Title: Deployment of Enhanced Critical Imaging Result Notification (DECIRN)

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Abstract

Purpose: We aim to evaluate critical imaging result communication between providers and assess the impact of a critical result communication policy and notification system.

Scope: We previously established an enterprise-wide Communication of Critical Test Results (CCTR) policy to enhance critical imaging result communication. We documented the CCTR Policy and evaluated its institution-wide implementation. In addition, we evaluated the impact of a notification system, Alert Notification of Critical Results (ANCR), on adherence to CCTR policy requirements.

Methods:
The CCTR policy was implemented in February 2006. We assessed adherence to CCTR policy through manual periodic review of radiology reports during the first 4 years of implementation and via performing trend analysis at 6-month intervals.

ANCR was implemented in January 2010. We evaluated ANCR's impact on adherence to CCTR policy, assessed by manually reviewing a random sample of radiology reports during the first 4 years of ANCR implementation and comparing them to those of 1 year prior. In addition, we evaluated adherence to policy for **all critical results** communicated through ANCR during the study period using trend analysis.

Results:
We successfully completed our study aims and documented an increase in adherence to CCTR policy from 28.6% in 2006 to 90.4% in 2010 ($p<0.001$). After ANCR implementation, adherence to policy further increased to 95% ($p<0.0001$). For all critical results communicated through ANCR, adherence to CCTR policy was 98% from 2011 through 2013. An implementation toolkit was made available online.

Keywords: critical result, communication system, communication policy, patient safety

Purpose

The Joint Commission has emphasized the need for improved communication of critical results of diagnostic procedures among caregivers as one of its National Patient Safety Goals for 2010.(1) Delays in communicating critical results pose a significant threat to patient safety by potentially hindering specific diagnoses, which may translate into inappropriate deferral of treatment, if not outright errors in management.(2-4) In addition, it creates significant anxiety for patients and dissatisfaction among caregivers, particularly when awaiting results for potentially life-threatening conditions. The American College of Radiology (ACR) in its 2005 Practice Guideline for Communication of Diagnostic Imaging Findings strongly advised radiologists to expedite notification of imaging results to referring physicians “in a manner that reasonably ensures timely receipt of the findings.”(5) However, they provided no further guidance as to the processes required to implement this guideline recommendation. Hence, no current standard exists for timeliness of communicating imaging results or the ideal communication venue (or venues); also, there is, notably, a lack of uniform criteria specifying which results need to be communicated urgently. The Brigham and Women’s Hospital (BWH) established an enterprise-wide Communication of Critical Test Results (CCTR) policy to enhance communication of Critical Imaging Results (CIR), a key component of a quality improvement initiative, including a critical result communication system for enhancing policy adoption.

Objectives of the Study:

A full-scale evaluation of this initiative is performed with the following objectives:

1. Evaluate an enterprise-wide critical result communication policy for enhancing communication of CIR;
2. Evaluate a critical result communication system by comparing its impact on adherence to the CCTR policy for documented alert notification of CIR within the appropriate notification timeline and using the appropriate mode of communication; and
3. Develop an implementation toolkit to enhance widespread dissemination, to include the novel CCTR policy and software tools required for implementation and evaluation.

Scope

Background:

Alert notification for critical test results has garnered national attention after publication of the 2010 National Patient Safety Goals by The Joint Commission.(1) It is widely acknowledged that failure to alert ordering physicians with critical test results may lead to significant delays or errors in diagnosis and management, such as missed follow-up of abnormal test results, or additional interventions or complications.(2-4) Critical test results include any findings that are deemed "critical" from various tests, including imaging studies, such as radiological imaging.

The role of radiological imaging to diagnose various diseases has greatly expanded in the past decade.(5-7) Unlike laboratory results, images are read by radiologists, with final results considered as consultation reports, typically finalized and signed by the attending radiologist. In practice, this required expertise drives communication of critical results, whereby the radiologist contacts the referring clinician whenever a critical imaging result is deemed significant. Failure to communicate abnormal imaging test results, however, is not uncommon, and delays in notification of critical imaging results are a major source of malpractice claims in radiology.(8-12)

No established guidelines exist for classifying results as "critical," unlike for laboratory tests, when an outlier value beyond the range of acceptable values is deemed abnormal – making them easily amenable to automated alerts.(13-15) The textual reports utilized in radiologic imaging do not lend themselves to automated processing for detection of abnormal results. No standardized descriptive "style" is used by radiologists for their reports. For any single imaging examination, multiple findings are often enumerated, and each can be described in various ways by different radiologists and even within the same radiologist can vary depending on different patients' anatomical image qualities and comorbid diseases. More importantly, some findings that are deemed critical in specific cases are not necessarily critical in others. For instance, thickened bowel walls are commonly observed on abdominal imaging postoperatively but can be a critical finding in another setting, such as in a patient with abdominal pain due to acute abdomen. Therefore, despite its importance in patient management, communicating critical results of imaging tests is a difficult task.

Context:

Consistent with the Safe Practice Recommendations, the Brigham and Women's Hospital (BWH) Department of Radiology subsequently developed and implemented a process for communicating critical imaging results as part of a Communication of Critical Test Results (CCTR) policy.(16) The goal of the CCTR policy was to enable widespread adoption of the process at the BWH and affiliated outpatient facilities. This initiative was successfully piloted because of the strong advocacy and commitment by senior hospital leadership. The policy was implemented, monitored, and reinforced utilizing continuous process improvement methodology, including routine reviews and feedback, publication in the web-based hospital scorecard, and prompt investigation of policy-related complaints. The project's first specific aim included documenting the CCTR Policy and its institution-wide implementation at the BWH.

After successful adoption of the CCTR policy, we identified barriers and solutions to further enhance timely communication of critical imaging results.

It was noted that implementation utilized a heavily “analog” process – consuming significant time and effort. Radiology physicians relied on posters to identify communication procedures and were individually creating alerts to notify referring physicians. They also had to wait for a response and document acknowledgment as well as the contents of their discussions, as appropriate. This process, although effective, was interrupting care and work flows and did not appear to be sustainable. Thus, the department has invested resources toward an alert notification system to enable sustained adherence to the policy and maintain continuous quality improvement.(17) The project's second aim included a comprehensive evaluation of the notification system for enhancing adherence to the CCTR policy.

Settings:

The project was based at The Brigham and Women’s Hospital (BWH) Center for Evidence-Based Imaging (CEBI). The CCTR policy and the alert notification system were implemented at BWH, a 750-bed urban adult tertiary referral academic medical center in which more than 500,000 radiological procedures are performed annually. Apart from the main hospital, the study site includes the emergency department and two associated offsite outpatient facilities.

Participants:

Within the study site, all patients with radiology reports were participants. They were expected to benefit from full implementation of the CCTR policy, as demonstrated in the evaluation. A waiver of informed consent for medical record review was granted by our institutional review board for this HIPAA-compliant study. A random sample of radiology reports between February 2006 and January 2010 was included in evaluating the CCTR policy implementation. Similarly, a random sample of radiology reports between January 2010 and December 2013 was analyzed to evaluate the notification system. Finally, all radiology reports communicated through ANCR from 2010 to 2013 were included in evaluating adherence to CCTR policy.

AHRQ Target Population

Baseline characteristics of the target population for this study included a mean age of 58 years (range 18-100), and gender distribution, with 56% women and 44% men. We did not assess ethnic and racial distributions, but we expect that they were consistent with the study site population, because we did not exclude any group belonging to AHRQ target populations. We included children between 18 and 21 years, elderly, patients in inner-city populations, and those needing chronic care.

Incidence:

The incidence of radiology reports that document critical results based on manual review ranges from 7% to 12% annually; average incidence of critical results in radiology reports is 10%(18)

Prevalence:

The prevalence of radiology reports that document critical results is similar to the incidence, because a critical result is defined as a new or unexpected radiologic finding or one that was significantly different from a preliminary interpretation, requiring direct notification of the patient's care team.(18)

Methods

Study Design:

The CCTR policy was implemented, monitored, and reinforced utilizing continuous process improvement methodology at the study site in 2006. Evaluation proceeded with manual review of a sample of radiology reports by radiology section chiefs, with feedback of results to staff radiologists. A trend analysis was conducted, assessing adherence to CCTR policy for 4 years in 6-month time periods.

Subsequently, an alert notification system was implemented – Alert Notification of Critical Results (ANCR) – in January 2010. Evaluation continued with manual review of a sample of radiology reports. A before-after comparison of adherence to CCTR policy was performed, comparing a random sample of radiology reports during the first 4 years post-intervention to baseline outcomes 1 year pre-intervention. In addition, a comprehensive evaluation of all critical radiology results that were communicated through ANCR was performed, assessing adherence to CCTR policy using trend analysis for 4 years in 6-month time periods.

Data Sources/Collection:

To determine the proportion of critical results adherent to the CCTR policy, we accessed data from bimonthly reviews conducted by radiology section heads as a quality improvement initiative regarding communication of critical test results. Beginning February 2006, on one randomly selected day every other month, heads of each radiology section reviewed all radiology reports for that day for critical results documented in the report. All reviewers were instructed regarding the CCTR policy and the review process. Each report was assessed as having a critical result or not, and if so, was further classified as adherent to CCTR policy or not.

We also determined adherence to CCTR policy, comparing the first 4 years after ANCR implementation to the year prior, utilizing data from the quality improvement initiative just described.

Finally, adherence to CCTR policy for all reports that utilized ANCR during the first 4 years of implementation was assessed. We queried the ANCR database that tracked the number of alerts during any specific time frame, the alert level, and information about the communication (radiologist name, ordering provider name, and date and time of communication).

Interventions:

The CCTR policy was implemented at the study site in February 2006. ANCR was implemented in January 2010.

Measures:

The primary study outcomes were impact on adherence to the CCTR policy during the first 4 years of CCTR policy implementation as well as during the first 4 years of ANCR implementation.

Adherence to the CCTR policy was measured by the proportion of radiology reports with critical results that were adherent to policy provisions for both timely and complete documentation for communicating those critical findings. Documentation was defined as complete if it included the name of the ordering provider who was contacted and the date and time the critical results were communicated. Timeliness was defined by the specific alert level communication policy. Proportion of CCTR adherence was calculated in the first 4 years of CCTR policy implementation in 6-month time periods, and chi squared trend analysis was used to analyze the proportion of critical results that adhered to the CCTR policy over time.

For assessing ANCR's impact on adherence to CCTR policy, a comparison of proportions was performed using two-sided chi squared analysis, comparing the first 4 years after ANCR implementation to the previous year prior.

Limitation:

In evaluating adherence to the institution’s CCTR policy, we utilized a time-series and a before-after study design, which is commonly used for quality improvement studies, rather than a randomized clinical trial (RCT). It carries the limitations inherent in such a study design, primarily posed by any secular trends affecting adoption of the policy. However, providers (both radiologists and ordering providers) would be exposed to ANCR in various settings (e.g., outpatient, inpatient), and it would be difficult to prevent exposure in order to perform a RCT.

Results

We successfully completed our Specific Aims, focused on (1) documenting the implementation of the CCTR policy, (2) evaluating ANCR by assessing its impact on adherence to the CCTR policy, and (3) developing an implementation toolkit to enhance dissemination of the CCTR policy.

Principal Findings:

Intervention 1: CCTR Policy

We published a scientific paper, entitled "Impact of a 4-Year Quality Improvement Initiative to Improve Communication of Critical Imaging Test Results," in Radiology. This publication addressed the project's first specific aim by documenting the Communication of Critical Imaging Test Results (CCTR) Policy and its institution-wide implementation at the BWH. Implementation of the CCTR policy resulted in significant sustained improvement in adherence to the policy from 28.6% to 90.4% over the 4-year study period (chi square for trend, $p<0.001$).

Intervention 2: ANCR

ANCR was implemented in 2010 and created a mechanism for automated graded notification of referring providers when results from imaging exams were deemed critical or unexpected by a radiologist at the time of interpretation. In addition, it enabled secure web-enabled acknowledgment by the ordering provider of the alerts received and was accessible from tethered or mobile devices. Additionally, every alert generated was tracked to ensure that findings were acknowledged in a timely fashion and that the communication loop was closed.

After ANCR implementation, adherence to CCTR policy increased from 91% to 95% ($p<0.0001$). There was a significant, increasing trend in adherence to the policy for all critical results communicated via ANCR (chi square for trend, $p<0.0001$).

Abstract: Four-Year Impact of An Alert Notification System on Critical Test Result Communication

Purpose: As part of Patient Safety Goals, The Joint Commission urges hospitals to develop written procedures, monitor, and measure adherence to policy on communication of critical test results. Although this can be successfully achieved with periodic manual reviews of radiology reports combined with continuous feedback of performance, it can be resource intensive, error prone, and impractical to implement in many institutions. The purpose of this study was to assess the utility of an automated alert notification and reporting system designed to comply with patient safety goals. Utility was measured by assessing the adoption of the system and its impact on adherence to policy.

Materials and Methods: An automated system for alert notification of critical results (ANCR) was implemented in January 2010; our institutional review board granted waiver of informed consent for medical record review. Adherence to a policy for timely and complete critical result communication was determined through manual review of a random sample of radiology reports during the first 4 years of ANCR implementation (n=37,604), which was compared to baseline outcomes 1 year before implementation (n=9,430). Adoption was evaluated by quantifying ANCR use and noninterruptive ANCR communication as a percentage of all radiology reports generated by 320 radiologists (n=1,538,059) and via a trend analysis at 6-month intervals over 4 years.

Results: Adherence to critical result communication policy increased from 91% to 95% (chi square, $p<0.0001$) after ANCR implementation. There was a significant, increasing trend in critical results communicated via ANCR (chi square for trend, $p<0.0001$); 41,445 alerts (41% of ANCR alerts) utilized a noninterruptive secure process for communicating less urgent critical results, sparing clinicians from unnecessary paging.
Conclusions: An automated alert notification system for critical imaging results was successfully adopted and associated with increased adherence to policy requirements for communicating critical test results.

Abstract: An Automated Critical Test Notification System: Architecture and Implementation Design

Purpose: Communicating critical results from diagnostic procedures is a National Patient Safety Goal. This paper describes the system architecture and implementation of a software application, Alert Notification of Critical Radiology Results (ANCR), designed to facilitate critical imaging test result communication between caregivers.
Materials and Methods: ANCR is publicly available and designed to provide alert notification to referring providers when results from imaging exams are deemed critical by their respective radiologists. This paper describes the system components and design decisions related to ANCR implementation and includes software tools at each of the following steps – ANCR user login, alert generation, alert acknowledgment and inventory, and alert reminder.
Results: ANCR was fully implemented (integrated into physician workflow) in January 2010. We enumerated several ANCR features that were identified as critical in our ANCR implementation, including active alert generation that is triggered by clicking a button and use of secure e-mail for asynchronous notification of less urgent findings.
Discussion: ANCR was designed to enhance critical result communication between physicians. We describe the design and implementation of ANCR, highlighting important design decisions that led to physicians' overall satisfaction with the system.
Conclusion: This study describes the design and architecture of an alert notification system for critical result communication.

Outcomes:

Implementation of the CCTR policy resulted in significant sustained improvement in adherence to the policy from 28.6% to 90.4% over the 4-year study period (chi square for trend, $p<0.001$).

After ANCR implementation, adherence to CCTR policy further increased from 91% to 95% ($p<0.0001$). There was a significant, increasing trend in adherence to the policy for all critical results communicated via ANCR over a 4-year study period (chi square for trend, $p<0.0001$).

Discussion:

We document successful implementation of the CCTR policy at our institution. Through feedback and performance, sustainable improvement in communication of critical test results was observed with adoption of a comprehensive policy that included definitions, stratification of alert urgency, escalation, and documentation requirements. In addition, use of an automated tool to facilitate and track the communication of critical imaging results was associated with further increases in adherence to the institution's CCTR policy.

Our findings suggest that health information technology tools for communicating critical test results can be embedded in physician workflow to significantly improve closed loop communication of critical results with its inherent relevance to improving patient safety.

Our ANCR implementation appears to have overcome a number of known barriers to implementing new clinical information systems in multi-setting healthcare institutions, including new or increased workload for clinicians, unfavorable workflow issues, and changes in communication patterns.(17,18) We believe that three major factors positively influenced adoption at our institution: 1) substantial institutional/executive support for the establishment, monitoring, and enforcement of a policy for communicating critical test results; 2) integration of ANCR within the existing physician workflow, both for radiologists and for referring providers, including secure web-enabled use of mobile devices to acknowledge alerts; and 3) ANCR's capability to enable secure HIPAA-compliant email (asynchronous and noninterruptive communication) to replace the more time-consuming, intrusive, and interruptive person-to-person or telephonic communication between providers using the paging system.

Conclusion:

We demonstrated successful adoption of a critical result communication policy and an alert notification system at our institution. Adoption of a critical result communication policy and an alert notification system were associated with timely and documented communication of critical test results between care providers, consistent with a national Joint Commission patient safety goal.

Significance:

Delays in communicating critical test results pose a significant threat to patient safety. We successfully instituted a CCTR policy for CIR, with documented definitions, urgency levels, corresponding communication and documentation requirements, and escalation mechanisms to ensure that CIR communications reached a responsible clinician. Implementation of the CCTR policy resulted in significant sustained improvement in documented, timely, closed loop communication of critical results from 28.6% to 90.4% over a 4-year study period.

Implementation of an automated critical result communication system, ANCR, resulted in further increase in adherence with the institution's policy for communicating critical test results. Barriers to adoption of the CCTR policy, primarily the heavily manual process of creating alerts, were addressed by automating the notification process (using ANCR) once radiologists recognized the presence of a CIR. In addition, the workflow for alert notification was rendered more efficient and less interruptive by enabling a secure communication system in which physicians have single secure log-ins (and do not need to log in multiple times to different systems) and are able to send and receive messages asynchronously utilizing secure e-mail, specifically for yellow alerts. Finally, ANCR also allowed automated tracking and analysis of adherence to CCTR policy, thereby augmenting the manual review required for section heads in the department. Post ANCR implementation, CCTR policy adherence increased from 90.7% to 97.9% over 4 years for ANCR-communicated test results. Considering that we currently have approximately 400,000 radiology reports annually, resulting in over 30,000 critical results, this increase in documented, timely, closed loop communication is likely to be clinically significant.

Implications:

Development of a critical result communication policy is crucial in helping enhance documented timely communication of critical test results, a national Joint Commission patient safety goal. Adherence to a critical result communication policy is further enhanced by utilizing an alert notification system integrated into physicians' workflows.

List of Publications and Products:

Dissemination Toolkit

The implementation toolkit was made available in the project website, http://www.brighamandwomens.org/Research/labs/cebi/CCTR/default.aspx. As described previously, components of the toolkit included a poster documenting the CCTR policy, a copy of the CCTR policy, training manuals and user guides, links to study-related abstracts, and the citation for the Radiology publication describing an evaluation of the CCTR policy initiative. This publication documented the implementation and subsequent adoption of the policy as well as barriers and factors that enhance adoption.

Implementation toolkit levels 2 and 3 were combined and made available on the ANCR website, http://www.brighamandwomens.org/Research/labs/cebi/CCTR/ANCR.aspx. The website included a description of ANCR, functional requirements, and added value for physicians. Nonproprietary software was made available for download, with instructions for deployment and EMR integration. Two sets of user guides were included to facilitate ANCR use – one for radiologists and another one for ordering providers.

Demonstrations of ANCR were presented at scientific conferences, including the following:

1. Luciano M.S. Prevedello, MD, Ryan Roobian, CIIP, Symantec, Elliot J. Wasser, MD, CIIP, ANCR – Alert Notification of Critical Results. Open Source in Medical Imaging. The Society for Imaging Informatics in Medicine. 2012 Open Source Plug Fest, Orlando, FL, June 2012.
2. Luciano Prevedello MD. Using IT to Improve Results Communication, Including Critical Results. Next Generation IT Requirements for Improving Quality and Safety for Radiology. Radiological Society of North America Scientific Assembly and Annual Meeting. Chicago, IL, December 2012.

Presentations of tools and algorithms for automating retrieval of reports with critical results that were necessary for evaluation of ANCR were also presented at conferences, as follows:

1. Warden G, Lacson R, Khorasani R. Leveraging Terminologies for Retrieval of Radiology Reports with Critical Imaging Findings. AMIA Annual Symposium, Washington, DC, October 2011.
2. Gershanik E, Lacson R, Khorasani R. Critical Finding Capture in the Impression Section of Radiology Reports. AMIA Annual Symposium, Washington, DC, October 2011.

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Anthony SG, Prevedello LM, Damiano MM, Gandhi TK, Doubilet PM, Seltzer SE, Khorasani R. Impact of a 4-year quality improvement initiative to improve communication of critical imaging test results. Radiology. 2011 Jun;259(3):802-7. doi: 10.1148/radiol.11101396.

Warden GI, Lacson R, Khorasani R. Leveraging terminologies for retrieval of radiology reports with critical imaging findings.AMIA Annu Symp Proc. 2011;2011:1481-8. Epub 2011 Oct 22.PMID: 22195212

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