Some Basic Concepts and Terms

The modern patient safety movement has emphasized medication errors, handoff errors, infections, and surgical errors; all areas amenable to technological (e.g., computerized order entry), procedural (e.g., double checks), and policy (e.g., “sign-your-site”) solutions. Diagnostic errors have been less well emphasized, in part because they are more difficult to measure and to fix.

Yet a number of studies have demonstrated that diagnostic errors are common, and that they can be deadly.¹,² At first glance, diagnostic errors would seem to represent human failings—pure failures of cognition. And it is true that, perhaps more than any other area in the field of patient safety, the training and skills of the diagnostician remains of paramount importance. However, in keeping with our modern understanding of patient safety, there are systems fixes that can decrease their frequency and consequences.

Missed Myocardial Infarction: A Classic Diagnostic Error

Annie Jackson (names are pseudonyms), a 68-year-old African-American woman with mild diabetes, high blood pressure, and elevated cholesterol presented to the emergency department after 30 minutes of squeezing chest discomfort. An ECG was quickly obtained. The ER physician, Dr. Bennett, studied the tracing and saw some nonspecific changes in the ST and T segments—not
entirely normal but not the ST-segment elevations that are classic for acute myocardial infarction (MI). On exam, he found mild tachycardia, clear lungs, and mild tenderness over the lower part of the patient’s sternum. He considered the latter discovery quite reassuring (after all, such tenderness would be more characteristic of a musculoskeletal process than a heart attack), but also ordered a troponin (a biomarker released by damaged heart cells). It came back mildly elevated, again not in the range specific for MI but not normal either. Nevertheless, he made a diagnosis of costochondritis (inflammation of the sternum-rib joint), prescribed an anti-inflammatory agent and bed rest, and released Ms. Jackson from the emergency department. She died later that night, a victim of an untreated MI.

We can only guess which cognitive error caused Dr. Bennett to release Annie Jackson from the ER. Perhaps because she was a woman, he underestimated her chance of having a heart attack. He almost certainly relied too heavily on chest wall tenderness for his diagnosis—it is unusual, but not unheard of, in MI patients. He also overemphasized the lack of clear evidence on the ECG and troponin tests. Although they were “nonspecific,” both were clearly abnormal and thus justified admission. Maybe he was just exhausted after a long day at work.

We do know, however, that this particular error—sending patients home with heart attacks—is distressingly common and frequently lethal. Nearly 1 in 25 patients with MIs are mistakenly sent home, and these patients have a much higher death rate than MI victims who are correctly diagnosed and hospitalized. Because the diagnosis of missed MI is the best-studied diagnostic error, I will use it to make several broader points about these errors.

Researchers studying the problem of missed MIs quickly concluded that many errors were related to patient demographics. Physicians were more likely to send patients home despite worrisome histories or abnormal data when the patients were in groups traditionally believed to be at lower risk for MI, such as women and those under age 55. Nonwhites were also mistakenly sent home more often, raising the question of racial bias, conscious or unconscious, among caregivers. In one particularly sobering study, 720 physicians were shown videotapes of actors playing patients with chest pain that could have been heart related. Four actors, each speaking precisely the same script, appeared on the videos: a white man, a white woman, a black man, and a black woman. Regardless of their own race and ethnicity, the physicians were far more likely to recommend cardiac
catheterization for the white male than for the black female. Similar variations in diagnostic and therapeutic practices have been seen elsewhere in medicine, catalyzing vigorous efforts to understand and abolish these “healthcare disparities.”

Researchers found that physician-specific differences were also at play. For example, one study showed that senior physicians were significantly more likely than their younger colleagues to correctly hospitalize chest pain patients (those with real MIs). Were the older physicians better diagnosticians? Perhaps not—the older physicians were also more likely to hospitalize patients without heart attacks. In other words, with experience came risk aversion. Another study showed that risk aversion was not simply a function of age. One-hundred nineteen physicians completed a questionnaire assessing their attitudes toward risk. Doctors who appeared to be risk seekers (e.g., those who like fast cars and sky diving) were four times more likely to send the same chest pain patient home than the risk avoiders.

One could easily look at cases like Annie Jackson’s and see careless doctoring, a blown diagnosis, and a fatal mistake. But by now, hopefully, you’re approaching this case with a more systems-focused mindset, thinking: How can we improve our ability to diagnose patients who come to the ER with a constellation of symptoms, findings, and risk factors that often yield ambiguous results but can be life-threatening? Too often, without a more systematic approach, the clinical decision—to admit or discharge the patient—is based on the physician’s faulty reasoning, which may be traced to poor training, inadequate experience, personal and professional bias, fuzzy thinking brought on by overwork and fatigue, or even the physician’s own tolerance for risk.

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COGNITIVE ERRORS: ITERATIVE HYPOTHESIS TESTING, BAYESIAN REASONING, AND HEURISTICS

As cognitive psychologists began to study how physicians think, they found that even well-trained doctors can engage in faulty thinking because they take cognitive shortcuts, reinforced by a professional culture that rewards the appearance of certainty over its reality. This means that fixing diagnostic errors is likely to depend on understanding how physicians think about diagnoses, and providing them with tools (either cognitive or adjunctive, such as information technology) to help them make correct decisions more often.
Beginning in the 1970s, several researchers began to try to understand how great diagnosticians think. Led by Dr. Jerome Kassirer (later the editor of the *New England Journal of Medicine*), they observed the diagnostic reasoning of dozens of clinicians, and found that the good ones naturally engaged in a process called *iterative hypothesis testing*. This means that, after hearing the initial portion of a case, they immediately began thinking about possible scenarios to explain the facts, modifying their opinions as more information became available. For example, a skilled physician presented with the case of a 57-year-old man with 3 days of chest pain, shortness of breath, and light-headedness, responds by thinking, “The worst thing this could be is a heart attack or blood clot to the lungs. I need to ask a few more questions to see if the chest pain bores through to the back, which would make me worry about an aortic dissection. I’ll also ask about typical cardiac symptoms, such as sweating and nausea, and see if the pain is squeezing or radiates to the left arm or jaw. But even if it doesn’t, I’ll certainly get an ECG to be sure no cardiac event has occurred. If he also reports a fever or cough, I might begin to suspect pneumonia or pleurisy. The chest x-ray should help sort that out.”

Every answer the patient gives and each positive or negative finding on the physical examination (yes, there is a fever; no, the spleen is not enlarged) triggers an automatic, almost intuitive recalibration of the probability of the various alternatives. The skilled diagnostician does this so effortlessly that novices often struggle as they try to understand the science that underlies the expert’s decision to embrace certain facts (the clear lung fields in the patient with dyspnea markedly elevates the probability of pulmonary embolism) while discarding others (the absence of an S3 gallop does little to dissuade the expert from the possibility of heart failure).

We now recognize that much of this art consists of applying an unconscious, intuitive version of *Bayes’ theorem*, developed by the eighteenth-century British theologian-turned-mathematician Thomas Bayes. In essence, Bayes’ theorem says that any medical test must be interpreted from two perspectives. The first: How accurate is the test?—that is, how often does it give right or wrong answers. The second: How likely is it that this patient has the disease the test is looking for? Bayesian reasoning is why it is foolish to screen apparently healthy 35-year-old executives with a cardiac treadmill test (or, for that matter, a “heart scan”), because positive results will mostly be false positives. Conversely, a 65-year-old smoker with high cholesterol who develops squeezing chest pain when shoveling snow has about a 95% chance of having significant coronary artery disease. In this case, a negative treadmill test only lowers this probability to about 80%, so the clinician who reassures the patient that the normal treadmill means his heart is fine is making a terrible, and potentially fatal, mistake.
In addition to misapplications of iterative hypothesis testing and failure to appreciate the implications of Bayesian reasoning, we now understand that many diagnostic errors are caused by cognitive shortcuts ("heuristics") that clinicians take, often in the name of efficiency. For example, many errors occur when clinicians are too quick to pronounce judgment, and then defend that turf too vigorously when contradictory evidence emerges. This is human nature, of course; we tend to see what we expect to see rather than what’s actually in front of our eyes. By the way, did you notice the word “than” used twice in a row in the previous sentence? Even when we don’t intend to do it, our brains can take cognitive shortcuts to get us to our goal—whether it’s finishing a sentence or discharging a patient from the ER.

This cognitive bias, known as “anchoring,” is only one of the many pitfalls that underlie many diagnostic errors. Others common biases include the availability heuristic, framing effects, blind obedience, and premature closure (Table 6-1).

IMPROVING DIAGNOSTIC REASONING

In Chapter 13, we will explore the role of computerized decision support and more general use of information technology in helping physicians to be better diagnosticians. At this juncture, suffice it to say that such computerized adjuncts are likely to help clinicians make better, more evidence-based decisions, but will not for the foreseeable future replace the clinician’s mind as the main diagnostic workhorse.

Can our cognitive biases be overcome? Perhaps more than any area in clinical medicine, when diagnosing patients we need to learn from our mistakes and to deepen our understanding of clinical reasoning. As with most errors, the answer will come through systems thinking, but here this means better systems for training physicians to avoid common diagnostic speed bumps (Table 6-1). As Canadian safety expert and emergency medicine physician Pat Croskerry puts it:

One uniquely distinguishing characteristic of those who make high-quality decisions is that they can largely free themselves from the common pitfalls to which novices are vulnerable. A rite of passage in all disciplines of medicine is learning about clinical pitfalls that have been identified by the discipline’s experts. This [says] in effect, “Here is a typical error that will be made, and here is how to avoid it.”

<table>
<thead>
<tr>
<th>Circumstance and pitfall</th>
<th>Classic definition</th>
<th>Corrective strategies</th>
<th>Clinical maxims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability heuristic</td>
<td>Judging by ease of recalling past cases</td>
<td>Verify with legitimate statistics</td>
<td>Pay attention to base rates: “If you hear hoof beats, think about horses, not zebras.”</td>
</tr>
<tr>
<td>Anchoring heuristic</td>
<td>Relying on initial impressions</td>
<td>Reconsider in light of new data or second opinion</td>
<td>Think beyond the most favored: “If the patient dies unexpectedly, what would it be from?”</td>
</tr>
<tr>
<td>Framing effects</td>
<td>Being swayed by subtle wording</td>
<td>Examine case from alternative perspectives</td>
<td>Deliberately consider from another angle: “Let’s play devil’s advocate …”</td>
</tr>
<tr>
<td>Blind obedience</td>
<td>Showing undue deference to authority or technology</td>
<td>Reconsider when authority is more remote</td>
<td>Tactfully reconfirm human work (in case of human authority); assess test accuracy (in case of technology)</td>
</tr>
<tr>
<td>Premature closure</td>
<td>Espousing narrow-minded belief in single idea</td>
<td>Return to case when refreshed (if clinical pace allows)</td>
<td>Give consideration to extremes: “What’s the diagnosis that I don’t want to miss?”</td>
</tr>
</tbody>
</table>

Interestingly, in the case of the chest pain triage decision (a decision that early researchers hoped to perfect through a combination of electronic decision support and a better appreciation of diagnostic pitfalls), most experts have concluded that the quest for diagnostic certainty is futile. In a number of research studies, even the best algorithms could not reliably identify patients whose actual risk of MI was so low that it was safe to send them home—especially when the penalty for even occasional failure can be a tragic death and a multimillion-dollar lawsuit. So the real progress in chest pain triage has come not from honing our diagnostic abilities, but rather from developing new ways (usually involving repeated cardiac biomarker tests and a predischarge treadmill test) to “rule out MI” inexpensively over a reasonably short (6–12 hours) observational period. In essence, we have abandoned our quest for diagnostic perfection and accepted instead the more mundane task of managing our uncertainty safely by resolving it quickly and inexpensively.

**KEY POINTS**

- Despite advances in laboratory testing, clinical imaging, and information technology, diagnostic errors remain commonplace.
- Clinicians’ diagnostic and therapeutic actions are influenced by both patient-related (e.g., age, gender, race) and clinician-related (e.g., past experience, risk tolerance) factors.
- Good diagnosticians correctly apply iterative hypothesis testing and Bayesian reasoning, and avoid cognitive pitfalls and biases, such as anchoring (getting stuck on initial impressions) and the availability heuristic (being unduly influenced by prior cases).
- Improving diagnostic reasoning will involve both computerized decision support and training clinicians to be more effective and evidence-based diagnostic thinkers.

**REFERENCES**


**ADDITIONAL READINGS**


When people think of information technology and patient safety, they generally think of electronic medical records, computerized order entry, and perhaps BCMA. However, it is worth pointing out that a wide range of other information-system-based solutions can help improve safety. For example, in many hospitals, staff members now wear voice-activated wireless microphones, or use modern text paging or cell phone systems, to facilitate instant communication between caregivers. The value of IT-based sign-out systems and computer-based simulation is discussed in Chapters 8 and 17, respectively. And we shouldn’t forget the importance of more clinically oriented HIT, such as the Picture Archiving and Communication Systems (PACS) that allow digital radiographs to be reviewed from a few miles, or a few thousand miles, away from the hospital. In addition to their convenience, PACS can decrease x-ray interpretation errors by facilitating double reads, computerized enhancements of images, and access to prior radiographs. Moving even closer to the patient, the use of handheld ultrasounds can lower the risks of central-line placement or thoracentesis.

Computerized Decision Support

Although much of HIT’s emphasis has been on replacing the paper chart and moving information around, the ultimate value may lie mainly in computerized decision support. Once clinical care is computerized, it becomes possible to provide information to clinicians at the point of care. For example, some systems provide simple alerts such as drug-drug, drug-allergy, or drug-lab interactions (Figure 13–1), or links to evidence-based guidelines (the clinician types in a diagnosis of “pneumonia” and a link to a recent pneumonia management guideline materializes).

But that is just the start. More prescriptive decision support systems can “hard wire” certain kinds of care. For example, order sets for common diagnoses can be loaded into a CPOE system, “making it easy to do the right thing” by simply clicking a few boxes. Or an intensive care unit (ICU) system can alert the physician or nurse when a patient’s vital signs go outside preset parameters (Figure 13–3). Note that these prescriptive systems usually permit clinicians to deviate from recommended protocols, but this takes more time (because the doctor needs to type out the
orders instead of accepting an order set, and may even be asked to state or check the reason for deviation). Even more prescriptively, the computer could all-but-force a given practice, making the clinician jump through several hoops (such as “call a specialist for approval”) before being allowed to deviate.

**IT SOLUTIONS FOR IMPROVING DIAGNOSTIC ACCURACY**

Finally, another type of decision support focuses on improving diagnostic accuracy (Chapter 6). Early clinical artificial intelligence programs—in which clinicians entered key elements from the history, physical
Solutions

examination, and laboratory studies and the computer fashioned a list of diagnosis—were disappointing, because the computer-generated diagnostic lists mixed plausible possibilities with nonsensical ones, and the data entry time (over and above clinical charting time) was prohibitive. Recent advances have generated new interest in diagnostic decision support. For example, some programs now pull data directly from the electronic medical record, bypassing the need for redundant data entry. Others mine textbooks and journal articles to find diagnoses most frequently associated with citations of certain symptoms and signs. Most modern programs not only suggest possible diagnoses but link to helpful resources and references. One can envision future computerized decision aids that draw their source information from the electronic medical record, produce possible diagnoses that are automatically updated with new information, and actually “learn” by integrating prior experiences from the system itself, making them ever-more-accurate over time.

THE CHALLENGES OF COMPUTERIZATION

Although one might see all of this as terribly exciting—and it is—the computerization of healthcare is also brimming with challenges. Systems that opt to be less prescriptive, perhaps focusing on providing physicians with additional information rather than forcing certain practices, will generally depend on “alerts” that pop up in the process of care. These can result in alert fatigue, as clinicians rapidly tire of the alerts and fail to notice even important ones. For example, one study of approximately 5000 computerized alerts showed that clinicians overrode “critical drug interaction” and “allergy-drug interaction” alerts in approximately three out of four cases. And these alerts may anger clinicians—in one famous case, an expensive CPOE system failed in part because physicians rebelled against all the alerts. As systems become more prescriptive, clinicians may bristle at the hardwired care protocols, especially if they appear to lack the necessary flexibility (“cookbook medicine”). Diagnostic decision support systems are likely to be judged on the seamlessness of the inputting process (the best will be those that draw their inputs directly from the electronic record) and the plausibility and helpfulness of the diagnostic possibilities emanating from the system. As of yet, few studies convincingly demonstrating that these systems improve patient outcomes or diagnostic accuracy.
On the other hand, given the frequency of non-evidence-based medicine and the high prevalence of diagnostic errors, it is difficult to argue that computerized decision support and other HIT solutions should not be aggressively researched and promoted. At this point, despite the emerging evidence of benefit and the promotion of HIT by payer coalitions and others (Chapter 20), adoption of CPOE and the electronic medical record has been remarkably slow. As of 2007, only about 15% of U.S. hospitals had fully adopted CPOE, an adoption curve far slower than that of other technologies such as the VCR, the Internet, and e-mail. The obstacles are many, including financial (particularly if the cost is borne by physicians and hospitals and many of the benefits accrue to insurers), the relative absence of standards (which inhibits interoperability of systems and opportunities for users to switch products over time), and the cultural barriers described above.2,31

As these barriers are overcome and pressure grows to meet publicly reported quality and safety standards (Chapter 3), the adoption of HIT is likely to skyrocket. As with so much else in patient safety, the key to the success of clinical IT systems will be careful design and implementation, because even information technology systems can create harm as well as benefit.

**KEY POINTS**

- The implementation of HIT has been remarkably slow until recently, but the pace is beginning to accelerate.
- Many healthcare activities require multiple providers (and others) to view (legible) patient-level information simultaneously, a powerful argument for electronic medical records.
- CPOE can ensure that physicians’ orders are legible and respect preset parameters.
- Bar coding or other similar systems can help decrease the frequency of medication administration (and other patient identification-related) errors.
- Ultimately, much of the benefit of HIT will come through the thoughtful implementation of computerized decision support, which ranges from simply providing information to clinicians at the point of care to more prescriptive systems that “hardwire” certain elements of care.
REFERENCES


