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# Next steps for electronic health records to improve the diagnostic process

**Abstract:** Electronic health record (EHR) usage is accelerating while preventable diagnostic error persists. EHRs may even contribute to diagnostic error through several pathways including poor usability and an over reliance on electronic chart based communication. The changing context of healthcare delivery offers potential financial incentives for organizations to leverage EHRs to reduce diagnostic error. The lack of standard quality metrics for reporting rates of diagnostic error, a lack of diagnostic feedback systems for physicians and organizations, and a lack of compelling evidence for specific interventions underscore the need for further research in preventing diagnostic error. Many potential strategies exist for EHRs to reduce the likelihood of diagnostic error. Practical next steps for leveraging EHR systems to assist in the diagnostic process are suggested. These include patient engagement strategies, closed loop result tracking, targeted next step reminder systems, and expansion of a list of actionable patient states based on diagnosis triggers.

**Keywords:** diagnostic error; EHR; informatics.

DOI 10.1515/dx-2014-0070

Received December 18, 2014; accepted March 18, 2015

Electronic health record (EHR) adoption in the United States is past the tipping point for hospitals and is advancing steadily for office-based providers. While previously demonstrating a gentle positive slope of adoption, the introduction of the Meaningful Use (MU) program created an inflection point leading to faster adoption rates within the United States [1]. Providers have worked not only to

adopt EHRs but also meet the eligibility requirements for incentive payments. As a result over \$9.5 billion has been paid to eligible providers and over \$14.7 billion has been paid to eligible hospitals [2]. These statistics suggest a primary goal of increasing EHR adoption in the US has been achieved through this program. Further, quality reporting, a mandate for MU, provided an opportunity for practices and hospitals to gain experience aggregating information across panels of patients [3].

Diagnostic error may be defined as a mistake in the diagnostic process leading to a misdiagnosis, a missed diagnosis, or a delayed diagnosis [4]. The burden of diagnostic error, while difficult to estimate, appears to be extremely high affecting over 12 million patients annually in the ambulatory context with half of these errors having significant potential for harm [4–6]. Although the Institute of Medicine will be issuing recommendations later this year, evidence supporting specific interventions that reduce diagnostic error remains quite limited [7–10]. There is thus also a need for further research to demonstrate efficacy and generalizable effectiveness of EHR based interventions intended to reduce diagnostic error.

As if to highlight the convergence of the substantial burden of diagnostic error and its intersection with electronic records, one may consider the case of a Davies Award winning organization in the United States in whose care a first patient with Ebola was misdiagnosed [11–13]. While a definitive explanation for the initial misdiagnosis remains unclear, a records review suggested several likely contributing factors. These include erroneous selection from pre-defined symptom options in the EHR, use of generic patient instructions missing the physician's true intent, failure to consider the diagnosis of Ebola, known EHR usability issues, use of templates for highly focused purposes limiting downstream use of information, over reliance on diagnostic testing, and reliance on electronic and not verbal communication for the red flag issue of travel from an Ebola reporting region. This case is particularly notable in that adoption of current generation EHRs, even within an organization praised for its effective deployment of IT systems, does not assure delivery

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of optimal diagnostic care nor the routine reporting (or measurement) of rates of diagnostic error.

The healthcare delivery context is also changing and this may encourage efforts to prevent diagnostic error. In particular, value based care models are growing for large populations of patients in the United States [14, 15]. While the still prevalent fee for service models of care incentivize volume, value based care models incentivize both quality and cost effective use of health care dollars. In this changing context it becomes financially important for organizations to optimize the overall health status for a population of patients. As a consequence of this broader motivation, efforts to reduce diagnostic error, while always the right thing to do, become financially aligned despite the complexity and likely costs [16, 17]. Unfortunately, precisely where these investments should be made by organizations to minimize risks for an inaccurate or delayed diagnosis remains unknown.

Given this changing healthcare delivery climate and the successful efforts of the MU program to encourage decision support and quality reporting, it would appear appropriate for organizations to invest in optimizing EHRs specifically to reduce diagnostic error. Unfortunately, even with this more narrow focus of improving diagnosis through use of EHRs, how best to achieve this is not yet clear. Limited evidence exists to support alerts, selected triggers, patient panel management and diagnostic protocols to prevent diagnostic error [18–20]. Unfortunately, the evidence basis remains scant for many of the tactics by which technology could theoretically improve the diagnostic process. In addition, for sustainable system based learning, detection and feedback of diagnostic errors (or risks for errors) are essential elements. Once triggers and metrics are established, the increased adoption of EHRs has provided the foundation to deploy consistent approaches for mandatory reporting, as is the case for other quality metrics. A conceptual framework for preventing diagnostic errors, Safer Dx, has been proposed that incorporates the various dimensions of the diagnostic process, prospective and retrospective measurement, and ongoing feedback for improvement [21]. Additional research into triggers for missed or delayed diagnoses and feedback of system findings can evolve the model facilitating future process adoption across organizations.

Use of EHRs has the potential to reduce or compound diagnostic risks at each step of the care process. Table 1 shows some of these possibilities and was created to complement the DEER taxonomy but focuses on EHR usage [20]. In particular, strategic use of EHRs in the following categories appears potentially beneficial to the diagnostic process: documentation, care coordination,

patient engagement, automation, physician and patient checklists, next step guidance, redundancy avoidance, monitoring, and broadened differential diagnoses [10, 16, 18–20, 22]. For example, when applied judiciously and in the appropriate workflow context, diagnostic error triggers already have a growing body of evidence behind their benefits [18, 23]. The risk of implementing these system changes, however, is that unless the system effects are carefully monitored, it is possible that interventions may be associated with worsened care as was seen with critical imaging alerts [24]. Some recommendations to optimize the response to diagnostic alert triggers include knowing who is responsible for follow-up care, alert persistence until it is acted upon, optimizing the signal to noise ratio for alerts, and monitoring responses to ensure appropriate action was taken for each alert [24].

With this background, several EHR tactics, in particular, appear to have short term process improvement plausibility. These approaches appear likely to enhance the diagnostic process despite low technical complexity and should be strongly considered by practices using EHRs while further research continues:

1. Encourage use of the problem list and problem centered documentation.

Justification: Situational awareness regarding a patient's health context is essential in order to consider the full spectrum of likely diagnoses. For example, failing to appreciate an immunocompromised state limits the diagnostic considerations for likely infectious etiologies. A well maintained problem list delivers efficient access to key clinical details required to generate a patient specific differential diagnosis for new symptoms. Physicians remain dissatisfied with existing electronic notes incorporating automatically entered content contributing to "note bloat." Encouraging adoption of problem-centered documentation using an accurate problem list should be considered a practical next step to improve decision-making and downstream efficiency including diagnostic efforts [25].

2. Encourage use of the patient portal.

Justification: The Meaningful Use program has now achieved some momentum for portal adoption. With attention to continued patient engagement, the patient portal may also serve several roles in preventing diagnostic error. Categories to consider include: Chart access, secure messaging, history submission, and reminders. Access to the chart enables patients to see diagnostic results and use secure messaging for any questions. Given ongoing physician failures to follow-up on results, portal access with direct patient

**Table 1:** Diagnostic process aware workflow.

Step in care	Typical workflow	Diagnostic process aware workflow
Appointment scheduling	“One size fits all”	Increase appointment duration when new symptoms are reported. Automated notifications when due for a visit based on chronic disease state or for symptom follow-up.
Pre-visit history	Fail to gather historical content ahead of the visit; store content in never reviewed silos.	Relevant family and personal history submitted prior to appointments avoiding a time crunch or failure to acknowledge symptoms.
Use of online documentation	Clinician focus on note formatting and creation, lack of attention to the problem list, use of rigid templates, and default entries.	Efficient documentation incorporating pre-entered patient history elements with symptom based suggestions to augment the history and ensure critical details are addressed. Consistent use of the problem list to ensure key issues are recognized by all clinical team members and by the patient along with corresponding treatment plans.
Assessments and plans	Constrained ordering process limiting diagnostic options. Absence of guided protocols for selected diagnostic tests.	Facilitated ordering linked to presumptive diagnoses; alternative diagnoses offered for consideration; time based reminders for future testing and follow-up tracking.
Result access	Lack of monitoring to ensure diagnostic studies are performed and results are reviewed.	Verification and escalation process to ensure ordered tests are completed and results reviewed by clinicians and selected next steps are taken.
Patient engagement	Lack of systems to ensure appointments are scheduled or symptoms are checked in follow-up. Lack of systems to monitor patient receipt of online results.	Systematic approaches to deliver results to patients with escalation if unviewed; systematic approaches to ensure appointments are scheduled and escalated if appointments are missed; systematic approaches to check in with patients at scheduled times to ensure symptom resolution.
Population management	Lack of population based approaches for diagnostic next steps in care.	Automated and then escalated approaches at a population level for defined outlier scenarios including overdue visits, missing actions for abnormal results (e.g., no chest x-ray despite presence of a positive purified protein derivative test (PPD)). Additional enhanced monitoring for early diagnosis of chronic disease deterioration.

This table highlights steps in the care process and a few opportunities to leverage EHRs to improve the diagnostic process.

engagement should provide another layer of diagnostic safety [23, 24]. Further, despite some misgivings from physicians, progress note access by patients is becoming more common [26]. This access can enable collaborative goal setting between patients and their physicians and thereby improve the diagnostic process [19]. A recent position paper for clinical documentation in the 21st century notes the patient’s story should be preserved [25]. How better to ensure preservation of the story than through direct patient submission for those so inclined? Time pressure relief should ensue as patients’ submit histories (including family history) and any symptoms prior to scheduled visits [20]. Lastly, the patient portal provides a convenient tool for practices to contact patients regarding overdue diagnostic tests or unscheduled referral appointments.

3. Identify results with overdue next step actions and monitor for completion.

Justification: The first step after a result is posted is to ensure an appropriate provider receives the result in a timely manner. Unfortunately, monitoring systems for

oversight to ensure receipt and follow-up for results are not yet common [18, 23, 24]. To increase system-based reliability, unviewed results could be resent to providers or escalated to a practice director if still unviewed after 5 days. The work required for such a system is relatively low tech utilizing basic reporting requirements less than required of Meaningful Use. As supported by the literature, initial efforts should emphasize abnormal PSA values, abnormal thyroid results, iron deficiency anemia, and fecal occult blood [15, 18, 23, 24, 27]. Extension to items such as macrocytosis, abnormally low B12 values, newly elevated or rising creatinine values, elevated TSH values, abnormal liver tests, and missing results for conditions that should be periodically monitored for worsening such as chronic leukemia constitute similarly straight forward and practical extensions of this approach. Distribution of these outlier reports to providers listing only entries for which an expected next step has not yet occurred after a reasonable delay period would contribute to defining an effective signal to noise ratio for these messages. Feedback by providers would

further improve the effectiveness of the lists over time. While the complexity of recognizing these diagnostic triggers appears low, as seen in the case of an elevated PSA, multiple factors contribute to delays in establishing the appropriate diagnosis and beginning expected next steps. These include diagnostic inertia, focus on other care elements, or technical issues in the result distribution process [23, 24]. It is not fully known how often these events occur across different centers; however, systems to detect these gaps are well within the feature set of current systems. Investment in the process of focused redundancy for items such as these would decrease the likelihood of diagnostic delays.

4. Identify and resolve care coordination gaps.

Justification: While somewhat related to the above result tracking process, this point emphasizes the diagnostic risks stemming from care coordination delays. Examples here include failure to schedule or attend referral and post discharge appointments or failure to complete ordered diagnostic tests within a reasonable timeframe. Each of these next steps in care is often required to establish or confirm a diagnosis under consideration. As noted above, the patient portal may assist with unscheduled appointments, but addressing gap closure is essential for all patients regardless of portal usage. As a direct financial incentive, even prior to significant value based reimbursement, addressing these gaps through simple EHR based reporting of care gaps will fuel enhanced use of appropriate resources to assist in the diagnostic process.

5. Deliver workflow integrated alternative diagnoses to consider.

Justification: Failure to consider alternative diagnoses is an important etiology for diagnostic error [28] and has long been recognized [29, 30]. Providing access to alternative diagnoses during the process of diagnosis entry would facilitate convenient workflow integration. The functionality to display similar diagnoses exists in tools such as DxPlain [31]. For example, when entering Acute Diverticulitis in a male as an encounter diagnosis, a list of alternative diagnoses as seen below could display for consideration that might prompt additional history taking, physical exam maneuvers, or further testing:

- Appendicitis
- Cystitis or prostatitis
- Nephrolithiasis
- Pancreatitis
- Testicular lesion
- Inguinal hernia
- Intestinal ischemia

6. Encourage and monitor use of external data sources. Justification: Understanding complete clinical context is essential to the diagnostic process. For example, providing integrated access to state based immunization information systems may raise or lower pre-test probabilities for a variety of vaccine preventable illnesses [32]. Further, dispensed medication histories from pharmacies may clarify which medications were provided to the patient [33]. These expanded medication lists may explain symptoms through consideration of the medications' adverse effects. Access to past evaluations of similar symptoms may assist diagnostic efforts and avoid additional testing. These outside evaluations may be in the form of summaries provided through health information exchanges, or even direct views into patients' charts maintained at outside organizations [19, 34, 35]. At present these external sources are not well integrated into workflow and users may remain unaware of their significance. Reminding users of their availability and reporting back to users their relative standing regarding frequency of use may assist with targeting specific users for further education. (Of note, information overload remains a concern and ongoing attention to usability is also warranted [36]).

7. Establish workflow for follow-up tracking of diagnostic uncertainty.

Justification: Although patients are encouraged to return if symptoms persist, this may still lead to unfortunate delays in care. Possible approaches using available tools in EHRs include provider generated messages to a recipient pool that manages follow-up checks for symptom updates. Alternatively, sending oneself future-dated messages as a reminder to check on the patient the following week may integrate well within workflow. Voice response tools to check on patients are being studied in this regard [19]. Instituting this type monitoring of patients by phone call, apps, or through a patient portal for early diagnosis of disease decompensation may ultimately prove to be effective. A phone based approach was found potentially helpful in clarifying issues such as symptoms or medications following hospital discharge [37].

In conclusion, despite increased adoption of EHRs, it is not clear that the substantial burden of diagnostic error has been addressed. Typical reasons for missed or delayed diagnoses offer several likely opportunities for EHR based assistance, although much more research is needed. These opportunities include specific documentation practices,

increased patient portal usage, routine use of external sources, and monitoring for a variety of expected next steps in care. As this still low hanging fruit is picked, perhaps incentivized by changes to value based care, research into more sophisticated approaches will be needed.

**Author contributions:** All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

**Research funding:** None declared.

**Employment or leadership:** None declared.

**Honorarium:** None declared.

**Competing interests:** The funding organization(s) played no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the report for publication.

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