

Teaching for Reducing Diagnostic Errors

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Diagnostic errors, constituted by a missed, wrong, or delayed diagnosis detected later by additional tests or findings, are one of the most vexing issues in medicine. They are one of the commonest causes of patient-harm and also medical negligence claims. Although a variety of constructs have been proposed to explain diagnostic errors, the complex interplay of cognitive- and system-factors that underlie these errors is rarely clear to the clinicians. In this write-up, we discuss the reasons for diagnostic errors and how medical students can be trained to avoid such errors. The errors have been classified as Cognitive errors, System errors, and No-fault errors, and cognitive interventions to address each of these are detailed.

Key words: *Clinical reasoning; Cognitive errors; Diagnosis; Misdiagnosis-related harm.*

One of the most challenging and stimulating tasks of a clinician is to arrive at a diagnosis. The diagnosis, for all practical purposes, is usually a working hypothesis to decide the management of the patient [1]. Medical diagnosis is the crux of the clinical encounter between the doctor and the patient, and is the cornerstone of most of the management decisions, and thereby, patient-satisfaction. However, medical diagnosis is not always a yes-or-no situation, especially at the initial consultation. It is a complex process involving many independent and inter-dependent variables that are difficult to tease out and enumerate completely. Arriving at a definitive diagnosis may require some or all of a characteristic thinking process, additional history-taking or examination, and further investigations or consultations. The Medical Council of India Vision 2015 document, although not specifically mentioning diagnostic errors, does stress on the diagnostic skills as one of the competencies required for the Indian Medical Graduate [2].

DIAGNOSTIC ERRORS

What are Diagnostic Errors?

Diagnostic errors, defined as a diagnosis that is missed, wrong, or delayed, as detected by some subsequent definitive test or finding [3], are gradually receiving significant attention from researchers and the authorities. The US Institute of Medicine Committee on Diagnostic Error in Health Care has recently defined diagnostic error as “the failure to (a) establish an accurate and timely explanation of the patient’s health problem(s) or (b) communicate that explanation to the patient” [4]. On the

other hand, harm due to diagnostic errors *i.e.*, misdiagnosis-related harm, can be defined as ‘preventable harm that results from the delay or failure to treat a condition actually present (when the working diagnosis was wrong or unknown) or from treatment provided for a condition not actually present’ [5]. With the introduction of Consumer Protection Act, and the increasing frequency of litigations related to wrong diagnosis or treatment, there is a need for training clinicians to reduce such errors.

Why these errors occur and how to reduce them is a hotly debated issue. It has been suggested that the focus of clinical teaching is mostly on ‘diagnosis’, and not as much on ‘misdiagnosis’ or errors of diagnosis and ways to avoid them. The elucidation of various theories on the cognitive process behind decision-making, and recognition of variety of ways to teach clinical reasoning to students have now enabled us to address the cognitive aspects of diagnostic reasoning [6]. Various mechanisms for reducing diagnostic errors [7,8], and teaching and assessing reduction of diagnostic errors [8,9] have been suggested. Electronic decision-support website or mobile applications (Apps) [10,11], written case-scenarios for teaching diagnostic errors, electronic trigger tools (electronic algorithms that identify potential adverse events by searching electronic health records and flagging specific occurrences) [12,13], simulated patients [14] etc. are increasingly being used as strategies to teach about and reduce diagnostic errors.

How common are They?

Although exact prevalence data are not available, and

diagnostic errors are difficult to document reliably, these have been estimated to be in the range of 5-15% [15,16]. In a survey of 726 pediatricians, more than half had made a diagnostic error at least once- or twice-a-month (the frequency was 77% among trainees); and nearly half reported diagnostic errors that harmed patients at least once- or twice-a-year [17]. Data from other countries also shows similar trends [18-21]. Incidence of medical errors in India is not documented, but probably these occur frequently [22]; however, they are usually under-reported, overlooked and remain a controversial area [23].

In addition to being highly prevalent, diagnostic errors also have important implications for both the patients and the physicians. Diagnostic errors are important causes of both adverse events (second largest cause) [24] and also malpractice suits against hospitals (second leading cause) [25]. Diagnostic discrepancy has been noted even in 20% cases of autopsy [26]. They may also cause harm to patients by inappropriate treatment, delayed treatment, or even harmful treatment. In addition, they may have psychological or financial repercussions, and lead to medical malpractice claims [4]. There is thus an urgent need to teach students to address and respond to diagnostic errors, and by extension, overall improvement in diagnosis.

FACTORS CONTRIBUTING TO DIAGNOSTIC ERRORS

Before we address the various mechanisms to teach reduction of diagnostic errors, two issues need to be deliberated upon viz., how physicians make diagnosis, and what are the causes of diagnostic errors?

How Physicians Make Diagnosis?

The skills required during a clinical encounter, including history-taking, physical-examination, synthesizing data, and presenting this information, represent an amalgamation of multiple cognitive and psychomotor skills and behaviors. The Dual Processing theory is one of the widely accepted theories and proposes that clinicians use two types of cognitive processes to arrive at a diagnosis; System I and System II approaches [27]. System I approaches are faster, more intuitive and based on past experience and pattern-recognition, whereas system II approaches are analytical and more deliberate [6]. A beginner primarily uses system II approach; whereas experts primarily use the system I approach, though they may switch between the approaches depending upon the complexity of the case [28]. Further details of these processes have been previously published [6].

Clinicians routinely use a lot of thumb-rules or heuristics, whether explicitly stated or self-developed [29]. Although, these are essential if multiple critical

decisions need to be made in a situation of constraints of time and information, a corollary of this process is a fixed proportion of error, due to inherent biases associated with each of these heuristics [30]. The principle that it is more likely for a single disease to explain multiple symptoms than for multiple diseases to occur, is called as the Occam's razor [31]. Although infrequently acknowledged, this is one of the most frequently relied upon argument for verifying a diagnosis. This is also accompanied frequently by the tendency to be biased by our initial hypothesis and thus paying minimal attention to other possibilities, also called as Premature closure [32]. This may sometimes just be due to overconfidence, but may occasionally be due to confirmation bias - a tendency to favor evidence that confirms our hypothesis than evidence favoring alternate diagnosis [30]. Clinicians frequently use diagnostic tests to rule-in or rule-out clinical diagnosis, but mostly intuitively, without using an objective method. Bayes' theorem is a method [33] to modify the probability of a particular diagnosis after the results of a diagnostic test. However, it is infrequently used in clinical practice, despite the information on pre- and post-test probability being available for many of the tests in use. Although infrequently taught, in practice, physicians use system I processes more often.

The deliberate diagnostic process consists of four sequential activities, which sometimes occur so rapidly in experienced clinicians so as to appear as if occurring simultaneously [30]. These include the initial recognition of the abnormal data, abnormal physical findings or radiological abnormalities (*Perception*); followed by generation of a clinical framework for analysis or a list of highly likely diagnosis (*Hypothesis-generation*). These initial diagnoses are then evaluated in the light of available test results (*Data-interpretation*). This is then followed by the confirmation of the working diagnosis (*Verification*). There are a variety of steps in this cognitive process of diagnosis, problems in either of which may lead to diagnostic errors.

Causes of Diagnostic Errors

Diagnostic errors have been categorized as No-fault errors, System errors, and Cognitive errors. A schematic representation of these categories, with various examples [30] is shown in **Fig. 1**. Due to its etiological underpinnings, this is an important differentiation as it also guides us towards preventive strategies to address each group. We also need to appreciate that in addition to multiple system errors, cognitive factors may co-exist, and an interaction between the two may be at the root of many cases of diagnostic errors [34]. Errors have been reported to be more likely to occur when the level of

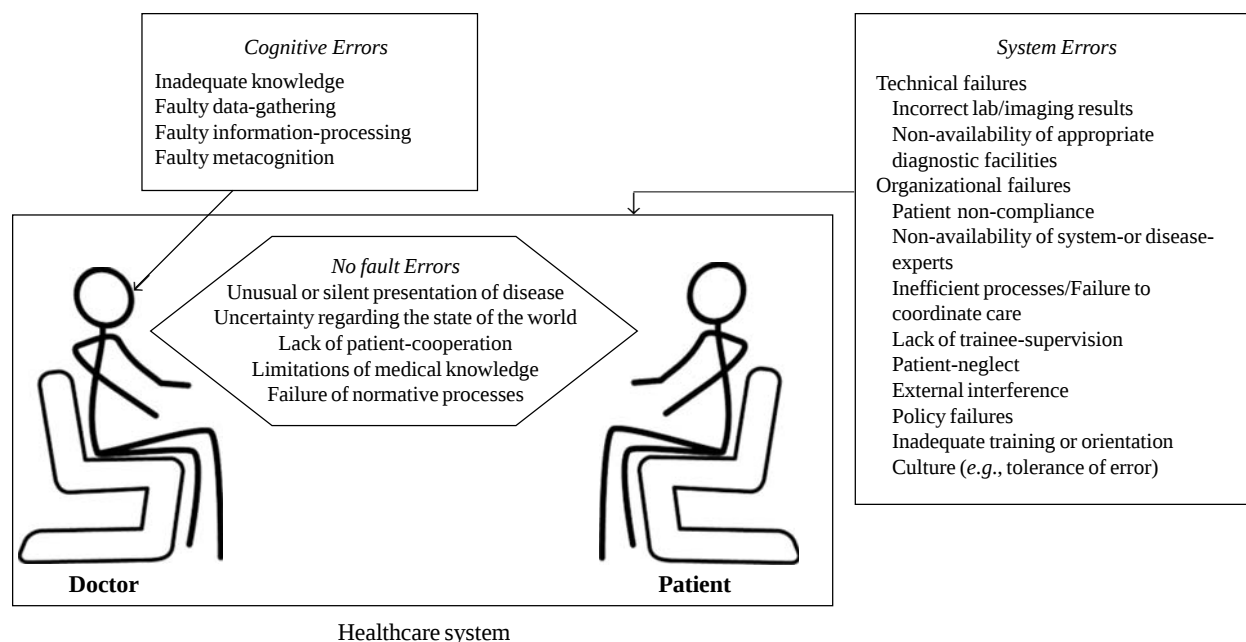


Fig. 1 Three types of diagnostic errors in the healthcare system.

uncertainty is high, there is unfamiliarity with the patient, there are co-morbid disorders confusing the clinical picture, and if atypical or non-specific manifestations are the presenting feature [35].

No-fault errors: These are cases where due to the unique illness- or patient-characteristics, making the correct diagnosis with the current state of medical knowledge is not likely to be routine [35,36]. This may be due to a rare disease, an atypical presentation, a non-compliant patient, and a new disease or an as yet unrecognized manifestation.

System errors, on the other hand, can be ascribed to the deficient functioning of the healthcare system, rather than on the patient-doctor interaction. These reflect latent flaws in the system [30], whether they are due to technical failure or failure of the organizational policies and protocols. These range from those affecting the individual diagnostician *e.g.*, stress or workload, to those affecting all beneficiaries/stakeholders of that system *e.g.*, defective communication and weak policies.

Cognitive errors: are those in which the problem is with the individual diagnostician and include inadequate knowledge or faulty data-gathering, inaccurate clinical reasoning, or faulty verification [9,35,36].

TEACHING TO REDUCE DIAGNOSTIC ERRORS

Although many complex constructs to explain diagnostic errors exist, most clinicians are unaware of the cognitive and system-based underpinnings of this phenomenon [7].

Whether some or all diagnostic errors can be prevented is not known presently, with experts even questioning the goal of zero diagnostic errors [30]. Still, it stands to reason that all attempts should be made to increase diagnostic reliability and decrease diagnostic errors. An expert committee of the Institute of Medicine in US has outlined eight goals to reduce diagnostic errors and improve diagnosis [4]. Two of these are primarily focused on teaching-learning activities *viz.*, “Enhance health care professional education and training in the diagnostic process” and “Research on the diagnostic process and diagnostic error”; in addition to the process of reflection addressed by the goal: “Develop and deploy approaches to identify, learn from, and reduce diagnostic errors and near missed in clinical practice” [4].

One major problem with addressing diagnostic errors is the multiplicity of the underlying factors; an average of six contributory factors per error were identified in an internal medicine department, with almost two-third being system-related ones [34]. Strategies to reduce diagnostic errors may focus on two inter-related aspects *viz.*, Educational activities (teaching-learning activities to teach avoidance of diagnostic errors), and System-related or Managerial strategies, which can be used in practice to address some aspects of diagnostic errors. In this communication, the focus would be on the educational interventions to reduce diagnostic errors. Educational interventions can be used to address both system-related and cognitive root causes [36,37]. Although, it may appear intuitive that only cognitive

errors would be amenable to teaching-learning strategies and it may not be possible to address system-errors, educational strategies have been suggested for both. Cognitive interventions to reduce diagnostic errors have been classified into three mutually exclusive categories by some experts [36-38]: (a) Interventions to increase clinicians' knowledge and experience; (b) Interventions to improve clinical reasoning and decision-making skills; and (c) interventions that assist clinicians with tools or access to other clinicians or experts.

Education for Reducing Cognitive Errors

Two educational strategies have been suggested for reducing diagnostic errors viz., efforts to directly improve cognition, and an indirect system-related approach. However, we need to be aware that cognitive shortcomings can always undermine potential improvements from system changes, and thus educational efforts to directly improve cognition are the lynchpins for reducing diagnostic errors. Moreover, cognitive shortcomings play a dominant role in contributing to diagnostic error [36-38], and thus need to be primarily addressed.

Directly improving cognition

The primary responsibility for training and teaching the diagnostic process and provide more opportunities for learning the same, is on medical colleges and clinical departments, so as to develop highly competent diagnosticians [36,37].

Although the normative approach to diagnosis (consisting sequentially of differential diagnosis, narrowing to a limited number possibilities, and Bayesian probability evaluation) is diligently taught and re-taught in medical school, it is infrequently used in clinical practice, and in fact may not work if the case is just too complicated [37-40]. The current paradigm of the diagnostic process by a knowledgeable and experienced physician is called as dual-process model, part automatic and part conscious [36-40]. The system 1 or the

subconscious, rapidly acting automatic system solves the common problems; whereas, the conscious, rational and analytical cognition (System II) comes into play when problems are complicated and not amenable to automatic decision-making, and also to check on the solutions to the easy problems. This process of diagnosis needs to be taught to trainees so that they know what are its shortcomings and ways to overcome these. The traditional model of medical education aiming for initial building up of the basic sciences theoretical knowledge, followed by clinical exposure and application of the knowledge, has been replaced completely by a Problem-based learning curriculum, where all teaching-learning activities are in the setting of a clinical problem [40,41].

A framework for considering educational interventions for reducing diagnostic errors has been suggested by Graber [36,37], wherein the diagnostician progresses from the basic level (using deductive reasoning) to intermediate level (using heuristics) to expert level skills, with increasing reliability and accuracy, in addition to decreased cost and effort (**Fig. 2**). Two possible educational strategies have been suggested based on this framework viz., by improving expertise, and by conscious, reflective review. As Croskerry [38-42] has suggested, this allows a cross-check of the solutions provided by the subconscious, System I.

Enhancing expertise is the apparently easier strategy to improve the diagnostic reliability and thereby reduce diagnostic errors. Students need to be trained for being better thinkers by teaching discriminative skills and providing more examples and repetitions. This improves their clinical-decision making skills. However, it needs long-term sustained efforts, changes in the educational curriculum, and application over the whole duration of the course.

A satisfactory skill-set coupled with an adequate knowledge base gives the ability to recognize patterns in disease presentations and make reliable diagnoses [42,43]. For the undergraduates, it will primarily involve

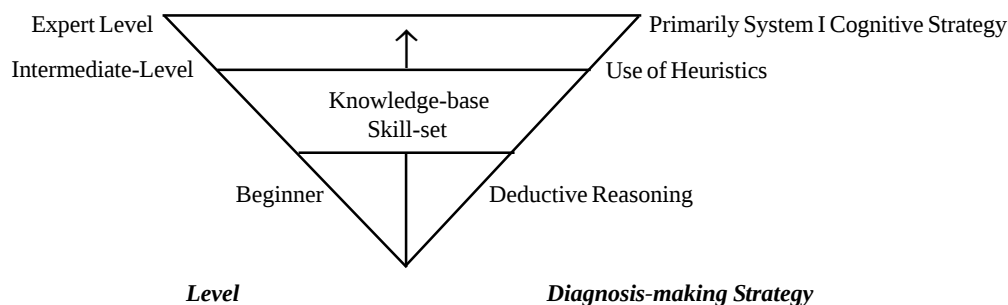


FIG. 2 An inverted pyramid model of diagnostic proficiency.

acquiring knowledge and the skills required to apply this for diagnosis *i.e.*, history-taking and examination skills. It has been the experience of many, and also published literature [43,44], that these skills are infrequently achieved. Failure to gather information through history, physical examination or chart-review was the most common system factor reported, according to a physician survey in US [17]. Although postgraduates already have a wide range of competencies, still further development is possible, though difficult. It requires extensive practice combined with formative feedback [36,37]. We need to recognize these principles and use the opportunity to teach superior diagnostic skills through opportunities to practice on a wide-range of diseases with all their spectrum of presentations – definitely a tall order in the limited period residents are in training. Simulated patients [44,45], especially for uncommon diseases or unusual presentations, may be helpful in this regard.

Encouraging sub (or so-called ‘super’)-specialization is another way to make available expert diagnosticians to diagnose diseases in a focused field, as their knowledge-base and skill set are still higher. However, in the absence of a trained person making an initial diagnosis and referring correctly to the appropriate specialist, and given the unequal distribution of expertise in our scenario, ensuring access to primary-care by a basic doctor may be a better goal than this approach.

Conscious reflective review: In the short term, conscious reflective review may gainfully be employed to improve clinical diagnosis and reduce diagnostic errors. The subconscious problem-solving, utilized to make diagnosis in a large number of cases, is characterized by automatic actions [38-40]. For effective use of reflections, the user needs to be taught and made aware of these and other pitfalls in the diagnostic process, though the benefits of reflections for improving diagnosis have also been questioned [45-48].

Students must be encouraged and provided an opportunity to reflect on their diagnostic approach, and think about what they could be missing. Morbidity and mortality conferences are a good place to do this [6]. Residents can be asked to reflect on their delivery of patient care based on actual case records (case based discussions) or on the discharge papers of patients (chart-stimulated recall) [6].

Use of a checklist to have a review of the diagnostic process and ensure a feedback loop has been suggested [36,37]. Using a checklist has a long history in other high-pressure multiple decision-making settings like aviation, and can be used to benefit the process of diagnosis. A checklist ensures that no step is overlooked and the same

steps are followed by all team members; one with an inbuilt feedback loop has been suggested recently [36, 37, 48,49]. The same has also been detailed in **Fig. 1**.

Metacognitive training: Metacognition, the ability of being aware of one’s thinking process, is apparently a unique human ability. One of the applications of this process is active open-mindedness, and has been shown to lead to ‘better’ decisions [30]. Training strategies for the same have been described and can be used to improve the cognitive process for diagnosis-making.

To incorporate these principles in to day-to-day clinical teaching, clinical case-presentations and case-based discussions are important opportunities. Structured case presentation models like SNAPPS (Summarize the case, Narrow the differentials, Analyze the differentials, Probe the preceptor about uncertainties, Plan management for the patient, Select case related issues for self-study) and One-Minute Preceptor (OMP) provide opportunities to get knowledge, probe students’ reasoning and provide opinion [6]. The opportunity to describe one’s clinical reasoning and being guided to the correct diagnosis provides important insight to the students regarding the diagnosis-making process. Such a metacognitive approach may help learners to recognize the need to slow down and avoid errors that occur due to premature closure of reasoning [49].

System-related approach

Majority of these inputs are administrative in nature and have only a small educational component.

Clinical Guidelines and Clinical decision-support systems: Clinical guidelines, and their extension, clinical decision-support systems, are likely to be helpful in reducing diagnostic errors [36,37]. Guidelines, if developed by considering appropriate prevalence rates and probability estimates, with efforts to minimize errors due to heuristics, may help to improve diagnosis in the clinical setting [50,51]. The problems with clinical guidelines are many, including clinicians being unaware of their existence or unwilling to follow them, not being available to all levels of healthcare, and quite a few of these themselves being heuristic in nature. Teaching about the evidence-based medicine, and consensus-building for synthesizing research evidence to generate guidelines will help in ensuring development of clinically relevant guidelines that are widely-accepted. Guidelines have in fact, been shown to be ineffective in reducing diagnostic errors, though effective in reducing errors in treatment and preventive settings [51,52].

Use of technology in health-management and patient care, the so called Health-information technology (HIT)

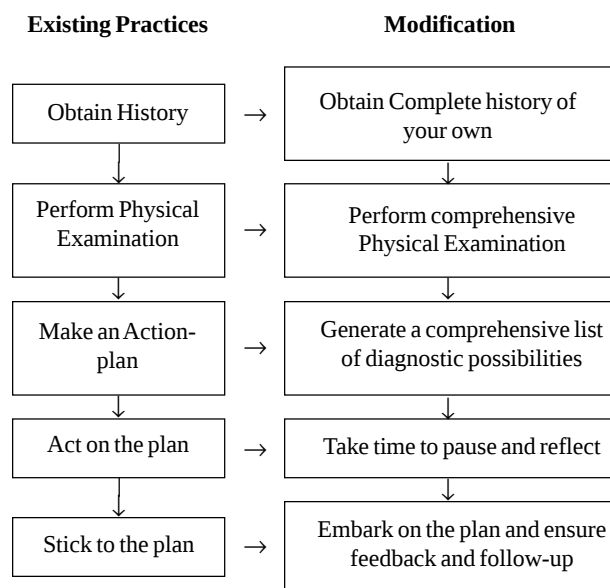


FIG. 3 Steps in improving the reliability of diagnosis (developed from Graber, 2009 [24]).

approaches, are one of the most rapidly expanding areas in the field of patient-safety. These tools and algorithms can be characterized as those assisting: (i) information gathering; (ii) information organization and display; (iii) differential diagnosis generation; (iv) weighing of diagnoses; (v) generation of diagnostic plan; (vi) access to diagnostic reference information; (vii) facilitating follow-up; (viii) screening for early detection in asymptomatic patients; (ix) collaborative diagnosis; and (x) facilitating diagnostic feedback to clinicians [52,53]. Recognizing the importance of information technology for the doctor of today, the General Medical Council in UK advocates that medical graduates should be able to “make effective use of computers and other information systems, including storing and retrieving information” [53], something which the MCI document overlooks [2]. A recent systematic review showed that HIT is efficacious in improving quality and efficiency of medical care [54]; though, electronic health records and electronic decision-support systems were the two of the HIT modalities most commonly used. There is an urgent need to incorporate these in the health management system, and train students in their appropriate use for a patient-centric healthcare.

Clinical decision-support systems directly incorporate computer-based decision system into the clinical practice of medicine at the bedside. These are gradually being used more widely, but the evidence of efficacy for clinical diagnosis is sketchy, though they have been shown to improve patient outcomes and provider behavior related to drug-dosing, preventive care and general process of care [54,55]. One reason for this

could be the poor quality of input into the system [30], thereby limiting the functionality of the system, which could either be due to time constraints preventing complete input of data, or biased data due to the initial hypothesis being considered, or sufficient input data has not been collected.

Improving perception: The method of presenting data has a major impact on our ability to pick up abnormalities [30]. Presenting data in such a way that abnormal findings stand out *e.g.*, highlighting (or using bold typeface) the abnormal results in a report, and presentation as graphs/figures may be more helpful in identifying an abnormal result from a series of normal results. SMS-based or other app-based reminders for abnormal results or need for follow-up a patient may also reduce diagnostic errors.

Expert-opinion: Non-availability of appropriate experts is a recognized reason for missed findings leading to diagnostic errors [55,56], and has been reported even from emergency-rooms in developed countries. It is likely to be more common in the developing country scenario. Although more training may appear a low-cost and direct method, its sustainability is questionable. As far as the educational aspects are considered, improved supervision of trainees [30] and posting of residents of varying seniority together are ways of making expert-opinion available on call, and possibly reducing diagnostic errors.

An extension of this approach, especially in non-urgent situations will be the concept of second opinion. These have been proven effective in decreasing medication errors and can also gainfully be utilized in diagnostic errors whether for diagnostic tests or for complex or difficult clinical diagnoses [57,58].

Education for Reducing System Errors

Given that system errors affect all persons and activities concerned with patient-care, addressing these is likely to reduce diagnostic errors for all diagnosticians working in the system, and also have a long-term effect [30].

A major educational strategy for system-related errors could be addressing communication-related deficits including communication between patient and healthcare personnel, and between various members of the healthcare team (among physicians, between physicians and other team members). This should also address the process of handing- and taking-over of patients' records at the time of shift changes ('handoffs' or 'sign-outs'), an issue that is especially relevant in the current scenario of restricted work hours of residents [59,60]. Improper handoffs may lead to insufficient clinical or test-related information being communicated, which may lead to increased opportunity for diagnostic errors [59].

Improvements in verbal and written communication between health care providers during patient handoffs can reduce injuries due to medical errors by up to 30 percent [61]. A study on a system of bundled communication and training tools for handoff of patient care between providers significantly increased patient safety without significantly burdening existing clinical workflows. Moreover, physicians in a study ranked access to electronic health records and following up with patients as effective strategies in preventing diagnostic errors [17].

There is ample evidence to demonstrate that communication skills can be increased through directed training [62]; thus making these a promising target for educational interventions. However, the current Attitudes and Communications (ATCOM) module of MCI is focusing primarily at doctor-patient communication [63], and needs to be expanded to also include communication between healthcare workers. Improving communication skills has been shown to reduce diagnostic errors due to communication-related system errors [61,64]. New tools to improve communication like Situation, Background, Assessment, and Recommendation (SBAR) technique (a framework for effective communication among members of the health care team) [65], and techniques for improved hand-off [66] can be included into training curricula of nursing staff and residents and serve as an opportunity to address diagnostic errors by educational intervention. Training of emergency medicine residents in SBAR [67] has been used to improve communication during hand-offs. Team training, is another educational intervention that may improve communication between the healthcare team and reduce system-related diagnostic errors [36,37]. Most of these educational interventions could gainfully be incorporated during the internship and residency training.

Education for Reducing No-fault Errors

As primarily these are due to the shortcomings of current medical knowledge and technological abilities of the diagnostic armamentarium, there is likely to be gradual reduction in them with advancement of medical knowledge and technological progress, which will allow recognition of newer diseases and also permit diagnosis at early stages of the disease.

However, there is certain inevitability about these errors and they are unlikely to be eliminated, *e.g.*, atypical presentations, early non-specific manifestations, emerging diseases (new diseases, new pathogens, or side-effects of newer drugs etc.) may continue to lead to diagnostic errors, and medical science will need to continuously evolve to catch up with the utopia of nil

diagnostic errors. Patient-specific factors include both non-compliance (due to a variety of reasons [67,68]), and the patients' appreciation and description of their symptoms (which may vary depending on their socio-cultural or educational background, and their belief-system). Such training in communication and coordination of care would go a long way in reducing this group of errors.

Educational intervention can be aimed at improving cognition directly by training better history-takers (able to tease out hidden aspects of history from the patient), and better communicators (thereby ensuring compliance with investigations, treatment and follow-up). The students need to be taught, in addition, to practice worst-case scenario medicine (always consider the worst possible diagnosis when faced with a particular symptom), and ask what (consider what symptoms or findings cannot be explained by the diagnosis) and why (thinking about the reason why some problem occurred, especially for an acute exacerbation of a chronic disorder) questions [7]. Addressing the culture of non-performance and tolerance of errors also needs to be addressed by educational interventions; departmental and Institutional mortality reviews and difficult-case meetings should aim to address these.

CONCLUSIONS

Improving the diagnostic process is not only possible, but also represents a moral, professional, and public health imperative [4]. Although, the individual physicians may be more comfortable in discussing the 'system-faults' rather than cognitive errors, which are apparently more personal, it is the cognitive aspect that is more amenable to educational interventions. Addressing diagnostic errors systematically will require a comprehensive approach; developing formal curricula to educate trainees about misdiagnoses is one such [68,69]. We hope that individual institutions and teachers will take the onerous responsibility of carrying out teaching-learning activities for reduction of diagnostic error, till such time professional or regulatory bodies develop such curricula.

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