regions where clinical algorithms are often promoted as the diagnostic standard and perhaps understandable for tuberculosis, where the sensitivity of unconcentrated AFB smear is poor. We were able to show, however, that actual medical practice reflected physicians’ beliefs that malaria and tuberculosis can be routinely diagnosed without laboratory confirmation and found evidence for similar practices with meningitis, UTIs, and bacterial gastroenteritis. We found positive malaria smear results to support between 10% and 15% of malaria diagnoses, and normal CSF results to support at most 62% of meningitis diagnoses. Likewise, while acknowledging that viruses constitute ~50% of gastroenteritis cases worldwide, a bacterial cause was sought in only 13% of patients. Previous studies corroborate these observations, but we would have expected better use given the condition of the laboratory facilities at KATH. Based on the physician survey, we postulate that reliance on syndromic diagnoses may have served as a major barrier where the value of diagnostic testing is under-appreciated.

A potential consequence of practicing medicine that is unsubstantiated by laboratory testing is the widespread use of empirical anti-microbials and subsequent cost. In our study, the discrepancies among diagnoses, test use, and volume of anti-microbials dispensed suggest that a significant proportion of prescribed antibiotics were empirical. In fact, only 44% of physicians indicated that laboratory results impacted their patient management. We acknowledge that inappropriate anti-microbial use is common even in the developed world where laboratory resources are plentiful and agree that empirical therapy is necessary in certain settings. However, inappropriate anti-microbial consumption occurs routinely in this region with potentially significant financial impact. From our analyses, costs incurred to patients for antibiotic therapy exceeded the costs for laboratory tests between 5- and 20-fold. This finding is particularly concerning in a region where patients are usually responsible for the bulk of medication costs and nearly one half of the population lacks regular access to essential medications. Although we did not evaluate susceptibility patterns, indiscriminate use of anti-microbial therapy can lead to an increase in antibiotic resistance requiring the use of alternative and more costly therapies. We did observe that with minimal use of newer, more expensive antibiotics, costs increased dramatically. Data both from Africa and elsewhere suggest that targeted laboratory testing decreases anti-microbial consumption and overall cost.
Practical limitations of this study include the inability to directly correlate individual patient diagnoses with their tests and medications. Data were collected retrospectively, and similar to other medical facilities in sub-Saharan Africa where information systems are lacking, data were collected manually from logbooks. We attempted to overcome this limitation by comparing multiple objective indicators of practice. The true burden of infectious disease in this population may have been under-represented because discharge diagnoses were not always recorded, and non-infectious clinical diagnoses could be not verified. We also acknowledge that actual laboratory test use may have been over-estimated in our efforts to include incompletely labeled samples. Prior administration of anti-microbials, a common practice in this region,\(^{21,43}\) is another potential confounder that may have resulted in false-negative malaria smears or bacterial cultures, leading to under-estimation of disease prevalence. Finally, while previous work in Ghana, our laboratory assessments, and physician surveys all suggest test quality was high, we were unable to independently verify the accuracy of test results.

This study is the first comprehensive evaluation of multiple, potential barriers to laboratory use in a sub-Saharan African health care center. KATH has focused on building its laboratory capacity over the past 5 years, and their relatively high standard of laboratory performance was reflected in our observations. Having built laboratory capacity and accurate reliable testing, ineffective delivery of results and physicians’ attitudes regarding the value of laboratory testing persist as significant barriers to laboratory use and management of antimicrobial resources. We conclude that empiricism resulting from under-use of laboratory resources can result in administration of a disproportionate amount of medications and increased medication costs. The implications of these findings warrant further study in prospective fashion with patient-specific clinical correlation and overall health care system outcome measures.

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