Monitoring the Diagnostic Process on an Inpatient Neurology Service

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Abstract

The Institute of Medicine report *Improving Diagnosis in Health Care* called for tools to monitor physicians' diagnostic process. We addressed this need by developing a tool for clinicians to record and analyze their diagnostic process. The tool was a secure web application in which clinicians used a structured grading system to assess the relative impact of clinical, laboratory, and neuroimaging data for every new diagnosis. Four neurohospitalists used the tool for 6.5 months on a general neurology ward service at a single tertiary-level teaching hospital. Process measures of tool use included number of diagnoses entered, time spent on each data entry, and concordance of diagnoses compared to the medical record. We also aggregated the data across clinicians to examine the average process scores across common inpatient disorders. The 4 clinicians entered 254 new diagnoses that took approximately 3 minutes per patient. In 50 randomly chosen cases, the neurohospitalists' diagnoses entered into the tool agreed with 92% of diagnoses in the medical record, which was better than the agreement between billing code and medical record diagnoses (74%). The diagnostic process varied across disease categories, showing a spectrum of clinical-dominant (eg, headache), laboratory-dominant (eg, encephalitis), and neuroimaging-dominant (eg, stroke) disorders. This study demonstrated the feasibility of a clinician-driven diagnostic process monitoring system, along with preliminary characterization of the process for common disorders. The tracking of diagnostic process has the potential to promote reflection on clinical practice, deconstruct neurologists' clinical decision-making, and improve health-care safety.

Keywords

diagnosis, clinical decision-making, process assessment

Introduction

Diagnostic errors account for 40 000 to 80 000 deaths every year.¹ These missed or delayed diagnoses are an important and underappreciated quality and patient safety issue in medicine.² The recent Institute of Medicine report *Improving Diagnosis in Health Care* called for enhanced training in the diagnostic process, health information technologies to detect errors, and feedback on diagnostic performance (Recommendations 2A, 4B, and 5).³ Monitoring the diagnostic process is critical to all of these solutions.

Current efforts to measure diagnosis have focused on retrospective detection of diagnostic errors including autopsies, patient and provider surveys, malpractice claims, and case reviews.^{1,4,5} These techniques establish the magnitude of the errors, but they do not reveal the mechanics of the diagnostic process in successful and unsuccessful encounters. Moreover, they do not provide timely feedback to providers on diagnostic outcomes, which is important for learning.⁶ To inform detection, education, and quality improvement efforts, more

granular, prospective tracking of the diagnostic process is necessary.

We developed a diagnostic monitoring tool tailored for neurology. The tool is based on a model of the diagnostic process developed through an anthropological study of neurologists in practice.⁷ In this model, neurological diagnosis was characterized by the coordination of clinical, laboratory, and neuroimaging information that varied by disease. For

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Did you make a new diagnosis for the patient? ☐ No ☒ Yes reset

* must provide value

The following section asks the impact of clinical, laboratory/electrodiagnostics, and imaging information in making your final diagnosis.

Please note the following definitions and examples:
 * **Diagnosis:** Threshold crossed to assign label in medical record and/or start treatment.
 * **"No contribution":** Diagnosis was not aided by this information (e.g., imaging in PD).
 * **"Moderate contribution":** Raises the possibility of diagnosis OR excludes highly probable competing diagnoses (e.g., EEG showing lateralized slowing after seizure, MRI to rule out venous sinus thrombosis in a pregnant patient with headache)
 * **"Important contribution":** Diagnosis strongly suggested, but not fully confirmed (e.g., fever, headache, neck stiffness in meningitis)
 * **"Principal contribution":** Mandatory to confirm diagnosis (e.g., imaging in stroke; tremor, rigidity, bradykinesia, postural instability in PD)

What impact did clinical information make to the final diagnosis (e.g., history and physical exam)? reset

☐ no contribution to the diagnosis
☐ moderate contribution to the diagnosis
☐ important contribution to the diagnosis
☒ principal contribution to the diagnosis

What impact did laboratory or electrodiagnostic information make to the final diagnosis (e.g., serum, CSF, EEG, EMG)? reset

☒ no contribution to the diagnosis
☐ moderate contribution to the diagnosis
☐ important contribution to the diagnosis
☐ principal contribution to the diagnosis

What impact did neuroimaging information make to the final diagnosis (e.g., CT, MRI)? reset

☐ no contribution to the diagnosis
☐ moderate contribution to the diagnosis
☒ important contribution to the diagnosis
☐ principal contribution to the diagnosis

Figure 1. Screenshot of tool's data entry form in the Research Electronic Data Capture (REDCap) platform.

example, neurologists' diagnostic process for stroke was characterized as clinical (4), laboratory (1), and neuroimaging (4) on a 4-point scale in which clinicians recorded the impact of each domain (1 = no contribution to 4 = principal contribution) as they established a new diagnosis.

This study reports the feasibility of a secure web application that operationalized this diagnostic process model among practicing neurohospitalists. This research has practical significance for the design of health information technology to support diagnostic process monitoring.

Methods

The tool was a secure web application designed and hosted in the Research Electronic Data Capture platform. It featured online accessibility from any computer, data storage on a local secure Health Insurance Portability and Accountability Act-compliant server, and multiuser compatibility.⁸

The tool was designed to serve both as a diagnostic process monitor and a case log system. Neurohospitalists entered diagnoses of all patients they evaluated at the time of discharge. If the clinician designated the entry as a new diagnosis, defined as a new neurological condition in the medical record, he or she also answered specific diagnostic process questions.

For new diagnoses, clinicians scored the impact of each domain (clinical, laboratory, and neuroimaging) on a 4-point scale developed in prior research (Figure 1).⁷ Score 1 was no contribution, meaning the diagnosis was not aided by this

information from this domain. Score 2 was moderate contribution, meaning the data (eg, laboratory testing) raised the possibility of diagnosis or excluded highly probable competing diagnoses. Score 3 was important contribution, meaning the diagnosis was strongly suggested but not fully confirmed. Score 4 was principal contribution, meaning the domain was mandatory to establish the diagnosis.

Every 2 months (or upon request), clinicians received a list of all cases and the diagnostic process scores for the subset with new diagnoses. These reports also included summary tables and graphs of common diagnostic categories, patient demographics, and educational cases. Neurohospitalists could compare their data to other clinicians' data. The opportunity to compile a complete case library and receive comparisons to their peers incentivized data entry.

Following pilot testing, we deployed the tool in a prospective observational study of 4 neurohospitalists over 6.5 months. The clinicians entered data during a study period when they were attending for patients admitted to the general neurology service. Due to scheduling differences, some clinicians were more active during the study period than others (range 4-10 weeks). This study was granted exempt status by the institutional review board of Washington University in St. Louis.

Analyses included process measures of tool usage, concordance analysis, descriptive statistics, and visualizations of the diagnostic process. All analyses were completed in R version 3.2.3.⁹

Figure 2. Diagnostic process for common neurological disorders. Dots correspond to the average percentage contribution of clinical, laboratory, and neuroimaging data when the specific diagnosis is established. Dots closest to a corner indicate higher influence of the labeled diagnostic process domain.

Results

The 4 neurologists entered 254 new diagnoses in 6.5 months. The self-reported average time required to enter data for each patient was 3 minutes. At least half of this time was devoted to the entry of details already in the electronic medical record such as patient demographics and length of stay.

In 50 randomly chosen new diagnosis cases, we completed a concordance analysis of the primary diagnosis in the tool and the final diagnosis in the medical record. A similar comparison was made between diagnosis billing codes and the medical record for the same cases. This analysis showed that 92% of diagnoses in the tool agreed with the medical record, as opposed to 74% agreement between billing codes and the medical record.

The diagnostic process varied across disease categories. It showed a spectrum of clinical-dominant (eg, seizure disorders), laboratory-dominant (eg, encephalitis/meningitis), and

neuroimaging-dominant (eg, myelopathy; Figure 2) disorders. The mean scores for the neurologists' diagnostic process was clinical 3.6 (standard deviation [SD] = 0.6), laboratory 2.6 (SD = 1.1), and neuroimaging 2.4 (SD = 1.1). The diagnostic process was relatively consistent across clinicians (Supplemental Figure 1).

Discussion

The Institute of Medicine *Improving Diagnosis in Health Care* report called for health-care organizations to monitor diagnostic process and provide systematic feedback (Recommendation 4).³ The committee also concluded that "bottom-up experimentation" would be necessary to develop approaches.³ Our program is an implementation of these recommendations. The system prospectively captured diagnostic process data, provided statistics on diagnostic process in

comparison to peers, and served as a case log. There was consistent usage among 4 neurohospitalists over 6.5 months, and strong agreement between diagnoses entered into the database and medical record.

A barrier for all monitoring programs is limited clinician time and resistance to additional electronic data entry. In anticipation of this, tools need to have embedded features that align with clinicians' interests. Our tool was created by neurologists and was grounded in realities of clinical care. The collective case library,¹⁰ in particular, motivated neurologists to enter data that could be compared among peers. Other features of the tool included integration in clinicians' workflow and bimonthly summary outputs. This case log function can be leveraged to provide timely feedback on diagnostic outcomes that would encourage clinicians to track and learn about successful and unsuccessful encounters.⁶ This learning feature of the tool may maintain clinician interest long after a mandate to enter diagnostic data has expired.

The article reiterates the importance of detailed conceptualization of diagnostic process before embarking upon tool building.¹¹ The findings in this article extend the model of neurological diagnosis into the inpatient environment. The results are a preliminary demonstration of how complex and heterogeneous data must be harmonized by the clinician.⁷ Qualitative studies have shown such coordination is crucial in general medical diagnoses.¹²⁻¹⁴ This model focuses on the information gathering and interpretation (traditionally, clinician work) that sits at the heart of the patient-centered Institute of Medicine diagnostic process model.³ When the coordination process is deconstructed, relevant contributions of clinical, laboratory, and neuroimaging data emerge. We believe this level of granularity is critical when trying to modify the components of diagnosis that affect quality, safety, and cost.

Practically, the tool is a means for clinicians to track and evaluate diagnostic process data that may inform cost containment strategies and training programs. The process of establishing a diagnosis is the intellectual activity that should, and likely does, drive resource utilization patterns. Therefore, improved understanding and monitoring of the diagnostic process is important to reduce test overutilization. It may not be unreasonable for future reimbursement to be tied to demonstration of a reasonable and defensible diagnostic process. Such documentation facilitated by our rubric, for example, may be helpful both for payers and other clinicians. In terms of educating trainees, the classification system of diagnoses offers an easy-to-understand "thinking pattern" of common diseases. It highlights clusters of diseases often not considered together and the key data type for clinching the diagnosis. The model can help trainees optimally use their time during a patient encounter and order the correct tests.

One limitation of this study was a single recording of the diagnostic process at the time of discharge. This was chosen to

encourage reflection upon all data and establish a consistent data entry protocol. It may be possible to capture the evolution of diagnostic process during a hospitalization by integration in the daily electronic note.¹⁵ A second limitation was a lack of confirmation of diagnostic accuracy. This would require longer prospective tracking and an established gold standard (eg, chart review or pathology) against which entered diagnoses were compared. Finally, social aspects of the diagnostic process, such as time spent with patient or number of interdisciplinary conversations, were not captured by this tool and may be as important to diagnostic accuracy as the data coordination process.

We anticipate that incorporation of diagnostic monitoring tools in the electronic medical record will be necessary to improve diagnostic performance. It is feasible for clinicians to use a short scoring rubric to assess their diagnostic process at the time of discharge note entry. The tracking of diagnostic process has the potential to promote reflection on clinical practice, demystify neurologists' clinical decision-making, and improve health-care safety.

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Declaration of Conflicting Interests

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Supplemental Material

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