PERSPECTIVES

# Reducing Diagnostic Errors through Effective Communication: Harnessing the Power of Information Technology

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Diagnostic errors are poorly understood despite being a frequent cause of medical errors. Recent efforts have aimed to advance the "basic science" of diagnostic error prevention by tracing errors to their most basic origins. Although a refined theory of diagnostic error prevention will take years to formulate, we focus on communication breakdown, a major contributor to diagnostic errors and an increasingly recognized preventable factor in medical mishaps. We describe a comprehensive framework that integrates the potential sources of communication breakdowns within the diagnostic process and identifies vulnerable steps in the diagnostic process where various types of communication breakdowns can precipitate error. We then discuss potential information technology-based interventions that may have efficacy in preventing one or more forms of these breakdowns. These possible intervention strategies include using new technologies to enhance communication between health providers and health systems, improve patient involvement, and facilitate management of information in the medical record.

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## THE PROBLEM OF DIAGNOSTIC ERRORS

Diagnostic errors are a frequent cause of medical errors in the United States. Large risk-management database studies have shown that out of all liability claims, those related to diagnoses are the most frequent and expensive (about 40% of all malpractice payments in 2003, with an average payment of approximately $300,000 per claim[1]). One such study analyzed 49,345 malpractice claims between 1985 and 2000 and found over one-third of the claims to be caused by diagnostic error.[2] Although the true prevalence of diagnostic error is unknown, 1 in 6 subjects interviewed in a National Patient Safety Foundation poll claimed to have personally experienced diagnostic error.[3] Such errors also appear to be burdensome in the training environment.[4–6]

Diagnostic errors are defined as those in which diagnosis was unintentionally delayed (sufficient information was available earlier), wrong (another diagnosis was made before the correct one), or missed (no diagnosis was ever made), as judged from the eventual appreciation of more definitive information.[7] Examples include failure to use an indicated diagnostic test, misinterpretation of test results, and failure to act on abnormal results.[8] Although diagnostic errors may occur when signs of a disease are atypical or absent, diagnostic errors are often attributed to cognitive (e.g., faulty clinical reasoning) and/or systems-related factors (e.g., inefficient processes and poor communication[7,9–21]). Despite the importance of diagnostic errors, relatively little is known about their causes and prevention.[22] Thus, a comprehensive approach to understanding diagnostic errors is needed to guide the development of future interventions to prevent the occurrence of these errors.

Little is known about the precise cognitive processes that physicians use to confirm and reject their diagnostic hypotheses,[20] and diagnostic difficulties persist despite practitioner experience and advances in diagnostic tests.[23,24] Although a refined cognitive theory of diagnostic decision making will require years of development, in the near term communication processes are a more feasible target for improving the timeliness and accuracy of diagnoses. Communication breakdowns are an increasingly recognized preventable factor in medical mishaps, and emerging data suggest a high prevalence of communication breakdowns among physicians, patients, and important members of the health care team who assist with the diagnostic process.[21,25–32] For example, in a study of abnormal mammograms, over a third of the women studied did not receive appropriate follow-up.[30] In another study, 68% of specialists reported not receiving any information from the primary care physician before the referral visit, and 25% of primary care physicians reported that they still had not received any information from specialists 4 weeks after referral visits.[28] Thus, addressing preventable communication breakdowns by using resources such as information technology offers a viable and timely opportunity to improve the diagnostic quality.

## THE ANATOMY OF COMMUNICATION BREAKDOWNS IN DIAGNOSIS

### Diagnostic Steps

According to Kuhn, the process of making a diagnosis involves 3 sequential, overlapping steps: data gathering, data integration, and verification of diagnosis.[23] Data gathering occurs when critical diagnostic information is collected during a physician–patient encounter primarily through history-taking, physical examination, and review of medical records;[23] hence, any information gathered before formulating one's thoughts or analyzing a patient's condition to formulate a diagnosis could be thought as data gathering.

The second step of the diagnostic process is data integration, a cognitive process involving physician judgment and expertise.[23] Inadequate data collection would lead to errors in clinical reasoning and therefore in data integration as well. The third diagnostic step, diagnosis verification, entails the confirmation or rejection of diagnostic hypotheses by obtaining further data such as laboratory tests, imaging, or pathology specimens.[23] Thus, all 3 of the above steps, but particularly data gathering and diagnosis verification, rely on good communication and may be targeted for interventions to improve the process of making a correct diagnosis.

### Communication Breakdowns in the Diagnostic Process

For the purpose of this article, we define 2 forms of communication that are relevant to the data gathering and verification steps of the diagnostic process: interpersonal communication and informational communication.[33] Interpersonal communication is the verbal exchange of information between 2 individuals (e.g., physicians, patients, nurses, etc.). Informational communication, conversely, entails the processing and management of data such as notes in a chart, written instructions, laboratory values, imaging reports, or any aspect of data retrieved with an electronic chart system.

In addition to identifying the diagnostic steps that are vulnerable to communication breakdowns (data gathering and diagnosis verification), and the types of communication involved (interpersonal or informational), we can further analyze the sources of diagnostic errors by examining the point at which errors occur in the chain of communication. In this paper, it is worthwhile to consider the goals of communication in the health care setting: often communication is not only intended to transfer information, but also to generate a response from the recipient of the information, such as taking an action and acknowledging receipt of the information.[34] In our recent work on informational communication related to diagnosis verification, we have validated a 3-point taxonomy of communication breakdowns proposed by Weinger in which communication errors are classified as breakdowns in message transmission, message reception, and message acknowledgement.[35] Breakdowns in message *transmission* include failure to transmit essential information for making a diagnosis, delayed transmission of this information, or transmitted information that is wrong, ambiguous, or incomplete. Breakdowns in message *reception* occur when the recipient does not perceive the information, when the perception is incorrect, or when the recipient fails to act on the message. Breakdowns in message *acknowledgement* include failures to acknowledge receipt or understanding of the received message or failure to state when appropriate action has been taken. Although message acknowledgement is not strictly necessary for data synthesis and follow-up action in all cases, acknowledgement facilitates concordance among parties and typically implies that some action will follow. Thus, an acknowledgement breakdown can still lead to a poor outcome because the sender may not be able to verify whether the message was received and the action took place.

## A FRAMEWORK TO UNDERSTAND AND REDUCE COMMUNICATION BREAKDOWNS

The 2 steps of the diagnostic process (data gathering and diagnosis verification) are the starting points of the flowchart shown in Figure 1, a three-level framework that ties these steps to the communication process. Using interpersonal or informational communication, messages are transmitted to, received by, and acknowledged by the physician during both the data gathering and diagnosis verification steps (see Fig. 1). Hence, our model includes twelve possible types of communication errors (see Table 1; henceforth we will refer to Examples 1–12 from this table). This framework posits that many diagnostic errors can be traced to 1 or more communication errors during data gathering and diagnosis verification. It serves as a conceptual foundation for designing future interventions to prevent communication breakdowns. Complex interventions can be developed and tested at multiple checkpoints along this framework.

## DEFINING THE ROLE OF INFORMATION TECHNOLOGY IN REDUCING COMMUNICATION BREAKDOWNS THAT RESULT IN DIAGNOSTIC ERRORS

To improve communication and patient safety, the Institute of Medicine has called for redesigning and error-proofing health care delivery systems.[36] One method for achieving this goal is to develop electronic information systems for the delivery of health care data.[36,37] Using information technology (IT) and adopting electronic medical records (EMR) can significantly improve the quality of information transfer[38,39] and reduce failures in several of the pathways we have described. Although we believe that IT-related interventions have tremendous potential in reducing communication breakdowns that lead to diagnostic errors, other innovative communication strategies have also been proposed. For example, the Situation-Background-Assessment-Recommendation (SBAR) technique implemented widely at health systems such as Kaiser Permanente standardizes communication and reduces breakdowns related to data gathering.[40] Another intervention known as "read-back verification" requires the clinician to repeat the information back to the person who transmitted it, completing the loop of reception and acknowledgement in a verifiable manner.[41] This technique could be useful to prevent the communication breakdown in Example 9.

IT-based interventions alone, however, cannot assure improvements in communication. For instance, computerized information systems themselves can lead to unintended errors

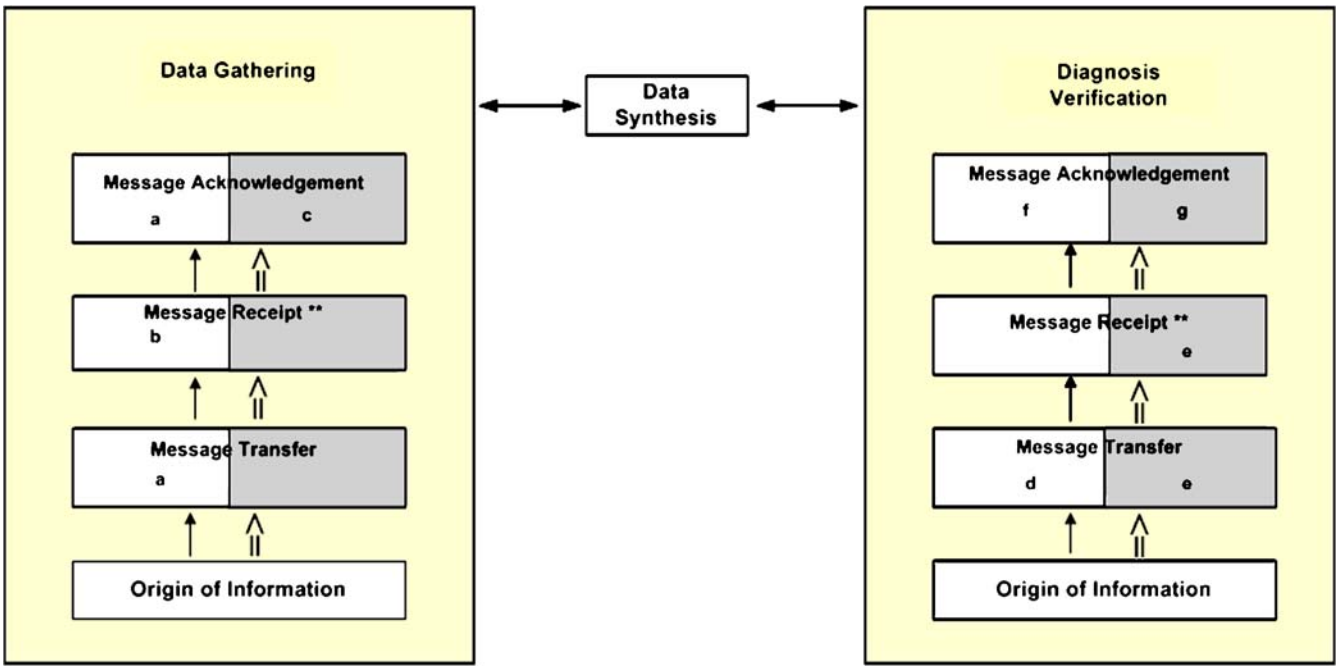


**Fig. 1. A Framework Integrating the Diagnostic Process with Communication Breakdowns. **Message reception can lead directly to data synthesis (and hence action) without message acknowledgement in some cases. => Interpersonal communication, □ Informational communication, Interpersonal communication, → Informational communication. a. Collaborative goal-setting using an Information Technology platform (Example 1 from table), b. Use of personal health records (Example 2), c. Using electronic progress notes requiring co-signatures of physician (Example 5), d. Electronic Medical Record generated report transmitted to pager or mobile phone of referring physician (Example 7), e. Use of alerts for abnormal test results (Example 10), f. Electronic Medical Record generated reminders to patient and physician (Example 3), g. Using software to track unacknowledged alerts (Example 12)**

including those that involve communication processes.[25,34,42] Studies including our own have reported communication breakdowns among providers even in systems that use advanced IT.[25] Thus, achieving high standards of patient safety through the use of IT also entails system redesign to include formal policies and procedures regarding the use of IT.[43–47] To improve the design of any IT-based system, the IOM proposes the application of engineering concepts and methods, especially in the area of human factors.[36,37] Systems that use IT must first be tested on their usability, which represents the effectiveness, efficiency, and satisfaction with which specific users can achieve a specific task by using the system. Efforts must also be targeted to train future physicians to adopt and use IT appropriately for diagnostic purposes.

## SPECIFIC TECHNIQUES TO ENHANCE COMMUNICATION

### Improving Communication Breakdowns Related to Data Gathering by Physicians

Data gathering problems may be the most common reasons for diagnostic errors, at least among trainees.[4] Clearly, the training curriculum needs to further emphasize traditional history and physical examination to our future physicians, who tend to over-rely on expensive and unnecessary diagnostic tests.[48] However, there are also several ways in which IT could play an important role in data gathering (Fig. 1) by practicing physicians, e.g.:

(1) An EMR can reduce the problem of missing clinical information that is frequently encountered in paper-based records.[49]
(2) Patients can use personal health records (PHRs; secure electronic repositories of health information[50]) to generate their own medical histories before their visits and integrate selected information with the physician's EMR at their discretion.[51] In Example 2, an interpersonal reception problem could be averted if the melanoma complaint were integrated with the physician's EMR through the patient's PHR.
(3) EMRs can provide effective decision support, clinical reminders, and other diagnostic aids so that the diagnostic workup can be automatically prompted based on complaints and findings.
(4) Provider-to-provider communication through electronic progress notes could reduce communication breakdowns between health providers as in Examples 4 and 5.
(5) EMR linkages can make available a "distributed" electronic health record to several providers across multiple health care systems and thereby centralize patient information to facilitate diagnosis.

### Improving Communication Breakdowns in the Diagnosis Verification Process

***Alerting for Diagnostic Test Result Management.*** Several EMRs use a notification system (for instance, the VA's View Alert system) that immediately alerts clinicians about clinically significant events such as abnormal test results. Electronic "alerts" have been shown to improve critical lab results communication in the inpatient setting, and they show

**Table 1. Types and Examples of Communication Breakdowns that Can Lead to Diagnostic Errors**

| Examples of communication breakdowns that may result in data gathering-related diagnostic errors |
|---|
| 1. Interpersonal transmission errors: A patient does not inform her physician about a new growth in her breast. |
| 2. Interpersonal reception errors: The patient informs his physician about a change in his mole, but the physician gets distracted by an interruption and fails to perform a complete history and exam. |
| 3. Interpersonal acknowledgment errors: The physician informs the patient to return to the clinic after an urgent x-ray, but does not verify that the patient understood. Patient gets lost to follow-up leading to delayed diagnosis. |
| 4. Informational transmission errors: A patient calls the nurse 2 days after a physician visit with continued symptoms of fever and chills; information is recorded appropriately but is lost before it reaches the physician. |
| 5. Informational reception errors: Information about a patient's continued symptoms is placed in the physician's message inbox but not dated; physician misunderstands and believes that the note was from 2 days ago. |
| 6. Informational acknowledgment errors: A physician reads an email from a nurse about a recent change in a patient's mole, but does not inform the nurse what to do next. The patient believes that the physician is not too concerned and does not seek care. |
| **Examples of communication breakdowns that may result in diagnosis verification related diagnostic errors** |
| 7. Interpersonal transmission errors: A radiologist fails to inform the referring physician about free air noted on a patient's abdominal x-ray. |
| 8. Interpersonal reception errors: The laboratory calls the on-call physician on a weekend to inform her about the abnormal test results, but the covering physician informs the wrong primary physician. The patient's physician never receives the abnormal test result. |
| 9. Interpersonal acknowledgment errors: The laboratory calls the on-call physician at night about a critical test result, but the physician is only partially awake; no action is taken. |
| 10. Informational transmission errors: An abnormal radiology report of a potential malignancy is not sent to the primary care physician. |
| 11. Informational reception errors: An electronic notification of the abnormal radiology report is sent to the physician via the electronic medical record, but the physician either does not read the alert transmitting the test result or fails to take action on it. |
| 12. Informational acknowledgment errors: Physician does not electronically acknowledge the receipt of transmitted abnormal test results. No further action is taken and the results are lost to follow-up. |

promise in improving the safety of outpatient test result follow-up.[45,52,53] Electronic alerting could help prevent the communication breakdown in Example 10, where the abnormal report would be sent to the provider's EMR screen automatically. However, what about Examples 11 and 12, when providers fail to take action or acknowledge the alert or simply ignore alerts because they receive too many? Customizing EMR screens to receive only critical alerts and using special alert management software to track them can avoid such problems. For instance, the VA's View Alert system tracks acknowledgement of abnormal test results, and results that go unacknowledged receive a higher degree of oversight to reduce the chance that the report would be lost in the system (e.g., Example 12).[25] In addition, "smart monitors" could reduce the total number of alerts by filtering information through algorithms so that providers are alerted only when immediate action is necessary.[54]

***Direct Reporting of Test Results.*** Providers may report test results directly to their patients through secure electronic mail, web-based portals, and other methods. Although direct reporting to patients may prevent loss of follow-up, physicians currently tend to favor direct reporting only when test results are normal, have less diagnostic severity, or have less potential for emotional impact.[55] This evolving concept is likely to gain strength in the future.

***Reinforcing Critical Result Transmission by More Than One Method.*** To complement the transmission of results through EMRs, pagers and other wireless data devices could be used to communicate abnormal test results requiring immediate attention.[56] Additional use of data mining, a technique used to search electronic repositories, can identify exceptions automatically. For example, automated programs can review all lab results over a given time period and alert clinicians to abnormal results that have not received appropriate follow up (e.g., positive fecal occult blood tests not followed up by a colonoscopy).

***Tracking Consultations.*** Consultations can be tracked from the moment the physician makes the electronic referral so that providers can identify patients who are not given an appointment or fail to show up for referral visits. The EMR can also be programmed to generate an urgent report to the referring physician by text messaging, which would have averted the communication breakdown in Example 7.

## Using Electronic Mail to Supplement Communication Related to the Medical Encounter

Secure email can be an adjunct to interpersonal communication and facilitates both data gathering and diagnosis verification. Email also has potential to enhance patient–physician interaction, particularly when face-to-face communication is limited,[57] and provides opportunities to improve the efficiency of clinical time use.[58,59] Although overall patient desire to communicate with their physicians electronically is high,[60] adoption by physicians is generally low[61–63] and several barriers exist.[64]

## Using IT to Strengthen Data Gathering-Related Communication with Patients

One prominent strategy to reduce diagnostic errors is shared decision making in the diagnostic process. Although patients employ many ingenious methods to engage clinicians, such as using notepads and tape recorders,[65] many of these processes are prone to the same errors that contribute to communication breakdowns. Standardized physician–patient communication software that is integrated with an EMR and a PHR could lead to better communication outcomes. Collaborative goal-setting is one promising intervention for reducing transmission and acknowledgement breakdowns in interpersonal communication.[66] If integrated with an IT platform, goal-setting may enhance patients' perceptions of risks pertaining to diagnostic tests, expectations regarding the significance of posttest results, and self-efficacy with the diagnostic process. This type of intervention could reduce delays in diagnosis and treatment resulting from communication breakdowns as in Example 1, especially among high-risk patients.

Websites of government agencies and large national organizations including the Agency for Healthcare Research and Quality (AHRQ) and the American Association of Retired Persons (AARP) offer patients information about how to get the most out of a doctor visit. Dissemination of these techniques using IT as a medium could enhance patient understanding of risks and expectations regarding diagnostic procedures and prompt them to discuss important information in future visits.

## Overcoming Communication Problems Related to Patient Follow-up and Monitoring

EMRs can track patient appointments for tests and consultations and hence can facilitate interpersonal communication during diagnosis verification. For instance, in Example 3 the interpersonal acknowledgement problem could be overcome using an EMR-generated reminder letter to the patient followed by a reminder notification to the physician. PHRs can also be used to provide patient reminders for tests and appointments.

Interactive communication between patients using IT is another avenue for reducing diagnostic errors. The internet has become a natural experiment for uncontrolled and unstructured peer communication regarding medical diagnoses. In a recent study, the internet proved to be a remarkably effective and accurate mechanism for enhancing peer communication.[67] Other studies testing a telephone-based peer support communication tool for chronic heart failure and diabetes care are currently underway. These studies use an interactive voice response tool to enhance self-care and improve the diagnosis of disease decompensation.[68,69] Closer monitoring of patients with increased health care needs in their homes via devices and applications connected to an electronic network can also facilitate earlier diagnosis when problems arise.

## CONCLUSIONS

Focusing interventions on diagnostic steps that are prone to communication breakdowns could achieve a significant reduction in diagnostic errors. We present a novel and comprehensive framework for understanding the complexity of communication breakdowns that lead to diagnostic errors. This framework can inform the design and testing of IT-based interventions to improve the effectiveness of communication. Multidisciplinary IT-based strategies that integrate the science of physician–patient communication and health informatics can offer a pragmatic approach to reduce diagnostic errors in health care.

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