cured with access to antibiotics and other essential medicines, deaths from malaria that would have been prevented by bed nets and access to therapy, and deaths from waterborne illnesses. Other excess mortality is attributable to the inadequacy of efforts to develop new preventive, diagnostic, and therapeutic tools. Those funding the discovery and development of new tools typically neglect the concurrent need for strategies to make them available to the poor. Indeed, some would argue that the biggest challenge facing those who seek to address this outcome gap is the lack of practical means of distribution in the most heavily affected regions.

The development of tools must be followed quickly by their equitable distribution. When new preventive and therapeutic tools are developed without concurrent attention to delivery or implementation, one encounters what are sometimes termed *perverse effects:* even as new tools are developed, inequalities of outcome—lower morbidity and mortality rates among those who can afford access, with sustained high morbidity and mortality among those who cannot—will grow in the absence of an equity plan to deliver the tools to those most at risk. Preventing such a future is the most important goal of global health.

3 Decision-Making in Clinical Medicine

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INTRODUCTION

To a medical student who requires hours to collect a patient's history, perform a physical examination, and organize that information into a coherent presentation, an experienced clinician's ability to decide on a diagnosis and management plan in minutes may seem extraordinary. What separates the master clinician from the novice is an elusive quality called "expertise." The first part of this chapter provides an overview of our current understanding of expertise in clinical reasoning, what it is, and how it can be developed.

The proper use of diagnostic tests and the integration of the results into the patient's clinical assessment may also be equally bewildering to students. Hoping to hit the unknown diagnostic target, novice medical practitioners typically apply a "shotgun" approach to testing. The expert, in contrast, usually focuses her testing strategy to specific diagnostic hypotheses. The second part of the chapter reviews basic statistical concepts useful for interpreting diagnostic tests and quantitative tools useful for clinical decision-making.

Evidence-based medicine (EBM) constitutes the integration of the best available research evidence with clinical judgment as applied to the care of individual patients. The third part of the chapter provides an overview of the tools of EBM.

BRIEF INTRODUCTION TO CLINICAL REASONING

Clinical Expertise Defining "clinical expertise" remains surprisingly difficult. Chess has an objective ranking system based on skill and performance criteria. Athletics, similarly, have ranking systems to distinguish novices from Olympians. But in medicine, after physicians complete training and pass the boards, no further tests or benchmarks identify those who have attained the highest levels of clinical performance. Of course, physicians often consult a few "elite" clinicians for their "special problem-solving prowess" when particularly difficult or obscure cases have baffled everyone else. Yet despite their skill, even master clinicians typically cannot explain their exact processes and methods, thereby limiting the acquisition and dissemination of the expertise used to achieve their impressive results. Furthermore, clinical virtuosity appears not to be generalizable, e.g., an expert on hypertrophic cardiomyopathy may be no better (and possibly worse) than a first-year medical resident at diagnosing and managing a patient with neutropenia, fever, and hypotension.

Broadly construed, clinical expertise includes not only cognitive dimensions and the integration of verbal and visual cues or information but also complex fine-motor skills necessary for invasive and noninvasive procedures and tests. In addition, "the complete package" of expertise in medicine includes the ability to communicate effectively with patients and work well with members of the medical team. Research on medical expertise remains relatively sparse overall, with most of the work focused on diagnostic reasoning, and much less work focused on treatment decisions or the technical skills involved in the performance of procedures. Thus, in this chapter, we focus primarily on the cognitive elements of clinical reasoning.

Because clinical reasoning takes place in the heads of doctors, it is therefore not readily observable, making it obviously difficult to study. One method of research on reasoning asks doctors to "think out loud" as they receive increments of clinical information in a manner meant to simulate a clinical encounter. Another research approach has focused on how doctors *should* reason diagnostically rather than on how they actually *do* reason. Much of what is known about clinical reasoning comes from empirical studies of nonmedical problem-solving behavior. Because of the diverse perspectives contributing to this area, with important contributions from cognitive psychology, sociology, medical education, economics, informatics, and decision sciences, no single integrated model of clinical reasoning exists, and not infrequently, different terms and models describe similar phenomena.

Intuitive versus Analytic Reasoning A contemporary model of reasoning, *dual-process theory* distinguishes two general systems of cognitive processes. *Intuition* (System 1) provides rapid effortless judgments from memorized associations using pattern recognition and other simplifying "rules of thumb" (i.e., heuristics). For example, a very simple pattern that could be useful in certain situations is "African-American women plus hilar adenopathy equals sarcoid." Because no effort is involved in recalling the pattern, typically, the clinician is unable to say how those judgments were formulated. In contrast, *analysis* (System 2), the other form of reasoning in the dual-process model, is slow, methodical, deliberative, and effortful. These are, of course, idealized extremes of the cognitive continuum. How these systems interact in different decision problems, how experts use them differently from novices, and when their use can lead to errors in judgment remain the subject of considerable study and debate.

Pattern recognition is a complex cognitive process that appears largely effortless. One can recognize people's faces, the breed of a dog, or an automobile model without necessarily being able to say what specific features prompted the recognition. Analogously, experienced clinicians often recognize familiar diagnosis patterns quickly. In the absence of an extensive stored repertoire of diagnostic patterns, students (as well as more experienced clinicians operating outside their area of expertise) often use the more laborious System 2 analytic approach along with more intensive and comprehensive data collection to reach the diagnosis.

The following three brief scenarios of a patient with hemoptysis demonstrate three distinct patterns:

- A 46-year-old man presents to his internist with a chief complaint of hemoptysis. An otherwise healthy nonsmoker, he is recovering from an apparent viral bronchitis. This presentation pattern suggests that the small amount of blood-streaked sputum is due to acute bronchitis, so that a chest x-ray provides sufficient reassurance that a more serious disorder is absent.
- In the second scenario, a 46-year-old patient who has the same chief complaint but with a 100-pack-year smoking history, a productive morning cough, and episodes of blood-streaked sputum fits the pattern of carcinoma of the lung. Consequently, along with the chest x-ray, the physician obtains a sputum cytology examination and refers this patient for a chest computed tomography (CT) scan.
- In the third scenario, a 46-year-old patient with hemoptysis who immigrated from a developing country has an echocardiogram as well, because the physician hears a soft diastolic rumbling murmur at the apex on cardiac auscultation, suggesting rheumatic mitral stenosis and possibly pulmonary hypertension.