Int J Med Rev 2021 June;8(2): 87-98

10.30491/IJMR.2020.248448.1145

INTERNATIONAL JOURNAL OF MEDICAL REVIEWS

Narrative Review

Excessive Utilization of Laboratory Investigations and its Relationship with Defensive Medicine Practice: A Saudi Arabia Perspective

Mohamed Khereldeen [1,2] *, Mazen Baazeem [3,4]

[1] Health Services Management, Faculty of Applied Medical Sciences, Umm Al-Qura University, Saudi Arabia
[2] Family Medicine Consultant, Ministry of Health, Alexandria Directorate, Egypt
[3] International Research Collaborative-Oral Health and Equity, School of Human Sciences, The University of Western Australia, Crawley, WA, Australia
[4] Ministry of Health Maternity and Children's Hospital, Makkah, Saudi Arabia

*** Corresponding Author:** Mazen Baazeem, International Research Collaborative - Oral Health and Equity, School of Human Sciences, The University of Western Australia, Crawley, WA, Australia. E-mail: mazen.baazeem@research.uwa.edu.au

Received September 15, 2020; **Accepted** November 11, 2020; **Online Published** June 5, 2021

Abstract

There is a growing deviated physicians' practice regarding laboratory requests due to fear of failing to notice something important, fear of being criticized by superiors for neglecting a test or not coping with the uncertainties related to diagnoses, and so-called defensive testing. This behavior was attributed to the health system culture of fear and the lack of transparency of the costs associated with such unnecessary health care services. A literature search was carried out on these topics: laboratory management, laboratory testing, test requesting, test ordering, physicians' ordering behavior, cost reduction, appropriateness and efficiency using evidence-based resources, including peer-review publications until 2019. The negative impact of defensive medicine practice exceeds the economic consequences and necessarily reduces the patient outcomes and the total quality of patient care. A consensus between experts that the root cause of defensive medicine began with the increasing number of medical malpractice lawsuits. In Saudi Arabia, malpractice claims increased by 416% between 2008 and 2013. Multiple solutions have been suggested for the problem of inappropriate laboratory testing and defensive testing, but no single approach has been widely adopted. Combined strategies proved to be more effective and more durable. Building a culture of trust inside the health system is increasingly perceived as a significant influence on health system functioning.

Keywords: Malpractice, Defensive Medicine, Laboratory Investigation

Introduction

Worldwide, cost containment of healthcare expenditure is rising as a central focus of healthcare policymakers and service providers.[1] Healthcare expenses and healthcare budgets are facing more and more pressure to decrease costs and improve efficiency and appropriateness of care, without compromising the high quality of care.[2]

The Saudi health system is considered as the largest health care system in the gulf region, constituting 48% of the total health expenses in the region with a budget of SR 147 billion in 2018 and SR 172 billion in 2019. During the last 20 years, Saudi health expenditure per capita has increased by five times.[3] Last updated health services utilization indicators available during 2016 are showing 3.5 million inpatients and 138 million visits to the outpatient departments and healthcare centers.[4] The population growth in Saudi Arabia puts a more significant burden on health resources. The total population of Saudi Arabia now is more than 33,000,000 with a 2.52% growth rate.[5]

Another unique aspect for Saudi Arabia is that every year the country serves millions of pilgrims and visitors; 2.371.675 in Hajj season 1439H, and more than 19 million for Umrah 1438H, half of them in Ramadan. The Saudi government provides free health services to pilgrims through the Ministry of Health (MOH) facilities.[6]

The mechanism of healthcare financing in Saudi Arabia puts another pressure on available resources. Free-of-charge services provided to all Saudi citizens and expatriates working in the public sector without any type of cost-sharing. High demand resulting from free services is combined by inflation of the volume and intensity of services used, accordingly increases cost and creates a problem of the inaccessibility of health services. This is obvious in long waiting times

for many services and facilities.[7] Between 2001 and 2015, expenditure on health of Saudi Arabia increased from 8,216 to 37,682 million US dollars with an annual rate that reached a maximum of 31.90 % in 2011. The majority of healthcare funding in Saudi Arabia depends mostly on the annual governmental budget; in 2008, governmental expenditure on health constituted 78.9% of total health expenditure.[8]

Although healthcare expenditure in Saudi Arabia is higher than those of upper-middle-income countries, the healthcare indicators are lower. This entails inefficient and inappropriate use of available resources that needs a health system reform. Between 2006 and 2008, the Saudi government launched compulsory employment-based health insurance (CEBHI) in which there are better monitoring and management of healthcare expenses.[9]

The first theme in Saudi vision 2030 is "Transform Healthcare" with a significant challenge of inefficient health services. The strategic objectives for this theme are improving the quality and efficiency of healthcare services, enhancing the total value provided to stakeholders through the improvement of the efficiency and quality of the healthcare services as well as increasing the safety of the healthcare facilities and ensuring adequate healthcare coverage with financial sustainability. A strategy to reduce medical costs and burdens has been developed to achieve these objectives.[10]

Over the past decade, there has been a dramatic increase in criticisms regarding the excessive utilization of laboratory test practices in the United Kingdom (UK). It has been evident that developing a better practice which is more relevant in health service organizations could minimise the number of unnecessary tests. This indicates a need to understand the various perceptions of the existed issue in healthcare. This paper will review the published literature to provide a comprehensive understanding of the issue. Also, this study gives suggestions for new strategies based on the literature analysis regarding the appropriateness or inappropriateness of this practice and developes or improves a better practice to produce more efficient health services.

Literature Review

Need for Appropriate Use of Laboratory Services

Laboratory services are used very widely in day to day management of patients. Taking blood sample for laboratory testing is almost done for every patient entering a medical facility, and most of the medical decisions are made upon the results of laboratory investigations.[11] "Routine" laboratory testing that is not evidence-based to improve patients' outcomes is considered as a significant drainer of healthcare resources.[12,13] In the UK, during 2008, pathology investigations were involved in 70% of clinical interventions. The potential annual savings from removing redundant pathology investigations were estimated to be £250-£500 million on a national basis.[14] In a recent study, 60-70% of clinical chemistry and coagulation tests may be inappropriate or at least of doubtful clinical importance.[11]

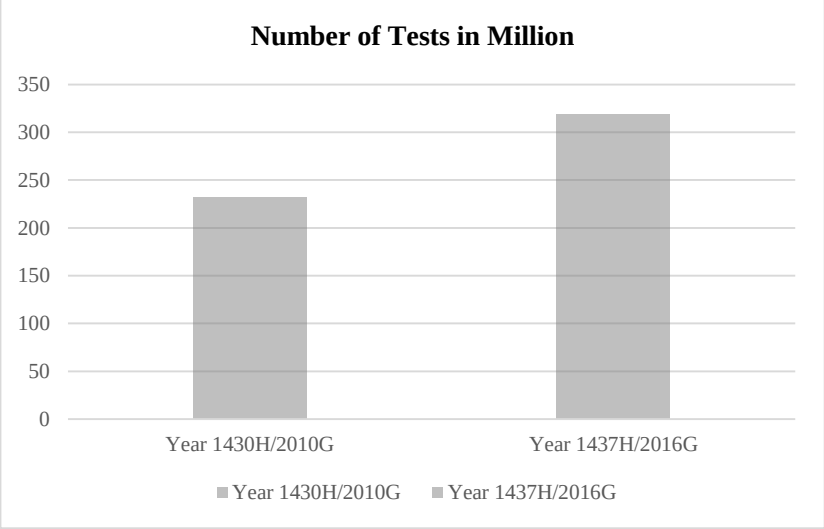

Figure 1. The differences in lab test in Saudi

In Saudi Arabia, during 1430H, there were 232.5 million laboratory investigations, which jumped to 319 million during 1437H.[4] Also, the pattern of diseases is changing with a higher prevalence of communicable diseases.[15] In 2017, the Saudi elderly population represented 4.19% of the total population compared to 2.83% during 2010, with a higher prevalence of chronic diseases in older age groups.[5] Chronic diseases account for around 50% of all pathology activity; this means a greater demand for pathology services and more pressure on the healthcare sector. Also, the future trend for more personalized medicine will create demand for more molecular-based investigations that will increase service costs.[14] Therefore, laboratory services are considered promising sources for major savings especially with relatively easily identifiable and quantifiable costs.[12]

What is an Appropriate Test?

Dekay and Asch [16], Plebani [17] described a threshold approach to decide which tests are considered appropriate; linking the benefits and risks of testing to the probability of disease. Only tests with great accuracy may improve the diagnostic reasoning and provide a positive benefit to risk ratio, and therefore they should be defined "appropriate". For tests with lower accuracy, the risk for patients may exceed the benefits and, therefore, they should be considered as "inappropriate".

Hauser and Shirts [18] stated that as published guidelines have become increasingly popular as audit criteria, any test order in violation of a guideline produced by a government or professional society is considered inappropriate. Van Walraven and Naylor [19] considered defining inappropriate tests if they did not change management plan is problematic. Because laboratory tests are considered only one of several parameters that can affect clinical decision making, another criterion that may be problematic in defining inappropriate laboratory tests is depending on whether the test result was abnormal. This is difficult because normal test results are the most common outcomes of laboratory testing.

Janssens [20] described that little information would be gained from inappropriate tests that had a low predictive value for the differential diagnosis of diseases being monitored.

Cadamuro et al. set seven questions that should be answered before ordering any laboratory test to identify tests of little significance:

1. Does the result contribute to diagnosis, prognosis or treatment?
2. Does the result impact patient care?
3. Are there other results in the same laboratory order that might be enough?
4. Are there previous results that would make my order superfluous?
5. Is my laboratory order in line with respective re-testing intervals?
6. Is the significance of tests clearly acknowledged by clinicians?
7. Are these tests in accordance with the current guidelines and recommendations?

The Magnitude of the Excessive Utilization of Laboratory Investigations

It is intricate to measure the magnitude of inappropriate testing. Data collection tools are mainly subjective responses to questionnaires and interviews. Tools that may be used as direct measures for appropriate use of laboratory tests as appropriateness evaluation criteria, including clinical pathways, is still not available for all diagnoses.[17] Van Walraven and Naylor [19] found large variations in the estimates of inappropriate laboratory use between studies ranged from 4.5% up to 95%. Prothrombin time, calcium, cerebrospinal fluid analysis for the VDRL test, and antiepileptic drug monitoring were the tests with the maximum estimates for inappropriate utilization.

Using recommendations developed by guidelines, Saxena et al. studied the utilization of CK-MB tests. The recommendations described that if acute myocardial infarction is suspected, creatine kinase (CK)-MB levels should be measured on admission and again at 12 and 24 hours. Of the 774 patients evaluated, 38% received only a single test, and 24% only received two tests. Three or more CK-MB tests were obtained in 38% of cases. The time interval between the first and second tests was inappropriately short in 70% and long in 24% of cases. The recommended timing for the third CK-MB was followed in only 4% of cases.

The report of the "The National Pathology Alliance Benchmarking Review" stated that all UK laboratories are facing a rise of 5% to 10% each year in laboratory requests that could not be explained as a natural

increase in demand.[22]

Carter [14] estimated that 25% of all pathology investigations were unnecessary, with no sufficient evidence of their impact on health outcomes.

Regarding inpatient laboratory tests, internal medicine, and general surgery, residents self-reported unnecessary inpatient laboratory test ordering was as high as 88.2% and 67.7%, respectively, occurring daily by 43.5% and 32.3%, respectively.[23]

Another example of the redundant use of laboratory testing is the annual cost of preoperative laboratory testing in the United States (US) that was estimated to be at least $18 billion annually with more than 30 million patient procedures affected, and up to 93% of preoperative tests not indicated.[24,25]

Regarding Saudi Arabia, the utilization of laboratory tests is higher than in many developing countries, as stated by 75% of general practitioners working in primary healthcare centers in Saudi Arabia. Almost 60% of physicians believed that laboratory investigations were improperly utilized.[26]

The Medical and Clinical Affairs at King Faisal Specialist Hospital and Research Center, Jeddah, Saudi Arabia, 2016, has been under the pressure of the unjustified increase in the total number of hospital lab tests over the last few years; with 30% increase over the last year only, studied laboratory tests utilization patterns using health analytics methods. As an expensive lab test, the researchers selected investigating Vitamin D test utilization patterns. They considered that more than once every three months is overutilization and is considered as a clinically insignificant test. Over ten months' duration, overutilization was calculated, showing 56% overutilization rate among vitamin D tests ordered more than three times per patient, and 34% among vitamin D tests ordered more than one time per patient, with an estimated annual avoidable cost of $43,200 for Vitamin D test only.[27]

Reasons for the Excessive Utilization of Laboratory Investigations

Ideally, laboratory tests are requested for reasons like diagnosis, monitoring, screening, prognosis, or to support clinical decision making for patients. Unfortunately, there is a growing deviated physicians' practice regarding laboratory requests due to fear of failing to notice something important, fear of being criticized by superiors for neglecting a test or not being able to cope with the uncertainties related to diagnoses, what is so-called defensive testing.[17,28,29] Nowadays, defensive testing is the most common practice of defensive medicine.[30,31]

This behavior was attributed to the health system culture of fear and the lack of transparency of the costs associated with such unnecessary health care services.[20,23,26] Surprisingly, liability risk merely was found to be enough to increase probabilities of diseases and so widens the testing range.[16]

Brown and Brown [32] interviewed physicians and nurse administrators who were involved in preoperative decision-making to study why physicians order unnecessary preoperative tests. Medico-legal worries emerged as one of the five major themes that cause such unnecessary preoperative testing.

This corresponds to the results by Bass et al.[33] that 54% of ophthalmologists were ordering unnecessary preoperative testing in healthy patients undergoing cataracts surgery, and 32% to 80% of them believed that tests were unnecessary primarily because of medico-legal concerns.

In 2012, 73% of neurosurgeons, members of the American Association of Neurological Surgeons, reported that there is a medical liability crisis, and 69% of them viewed every patient as a potential lawsuit. The inevitable result was tailoring their practice. Also, 67% of the respondents ordered unnecessary laboratory tests.[34]

In 2014, physicians in UK working in three hospitals, surveyed for their practice of defensive medicine. About 78% of the respondents reported practicing one form or another of defensive medicine. Also, 59% of the respondents ordered unnecessary laboratory tests as the most standard form of defensive medicine practice.[30] Interestingly, the same result was reported by Studdertet al.[35]

Many other causes were identified in the literature for rising workload and costs in laboratories as considering the unnecessary requesting of laboratory tests as just a laboratory problem and not owned by clinicians, decreased knowledge about the prudent application of laboratory test laboratory, technological advancements with relatively short turn-around times making tests easier and more comfortable, and laboratory ordering profiles or panels containing as many tests as possible.[12,20,37,38]

Besides the fear of medico-legal responsibilities, the fact that laboratory services were free, readily

available, patients demanded them, were the essential factors in utilization differences between Saudi Arabia and other countries. Unfortunately, it seems more accessible and often safer medico-legally to comply with such practice than not, even when unjustified.[26]

What is Defensive Medicine

"Jobsworth", in British slang, means "it is more than my job worth" and is commonly applied to those who will not cross their limits, even to a small degree, in providing assistance for protecting themselves. Healthcare professionals are not immune to "Jobsworth" behavior.[39]

Doctors are no more blindly trusted. Nowadays, all aspects of their practice, and even their motives are questioned. Most, if not all, of the health professionals are ill-prepared to deal with medico-legal issues. Moreover, no one is immune, and our best practitioners may face litigations of some description. This resulted in a pattern of medical practice that is called defensive medicine.[40] Nowadays, defensive medicine is considered as the natural response to a pandemic of malpractice litigation and has become an undeclared standard of care.[41]

Multiple definitions have been reported in other literature. According to McQuade [42], defensive medicine is "the ordering of treatments, tests, and procedures for protecting the doctor from criticism rather than diagnosing or treating the patient". Mello et al. [43] defined defensive medicine as a “clinician’s intentional overuse of health services to reduce their liability risk with the sole purpose of decreasing exposure to medical malpractice". According to Bishop and Pesko [44], defensive practice means that care is performed, or not performed, primarily to reduce the risk of litigation.

Types of Defensive Medicine

Defensive medicine practice may be in two forms. First, the assurance of behavior or positive defensive medicine. This involves providing a health service of little or no medical value just for protecting the healthcare provider from malpractice claims as ordering more tests, prescribing more medications than medically indicated, referring to specialists in extreme circumstances, and suggesting invasive procedures against professional judgment. Second, the avoidance behavior or negative defensive medicine. This involves a physician who wants to get himself/herself away from sources of legal risk as not conducting specific procedures or interventions and avoiding high-risk patients.[35,44]

However, Summerton [36] argues that some defensive practices may be beneficial, and this is the positive defensive medical practices as increased screening, development of audit or consumer satisfaction activities, and more detailed patient explanations or detailed note-taking. In contrast, negative defensive practice occurs when the practice increases the likelihood of adverse effects on both patient care and resource allocation as prescription of unnecessary drugs, increases in follow-up, referral rate, and diagnostic testing, avoidance of specific treatments and the removal of patients from the practitioner's list.

The Magnitude of the Problem of Defensive Medicine

Defensive medicine is a phenomenon that has increasing prevalence across healthcare systems. The incidence of defensive medicine is increasing to epidemic proportions because of the atmosphere of fear related to medico-legal issues and lawsuits.[42] In a study by Jackson Healthcare [45], hospital administrators estimated an average of 57% of physicians practicing defensive medicine.

Summerton [36] studied the prevalence of defensive medicine in general practice in all UK medical schools. About 80.6% of the respondents were worried about being sued. This is clearly why almost all (98%) respondent physicians claimed to have done some defensive practices. With 59.6%, increased diagnostic testing was third on the list of these practices.

In Pennsylvania, Studdert et al. surveyed physicians working in specialties with a known higher risk of litigation: emergency medicine, general surgery, orthopedic surgery, neurosurgery, obstetrics/gynecology, and radiology. Nearly all (93%) reported practicing defensive medicine. About 59% of the respondents reported that they often ordered more diagnostic tests than were medically indicated; 70% of them were emergency physicians, with 12% obtained unnecessary cardiac workup. Ordering unnecessary diagnostic tests was the most recent assurance act among 70% of all physicians. Specialists who lacked confidence in their insurance coverage were more than twice as likely as other specialists to order unnecessary diagnostic tests.

Defensive testing is also a significant phenomenon in the Dutch health system. Physicians recognized defensive testing in 27% of all tests. About 60% of tests initiated in response to patients' demand, 68% of tests ordered for just reassuring patients, and 30% of blood tests were defensive. Unsurprisingly, 81% of slightly defensive and 85% of clearly defensive blood tests were normal. Tests were ordered defensively in 56% of patients complaining of tiredness and general weakness and in 62% of patients complaining of dizziness.[46]

Defensive testing is also significant in the US and France among general practitioners and general internists. Although clinical practice guidelines do not recommend routine screening of prostatic cancer in asymptomatic patients, physicians were found to be routinely ordering prostate-specific antigen for patients aged 55 years and older. Regret over not ordering a PSA test for a patient who was subsequently found to have advanced cancer was the strongest predictor of ordering PSA tests, with the link with other psychological factors, such as the intolerance of risk and worry about malpractice claims.[47]

The Negative Impact of Defensive Medical Practice

Defensive medicine adversely affects providers, patients, and health systems. The negative impact of defensive medicine exceeds the economic consequences and necessarily reduces patient outcomes and the overall quality of patient care.[16,48]

Hospital administrators estimated that one-third of healthcare costs are the result of tests and treatments that are not medically necessary and ordered only to prevent lawsuits.About 65% of executives believed defensive medicine negatively impacts hospitals' performance.[45]

In 2008, wasteful spending in the US health system was $1.2 trillion, about half of all health expenses. At the top of the list, there was defensive medicine with $210 billion. Despite the considerable healthcare budget in the US, it was ranked 36th in life expectancy in the world.[49]

A much higher estimation of these costs was reported by physicians in an American national survey between 2009 and 2010. In their opinion, lawsuit-driven practices make $650-$850 billion annually, and the medically unnecessary diagnostic and treatment services, ordered to avoid lawsuits, are the primary problem driving healthcare costs.[50]

Specific estimation of the cost of defensive testing alone is difficult because surveys may overestimate or underestimate the actual magnitude of defensive practices. Also, variations in practice styles due to liability pressures are difficult to adjust between different locations. Overall estimation of the cost of the overuse of tests because of fear of malpractice litigation to be $46 billion annually in the US.[43] As Rothberg et al. [51] have indicated, an extra $226 per patient was estimated to be due to defensive testing.

Defensive testing not only led to increased health care costs but also harmed patients. False or delayed diagnosis is associated with the inappropriate use of laboratory resources, either due to the ordering of unnecessary tests or by missing the appropriate diagnostic test, thus potentially jeopardizing patient safety. Also, large test volumes increased the complexity of the management of test results.[11,17] About 83% of primary healthcare physicians reported at least one delay in reviewing test results "they wished they had known about earlier" during two months. There were enormous opportunities for the critical test results to be lost in the "sea" of normal results.[52] The Agency for Healthcare Research and Quality [53] is advising patients that "no news (on test results) is not good news." It recommends that patients need to be sure their physicians review all their test results.

Culture of fear, resulting in defensive medical practice, will be associated with under-reporting of medical errors, masking actual situation and affecting the collection of data that is essential for improving patient safety.[43]

Many other negative consequences for practicing defensive medicine have been reported by physicians as it decreases patients' access to healthcare (76%), negatively impacts patient care (72%), has had a negative effect on the way physicians view patients (71%), hampers physicians' decision-making ability (57%), and delays adoption of new techniques, procedures, and treatments due to fear of a lawsuit (53%).[54]

Reasons for the Practice of Defensive Medicine

Clinical decision making is a meticulous process. Understanding the specific motives behind clinical decisions and the determination of their purposes is hard to identify and measure. A consensus between

experts that the root cause of defensive medicine began with the increasing number of medical malpractice lawsuits.[41]

Even in the early periods of medical practice, clouds of fear are controlling minds. Rodriguez, et al.[55] found that 75% of interns in the emergency room had malpractice concerns. Accordingly, the adoption of defensive practice arises during medical school education. Moreover, the problem is turning into a snowball; 83% of physicians aged 25 to 34 years were trained to practice defensive medicine in medical school or during their residency by an attending physician or mentor, and practice it more frequently than their older counterparts.[56]

With no support from both employers and insurance companies, the medical litigation process in Saudi Arabia encompasses severe consequences, especially for expatriate practitioners, as a travel ban for the whole period of legal investigations with no clear criteria and for no limited time frame. Moreover, accused doctors are required to respond with a clear and understandable medico-legal report with little or no technical terms that may put them in legal pitfalls, mostly when doctors must write it in Arabic. This is considered by many as a perfect fertile ground for developing defensive medicine practice.[57,58]

In 2015, a survey study was conducted in MOH hospitals, Taif city, Saudi Arabia. In this study, 45.8% of expatriate doctors had at least one medical malpractice litigation, and 76.3% of them were prevented from travel more than two years until the end of the investigations. About 90% had no employers support in their cases. Overall, patient care was negatively affected in the opinion of 78% of expatriate doctors.[57]

Increased public awareness regarding health matters, concerns regarding the quality of care and advancement in healthcare have resulted in increased medical malpractice litigation against physicians in Saudi Arabia.[59] According to the medico-legal committee in Saudi Arabia, malpractice claims increased by 416% between 2008 and 2013. About 74% of claims placed blame on the practitioners themselves.[60] Now, the law of practicing healthcare professionals in Saudi Arabia, issued on the 6th of December 2005, has made it compulsory for all physicians and dentists of public and private health institutions to have malpractice insurance.[61]

Analysis of the official records of the National Medico-Legal Committee in Saudi Arabia between 1999 and 2003 revealed a steady increase in the total number of medical litigations. A 21% increase in medical malpractice litigations was noted between 2001 and 2002. The obstetrical practice was highest with 27% of cases, and 3.5% of cases was related to radiology laboratories and blood banks.[40,62]

All medical practitioners are at risk of malpractice liabilities, but specific specialties are considered as high-risk specialties, including Emergency Medicine, General Surgery, Orthopedic Surgery, Neurosurgery, Obstetrics/Gynecology, and Radiology.[35] These specialties are continuously dealing with acute medical problems, and the outcome is highly dependable on the skills, experience and personal judgment of the treating physicians leading to more defensive behavior.[63]

In UK, consultants and physicians aged more than 40 years were the least practicing defensive medicine, maybe due to the higher confidence in their practice and that most of the consultants were used to deal with malpractice claims on frequent basis as they take the ultimate responsibility for most of the work in NHS.[30]

Ferrier et al. [64] found a greater tendency among female doctors to order more defensive laboratory tests with a higher cost of laboratory tests per patient. This is opposite to the findings of Rothberg et al. [51], who found that physician factors, like sex and training, were not associated with defensive orders or costs.

Patients' that are more likely to be affected by defensive practices were those requiring surgery, women, and those visiting emergency rooms.[54]

The incentives for increasing profit also increased defensive practices. Defensive medicine increases the total cost of healthcare for patients thus increases revenues for for-profit healthcare organizations.[48]

Solutions

Multiple solutions have been studied for the problem of inappropriate laboratory testing and defensive testing, but no single approach has been widely adopted as the ultimate solution. Relatively labor-intensive methodologies and scarcity of organized data are among the reasons why a single approach usually fails. However, a combination of several strategies is more likely to be more successful than any single approach.[12,20]

Table 1. Summery of suggested solutions with benefits

Suggested Solutions	Benefits
Educational programs	Raising awareness in healthcare providers.
Requisition redesign	Confirming a medical necessity of ordered tests.
Computer-based interventions	Delivers automated reminder messages with an explanation for each test.
Evidence-based medicine and appropriateness evaluation criteria	Clinical based evidence provides more powerful, more accurate, more efficacious, and safer tests.
Medical education	Delivering an appropriate care and improving in cost containment.
Requesting policies	Providing control for the unauthorized tests.

Educational Programs: The use of educational programs delivered to health services providers has been tested many years ago. Eisenberg [65] used an educational program to decrease prothrombin time overutilization as a routine admission test. After illustrating the specific indications for the use of prothrombin time, its use was decreased from 87% to 55% of patients' admissions. However, the long-term effects of such educational programs are not certain as, after 18 months, the use of this test by the study group had returned to its initial levels.

Requisition Redesign: A more long-lasting effect on test ordering practice has been noted with requisition redesign. This may include statements confirming a medical necessity of ordered tests and signed by the ordering physician, approved panels de-emphasized by locating them on the requisitions in less prominent positions, or the requirement for diagnostic information indicating such testing.[66,67]

After implementing the new requisition form, Emerson and Emerson [66] found that overall laboratory utilization, as measured by the number of tests ordered per patient visit, decreased significantly and for a longer time.

Bailey et al. [68] redesigned the requisition form used by the community doctors with deletion of tests that were more appropriate for hospital use. This reduction in the number of tick boxes decreased the request rate for calcium to an average of 38% of the original request rate. Serum LDH showed a fall to 21% of the original request rate. The study supported the idea that multiple tick boxes can encourage excessive laboratory requests by offering a simple list of accessible tests that may not have been foremost in the clinician's mind.

Computer-based Interventions: Recently, many institutions tried computer-based interventions to reduce the utilization of redundant laboratory tests. Some interventions included a computerized reminder at the time of test ordering that seems to be unnecessary. In Boston at a large teaching hospital and during a 15-week period, 69% of tests were canceled in response to computerized reminders.[69]

Chen et al. also used computerized reminders to manage the utilization of antiepileptic drug level monitoring. For orders appearing redundant, the cancellation rate was 27% and sustained after four years. There has also been a 19.5% decrease in total antiepileptic drug testing volume.

Among multiple solutions, Janssens [20] considered that computerized clinical decision support systems (CDSS) is the most promising tool. CDSS delivers on-time automated messages, including proposals for tests.

Evidence-based Medicine and Appropriateness Evaluation Criteria: With an increased focus on evidence-based practice and related evidence-based testing, there is hope that test order will follow a more scientific structured approach with the propagation of clinical algorithms and away from the habituated test panels, thereby reducing variation in healthcare practice and subsequently the overall cost of health care.[71]

In its effort to respond to the need for the appropriate use of diagnostic services in the delivery of high-quality care, the American College of Cardiology Foundation (ACCF) has developed a process to evaluate the appropriateness of cardiovascular imaging and diagnostic testing for selected patient indications. The main objective was to improve patient care and health outcomes in the most cost-effective manner. Nevertheless, the local parameters, such as equipment or personnel availability, may affect the selection of appropriate diagnostic procedures. Thus, appropriateness criteria should not be a substitute for sound clinical decision making and practice experience.[72] External clinical-based evidence invalidates both previously accepted diagnostic tests and medications and typically replaces them with new ones that are more powerful, more accurate, more efficacious, and safer.[73] This may add to the confidence of healthcare providers in their

clinical decisions as evidence supports their decisions.[74]

Medical Education: As many misconceptions start during the very early phases of medical practice, the solution may be started at the medical education level, and consultants should play a crucial part as leaders for the junior staff. A course on the appropriate care and the need for cost containment in healthcare should be compulsory in all medical and paramedical curricula.[37] The EBM for undergraduate and postgraduate medical courses have become a necessity for most medical schools in the US and other countries.[75]

Requesting Policies: Policies managing the utilization of laboratory services should be in place. A quality assurance study of cardiac isoenzyme utilization in a large, university-affiliated teaching hospital had established a policy for controlling inappropriate requests of lactate dehydrogenase isoenzyme. Unless it was approved by the laboratory staff, it was cancelled if the request originated from an unauthorized location. This policy led to more than 90% reduction in the requests for lactate dehydrogenase isoenzyme testing.[21]

Combination Strategies: As stated before, no single approach for solving the problem of the inappropriate utilization of laboratory services could stand alone. The solution may lie in the combination of multiple strategies. Many combinations have been tried.[12,20]

Brown and Brown [32] suggested that a combination of implementing guidelines, improved education, and greater collaboration between healthcare providers could lead to decreased cost, improved effectiveness, and an enhanced patient experience regarding unnecessary preoperative testing.

Attali et al. investigated the effect of a combination strategy to improve the requesting behavior of blood tests by physicians for three consecutive years. The intervention was composed of a form-based system for ordering blood tests with unbundling of test panels and educating physicians about the economic implications of excessive laboratory testing. The total number of lab tests per admission prior to the intervention was 1.91 +/- 0.89; for each of the next three years it was: 0.76 +/- 0.61, 0.80 +/- 0.62 and 0.78 +/- 0.63 respectively. There was a drop of 97,365 tests during the three years, saving 1,914,149 US dollars. Significantly, this combined strategy produced an effective and sustained reduction in the number of laboratory testing in addition to the financial savings without negatively impacting diagnostic capability or patient care.

After a 31% increase in C-reactive protein requests between 2003-2004 and 2004-2005, the University Hospital of North Staffordshire, UK, started to implement a demand-management strategy to reduce CRP requests in acute admission units. The strategy composed of agreed disease-related protocols, consultant-only requesting, an IT-based logic rule to lower CRP requests made within a 24h time frame of an initial request and educating users. Implementation of these demand-management strategies has resulted in an overall reduction of 85% in the numbers of requests, saving the trust almost £10,000 per annum.[77]

Solutions Implemented in Saudi Arabia: Department of Pathology and Laboratory Medicine at King Faisal Specialist Hospital and Research Centre, Jeddah, Saudi Arabia, encountered a 7% increase each year in testing volume for consecutive five years. In response, a demand optimization strategy has been started for a six months period between 2016 and 2017. The strategy composed of implementing time-based restrictions (minimum retest interval) on ordering 13 high costs (as BCR/ABL1 FISH), high volume (as complete blood count) and high risk (usually reported as overused in the literature as ESR, ova and parasite screening) tests. Results were impressive for a short time interval; a 6.6% decrease in the number of ordered tests, this means an actual decrease of 13.6% (70.3% decrease for enzyme immunoassay) saving 2.03 million Saudi Arabian Riyals (SAR). Savings were 1.4 million SAR in hematology and 0.36 million SAR in microbiology.[78]

Culture of Trust: Building a culture of trust inside the health system that emphasizes that the trustee will not harm the trustor is increasingly perceived as a significant influence on health system functioning. Acknowledging and supporting trust processes between patients and health providers and between co-workers and managers will improve health sector collaboration and improve demand for health care services.[79,80]

Role of Healthcare Facilities: The role of healthcare facilities should complement that of physicians in

reducing the risk of litigations. Implementing clinical practice guidelines, operational policies and procedures being in place, keeping good medical records, establishing a system of checks to assess its performance, defining the credentials and privilege for all practitioners and encouraging continuous medical education are among interventions that healthcare facilities should adopt for building a more reassuring atmosphere.[40]

Role of Physicians: Practitioners have a significant role in securing their practice. Avoiding tunnel vision and considering a more holistic approach for patient's needs, documentation of every detail related to patient's management, consulting with colleagues for critically ill patients, continuously updating their knowledge, practicing according to their privileges limits, referring to a senior colleague if appropriate, adopting shared decision-making with patients and their families and obtaining informed consent when indicted are considered general guidelines for more safe practice.[40,59,60] The communication style distinguishes a "no claim" physicians include more extended visits; orienting statements and explanations, humor and facilitating the patients' expressions.[81]

Role of Patients: Patients must assume an active role in the treatment decision and thus accept some responsibility for their care. Patients should play an active role regarding adherence to their treatment regimens. Patients also should know the difference between a bad outcome and medical negligence and that it is impossible to practice error-free medicine.[82,83] Removing patients' misconceptions should be considered when dealing with overutilization of laboratory tests, especially with introducing a shared decision-making strategy in clinical practice.[84]

Conclusion

There is a growing interest in reducing healthcare costs and better utilization of resources. Excessive utilization of laboratory investigations is considered as a significant source of waste in healthcare. Physicians are ordering unnecessary laboratory investigations to protect themselves from medico-legal lawsuits, which is growing as a regular clinical practice. Efforts to efficiently use the resources should address this deviated practice as a potential source for significant savings in cost and better patients outcomes.

References

1. Stadhouders N, Kruse F, Tanke M, Koolman X, Jeurissen P. Effective healthcare cost-containment policies: A systematic review. Health Policy. 2019;123(1):71-9. doi:10.1016/j.healthpol.2018.10.015
2. Orszag PR. US Health Care Reform: Cost Containment and Improvement in Quality. JAMA. 2016;316(5):493-5. doi:10.1001/jama.2016.9876
3. The Arab Hospital Magazine. Health sector in Saudi Arabia. The Arab Hospital Magazine. 2018. Available from: http://thearabhospital.com/features-ar/%D8%A7%D9%84%D9%82%D8%B7%D8%A7%D8%B9-%D8%A7%D9%84%D8%B5%D8%AD%D9%8A-%D9%81%D9%8A-%D8%A7%D9%84%D8%B3%D8%B9%D9%88%D8%AF%D9%8A%D8%A9/
4. audi Arabian MOH. MOH Statistics and Indicators - MOH Vision of Statistics and Indicators.; 2018. Available from: https://www.moh.gov.sa/en/Ministry/Statistics/book/Documents/book-Statistics.pdf
5. Saudi General Authority for Statistics. The total population in 2018. 2018. Available from: https://www.stats.gov.sa/en/indicators/1
6. Saudi General Authority for Statistics. GASTAT: The total number of pilgrims in 1439H Hajj season reached (2.371.675) pilgrims. 2018. Available from: https://www.stats.gov.sa/en/news/280
7. Walston S, Al-Harbi Y, Al-Omar B. The changing face of healthcare in Saudi Arabia. Annals of Saudi Medicine. 2008;28(4):243-50. doi:10.4103/0256-4947.51704
8. Saudi Ministry of Economy and Planning. In: Achievement of Development Plan, Facts and Figures. Achievement of Development Plan, Facts and Figures. Issue 378, 2008. Riyadh: Ministry of Economy and Planning.
9. Alkhamis A, Hassan A, Cosgrove P. Financing healthcare in Gulf Cooperation Council countries: a focus on Saudi Arabia. International Journal of Health Planning and Management. 2014;29(1):e64-e82. doi:10.1002/hpm.2213
10. Saudi Arabia Vision 2030. In: The National Transformation Program 2030. 2018.
11. Cadamuro J, Ibarz M, Cornes M, Nybo M, Haschke-Becher E, von Meyer A, et al. Managing inappropriate utilization of laboratory resources. Diagnosis. 2019;6(1):5-13. doi:10.1515/dx-2018-0029
12. Gama R, Hartland A, Holland M. Changing clinicians' laboratory test requesting behaviour: can the poacher turn gamekeeper? Clinical laboratory. 2001;47(1-2):57-66.
13. Fryer AA, Smellie WSA. Managing demand for laboratory tests: a laboratory toolkit. Journal of Clinical Pathology. 2013;66(1):62. doi:10.1136/jclinpath-2011-200524
14. Carter L. Report of the second phase of the review of NHS pathology services in England. London: National Health Services. 2008.
15. Almalki M, Fitzgerald G, Clark M. Health care system in Saudi Arabia: an overview. Eastern Mediterranean Health Journal. 2011;17(10):784-93. doi:10.2147/NDT.S48782
16. Dekay ML, Asch DA. Is the Defensive Use of Diagnostic Tests Good for Patients, or Bad? Medical Decision Making. 1998;18(1):19-28. doi:10.1177/0272989X9801800105
17. Plebani M. Defensive medicine and diagnostic testing. Diagnosis. 2014;1(2):151-4. doi:10.1515/dx-2014-0002
18. Hauser R, Shirts B. Do we now know what inappropriate laboratory utilization is? An expanded systematic review of laboratory clinical audits. American Journal of Clinical Pathology. 2014;141(6):774-83. doi:10.1309/AJCPX1HIEM4KLGNU
19. Van Walraven C, Naylor CD. Do We Know What Inappropriate Laboratory Utilization Is?A Systematic Review of Laboratory Clinical Audits. JAMA. 1998;280(6):550-8. doi:10.1001/jama.280.6.550
20. Janssens PMW. Managing the demand for laboratory testing: Options and opportunities. Clinica Chimica Acta. 2010;411(21-22):1596-1602. doi:10.1016/j.cca.2010.07.022
21. Saxena S, Anderson D, Kaufman R, Hannah J, Wong E. Quality assurance study of cardiac isoenzyme utilization in a large teaching hospital. Archives of Pathology & Laboratory Medicine. 1993;117(2):180-3.
22. Gopal Rao G, Crook M, Tillyer ML. Pathology tests: is the time for demand management ripe at last? Journal of Clinical Pathology. 2003;56(4):243-8. doi:10.1136/jcp.56.4.243

23. Sedrak MS, Patel MS, Ziemba JB, Murray D, Kim EJ, Dine CJ, et al. Residents' self-report on why they order perceived unnecessary inpatient laboratory tests. Journal of Hospital Medicine. 2016;11(12):869-72. doi:10.1002/jhm.2645
24. Vogt AW, Henson LC. Unindicated preoperative testing: ASA physical status and financial implications. Journal of Clinical Anesthesia.1997;9(6):437-41. doi:10.1016/S0952-8180(97)00060-3
25. Pasternak LR. Preoperative Testing: Moving from Individual Testing to Risk Management. Anesthesia & Analgesia. 2009;108(2):393-4. doi:10.1213/ane.0b013e31819278ea
26. Bakarman MA, Kurashi NY, Hanif M. Utilization of laboratory investigations: study of knowledge, attitude and practice among primary care physicians. Journal of Family & Community Medicine. 1996;3(2):32-40.
27. Khalifa M, Zabani I, Khalid P. Exploring lab tests over utilization patterns using health analytics methods. IOS Press Ebooks. 2016;226:190-3. doi:10.3233/978-1-61499-664-4-190
28. Hershey N. The Defensive Practice of Medicine Myth or Reality. Milbank Memorial Fund Quarterly. 1972;50(1):69-97. doi:10.2307/3349487
29. Axt-Adam CP, Van Der Wouden CJ, Van Der Does CE. Influencing Behavior of Physicians Ordering Laboratory Tests: A Literature Study. Medical Care. 1993;31(9):784-94. doi:10.1097/00005650-199309000-00003
30. Ortashi O, Virdee J, Hassan R, Mutrynowski T, Abu-Zidan F. The practice of defensive medicine among hospital doctors in the United Kingdom. BMC Medical Ethics. 2013;14(1):42. doi:10.1186/1472-6939-14-42
31. van der Horst A, van de Wijngaart DJ, Scherrenburg J, van Dijk N, Janssens PM. Practical motives are prominent in test-ordering in the Emergency Department. Clinical Chemistry and Laboratory Medicine (CCLM). 2017;55(10):1523-9. doi:10.1515/cclm-2016-1092
32. Brown SR, Brown J. Why do physicians order unnecessary preoperative tests? A qualitative study. Family Medicine. 2011;43(5):338-43.
33. Bass EB, Steinberg EP, Luthra R, Schein OD, Tielsch JM, Javitt JC, et al. Do ophthalmologists, anesthesiologists, and internists agree about preoperative testing in healthy patients undergoing cataract surgery? Archives of Ophthalmology. 1995;113(10):1248-56. doi:10.1001/archopht.1995.01100100036025
34. Nahed B, Babu M, Smith T, Heary R. Malpractice liability and defensive medicine: A national survey of neurosurgeons. PLoS ONE. 2012;7(6):e39237. doi:10.1371/journal.pone.0039237
35. Studdert DM, Mello MM, Sage WM, DesRoches CM, Peugh J, Zapert K, et al. Defensive Medicine Among High-Risk Specialist Physicians in a Volatile Malpractice Environment. JAMA. 2005;293(21):2609-17. doi:10.1001/jama.293.21.2609
36. Summerton N. Positive and negative factors in defensive medicine: a questionnaire study of general practitioners. British Medical Journal. 1995;310(6971):27-9. doi:10.1136/bmj.310.6971.27
37. Bulusu S. Rational, cost effective use of investigations: rising workload and costs in diagnostic departments must be contained. British Medical Journal. 2002;325(7357):222. doi:10.1136/bmj.325.7357.222/a
38. Cadamuro J, Gaksch M, Wiedemann H, Lippi G, Von Meyer A, Pertersmann A, et al. Are laboratory tests always needed? Frequency and causes of laboratory overuse in a hospital setting. Clinical Biochemistry. 2018;54:85-91. doi:10.1016/j.clinbiochem.2018.01.024
39. Jani A, Papanikitas A. "More than my job is worth"–defensive medicine and the marketisation of healthcare. In: Marketisation, Ethics and Healthcare: Routledge; 2018. p. 99-110.
40. Alsaddique AA. Medical liability. The dilemma of litigations. Saudi Medical Journal. 2004;25(7):901-6.
41. Tuers DM. Defensive medicine in the emergency department: increasing health care costs without increasing quality? Nursing Administration Quarterly. 2013;37(2):160-4. doi:10.1097/NAQ.0b013e318286de06
42. McQuade JS. The medical malpractice crisis - Reflections on the alleged causes and proposed cures: Discussion paper. Journal of the Royal Society of Medicine. 1991;84(7):408-11. doi:10.1177/014107689108400710
43. Mello MM, Chandra A, Gawande AA, Studdert DM. National costs of the medical liability system. Health affairs. 2010;29(9):1569-77. doi:10.1377/hlthaff.2009.0807
44. Bishop TF, Pesko M. Does defensive medicine protect doctors against malpractice claims? British Medical Journal. 2015;351:h5786. doi:10.1136/bmj.h5786
45. Jackson Healthcare. Hospital Executives: 32 Percent of Healthcare Costs Due to Defensive Medicine - Jackson Healthcare.; 2014. Available from: https://jacksonhealthcare.com/media-room/news/hospital-executives-on-defensive-medicine-2014/
46. K Van Boven, Dijksterhuis P, Lamberts H. Defensive testing in Dutch family practice. Is the grass greener on the other side of the ocean? The Journal of family practice. 1997;44(5):468-72.
47. Sorum PC, Shim J, Chasseigne G, Bonnin-Scaon S, Cogneau J, Mullet E. Why do Primary Care Physicians in the United States and France Order Prostate-Specific Antigen Tests for Asymptomatic Patients? Medical Decision Making. 2003;23(4):301-13. doi:10.1177/0272989X03256010
48. Sekhar M, Vyas N. Defensive medicine: A bane to healthcare. Annals of Medical and Health Sciences Research. 2013;3(2):295-6. doi:10.4103/2141-9248.113688
49. PricewaterhouseCoopers' Health Research Institute. The Price of Excess: Identifying Waste in Healthcare Spending. Medical Benefits. 2008;25(12):4-5.
50. Jackson Healthcare. Physician study: quantifying the cost of defensive medicine; 2010. Available from: https://jacksonhealthcare.com/media-room/surveys/defensive-medicine-study-2010/
51. Rothberg MB, Class J, Bishop TF, Friderici J, Kleppel R, Lindenauer PK. The Cost of Defensive Medicine on 3 Hospital Medicine Services. JAMA Internal Medicine. 2014;174(11):1867-8. doi:10.1001/jamainternmed.2014.4649
52. Poon EG, Gandhi TK, Sequist TD, Murff HJ, Karson AS, Bates DW. "I Wish I Had Seen This Test Result Earlier!": Dissatisfaction With Test Result Management Systems in Primary Care. Archives of Internal Medicine. 2004;164(20):2223-8. doi:10.1001/archinte.164.20.2223
53. Agency for Healthcare Research and Quality. Chapter 2. Getting Started. Rockville, MD: AHRQ; 2008. Available from: https://archive.ahrq.gov/professionals/quality-patient-safety/patientsafetyculture/nursing-home/nhguide/index.html
54. Jackson Healthcare. DEFENSIVE MEDICINE: IMPACTS BEYOND COSTS SUMMARY OF PHASE III FINDINGS; 2019. Available from: https://jacksonhealthcare.com/media-room/surveys/def-med-phase-3-summary/
55. Rodriguez RM, Anglin D, Hankin A, Hayden SR, Phelps M, McCollough L, et al. A Longitudinal Study of Emergency Medicine Residents' Malpractice Fear and Defensive Medicine. Academic Emergency Medicine. 2007;14(6):569-73. doi:10.1197/j.aem.2007.01.020
56. Jackson Healthcare. Young Physicians Taught to Practice Defensive Medicine, Survey Finds; 2010. Available from: https://jacksonhealthcare.com/media-room/news/young-physicians-taught-to-practice-def-med/
57. Alkindy SAR. Expatriate doctors, medical litigations, and overall patient care: Taif study. Saudi Surgical Journal. 2016;4(3):104.
58. Bird S. How to write a medico-legal report. Australian Family Physician. 2014;43(11):777-9.
59. Alhajjaj MS. Medical practice in Saudi Arabia the medico-legal aspect. Saudi Medical Journal. 1996;17(1):1-4.
60. Aldakhil LO. Obstetric and gynecologic malpractice claims in Saudi Arabia: Incidence and cause. Journal of Forensic and Legal Medicine. 2016;40:8-11. doi:10.1016/j.jflm.2016.02.001
61. Jones W, Karim S, McDonald L. Saudi Arabia: An Overview Of Medical Malpractice In The Kingdom Of Saudi Arabia. 2014 UK: Clyde & Co. Available from: http://www.mondaq.com/saudiarabia/x/361000/Professional+Negligence/An+Overview+Of+Medical+Malpractice+In+The+Kingdom+Of+Saudi+Arabia
62. Samarkandi A. Status of medical liability claims in Saudi Arabia. Annals of Saudi Medicine. 2006;26(2):87-91. doi:10.5144/0256-4947.2006.87
63. Brown TW, McCarthy ML, Kelen GD, Levy F. An Epidemiologic Study of Closed Emergency Department Malpractice Claims in a National Database of Physician Malpractice Insurers. Academic Emergency Medicine. 2010;17(5):553-60. doi:10.1111/j.1553-2712.2010.00729.x
64. Ferrier BM, Woodward CA, Cohen M, Goldsmith CH.

Laboratory Tests: Which Physicians Order More?: How women's practices differ from men's. Canadian Family Physician. 1991;37:349.
65. Eisenberg JM. An educational program to modify laboratory use by house staff. Journal of Medical Education. 1977;52(7):578-81.
66. Emerson JF, Emerson SS. The impact of requisition design on laboratory utilization. American journal of clinical pathology. 2001;116(6):879-884. doi:10.1309/WC83-ERLY-NEDF-471E
67. May TA, Clancy M, Critchfield J, Ebeling F, Enriquez A, Gallagher C, et al. Reducing Unnecessary Inpatient Laboratory Testing in a Teaching Hospital. American Journal of Clinical Pathology. 2006;126(2):200-206. doi:10.1309/wp59ym73l6cegx2f
68. Bailey J, Jennings A, Parapia L. Change of pathology request forms can reduce unwanted requests and tests. Journal of Clinical Pathology. 2005;58(8):853. doi:10.1136/jcp.2004.023101
69. Bates DW, Kuperman GJ, Rittenberg E, Teich JM, Fiskio J, Ma'luf N, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. The American Journal of Medicine. 1999;106(2):144-150. doi:10.1016/s0002-9343(98)00410-0
70. Chen P, Tanasijevic MJ, Schoenenberger RA, Fiskio J, Kuperman GJ, Bates DW. A computer-based intervention for improving the appropriateness of antiepileptic drug level monitoring. American Journal of Clinical Pathology. 2003;119(3):432-8. doi:10.1309/A96XU9YKU298HB2R
71. Sood R, Sood A, Ghosh AK. Non-evidence-based variables affecting physicians' test-ordering tendencies: a systematic review. The Netherlands Journal of Medicine. 2007;65(5):167-77.
72. Douglas PS, Khandheria B, Stainback RF, Weissman NJ, Brindis RG, Patel MR, et al. ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 Appropriateness Criteria for Transthoracic and Transesophageal Echocardiography: A Report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American Society of Echocardiography, American College of Emergency Physicians, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and the Society for Cardiovascular Magnetic Resonance Endorsed by the American College of Chest Physicians and the Society of Critical Care Medicine. Journal of the American College of Cardiology. 2007;50(2):187-204. doi:10.1016/j.jacc.2007.05.003
73. Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. British Medical Journal. 1996;312:71. doi:10.1136/bmj.312.7023.71
74. Rodby RA, Orland BI, Lewis SJ, Hunsicker LG. An evidence-based approach: the emerging role of renal protection in hypertension; a focus on clinical and economic factors that impact formulary decision making. Journal of Managed Care Pharmacy. 2004;10:1-32. doi:10.18553/jmcp.2004.10.S5-A.1
75. Green LM. Graduate medical education training in clinical epidemiology, critical appraisal, and evidence-based medicine: a critical review of curricula. Academic Medicine. 1999;74(6):686-94. doi:10.1097/00001888-199906000-00017
76. Attali M, Barel Y, Somin M, Beilinson N, Shankman M, Ackerman A, et al. A cost-effective method for reducing the volume of laboratory tests in a university-associated teaching hospital. The Mount Sinai journal of medicine, New York. 2006;73(5):787-94.
77. Hutton HD, Drummond HS, Fryer AA. The rise and fall of C-reactive protein: managing demand within clinical biochemistry. Annals of Clinical Biochemistry. 2009;46(2):155-8. doi:10.1258/acb.2008.008126
78. Morris TF, Ellison TL, Mutabagani M, Althawadi SI, Heppenheimer M. Demand management and optimization of clinical laboratory services in a tertiary referral center in Saudi Arabia. Annals of Saudi Medicine. 2018;38(4):299-304. doi:10.5144/0256-4947.2018.299
79. Kohn L, Corrigan J, Donaldson M. To err is human building a safer health system. Washington, D.C: National Academy Press; 2000.
80. Qstergaard LR. Trust matters: A narrative literature review of the role of trust in health care systems in sub-Saharan Africa. Global Public Health. 2015;10(9):1046-1059. doi:10.1080/17441692.2015.1019538
81. Stewart M, Brown JB, Boon H, Galajda J, Meredith L, Sangster M. Evidence on patient-doctor communication. Cancer Prevention & Control. 1999;3(1):25-30.
82. Emanuel EJ, Emanuel LL. Four models of the physician-patient relationship. JAMA. 1992;267(16):2221-6. doi:10.1001/jama.1992.03480160079038
83. Levinson W. Physician-Patient Communication: A Key to Malpractice Prevention. JAMA. 1994;272(20):1619-20. doi:10.1001/jama.1994.03520200075039
84. van Bokhoven MA, Pleunis-van Empel MCH, Koch H, Grol RPTM, Dinant G-J, van der Weijden T. Why do patients want to have their blood tested? A qualitative study of patient expectations in general practice. BMC Family Practice. 2006;7(1):75. doi:10.1186/1471-2296-7-75