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# APPROPRIATENESS OF HOSPITAL LABORATORY SERVICES UTILIZATION

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**ABSTRACT**
The appropriate use of hospital services (diagnostic testing and therapy) belongs firmly in the domain of quality care and clinical accountability. Laboratory tests utilization is appropriate if it allows accurate diagnoses to be made, ideal treatment to be identified and monitored, accurate prognoses to be established and patients' hospital stays to be shortened. The appropriateness of the services including the appropriate diagnostic testing formed the first challenge facing people who wish to improve healthcare systems in the developing world. This review addressed the definition of appropriate laboratory utilization - as an ongoing process of making the best use of laboratory resources, the principles of appropriate laboratory test selection and use, assessment methods of appropriateness of laboratory utilization and magnitude of inappropriate laboratory utilization at hospitals.

**KEYWORDS:** Appropriate, laboratory tests utilization, appropriateness, inappropriate.

## 1. INTRODUCTION

Clinical laboratory tests are an important part of medical practice because laboratory information is essential for diagnosis and management of patients. Laboratory findings are used in two distinct circumstances, on the one hand in managing ambulatory patients, including the screening of apparently healthy subjects, and on the other hand in managing hospitalized patients, including pre-admission screening.[1,2]

Appropriate laboratory tests utilization is a cornerstone of optimal medical practice. Laboratory tests utilization is appropriate if it allows accurate diagnoses to be made, ideal treatment to be identified and monitored, accurate prognoses to be established and patients' hospital stays to be shortened.[3,4]

The inefficient use of laboratory resources is of increasing concern to health insurers, local and regional health administrators and laboratory directors. Where inappropriate laboratory utilization can not only harm patients, it is also expensive. Performing unnecessary tests may have adverse effects, for example, unnecessary exposure to toxic treatments or false positive results that may induce fear and anxiety in patients, or may result in a cascade of further unnecessary testing.[5,6]

Laboratory tests cost the health care system large amounts of money, and their inappropriate use may be associated with other inefficiencies in health care delivery. Identifying inadequacies in the use of laboratory services may disclose problems in other areas of health care. For example it has been estimated that by ordering 10 tests in a healthy person there will be a 40% chance of a false-positive result, requiring further investigation and follow up, thus utilizing even more time and money.[7]

Influencing the ordering of laboratory investigations, and in particularreducing unnecessary ones, is a vital concern to many hospitals. The different ordering control methods include requesting form redesign, education, protocols and decision supportsystems and feedback. These methods are likely to be ineffectiveunless they take place in the correct environment. Elements of this includecorrect attitude and commitment by senior staff, a long term strategy anddifferent approaches for different groups of doctors.[8-11]

The present review is designed to address the definition of appropriate laboratory utilization, the principles of appropriate laboratory test selection and use, assessment methods of appropriateness of laboratory utilization and magnitude of inappropriate laboratory utilization at hospitals.

## 2. LITERATURE REVIEW

### A. Laboratory Utilization

Appropriate laboratory utilization - as an ongoing process of making the best use of laboratory resources - could be defined as ordering the right tests and interpreting them properly to complete the diagnosis and

evaluation of the patient disease. Over utilization would be from the tests that were ordered during a patient disease workup that do not provide information about the disease. Under-utilization would be from the tests that do provide critical information for the diagnosis and evaluation of patient disease that were not ordered. Ultimately, the appropriate laboratory utilization could be achieved when cliniciansorder the right tests, at the right time, in the right order. If appropriate laboratory utilization is adopted, the number of test ordered for some disorders would go up (presumably the right tests) and for other disorders (presumably the uninformative tests) would go down.[12]

However, there have been few attempts made to define an 'appropriate test request'. A diagnostic test is one of the tools available to help a clinician make a decision about the care of a patient and so the pre-eminent definition of appropriateness must be couched in terms of supporting clinical decision making. Thus, an appropriate test request is one in which there is a clear clinical question for which the result will provide an answer, which enables the clinician to make a decision and initiate some form of action leading to a health benefit for the patient.[13]

In practice, the laboratory services may be overutilized, underutilized, or maluitilized. Each can contribute to an increase in costs. Overutilization is expensive because it consumes laboratory resources and often initiates expensive, inappropriate medical investigations of nonexistent disease. Underutilizalion can result in an incorrect diagnosis or inadequate patient management. Malutiliznlion can be costly because, inappropriate testing can lead to delay in needed care or the expense of unnecessary follow-up testing. This would include the use of obsolete tests. From the laboratory's standpoint; the use of inadequately controlled or insensitive and nonspecific methods will similarly contribute to mal-management.[14]

The issue of laboratory utilization is more than the issue of costs. Fundamentally it is making the best use of available resources to maximize patient outcomes. Improving the appropriateness of testing behavior and reducing the number of laboratory tests have been recognized as essential parts of quality improvement.[15] Appropriateness plays a key role in programs for quality improvement. Appropriateness in laboratory utilization can be assessed, and improved, through the governance of the entire testing process. This begins with test selection, proceeds through valuable pre-, intra- and post-analytical procedures and concludes by assuring the correct interpretation and utilization of laboratory information.[16,17]

Therefore, the term "appropriateness" related to laboratory utilization should be translated and applied to all the different phases (pre-analytical, analytical and post analytical) of the total testing process (TTP). In this way, it would be possible to select specific targets for improving the utilization of human and technological resources. In this context, the integration between laboratory and clinicians seems to be relevant for its strong influence on changes and choices of the laboratory management and organization.[12]

## 1. Principles of Appropriate Laboratory Test Selection and Use

Each laboratory test or procedure possesses a set of characteristics that reflects the information expected in patients with and without the disorder in question. These test characteristics provide clinicians with answers to two fundamental questions: 1) If the disorder is present, what is the likelihood that the test result will be abnormal (positive)? And, if the disorder is not present, what is the likelihood that the result will be normal (negative)? The answer to the first question defines the sensitivity of the test and the answer to the latter defines its specificity.[18]

Clinicians should use measures of test performance such as sensitivity and specificity to judge the quality of a diagnostic test for a particular disease. Test sensitivity is the likelihood that a diseased patient has a positive test. If all patients with a given disease have a positive test (i.e., no diseased patients have negative tests), the test sensitivity is 100%. Generally, a test with high sensitivity is useful to exclude a diagnosis because a highly sensitive test will render few results that are falsely negative.A test's specificity is the likelihood that a healthy patient has a negative test. If all patients who do not have a given disease have negative tests (i.e., no healthy patients have positive tests), the test specificity is 100%. A test with high specificity is useful to confirm a diagnosis, because a highly specific test will have few results that are falsely positive.[19]

Positive predictive value (PPV) is a measure of the frequency of the disease in all population with positive results. It is the probability that a person has the disease, given a positive test result. It combines the disease prevalence with test sensitivity and specificity. Negative predictive value (NPV) is a measure of the frequency of the absence of the disease in all population with negative results. It is the probability that, given a negative result, the patient is free from disease.[19,20]

An ideal test is one for which there is no overlap in the range of results among patients with and without the disorder in question. Few tests are ideal. Usually there is an overlap of results among patients with or without a specific disorder. Each point along the distribution of results that overlap defines a set of operating characteristics for the test. As the point used to define an abnormal result (cutoff point) is moved in the direction of patients with the disorder, the sensitivity decreases. As it is moved in the direction of patients without the disorder, the reverse is true. Some tests may be used both to exclude or to confirm a disorder by altering the criteria

for a positive test according to the purpose of the test.[21,22]

Knowledge of test characteristics is important in deciding which test to select for a given purpose. The process of confirming a disorder requires a test whose specificity is high. When two or more tests are available for this purpose, the one with the highest specificity is ordinarily preferred. When a test is used either for the purpose of screening or to exclude a diagnostic possibility it must be sensitive. When two or more such tests are available, that with the highest sensitivity is ordinarily preferred. Multiple tests are most helpful when: 1) all are normal, thus tending to exclude the disorder; and 2) when all are abnormal, thus tending to confirm the presence of the disorder. Multiple tests are least helpful when one is positive and the others are normal. If two or more tests are highly sensitive and the primary purpose of the test is to exclude a disorder, the gain in sensitivity obtained by ordering more than one test may be offset by the increase in false-positive results.[23,24]

Laboratory procedures can be used as screening devices to identify "at risk" patients who may be prone to an illness that can be prevented or diminished by early detection and care. For example, routine measurement of cholesterol can be useful in determining which patients should start on preventive management for atherosclerotic cardiovascular disease. The problem with screening, though, is the number of false-positive results it produces. As the prevalence of a disorder in a population falls, the percentage of false-positive results rises dramatically, so there are five to ten false-positive results for every true-positive one. In order to deal with this situation, many attempts have been made to develop guidelines for selection of appropriate patients and tests for early detection.[25] The use of laboratory tests for screening purposes should include selection of a highly sensitive laboratory test(s), the appropriate application of the test(s) to health problem(s) which are common, have significant morbidity/ mortality and are preventable and/or amenable to effective care.[26]

A second reason for using clinical laboratory tests is to provide assistance in establishing diagnostic hypotheses. The laboratory may be particularly helpful in sorting out whether a patient's clinical complaints are due to a functional or organic disorder.[27] To rule out a disorder, very sensitive tests are most effective in reducing the probability of that disorder. Very specific tests are most effective in raising the probability of the presence of a disorder and thus are useful for ruling in diagnoses. Such tests when abnormal can confirm the presence of a disorder.[28]

The intelligent selection of an appropriate laboratory test depends on choosing the proper test for the purpose intended. The purpose of the test is affected by the physician's estimate of the pretest likelihood that a disorder is present based on an assessment of the available clinical information. The use of a test to exclude or confirm a diagnosis should indicate that the physician's best estimate after a careful evaluation of the patient's problem is that the diagnosis in question is either relatively unlikely or probable, respectively. When these principles are followed, the conclusions reached from laboratory test results are likely to be correct and lead to appropriate action.[10,11,29]

Laboratory tests are used for patient management which includes monitoring patient's response to care, the need for care and determination of prognosis. Compared with tests for screening and diagnosis, tests used for monitoring are more likely to have abnormal results, show a change from previous test values, cause a change in patient care and be followed up with repeat testing.[30,31]

The precision of the test is the most important characteristic when selecting laboratory tests for monitoring (test precision is a measure of a test's reproducibility when repeated on the same sample, thus an imprecise test is one that yields widely varying results on repeated measurements).The optimal frequency for monitoring patients cannot be predicted solely on the basis of knowledge of the disorder or the effectiveness of the provided care. It requires the application of normal physiology, knowledge of the natural history of the underlying disorder, tests or procedures used to monitor the disorder and awareness of factors other than the disorder that may influence the test results.[32]

**2. Volume of Laboratory Utilization**

Laboratory utilization measuring could be conducted on hospitalizedpatients and ambulatory population in term of number of tests per admission, average tests ordered per patient per day, median number of tests per physician per year, per clinical problem, requests per practice per months, number of tests ordered per visit, or tests ordered by primary carepractitioners.[33]

The utilization of laboratory services has increased during the past several decades in many health care jurisdictions around the world. In the UK, reports indicated that nearly all laboratories continue to witness a rise of 5% to 10% each year in requests for laboratory tests.[33]

In Australia, for almost a decade and a half the annual growth rates of governmental-funded services have shown that the rates for laboratory services have generally exceeded and often been more than double, those of other medical services. In the financial year 1997-98, laboratory, diagnostic imaging and general practitioner services grew by 4.28%, 3.86% and 0.59%, respectively, compared with the previous 12-month period. In the same period, the Medicare outlays (i.e., "benefits") paid by the Health Insurance Commission for total medical services were $6.334 billion, of which 14.59% were for laboratory services and 14.81% for

diagnostic imaging services. Together with general practitioner services (37.39%), these account for two-thirds of Medicare outlays.[34]

In Canada, health care costs 70 billion (70 x$10^9$) $ or $2500 per person per year. Laboratory costs in Ontario are 1 billion dollars per year, about 7% of the health care budget. They have grown at a rate of about 12% per year, an increase greater than that of population, physician numbers, or inflation.[35]

Many studies provided an explanation for the growth of laboratory services utilization. Many reasons are given: among these are diagnosis, monitoring, screening and prognosis; availability and accuracy of prior result; pressure from patients, relatives and peers; reassurance; medico legal issues; profit; fraud; research; insecurity; and habit. Given this list, some services would clearly be unnecessary and wasteful in the clinical setting.[34,36]

## 3. Assessment of Appropriateness of Laboratory Utilization

The appropriateness of laboratory utilization could be assessed based on implicit as opposed to explicit criteria. The implicit review is based on subjective criteria and relieson interpretation by the reviewer. Implicit criteria are versatile because a single definitioncan be applied to a broad range of tests. They allow a morecomplete review of laboratory utilization because the reviewercan consider multiple components of a patient's situation whendetermining the appropriateness of a laboratory test. Medical record review or a summary of themedical record review should be used to apply the criteria. All audit criteriarequire the chart reviewer to identify each patient's symptomsor diagnoses to determine test appropriateness.[33,37,38]

However, there are many drawbacks to using implicit appropriateness criteria, including inter-reviewer variability in their interpretationand application. Use of implicit criteria usually demands detailedreview of medical records. If physicians do not completely documenttheir clinical reasoning or the patient's findings, laboratorytests may be judged inappropriate. The review could then becomemore an assessment of clinical documentation than of laboratoryutilization. Also, medical record review is time-consuming andexpensive. This will decrease the number of diagnostic episodesthat can be assessed and therefore decrease the scope and precisionof any assessment of laboratory utilization.[33,37-39]

The explicit criteria for inappropriateness are based on testing frequency, timing of the test in relation to previousmedications and tests, test choicecompared with possible alternatives, clinical indicationsfor the test, or probability thata test result was abnormal. With explicit criteria, it is often possible to collect the necessary data from databasesor requisition forms completed by the orderingphysician, thus avoiding many of the problems associatedwith retrospective medical record review. Finally, explicitcriteria make it possible to determine appropriateness criteriausing prospectively collected data (e.g., from a data requisitionform). Prospectively collected data help avoid bias due to omissionof physician documentation.[34-37]

## 4. Magnitude of Inappropriate Laboratory Utilization

Many studies and reports indicated that a significant proportion of laboratory testing performed throughout all tiers of the health system is inappropriate and contributes significantly to overall health costs. For example in the UK, between 25% and 40% of all tests sent to the laboratory are unnecessary.[33] Similarly, one Australian study found that at one hospital up to 20% of all laboratory tests were unnecessary.[40]

A systemic review of clinical laboratory audit built on thirty-one studies from the US and six studies from Europe (United Kingdom and Netherlands). This review cited large variations in the estimates of inappropriate laboratoryuse (4.5%-95%). Studies indicated that15% of ordered general biochemistry and haematology tests, 46% of microbiology tests, 39% of cardiac enzymes tests, 30% of thyroid function tests, and 46% of drug monitoring tests were inappropriate tests.[37]

In one Norwegian hospital, a study was conducted in order to highlight the possibly unnecessary requisitioning of biochemical analyses including serum protein electrophoresis, thyroid function tests in serum and an analysis package of 13 single tests designed for the primary investigation of "acute abdomen". Results revealed that 69% of the acute abdomen test package requisitions were incorrect and nearly all serum protein electrophoresis and thyroid analyses were unnecessarily repeated.[41]

In Thailand, a study aimed to obtain information on laboratory utilization, to evaluate the appropriateness of the residents' test ordering behavior and to estimate the cost of unnecessary tests at a general hospital. Results revealed that the utilization pattern was not correlated to the level of seniority of the physicians and there was inappropriate laboratory utilization by residents: overutilization defined as should not be ordered (26.9%) and underutilization defined as should have been ordered (17.7%). Most of the inappropriateness occurred in the ordering of microbiology (50%) and special blood chemistry (40%) and the cost of unnecessary tests accounted for 17.6 % of the total cost of tests ordered by the residents.[42]

A study conducted at a public hospital in Egypt, revealed that 31.4% of the tests were inappropriate, 20.1% of test results were not used in treatment decisions and 16.3% were not performed. Inappropriate and unused tests accounted for 22.6% of the annual total budget deficit for the hospital laboratory.[43] Another Egyptian study

revealed that a considerable proportion of the diagnostic investigations ordered either for diagnosis or treatment and follow up of the ICU medical patients was judged unnecessary. The proportion ranged between 27.7% and 61.0% when the tests were ordered for diagnostic purposes and ranged between 23.6% and 42.1% when the tests were ordered for treatment and follow up. Laboratory investigations represented the most frequent unnecessary investigations (91.2% of the total unnecessary ordered investigations).This study also demonstrated a high percentage of repeat investigations (60.5% of the total ordered laboratory tests).[44] This figure was higher than that reported by a previous study that was conducted in the same hospital to assess physicians' practices in the use of laboratory tests, where 16.7% of laboratory tests were repeats.[45]

Many studies were conducted to evaluate laboratory requesting in emergency departments. One study conducted in USA, found that of 630 tests, 433 (68%) were classified as "necessary" for clinical decision-making in the emergency department, an additional 68 (11%) as "relevant" and 125 tests (20%) classified as "not indicated". The correlation between the number of tests done per patient-visit and the evaluation of necessity of the tests showed a strong negative correlation. For the 82 visits in which only one laboratory test was performed, fully 94% of these tests were considered necessary. In visits with two to four tests, 79% were classified as necessary, while only 55% of the tests in patients with five or more tests per visit were so classified. The trend for decreasing percentage of necessary tests with increasing number of tests given was found to be statistically highly significant. It is noteworthy that the total of 197 tests not considered necessary were obtained in only 44 patient visits.[46] Similarly, a study conducted in Scotland, found that 384 (75%) of 509 emergency test requests, were appropriate and 125 (25%) were inappropriate.[47] Another study conducted in UK, found nearly a third (32%) of requests for biochemistry investigations from emergency departments were considered unnecessary, with a negative correlation between the tests requested on each visit and the quality of care.[48]

The increase of inappropriate requests for tests received by hospital clinical laboratories, stems from several factors; including "routine" diagnostic testing, fear of censure by seniors, entertainment of obscure diagnoses by junior medical staff, excessive frequency of repeat tests and irrelevant test results stimulating further inappropriate testing. The gathering momentum of widespread inappropriate testing has been aided by the ever increasing automation of laboratory procedures, which make individual tests fairly cheap and the effort to control inappropriate requests comparatively expensive.[49] In Canada, a study indicated that inappropriate use of laboratory services derives from multiple factors, including the use of multi-test profiles, organ- or disease-specific test panels, indiscriminate ordering, standing orders, excessive reporting delays, poor audit trails of test requests, rigid group test ordering, failure to eliminate obsolete tests and some features of computer software design.[35]

## 5. Test Ordering Behavior

Understanding physician ordering practices may be useful in designing strategies to improve their practice and helpful in developing appropriate endpoints for evaluations of these strategies. Physician ordering practices have been analyzed extensively and inappropriate test ordering found to be a primary reason for increased laboratory use. Review of physician ordering practices indicated that inappropriate ordering may be the result of inexperience or lack of knowledge about the appropriate use of tests, failure to check previous results, test ordering routines that are difficult to change, or fear of errors of omission and litigation. Moreover, patients actively ask for tests and often attach greater value to test results than is justified.[50]

A study analyzed the ordering patterns of junior medical staff, who generate most of the test requests in a 450-bed acute care hospitalin Australia. The result showed that the number of tests per patient fluctuated between 9.9 and 11.8. Patterns of unnecessary ordering that emerged included duplicate ordering of identical tests due to poor communication between house-staff, too frequent repeats of tests (for example, daily liver function tests) and tests generated by nursing staff.[51] Another study described test ordering behavior of 229 physicians in 40 local groups from five regions in the Netherlands and showed that the professional characteristics such as knowledge about and attitude towards test ordering appeared to be strongly associated with the number of tests per physician per year.[52] Similarly, a study investigated the physician's perception of determinants of test-ordering behavior in twenty-one general practices in rural and urban areas. Results revealed that Dutch physicians vary considerably in their motives for ordering tests. Numerous motives emerged from the data. Some examples of important themes include personal routines, tolerance of diagnostic uncertainty and time pressure.[53] Another study conducted interviews with 75 general practitioners in Netherlands. The results of the Spearman correlation analyses indicated that test ordering behavior had a significant positive relation to years of experience ($P$= 0.01), conception of task (P = 0.03) and hours per week in practice (manpower) ($P$ = 0.02).[54]

In a study conducted among 27 private office physicians, the doctors were surveyed for their beliefs about appropriate levels of use for common tests, how they compared with other doctors in frequency of use and their reasons for ordering tests. Results showed that beliefs about appropriate levels of testing were correlated with actual use (0.45 to 0.63, Pearson). Usage also correlated with beliefs about relative ordering patterns. Annual testing charges incurred by physicians who believed they ordered tests “more frequently” than

average were higher than those who believed they ordered tests "less frequently" than average ($p < 0.05$). Reasons for ordering tests were (in order of importance): establishing a baseline, assessing prognosis, reassuring patients and helping with treatment decisions.[55]

Studies suggestwide variation in test ordering behavior for seemingly similarindications. A study revealed that there are large differences in the use of laboratory tests between hospitals in Sweden. These differences are not only due to differences between the patients treated but also to differences in practice. Use of laboratory tests seems to reflect local traditions to a large extent.[56] Similarly, a study analyzed the most frequent order combinations of the 20 most common clinical chemistry tests encountered at the same two tertiary care hospitals in USA. The study showed that physicians order tests for varied and complex reasons, which include personality and cultural environment. Orders at the two hospitals displayed strikingly dissimilar preferences for test combinations of different size. For instance, in one hospital three-test and five-test combinations were shunned, while four-test combinations were favored. Apart from the four-test electrolyte combination, exactly opposite preferences for three- to five-test combinations were seen at the other hospital. Similar discrepancies occurred with seven- to ten-test combinations. The study concluded that local medical habit influences ordering and the mix of patients served can be expected to represent another influence on ordering.[57]

## 3. CONCLUSIONS

The appropriate use of health care services (diagnostic testing and therapy) belongs firmly in the domain of quality care and clinical accountability. Appropriate use and understanding of diagnostic testing will reduce unnecessary patient discomfort while also reducing costs.

The appropriateness of the services including the appropriate diagnostic testing formed the first challenge facing people who wish to improve healthcare systems in the developing world. The challenge has its origin in issues that most healthcare systems face: rising healthcare costs, variations in service delivery among providers, hospitals and geographic regions and the presumption that at least some of this variation stems from inappropriate care, either over- or under-use of services; and the intrinsic desire of health-care professionals to offer and patients to receive the best care possible.

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