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ORIGINAL RESEARCH

Connected: Using a Novel In-House Communication System to Efficiently Deliver Imaging Results

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Introduction: The primary objective was to investigate the effectiveness of a fully staffed electronic communication system (1Connect) in delivering timely critical imaging results and incidental findings. The secondary objective was to evaluate the financial impact of this system on a radiology practice.

Methods: From January 2014 through June 2016, the 1Connect database was retrospectively reviewed and sorted by category of submission type: Critical (1-hour communication time), STAT (2 hours), or Unexpected finding (3 business days). The percent of successful communications completed within the appropriate time frame was calculated for each priority category and used as a measure of the system's efficiency and effectiveness. The financial impact of 1Connect was then estimated using an average radiologist salary in Portland, Maine, combined with the radiologist time saved using this system.

Results: More than 96% of time-sensitive results (critical and STAT categories) were communicated within their predetermined time limits with the 1Connect system. Using this system, the estimated value of radiologist time saved by 1Connect staff was approximately \$50 997 per year.

Conclusions: Spectrum Radiology's 1Connect system presents a novel approach that supports timely and cost-effective communication of imaging findings to treating providers. While patient outcomes and safety were not evaluated in this study, patient care is likely enhanced when critical findings are promptly communicated to referring providers.

Keywords: radiology, time savings, cost-effectiveness

Interfacing with ordering providers is a crucial, and potentially time-consuming, part of the radiologist's workflow. It is important to communicate critical and unanticipated findings that will affect patient care in an effective and timely manner. Communication errors in radiology can have a significant negative impact on patient outcomes.¹ Therefore, patient safety is enhanced with efficient communication between radiologists and referring providers. Failure to communicate findings appropriately is important for patient care, and is the second-most-common reason for a radiologist to be named in a malpractice suit.² With accurate interpretation and communication of findings as the unequivocal primary goal, a key

secondary focus becomes minimizing the time expenditure, associated financial impact, and stress burden on the interpreting radiologists. In isolation, a short period of time spent on a phone tree does not have a significant impact; however, when multiplied many times throughout the day, the negative impact on stress and job satisfaction is amplified.^{3,4} Additionally, attempting multiple different pager or phone numbers to communicate results to a difficult-to-reach provider can significantly interrupt a radiologist's workflow. And radiologist interruptions result in increased reading time⁵ and a tendency to conclude that an abnormal case is normal.^{1,6} Therefore, a streamlined communication system that reduces interruptions is important for patient safety.

Often, there are imaging findings that should be communicated directly to the ordering clinician by phone, but do not require a physician-level

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consultation. Such findings may even be time-sensitive and key to patient care, but also considered straightforward. An example would be low positioning of an endotracheal tube identified on a chest radiograph. In contrast, radiologists directly communicate critical and time-sensitive imaging findings, such as intracranial hemorrhage, tension pneumothorax, or testicular torsion. In addition, radiologists must communicate important non-critical incidental findings, such as a new suspicious pulmonary nodule. The advent of picture-archiving and communication system (PACS), an organized electronic architecture, has increased the number of these reported incidental findings. This increase relates to PACS providing dynamic imaging control—the ability to manipulate viewing parameters (eg, window, level, magnification) to accommodate the reviewer's preference.⁷ Additionally, iterative improvement in imaging quality, technology, and more advanced imaging modalities has also increased radiologists' ability to identify important incidental findings. Consequently, the time commitment required to communicate these findings also increases. However, these incidental findings can often be safely and appropriately delivered by a non-clinical staff member rather than a radiologist.

There are many existing electronic communication systems to help radiologists deliver critical and incidental findings to providers.⁸⁻¹⁶ Several of these systems are automated and send a page or email to the intended recipient. In one system, a text page that describes findings of pneumonia on a chest radiograph is sent to the charge nurse in the emergency department, and then this finding is communicated to the treating provider. However, this system could not verify that the message was received. It was also found to prolong the time to antibiotic treatment, likely due to delayed communication.⁸ Another system implemented at Massachusetts General Hospital sends an email to the provider to alert them of important, but non-urgent, results. This system has a built-in receipt confirmation to acknowledge results were received. However, in a retrospective review of its effectiveness, only 75% of these emails were read by the providers.⁹ In contrast, there are electronic systems that successfully communicate results. For example, a fax-based system with a built-in receipt mechanism implemented at a large academic hospital was designed to communicate incidental findings, such as lung nodule follow-up. This system

successfully delivered over 99% of findings to the provider.¹⁰ Another system described by Lacson et al. used a combination of email and paging with a built-in receipt-confirmation mechanism, which significantly improved timely closed-loop communication of critical results.¹¹ However, both of the aforementioned automatic systems are less resourceful than a human staff member when unexpected problems arise, such as an incorrect physician or pager number being attributed to a study, or a provider remaining unavailable for a prolonged time period. Another system implemented at Beth Israel Deaconess Medical Center used human communication facilitators to effectively communicate important, but non-urgent, results within 48 hours.¹² However, this system was not used for time-sensitive, critical results.

The Radiology Division of Spectrum Health Care Partners (Spectrum Radiology) is a private practice group that provides radiology services to Maine Medical Center, the MaineHealth network, and other hospital and imaging sites throughout Maine and New Hampshire. Responding to the ever-increasing time-burden to communicate imaging findings, the group developed and deployed an internal system to aid in this process. This 1Connect system uses software embedded within the user interface of PACS and is available for all attending radiologists. The 1Connect database, launched in January 2014, is owned and managed by Spectrum Radiology. It is operated by several non-clinical staff at Spectrum Radiology who also have other administrative and support responsibilities. One staff member covers the 1Connect system each day on a rotating basis, with one additional staff member on standby each day to assist during periods of increased case volumes. Maintenance of the system requires approximately 15 hours per year and is managed by software engineers within Spectrum Radiology.

1Connect is activated by clicking on an icon on the PACS toolbar, with 2 options available: Findings and GetMe. After clicking on the Findings icon, the radiologist types a message into the text box, detailing imaging findings and recommendations. The communication level is also categorized, determined by the radiologist on the basis of urgency with which the results should be communicated to the provider: Critical (1-hour communication time), STAT (2 hours), or Unexpected (3 business days). These times mirror recommendations from the Actionable Reporting Work Group of the American

College of Radiology.¹⁷ This prioritization is used by support staff as cases are submitted. When a case is submitted, the 1Connect database auto-populates to include patient name, study description, medical record and study accession numbers, study findings, and any follow-up recommendations. The entry is then “claimed” by a member of the 1Connect team, who is responsible for the communication. After connecting via telephone with the responsible clinician, the clinical information is read verbatim by 1Connect staff. If the clinician who ordered the exam is not available, the information may also be communicated to a covering clinician, mid-level provider, nurse, or medical assistant. The name of the receiving provider and the time and date at which the communication was completed are then incorporated into the 1Connect database and saved in the archives for medical-legal and clinical documentation purposes (Figure 1).

With activation of GetMe, 1Connect staff directly calls the office or pager of the ordering provider. The call is then transferred directly to the radiologist at their workstation to discuss the findings, which often include critical, time-sensitive results, more complex cases that warrant radiologist-to-provider consultation, or a need to acquire additional pertinent clinical information. Like with Critical findings, there is a 1-hour time limit to this service.

The goal of this study was to investigate the effectiveness of the 1Connect system in delivering results as measured by communication time, as well as to assess the financial impact of the system on a radiology practice.

METHODS

Submissions to the database from January 2014 through June 2016 were included in this study, which was approved by the Institutional Review Board at Maine Medical Center. For each submission, priority category (Critical, STAT, and Unexpected) and type (Findings or GetMe) were recorded. The times of initial submission and successful completion of each request were recorded, and the overall time needed for each request was calculated. Time to complete each request was compared with the allotted time for the type of request. The primary objective was investigated by calculating the percent of communications successfully completed within the appropriate time for each category. Median time to successful communication was also calculated, and overall median was reported (Table 1).

To estimate the time spent actively communicating, additional documentation was required. The documented call logs within the database did not separate “active” time in attempted communication from “inactive” waiting time, both of which were encompassed in the documented time between the initiation and closing of the request. To mitigate this issue, between May and June 2016, the 1Connect staff were asked to prospectively monitor the time spent in active communication. During that period, 194 contiguous encounters were recorded and sorted by type of provider to whom results were communicated (Table 2). During these encounters, every member of the 1Connect support team participated in this documentation. Active time was recorded as the time spent by staff calling or paging, working through phone trees, waiting on hold,

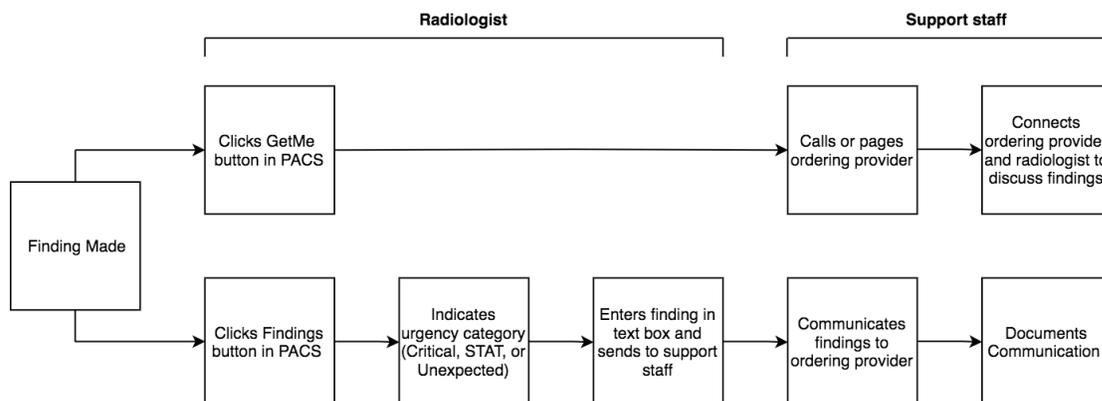


Figure 1: Workflow to Communicate Findings through 1Connect. PACS, picture-archiving and communication system.

Table 1. Response Performance by Encounter Type.

Encounter type	Target response time	Number of communications, No.	Frequency within time limit, No. (%)	Time to communication, minutes, median (IQR)
Critical	1 hour	271	261 (96.3)	10 (6, 18)
STAT	2 hour	2982	2881 (96.6)	11 (6, 23)
Unexpected	3 business days	461	458 (99.3)	37 (10, 914)
GetMe	1 hour	1899	1700 (89.5)	11 (6, 24)

Abbreviations: IQR, interquartile range.

Table 2. Active Communication Time by Type of Provider.

Provider type	Frequency, No. (%)	Average active communication time, minutes
Physician	62 (32.0)	6.1
Mid-level provider	9 (4.6)	4.1
Nurse	68 (35.1)	5.2
Other clinical staff	55 (28.4)	5.0
Overall	194 (100.0)	5.4

reporting findings, and receiving active feedback to confirm receipt of findings. In contrast, inactive time was considered the time spent waiting for providers to return a page or phone call. The support staff would cumulatively add up each step of active time and record this total number for each encounter.

The secondary objective was to estimate the financial implications of the 1Connect system. A median radiologist salary for Portland, Maine, the primary metropolitan center served by Spectrum Radiology, was used to estimate a time-value for a radiologist's time, extrapolated to a "per-minute" basis. The radiologist's per-minute time and average call time was then used to estimate the monetary value of radiologist time saved per year.

RESULTS

Primary objective

During the 30-month study period, a total of 5613 submissions were made to the 1Connect database, including 3714 Findings and 1899 GetMe requests. Of these, 96.3% (261/271) of Critical, 96.6% (2881/2982) of STAT, and 99.3% (458/461) of Unexpected category results were communicated within their predetermined time limits using the 1Connect system. Of the GetMe requests, 89.5% (1700/1899) were fulfilled within the predetermined time limit of 1 hour. Given the presence of outliers that statistically skew the mean, the communication time was calculated in median and interquartile range (Table 1). The median overall communication

times were 10 minutes for Critical, 11 minutes for STAT, 37 minutes for Unexpected, and 11 minutes for GetMe category results.

The overall call time was estimated at an average of 5.4 minutes. These data were further stratified by type of provider: 6.1 minutes for physicians, 4.1 minutes for mid-level providers, 5.2 minutes for nurses, and 5.0 minutes for other clinical staff (Table 2).

Secondary objective

The 1Connect system also financially benefited our radiology group. As of July 2019, the conservative salary estimate for a radiologist in Maine was \$406254.¹⁸ Assuming a 40-work year and 40-hour work week (1600 work hours per year), this translates to an hourly rate of \$253.90, or \$4.23 per minute. Using the estimated average call time of 5.4 minutes, each call results in a savings of approximately \$22.84 in radiologist time-value. Over our sample time of 30 months, a total of 5613 call events occurred, yielding an average of 2245 call events per year. Assuming the average time from the survey results accurately represents the time spent by support staff on each call, a total of 12 123 minutes was spent on the telephone in one year. Taking the \$4.23/minute time-value for radiologists, the value of radiologist time saved by 1Connect staff was \$51280 per year. The hourly wage of our current support staff ranges between \$16 and \$19 per hour, which translates to approximately \$30 720 to \$36 480 per year. Therefore, after accounting for the yearly salary of one support staff member, the savings of the system is approximately \$14 800 to \$20 560 per year.

DISCUSSION

The most critical question in this study was whether the 1Connect system could effectively and efficiently communicate clinical findings to a responsible member of the care team. The answer is a resounding affirmative: 96.3% of the Critical category results, 96.6% of the STAT category results, and 99.3% of the non-time-sensitive Unexpected category results were communicated within their predetermined time limits. In fact, the median time to communicate findings were 10 minutes for Critical, 11 minutes for STAT, and 37 minutes for Unexpected results. These times are far below the recommended time limits of 60 minutes, 120 minutes, and 3 business days. 1Connect staff

successfully communicated key findings to the relevant clinical providers in an appropriate time. Thus, patient care is well-served by this timely and efficient system.

For database entries completed outside of the prescribed time limits, communication was ultimately made in 100% of cases. The most common reasons for delayed communication time were unanswered pages to providers and incorrect contact information associated with the study ordered. In these cases, support staff continued trying different pager and phone numbers until they connected with the appropriate provider. These outliers were not specific to a particular type of study. While unexpected category results can now be submitted to the 1Connect database over the weekend, during the study period, 1Connect did not have weekend staffing. Therefore, all such submissions waited until the following Monday morning for completion. As such, the communication time data is best presented in median and interquartile range, as there are multiple outliers within the unexpected results category that reflect a blend of weekday and weekend results. While these outliers artificially inflate the average time of communication, 99.3% of Unexpected results were still communicated within the time limit of 3 business days.

The second important question in this study regarded the financial impact of a staff-supported communication system on a radiology practice, which has not been previously described in the literature. By having 1Connect staff communicate results, the total savings per year was enough to pay for the entire annual salary of one support staff member and save an additional \$14 800 to \$20 560 per year. This estimated savings does not attempt to encompass any time-value savings on the receiving end, but rather focuses only on those provided to the radiology department. Any efficiencies afforded to those clinical care providers who receive 1Connect findings are considered an additional economic savings not included in this calculation. For example, communication of non-critical results between 1Connect staff and ordering clinician support staff alleviates interrupting a primary care provider and allowing review during a more convenient time, improving efficiency and patient safety.

Although not specifically measured in this study, the 1Connect system provides other benefits to

radiologists. With a staff-supported communication system, a radiologist spends less time waiting on hold or attempting to get in touch with the appropriate provider. Additionally, using 1Connect to reduce interruptions provides more accurate interpretations and increases reading speed, thereby increasing a radiologist's case volume—and productivity—per day. More accurate reports and improved communication also have significant medical-legal implications. A survey conducted in 2013 by the American College of Radiology found that 23% of all radiologists were involved in at least 1 malpractice lawsuit due to failed communication.¹⁹ Additionally, according to the Physician Insurers Association of America, errors in communication are among the top 5 reasons for medical malpractice litigation.²⁰ The 1Connect system streamlines communication of imaging findings and management recommendations, and it provides a legal repository for appropriate documentation of this communication. As a result, there is a potential decreased chance of litigation related to lack of communication of important findings. This decrease may also offer a large, but difficult to measure, cost savings.

This study has several limitations. Active time spent communicating findings was self-reported by support staff, and therefore could be prone to inaccuracy. In terms of the financial benefit, multiple assumptions were used to estimate the cost savings to the radiology group, such as the radiologist's salary and the estimated 40-hour work week. For a more accurate estimate, further studies could explore the cost saved by using actual hours worked and salary figures. Additionally, the data was collected from 2014 to 2016, and the estimated radiologist salary used for this study was based on 2019 data. Unfortunately, an average salary estimate from 2014 to 2016 was not available. As noted above, the estimated cost savings on a radiology practice is likely an underestimation as it does not take into account increased efficiency afforded to radiologists likely resulting in higher revenue or the decreased risk of litigation. The study also does not attempt to monetize the added benefit of improving radiologists' quality of work life based on removing the many interruptions and time requirements for communicating findings from the radiologists workflow.

Our primary outcome measure was active communication time between 1Connect initiation

and successful delivery of results rather than patient harm due to delayed communication, a fundamental goal in patient safety. As such, the 1Connect system likely improves patient safety by ensuring that critical findings are promptly communicated to treating providers. However, this study did not analyze patient outcomes, and therefore patient safety was not specifically evaluated.

CONCLUSIONS

1Connect, a novel communication system, is both time-efficient and cost-effective in delivering critical and incidental radiology findings to ordering providers. The savings in radiologists' time, and therefore monetary value, is sufficient to support the necessary staffing. While patient safety was not evaluated in this study, patient care is likely enhanced when critical findings are promptly communicated to referring providers. With a dedicated information technology and administrative support staff, a similar system can be developed and implemented in both the private practice and academic setting to improve radiologist workflow, optimize communication of radiology findings, and enhance patient care.

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Conflicts of Interest: None

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