

Forum

Diagnostic Errors in Medicine: A Case of Neglect

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More than 90 years have passed since Harvard's Dr. Richard Cabot illustrated the value of autopsies to reveal diagnostic error.¹ At his weekly meetings with medical students, Cabot would compare the clinical impressions before death with the findings at autopsy, creating the powerful and enduring teaching format known as the "CPC" (clinical-pathological correlation). From his experience with more than 3,000 cases, Cabot estimated that the clinical diagnosis was correct less than half the time in patients dying of thoracic aneurysms, cirrhosis, pericarditis, nephritis, and a variety of other conditions. The reaction at the time was one of incredulity.² Dr. Alfred Croftan, a Chicago physician, responded that "the overwhelming majority of cases are today diagnosed correctly..." and that the errors noted by Dr. Cabot could only reflect the "unpardonably careless work" by the physicians of Boston.^{3(p. 145)}

Modern clinicians still struggle to recognize and accept the possibility of diagnostic error. Although many of the diseases on Dr. Cabot's list can now be diagnosed with routine blood tests or imaging, diagnostic error still exists and always will.⁴ Medical diagnoses that are wrong, missed, or delayed make up a large fraction of all medical errors and cause substantial suffering and injury. Compared with other types of medical error, however, diagnostic errors receive little attention. We and others have previously proposed that this neglect is a major factor in perpetuating unacceptable rates of diagnostic error.⁴⁻⁶ In this article, I explore the reasons for this neglect in detail. I propose that three factors explain why diagnostic errors tend to be ignored. First, these errors are fundamentally obscure. Diagnostic errors are difficult to identify and when found are less

Article-at-a-Glance

Background: Medical diagnoses that are wrong, missed, or delayed make up a large fraction of all medical errors and cause substantial suffering and injury. Compared with other types of medical error, however, diagnostic errors receive little attention—a major factor in perpetuating unacceptable rates of diagnostic error. Diagnostic errors are fundamentally obscure, health care organizations have not viewed them as a system problem, and physicians responsible for making medical decisions seldom perceive their own error rates as problematic. The safety of modern health care can be improved if these three issues are understood and addressed.

Solutions: Opportunities to improve the visibility of diagnostic errors are evident. Diagnostic error needs to be included in the normal spectrum of quality assurance surveillance and review. The system properties that contribute to diagnostic errors need to be systematically identified and addressed, including issues related to reliable diagnostic testing processes. Even for cases entirely dependent on the skill of the clinician for accurate diagnosis, health care organizations could minimize errors by using system-level interventions to aid the clinician, such as second readings of key diagnostic tests and providing resources for clinical decision support. Physicians need to improve their calibration by getting feedback on the diagnoses they make. Finally, clinicians need to learn about overconfidence and other innate cognitive tendencies that detract from optimal reasoning and learning.

Conclusion: Clinicians and their health care organizations need to take active steps to discover, analyze, and prevent diagnostic errors.

easily understood than other types of medical error. Second, health care organizations have not viewed diagnostic errors as a system problem. Third, physicians responsible for making medical decisions seldom perceive their own error rates as problematic. The safety of modern health care can be improved if we understand and address these three issues in an effort to make diagnostic errors visible.

Neglected Errors

Although clinicians routinely arrive at most of their diagnoses with ease and accuracy, diagnostic errors occur at non-negligible rates. Diagnostic errors are encountered in every specialty and every type of practice. It is estimated that mistakes are made in roughly 5% of radiology and pathology diagnoses.^{7,8} Error rates in clinical practice are not known with certainty but might be as high as 12%, for example in the emergency department where complex decision making is involved in settings of above-average uncertainty and stress.⁹ Diagnostic errors are easily demonstrated when physicians are tested with standardized patients or scenarios.^{10,11} There is excess variation between providers who analyze the same case,^{12,13} and physicians at times even disagree with themselves when re-presented with a case they have previously diagnosed.¹⁴

Medical residents report that diagnostic errors are the most common medical errors they encounter, and only a minority of these are ever discussed with their mentors.¹⁵ In the Harvard Medical Practice Study, diagnostic errors were the second leading cause of adverse events.¹⁶ Autopsies are considered the gold standard for detecting diagnostic errors, and, indeed, discrepancies from the clinical diagnosis are found in approximately one quarter of cases.¹⁷ Not all these discrepancies have clinical relevance, but errors that potentially could have changed the outcome are found in 5% to 10% of all autopsies.^{17,18}

Despite this evidence that diagnostic errors are a major issue in patient safety, they receive scant attention. This may reflect the general tendency for clinicians to be unaware of medical error,¹⁹ but even within the patient safety community diagnostic errors are barely on the radar screen. Clinical decision making is an underfunded research area, and the topic is generally neglected in patient safety symposia and in medical school

curricula. If we are ever to optimize patient safety, it will require that we minimize diagnostic errors. As a start, we need to understand why these errors are neglected.

Fundamental Issues

Although clinical decision making has been described in general terms, at a fundamental level the process is complicated, hidden, and only partially understood.^{20,21} Making a diagnosis is primarily a cognitive process and is subject to influence by the affective state of the clinician.²² These processes are difficult to study and quantify and to understand. Even the decision maker may not be aware of how or why a given diagnosis was reached. Experts in this field work in the area of cognitive psychology and discuss specialized concepts such as “metacognition,” “heuristics,” and “debiasing.” It is little wonder that practicing clinicians and patient safety staff have difficulty acquiring a comprehensive understanding of clinical decision making, the first step in trying to understand diagnostic errors. Root cause analysis, so powerful in understanding other types of medical error, is less easily applied when the root causes are cognitive.

Diagnostic errors often escape detection. It has been estimated that for every error we detect, scores are missed.²³ Compared with adverse events related to surgery or other “process” and treatment errors, which are often glaring and obvious, diagnostic errors tend to be more subtle and difficult to pinpoint in time and place. Detecting unacceptable delays in diagnosis is especially difficult, because clear standards are lacking, and the perceptions of the clinician regarding the existence of a delay may differ substantially from the impressions of an affected patient.

Physicians are uncomfortable discussing diagnostic error. It is unsettling to consider the possibility that one’s own diagnostic capabilities might be in question. This reflects, in part, the real concern that diagnostic errors can lead to career-threatening malpractice suits. A substantial proportion of these suits are provoked by diagnostic errors. In the Veterans Health Administration, tort claims related to diagnostic errors were twice as common as claims related to medication errors.²⁴ Malpractice suits related to diagnostic errors involve all specialties and are the most difficult to defend.²⁵

System Issues

Health care organizations view diagnostic error as physician failure rather than as an institutional problem. The available data, however, suggests that system-related factors commonly contribute to diagnostic error. Emergency departments are particularly predisposed to system-related diagnostic errors relating to workload-related stress, constant distractions, nonstandardized processes, and a variety of associated issues.²⁶ Similarly, when diagnostic errors involve internists, both cognitive and latent system flaws are typically identified as root causes.²⁷ The system-level processes most commonly found in these cases involve cultural acceptance of sub-optimal systems, inadequate policies and procedures, inefficient processes, and problems with teamwork and communication.

Diagnostic errors are simply not a priority for health care organizations. No one has told them they should be. Patient safety is an enormous universe, and many organizations look to expert advisory groups for advice on which areas need attention. Unfortunately, the guidance provided by advisory organizations has yet to identify diagnostic error as an area in need of attention. The Joint Commission on Accreditation of Healthcare Organizations encourages facilities to develop their own patient safety priorities using the tools of root cause analysis to investigate serious injuries.²⁸ In practice, however, organizations tend to focus on the initial seven National Patient Safety Goals, none of which directly involves diagnostic error (but see page 110). The Joint Commission also requires organizations to study and report on 13 categories of sentinel event, but none of these address diagnostic accuracy,²⁸ nor do the 27 reportable events advocated by the National Quality Forum.²⁹ Similarly, the Leapfrog Group, a consortium of 145 organizations providing healthcare benefits, has issued patient safety priorities for healthcare organizations, none directly involving medical diagnosis.³⁰ The Agency for Healthcare Research and Quality recently compiled evidence-based patient safety practices.³¹ Of the 25 measures with the strongest evidence base, none are measures to improve diagnostic accuracy or timeliness.

Health care organizations have many incentives to bypass thorny issues, such as diagnostic error, and focus instead on “low-hanging fruit,” such as medication errors and wrong-site surgery. These errors are easier to

understand, interventions are more obvious, and the organization can show progress towards achieving patient safety goals.

Provider Issues

Although the act of making a medical diagnosis is a defining skill of physicians, clinicians seldom think about how well they carry out this function. Two questions immediately arise: (1) Are clinicians aware that diagnostic errors can occur? (2) Are they themselves susceptible to this problem? The answer to the first question is unequivocally yes: Physicians are keenly aware that diagnostic errors are made. Throughout their training and on a regular basis in their practice years, physicians learn of diagnostic errors via quality assurance proceedings and malpractice suits. The fear of a malpractice suit relating to diagnostic error is a major impetus for the practice of defensive medicine—excessive referrals to specialists and the use of expensive and redundant tests and procedures.³² Defensive practice is ubiquitous, and some estimate that it accounts for 5% to 9% of health care expenditures in the United States.³³ Of direct relevance, this malpractice pressure likely has more significant impact on diagnostic decisions than management decisions.³⁴

The answer to the second question is more interesting: Although clinicians are aware of the possibility for diagnostic error and that they are personally at risk, they believe that their own diagnoses are correct. Errors are made by someone else. Clinicians can perhaps remember a diagnostic error or two they’ve made in their career, but when asked about their current patients and their current diagnoses, my personal observation is that most believe, like Dr. Croftan, that virtually all of these are accurate. Indeed only 29% of physicians reported encountering any medical error in the past year.³⁵ Given the evidence that the true error rate is in the range of 5% to 15%, how is it possible that individual physicians believe that their own error rates approach zero? Inadequate calibration and overconfidence may help explain this contradiction.

Inadequate calibration. Across a wide spectrum of skills and professions, receiving feedback on one’s performance is an essential requirement for developing expertise. Feedback provides the follow-up information necessary to assess the accuracy of initial predications, a process referred to as calibration. Professionals who

are well calibrated agree with each other and correctly interpret “gold standard” cases.

Physicians occasionally receive feedback regarding some of their diagnoses as patients move through a diagnostic evaluation or return for follow-up after treatment. Feedback is too sporadic, however, and lack of feedback contributes to the physician’s sincere belief that the great majority (or all) of their diagnoses are correct. A variety of factors limit feedback.³⁶ Some of the more important factors follow:

- Availability of definitive diagnostic information. The true diagnosis is not known in every case. This would include, for example, most diagnoses regarding less serious ailments; if a patient’s knee pain resolves after two weeks of treatment with aspirin, the clinician may never know if the correct diagnosis was arthritis, bursitis, or tendonitis.

- Communication barriers. If definitive diagnostic information does become available at some later time, the clinician making the initial diagnosis may no longer be in the information loop. The clinician in an outpatient setting may not be routinely informed if his or her initial diagnosis is later modified in the hospital, or vice versa. Even if the opportunity does arise to convey knowledge of an error, clinicians feel awkward informing colleagues their diagnoses were wrong.

- Paucity of planned feedback. The autopsy rate in the United States is now estimated to be less than 5%, depriving clinicians of a unique calibration tool. Although some medical specialty organizations provide formal programs that provide and encourage feedback, this is more the exception than the rule. Physicians are rarely expected to show evidence that they have tracked or processed feedback in any organized way.

Overconfidence. Lack of calibration contributes to overconfidence, a second factor causing clinicians to overestimate their diagnostic accuracy. There is substantial evidence that humans are overconfident in a variety of settings; we routinely overestimate our ability to function flawlessly.³⁷ A classic example is eyewitness testimony—the correlation between the accuracy of eyewitness identification and the confidence level of the witness is generally less than 0.25.³⁸ Another sobering statistic is that only 1% of drivers rate their driving skills below those of the average driver.³⁹

Just as we overestimate our skills and knowledge, we are overconfident that our decisions, such as medical diagnoses, are correct.^{37,40} Overconfidence in the setting of medical decision making, however, is particularly inappropriate given the general uncertainty that surrounds most diagnostic endeavors.

A chilling observation in studies of overconfidence is that the least skilled are the most overconfident. In tests of grammar, logic, and humor, the subjects scoring the lowest by objective criteria are substantially more overconfident of their performance than subjects who score well on these tests.⁴¹ Exactly the same phenomenon is seen when medical residents estimate their skill in communicating with patients.⁴² Those residents least skilled in communicating were exactly the ones least able to judge their skill level and the most likely to overestimate it. In the same vein, trainees dismissed from residency training programs believed that they rarely made any mistakes.⁴³ This phenomenon fits well with current theories regarding the development of expertise. Experts not only possess superior knowledge of their field but are highly aware of their performance level and are less likely to exhibit overconfidence in regard to their performance. Superior metacognition and accurate calibration are the hallmarks of an expert.

Overconfidence and poor calibration become self-perpetuating if our (inappropriate) certainty about our diagnoses dissuades us from asking for autopsies.⁴⁴ Is our diagnostic acumen sharp enough to predict that an autopsy will simply confirm our suspicions? The available evidence would suggest otherwise.⁴⁵ For example, in a recent study, clinicians were asked about the certainty of the diagnosis; fatal but potentially treatable errors were found at autopsy in 10% of the cases regardless of whether the clinicians were certain or not.⁴⁶

Physicians are uncomfortable with uncertainty. Partly in response to pressures from our patients and partly to satisfy our own unease, we assign a “working” diagnosis. Typically, this is produced by a “cognitive disposition to respond” without always ensuring that the process is rigorous and the product is accurate.⁴⁷ Physicians are expected to present a professional air of confidence and expertise. Diagnostic errors fall in our blind spot—we ignore them.

Solutions

Opportunities to improve the visibility of diagnostic errors are evident.

Fundamental Issues

Diagnostic error needs to be included in the normal spectrum of quality assurance surveillance and review. Staff responsible for organizational performance needs simple definitions and working rules to identify, classify, and study these errors. A simple working definition of diagnostic error is those diagnoses that are missed, wrong, or delayed, as detected by some subsequent definitive test or finding. The origins of these errors can be classified by considering the provider-specific (cognitive) elements, the system-related contributions, and “no fault” elements reflecting diseases that present atypically or involve excessive patient noncompliance.^{4,27} Medical schools need to teach principles of optimal decision making and cognitive debiasing.^{47,48}

More research on the nature of clinical decision making is needed to understand how errors arise and how they can be prevented. Research specifically targeted at diagnostic errors is currently being sponsored by the Agency for Healthcare Research and Quality,⁴⁹ as well as the National Patient Safety Foundation, and hopefully future research funding can be identified to build on this foundation.

System Issues

A host of system properties contributes to diagnostic errors, and these need to be systematically identified and addressed, including issues related to reliable processes related to diagnostic testing, which are addressed in this issue of the *Joint Commission Journal on Quality and Patient Safety*.

Health care organizations need to accept partial responsibility for diagnostic errors,⁵⁰ and diagnostic accuracy should be a concern of regulatory groups and policy-guiding organizations. The Joint Commission has taken a positive step in this direction by adding two requirements to the 2005 National Patient Safety Goals which are directed at improving the timeliness of reporting abnormal laboratory results and ensuring that critical abnormalities are communicated to a licensed caregiver.⁵¹ These requirements address one of the more

common system-related diagnostic errors—failure to appropriately communicate abnormal test results. Health care organizations would also be well advised to address another common system-related condition that predisposes to error: ensuring that specialty expertise is available when needed, at all times and on all days.

Mandatory second opinions and computer-assisted diagnosis have the potential to reduce errors in pathology and radiology.⁵²⁻⁵⁶ Health care organizations need to evaluate the costs versus benefits of these novel interventions.

Even for those cases entirely dependent on the skill of the clinician for accurate diagnosis, health care organizations could help minimize errors by using system-level interventions to aid the clinician. For example, second readings of key diagnostic tests improve diagnostic accuracy,⁵⁷ and clinical decision support tools may be helpful in a variety of settings. Similarly, efforts to enhance feedback to clinicians regarding their diagnoses would be beneficial. Organizations also have responsibility for training their clinicians in both the fundamentals of their science and in the diagnostic pitfalls that contribute to errors.⁵⁸

Provider Issues

Physicians need to improve their calibration by getting feedback on the diagnoses they make. Cognitive feedback improves judgment and decisions made under conditions of uncertainty.⁵⁹ For example, feedback regarding their diagnostic accuracy in reading standardized cases is thought to be a major factor explaining how radiologists in the United Kingdom have reduced their rate of diagnostic error.⁶⁰

For the perceptual specialties (radiology, pathology, and dermatology), feedback can be provided through voluntary or mandated participation in quality assurance procedures. For primary care physicians and specialists, the pathway to enhanced feedback is not so clear-cut, and creative ideas are needed to identify how to obtain and provide this information.

The value of an autopsy as a feedback tool needs to be rediscovered.⁶¹ Beyond identifying what diagnoses were missed or wrong, the autopsy is the best tool we have to combat the overconfidence that seems to be ubiquitous in modern medicine. If providers and organizations are unable to increase the autopsy rate voluntarily, autopsies

could be required as a condition of Medicare participation or for Joint Commission certification.⁶² A novel strategy just emerging is the use of postmortem magnetic resonance imaging examination as a supplement or alternative to autopsy.⁶³ Grieving family members may view this noninvasive procedure as a more acceptable alternative to autopsy.

Although they are less likely to feature autopsy findings than in Cabot's day, conferences dedicated to reconciling clinical and pathological findings (CPCs) continue to be warranted. Morbidity and mortality conferences, while ubiquitous today in virtually all medical schools, need to be better structured to distill and learn from diagnostic mistakes.⁶⁴ An extension on this theme is the growing number of sections in leading medical journals featuring quality and safety discussions, and the creative, multimedia "Web M&M" conferences sponsored by the Agency for Healthcare Research and Quality, presenting monthly cases of medical error in internal medicine, surgery and anesthesiology, critical care, and emergency medicine.⁶⁵ These new resources, like autopsies, can increase awareness of medical error. It remains to be seen, however, whether they are as effective a feedback tool, insofar as the autopsy focuses on one's own case while the literature and Web resources focuses on the errors of others: "... the goal of autopsy is not to uncover clinician's mistakes or judge them, but rather to instruct clinicians in the sense of *errando discimus* (to be taught by one's own mistakes)." ^{66(p. 37)}

Finally, clinicians need to learn about overconfidence and the many other innate cognitive tendencies that detract from optimal reasoning and learning.^{6,22,37} Principles and pitfalls of clinical decision making need to be incorporated into the medical school curriculum,⁴⁸ and education must also reach the legions of practicing

clinicians who have had inadequate exposure to these concepts.

A potential concern is that feedback, though likely to improve calibration, may not be well received. An interesting and relevant experiment is currently underway in Major League Baseball, exploring the possibility that umpires can be improve the consistency of their strike calls by viewing videos of each pitch at the completion of a game.⁶⁷ The umpires have filed suit to stop the experiment, viewing the process as an objectionable intrusion. Similarly, some radiologists have resisted mandatory self-assessment meant to improve the accuracy of reading mammograms.⁶⁸ This tension between autonomy and the need to improve calibration via feedback challenges efforts to increase diagnostic accuracy through this approach, but perhaps new incentives can be offered to make clinicians more interested in self-improvement.

Conclusion

A bright light is now being focused on patient safety, but diagnostic errors lie in the shadow. Clinicians and their health care organizations both need to take active steps to discover and analyze these errors. Diagnostic error rates will fall as remediable problems are identified, but the first step is to make these errors visible. **I**

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References

1. Cabot R.C.: Diagnostic pitfalls identified during a study of three thousand autopsies. *JAMA* 59:2295-2298, Dec. 28, 1912.
2. Gore D.C., Gregory S.R.: Historical perspective on medical errors: Richard Cabot and the Institute of Medicine. *J Am Coll Surg* 197:609-611, Oct. 2003.
3. Croftan A.C.: The diagnostic doubts of Dr. Cabot. *JAMA* 60:145, 1913.
4. Graber M., et al.: Reducing diagnostic error in medicine: What's the goal? *Acad Med* 77:981-992, Oct. 2002.
5. Kuhn G.J.: Diagnostic errors. *Acad Emerg Med* 9:740-750, Jul. 2002.
6. Croskerry P.: The importance of cognitive errors in diagnosis and strategies to minimize them. *Acad Med* 78:775-780, Aug. 2003.
7. Foucar E., Foucar M.K.: Error in anatomic pathology. In: Foucar M.K. (ed.): *Bone Marrow Pathology*, 2nd ed. Chicago: ASCP Press, 2000.
8. Fitzgerald R.: Error in Radiology. *Clin Radiol* 56:938-946, Dec. 2001.
9. O'Connor P.M., et al.: Unnecessary delays in accident and emergency departments? Do medical and surgical senior house officers need to vet admissions? *J Accid Emerg Med* 12:251-254, Dec. 1995.
10. Gorter S., et al.: Psoriatic arthritis: Performance of rheumatologists in daily practice. *Ann Rheum Dis* 61:219-224, Mar. 2002.
11. Christensen-Szalinski J.J., Bushyhead J.B.: Physicians' use of probabilistic information in a real clinical setting. *J Exp Psychol Hum Percept Perform* 7:928-935, Aug. 1981.
12. Margo C.E.: A pilot study in ophthalmology of inter-rater related reliability in classifying diagnostic errors: An under-investigated area of medical error. *Qual Saf Health Care* 12:416-420, Dec. 2003.
13. Beam C.A., et al.: Variability in the interpretation of screening mammograms by US radiologists: Findings from a national sample. *Arch Intern Med* 156:209-213, Jan. 22, 1996.
14. Hoffman P.J., et al.: An analysis-of-variance model for the assessment of configural cue utilization in clinical judgment. *Psychol Bull* 69:338-349, May 1968.
15. Wu A.W. et al.: Do house officers learn from their mistakes? *JAMA* 265:2089-2094, Apr. 24, 1991.
16. Leape L. et al.: The nature of adverse events in hospitalized patients: Results of the Harvard Medical Practice Study II. *N Engl J Med* 324:377-384, Feb. 7, 1991.
17. Shojania K.G., et al.: Changes in rates of autopsy-detected diagnostic errors over time. *JAMA* 289:2849-2856, Jun. 4, 2003.
18. *The Autopsy as an Outcome and Performance Measure*. Evidence report/Technology assessment #58. AHRQ Publication No 03-E002. Agency for Healthcare Research and Quality, Rockville, MD, 2003.
19. Berwick D.M.: Errors today and errors tomorrow. *N Engl J Med* 348:2570-2572, Jun. 19, 2003.
20. Kassirer J.P.: Diagnostic reasoning. *Ann Intern Med* 110:893-900, Jun. 1, 1989.
21. Elstein A.S.: Clinical reasoning in medicine. In: Higgs J.M. (ed.): *Clinical Reasoning in the Health Professions*. Oxford, U.K.: Butterworth-Heinemann, 1995, pp. 49-59.
22. Croskerry P.: The cognitive imperative: Thinking about how we think. *Acad Emerg Med* 7:1223-1231, Nov. 2000.
23. Croskerry P., Wears R.L.: Safety errors in emergency medicine. In: Markovchick V.J., Pons P.T. (eds.): *Emergency Medicine Secrets*. Philadelphia: Hanley & Belfus, 2003, pp. 29-37.
24. Weeks W.B., et al.: Tort claims analysis in the Veterans Health Administration for quality improvement. *J Law Med Ethics* 29:335-345, Fall-Winter 2001.
25. Bartlett E.E.: Physicians' cognitive errors and their liability consequences. *J Healthc Risk Manag* 18: 62-69, Fall 1998.
26. Adams J.G., Bohan J.S.: System contributions to error. *Acad Emerg Med* 7:1189-1193, Nov. 2000.
27. Graber M.L., et al.: Diagnostic error in internal medicine. Poster presented at the National Patient Safety Foundation Annual Meeting, Boston, May 3-7, 2004.
28. Joint Commission on Accreditation of Healthcare Organizations: Reporting of Medical/Health Care Errors. A position statement of the Joint Commission on Accreditation of Healthcare Organizations. Nov. 8, 2003.
29. National Quality Forum: *Serious Reportable Events in Healthcare: A Consensus Report*. National Quality Forum Publication # CR01-02. Washington, D.C.: National Quality Forum, 2002.
30. The Leapfrog Group for Patient Safety. <http://www.leapfroggroup.org> (last accessed Dec. 8, 2004).
31. Shojania K.G., et al.: *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*. Evidence Report/Technology Assessment No. 43 from the Agency for Healthcare Research and Quality: AHRQ Publication No. 01-E058. Rockville, MD, 2001. <http://www.ahrq.gov/clinic/ptsafety/> (last accessed Dec. 8, 2004).
32. Anderson R.E.: Billions for defense: The pervasive nature of defensive medicine. *Arch Intern Med* 159:2399-2402, Nov. 8, 1999.
33. Kessler D.P., McClellan M.B.: Do doctors practice defensive medicine? *Q J Econ* 111:353-390, 1996.
34. Kessler D.P., McClellan M.B.: How liability law affects medical productivity. *J Health Econ* 21:931-955, Nov. 2002.
35. Blendon R.J., et al.: Views of practicing physicians and the public on medical errors. *N Engl J Med* 347:1933-1940, Dec. 12, 2002.
36. Croskerry P.: The feedback sanction. *Acad Emerg Med* 7:1232-1238, Nov. 2000.
37. Parker D., Lawton R.: Psychological contribution to the understanding of adverse events in health care. *Qual Saf Health Care* 12:453-457, Dec. 2003.
38. Sporer L.E., et al.: Choosing, confidence, and accuracy: A meta-analysis of the confidence-accuracy relation in eyewitness identification studies. *Psychol Bulletin* 118:315-327, Nov. 1995.
39. Reason J.T., et al.: Errors and violation on the roads: A real distinction? *Ergonomics* 33:1315-1332, 1990.
40. Russo J.E., Schoemaker P.J.H.: *Decision Traps: Ten Barriers to Brilliant Decision-Making and How to Overcome Them*. New York: Doubleday/Currency, 1989.
41. Kruger J., Dunning D.: Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *J Pers Soc Psychol* 77:1121-1134, Dec. 1999.
42. Hodges B., et al.: Difficulties in recognizing one's own incompetence: Novice physicians who are unskilled and unaware of it. *Acad Med* 76(10 Suppl):S87-S89, Oct. 2001.
43. Hall J.C., et al.: Surgeons and cognitive processes. *Br J Surg* 90:10-16, Jan. 2003.
44. Gawande A. Final cut: Medical arrogance and the decline of the autopsy. *The New Yorker*. 19, 2001, pp. 94-99.
45. Shojania K.G.: Diagnostic surprises and the persistent value of the autopsy. *AHRQ Web M&M 2004*. <http://webmm.ahrq.gov/cases.aspx?ic=54> (last accessed Dec. 8, 2004).
46. Podbregar M. et al.: Should we confirm our clinical diagnostic certainty by autopsies? *Intensive Care Med* 27:1750-1755, Nov. 2001.
47. Croskerry P.: Achieving quality in clinical decision making: Cognitive strategies and detection of bias. *Acad Emerg Med* 9:1184-1204, Nov. 2002.
48. Cosby K.S., Croskerry P.: Patient safety: A curriculum for teaching patient safety in emergency medicine. *Acad Emerg Med* 10:69-78, Jan. 2003.

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References, continued

49. Schiff G., et al.: *Diagnostic Errors: Lessons from a Multi-Institutional Collaborative Project for the Diagnostic Error Evaluation and Research Project Investigators*. Rockville, MD: Agency for Healthcare Research and Quality, 2004.
50. Nolan T.W.: System changes to improve patient safety. *BMJ* 320:771-773, Mar. 18, 2000.
51. Joint Commission on Accreditation of Healthcare Organizations: *2005 Laboratory Service National Patient Safety Goals*. http://www.jcaho.org/accredited+organizations/patient+safety/05+npsg/05_npsg_lab.htm (last accessed Dec. 8, 2004).
52. Hunt D.L., et al.: Effects of computer-based clinical decision support systems on physician performance and patient outcomes: A systematic review. *JAMA* 280:1339-1346, Oct. 21, 1998.
53. Trowbridge R., Weingarten S.: Clinical decision support systems. In: Shojania K.G., et al. (eds.): *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*. Evidence Report/Technology Assessment No. 43 from the Agency for Healthcare Research and Quality: AHRQ Publication No. 01-E058. Rockville, MD, 2001. <http://www.ahrq.gov/clinic/ptsafety/> (last accessed Dec. 8, 2004).
54. Espinosa J.A., Nolan T.W.: Reducing errors made by emergency physicians in interpreting radiographs: Longitudinal study. *BMJ* 320:737-740, Mar. 18, 2000.
55. Kripalani S., et al.: Reducing errors in the interpretation of plain radiographs and computed tomography scans. In: Shojania K.G., et al. (eds.): *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*. Evidence Report/Technology Assessment No. 43 from the Agency for Healthcare Research and Quality: AHRQ Publication No. 01-E058. Rockville, MD, 2001. <http://www.ahrq.gov/clinic/ptsafety/> (last accessed Dec. 8, 2004).
56. Westra W.H., et al.: The impact of second opinion surgical pathology on the practice of head and neck surgery: A decade experience at a large referral hospital. *Head and Neck* 24:684-693, Jul. 2002.
57. Ruchlin H.S., et al.: The efficiency of second-opinion consultation programs: A cost-benefit perspective. *Med Care* 20:3-19, Jan. 1982.
58. Croskerry P.: Cognitive forcing strategies in clinical decision making. *Ann Emerg Med* 41:110-120, Jan. 2003.
59. Balzer W.K., et al.: Effects of cognitive feedback on performance. *Psychol Bull* 106:410-433, 1989.
60. Smith-Bindman R., et al.: Comparison of screening mammography in the United States and the United Kingdom. *JAMA* 290:2129-2137, Oct. 22, 2003.
61. Hill R.B., Anderson R.E.: *Autopsy: Medical Practice and Public Policy*. Oxford, U.K.: Butterworth-Heinemann, 1988.
62. Lundberg G.D.: Low-tech autopsies in the era of high-tech medicine: Continued value for quality assurance and patient safety. *JAMA* 280:1273-1274, Oct. 14, 1998.
63. Patriquin L., et al.: Postmortem whole-body magnetic resonance imaging as an adjunct to autopsy: Preliminary clinical experience. *J Magn Reson Imaging* 13:277-287, Feb. 2001. Erratum in: *J Magn Reson Imaging* 13:818, May 2001.
64. Pierluissi E., et al.: Discussion of medical errors in morbidity and mortality conferences. *JAMA* 290:2838-4282, Dec. 3, 2003.
65. Agency for Healthcare Quality and Research: Welcome to AHRQ Web M&M. <http://webmm.ahrq.gov/default.aspx>. (last accessed Dec. 8, 2004)
66. Kirch W., Schaffi C.: Misdiagnosis at a university hospital in 4 medical eras. *Medicine* (Baltimore) 75:29-40, Jan. 1996.
67. Silver N., Wooner K.: QuesTec not yet showing consistency from umpires. *ESPN Baseball*. Jun. 5, 2003.
68. Maguire P.: Is an access crisis on the horizon in mammography? *ACP Observer* 23:1, Oct. 2003. <http://www.acponline.org/journals/news/oct03/mammo.htm>.