Improving Consistency in Radiology Reporting through the Use of Department-wide Standardized Structured Reporting[1]

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Purpose: To successfully develop a department-wide standardized structured reporting program and achieve widespread adoption throughout the radiology department.

Materials and Methods: A structured reporting work group was formed in February 2010 to oversee development of standardized structured reports for a radiology department of 36 radiologists at a tertiary care children's hospital. The committee reached consensus on report organization and provided written guidelines and checklists for division representatives to aid in creation of the structured reports. Report drafts were reviewed by a subcommittee and revised until agreement was reached with the report author. Each report was vetted by all radiologists who would be using the report, and further revisions were made, as appropriate. Reports were then entered into the speech recognition system so that each report was associated with a procedure code or a group of codes from the radiology information system. This enabled automatic report population within the speech recognition system. The initiative was completed by September 2011. Quarterly audits were performed to evaluate for adherence to the standard report format and use of the normal report in cases in which the radiologist believed the study was normal. In August 2012, radiologists were surveyed as to their impressions of the structured reporting program.

Results: A total of 228 standardized structured reports were created within 2 years after initiation of the project, corresponding to 199 000 (94%) of 212 000 departmental studies by volume. By the end of the implementation period in September 2011, all 223 (100%) audited reports adhered to the standard report format and 80 (99%) of 81 reports adhered to the normal report. Radiologist feedback was largely favorable.

Conclusion: Standardized department-wide structured reporting can be implemented in a radiology department, with a high rate of adoption by the radiologists.

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The capability to automatically populate structured radiology reports has become a standard feature of modern speech recognition software (1–3). Furthermore, certain speech recognition software products allow the user to create fields that can be filled in, that can contain default text, and/or that can contain "pick lists," from which users can select the most-appropriate text (1). This technologic advancement provides the opportunity to implement department-wide standardized structured reporting, with the promise of improved report consistency, increased radiologist productivity, and heretofore unavailable opportunities for research and quality assurance and improvement (4–6). In fact, articles touting the theoretical benefits of structured reporting have been published for over a decade (7–9). However, despite the perceived potential benefits and the technical feasibility, in the words of Reiner (10), "adoption to date has been tepid." Successful implementation of automatically populated structured reports requires radiologist acceptance of report standardization. The tension between the two desirable principles of systemic consistency and physician autonomy quickly becomes apparent during the implementation of a structured reporting program (11,12). Although the technologic challenges may be difficult in and of themselves, the difficulty of persuading a large group of radiologists to agree on standard reporting practices may be the greater challenge (13). In this article, we describe how we addressed both of these aspects to implement a department-wide structured reporting program.

In 2009, our department purchased a new speech recognition software product (Radwhere; Nuance Communications, Burlington, Mass) that enabled the development and use of department-wide, examination-specific standardized structured reports. The purpose of this project was to successfully develop a department-wide standardized structured reporting program and to achieve widespread adoption throughout our radiology department.

Specific aims of the project were to *(a)* create department-wide structured reports for examinations corresponding to more than 90% of departmental reports by volume; *(b)* ensure that all reports created are endorsed by all division leaders and vetted by all affected radiologists prior to implementation; *(c)* achieve use of the standard report format (defined as the use of standard paragraphs, headings, content order, etc) in more than 90% of radiology reports; and *(d)* achieve the use of the default normal structured report in more than 90% of cases in which the radiologist believes the study to be normal.

Advances in Knowledge

- Successful implementation of department-wide structured reporting requires radiologists to accept standardization.
- Consensus-building efforts are critical in the development and implementation of department-wide structured reports.
- Department-wide structured reporting can be implemented in such a way that radiologists will prefer using department standard reports to creating, maintaining, and using their own reports.

Materials and Methods

Setting

This study did not meet the criteria to be considered human subjects research. Cincinnati Children's Hospital Medical Center is a tertiary care pediatric hospital and an academic medical center located in a metropolitan area in southern Ohio. The department currently employs 36 radiologists (approximately 25 full-time equivalents), all of whom are subspecialized in pediatric radiology. All radiologists are employees of the hospital.

Implication for Patient Care

- Successful implementation of a standardized structured reporting system reduces variation in reporting across the department.

Report Generation, Editing, and Implementation

When it was determined that the new speech recognition software would enable the use of structured reporting, the department leadership team, which consisted of five radiology leaders and two administrators, weighed the merits and challenges of implementing a department-wide standardized structured reporting program. They decided to proceed, and a structured reporting work group was formed in February 2010 that consisted of seven radiologists, including the radiologist-in-chief, representatives from each division, leaders of the quality improvement and informatics divisions, and two administrative personnel. A structured reporting work group subcommittee was also formed, which consisted of two radiologists (quality improvement and informatics leaders), a quality improvement support staff member (who was also a radiology technologist), and an administrative assistant.

The committee began its work by reading background literature relative to structured reporting (1,14) and identifying broad goals of the work group. For global aspects of the project, the subcommittee developed and presented options and recommendations regarding report structure to the work group. These included overall report organization, including section headers, the use of narrative language versus ordered lists, guidelines for terminology, and decisions regarding technical details of the reports. Once

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Conflicts of interest are listed at the end of this article.

consensus had been reached regarding these issues, the subcommittee provided written guidelines and checklists for the division representatives to aid in the creation of the structured reports. By March 2010, division representatives were assigned the task of creating reports pertaining to their areas of specialization. Prioritization was determined based on the volume of the study represented by the report; structured reports for high-volume studies were developed first.

Radiologists were asked to adhere to general guidelines with respect to formation of the reports, including that the report be concise, that the default report serve as a "normal" template with no or minimal data entry, that it answer the most common clinical questions with appropriate use of pertinent negatives, that it include language necessary for reimbursement, and that it include structured choices for the most commonly encountered abnormal diagnoses. The checklist used to guide report authors is shown in Figure 1.

After each report was developed by the respective division representative, it was reviewed by the subcommittee to correct any grammar, punctuation, or spelling errors and to ensure consistency in format and language across the department. The subcommittee suggested changes to improve the completeness, succinctness, and consistency of the reports. The subcommittee and report author also attempted to minimize the likelihood of user-driven report errors, which ranged from inappropriate use of punctuation to failing to remove an inappropriate reference to a normal finding. The report author continued to revise the report until agreement was reached between the subcommittee and the author. Each report was also approved by the respective division leader.

After preliminary approval was obtained, the report draft was distributed to all radiologists who would be affected by the report for a 1-week comment period. The subcommittee and report author reviewed and addressed all comments. Submitting radiologists were notified of changes made to the report on the basis of their suggestions or of reasons that their suggested changes were not incorporated. Reports were then finalized after approval of the report author, division director, and report subcommittee.

Once a report was finalized, it was entered into the department-wide speech recognition software. Reports were mapped to the corresponding radiology information system examination code or codes, incorporating patient sex as appropriate, which enabled automatic population of the report by the speech recognition system. At least two individuals reviewed every report to screen for errors.

After deployment of each structured report, signed reports were randomly

Figure 1

Guidelines/Checklist for the Structured Report Template

Format:

- ☐ Template should follow standard format/headers (CLINICAL HISTORY, COMPARISON, PROCEDURE COMMENTS, FINDINGS, and IMPRESSION).
- ☐ Should be divided into logical sections.
  - If narrative format, paragraphs should be succinct, few (<= ~4 in the findings section), and logically grouped according to anatomy.
  - If ordered list format, should have logical order and items should be limited to those important to clinicians.
- ☐ Minimizes number of tab stops and fill-in fields. No. of tab stops:_____
- ☐ Draws attention to abnormalities in findings and impression.

Language:

- ☐ All phrases are commonly understood by radiologists and clinicians.
- ☐ Minimizes language that radiologists would frequently remove from a normal report.
- ☐ No impressions in the findings section.
- ☐ Avoids noncontributory language in template (e.g. is seen, no definite, grossly…).
- ☐ No grammar, punctuation, or spelling errors.

Report elements:

- ☐ Describes normal findings desired by the clinicians in a normal report.
  - Findings include pertinent negatives referring to the most common/important clinical questions.
- ☐ Includes fill-in fields for most common abnormal diagnoses.
  - Not for less relevant findings or less common diagnoses.
- ☐ Normal exam should require no or minimal data entry.
- ☐ The radiologist should not have to remove any text for a normal report.
- ☐ Easy to choose single areas of concern and replace with abnormal findings.
  - Prevents accidentally leaving in normal findings when the study is abnormal.
- ☐ For more specialized exams, also functions as a checklist. (Logical order)
  - More general exam templates should be more succinct, less thorough.
- ☐ Includes elements necessary for reimbursement.

Figure 1: Checklist used to guide authors in the development of each report.

audited to evaluate for appropriate use of the structured report. Reports were graded according to two criteria: *(a)* whether the report used the standard report format (maintained standard report headers and structure) and *(b)* if it was a normal report, whether the radiologist used the standard normal template language (as opposed to routinely adding or deleting language from the standard report for a normal study). If a clinician asked a specific clinical question, radiologists were encouraged but not required to add information to address that question; such reports were considered to meet the criteria. For example, if a chest radiograph was obtained for cough and fever to evaluate for pneumonia, a change from "normal radiograph of the chest" to "normal radiograph of the chest; no pneumonia" was considered acceptable. For incidental findings, if the radiologist included minor incidental findings but left the remainder of the report intact, it was considered to be an acceptable normal report. However, inclusion of a routine normal finding that did not address a clinical question specific to the case at hand was considered to not meet the criteria. For example, if the radiologist added "the aortic arch is left-side" to a radiograph with a history of "fever, rule out pneumonia," this would not meet the criteria, and the radiologist would be asked to either work within established channels to gain consensus to change the normal report template or learn to live with the report in its current state.

At the time of this project, the department leadership decided to change the financial bonus structure from one that had been offered yearly as a retention bonus to an incentive bonus based on multiple department-wide goals. One of those goals was successful adoption of structured reporting. Eligibility for the bonus, equivalent to approximately 3% of the radiologist's annual salary, was contingent on meeting three goals: *(a)* successful development of structured reports corresponding to 90% of studies by volume, *(b)* appropriate use of the standard report format in at least 90% of the randomly sampled reports per year, and *(c)* appropriate use of the standard normal template in at least 90% of the randomly sampled reports per year in which the radiologist considered the study to be normal.

This was a collective incentive rather than an individual incentive. In other words, if the goals were not reached, no incentive payments would be made to any radiologist, and the funds would be retained by the hospital.

Evaluation and Analysis

Evaluation of appropriate use of the reports was accomplished by randomly sampling approximately 100 report examples per month from studies that had a structured report available as they were being deployed, with relative oversampling of more recently released reports. Sampling and auditing were performed by the quality improvement support staff subcommittee member. After reports had been deployed, formal report audits were performed once every 3 months. Appropriate use of the structured report was monitored by using percentage run charts (*p* charts) for both criteria.

The number of standard reports completed and deployed, as well as the corresponding percentage of total examinations performed for which a standard report was available, were tracked over time. Trends were also evaluated as to structured report availability compared with the volume of that particular report. In August 2012, approximately 2 years after introduction of the first structured report, the radiologists were asked to complete an anonymous survey regarding their impressions of structured reporting. Other elements were monitored on an informal basis only, including radiologists' receptiveness to the change, incorporation of input from referring physicians, radiology report completion time, and report accuracy.

Results

Preliminary meetings to plan the structured reporting work group occurred in

Figure 2

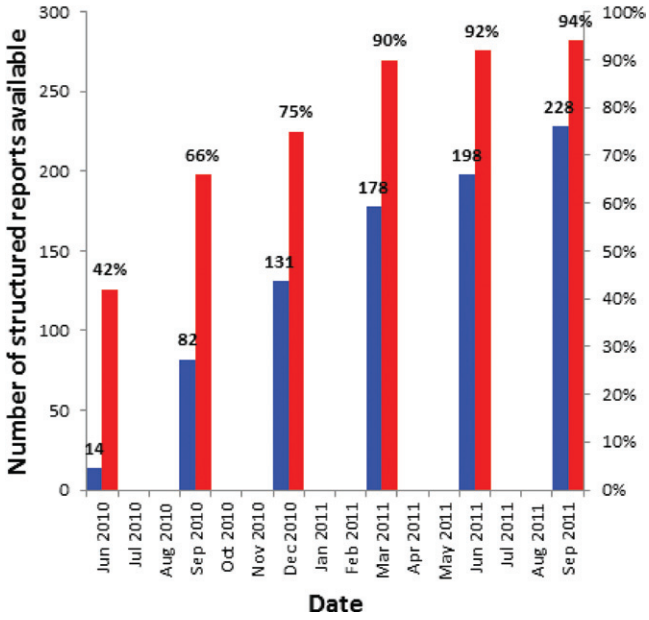

Figure 2: Timeline of completion of structured reports. Blue bars = number of structured reports completed, red bars = percentage of studies with completed reports by overall department study volume. Percentages are based on overall estimated annual radiology report volumes of 217 000 on dates preceding July 2010, 209 000 from July 2010 to June 2011, and 212 000 after June 2011.

Figure 3

CLINICAL HISTORY: [ ].

COMPARISON: [None | Prior study from]

PROCEDURE COMMENTS: Two views of the chest.

FINDINGS:
[The lungs are clear. There is no pneumothorax or pleural effusion.
The cardiothymic silhouette and mediastinal contours are normal.
The upper abdomen is normal.

|

There are increased parahilar peribronchial markings bilaterally. The lungs are symmetrically hyperinflated. There is no focal consolidation, pleural effusion, or pneumothorax.

The cardiothymic silhouette and mediastinal contours are normal.

The upper abdomen is normal.

|

There are increased parahilar peribronchial markings bilaterally. There is no focal consolidation, pleural effusion, or pneumothorax.

The cardiothymic silhouette and mediastinal contours are normal.

The upper abdomen is normal.]

IMPRESSION:
[Normal chest radiograph. | Findings consistent with viral or reactive airways disease without focal pneumonia.]

a.

CLINICAL HISTORY:
Cough and fever for 3 days.

COMPARISON: None.

PROCEDURE COMMENTS:
Two views of the chest.

FINDINGS:
The lungs are clear. There is no pneumothorax or pleural effusion.

The cardiothymic silhouette and mediastinal contours are normal.

The bones and upper abdomen are normal.

IMPRESSION:
Normal chest radiograph.

b.

Figure 3: **(a)** Structured report example for a two-view radiograph. Brackets indicate fields to be populated. Text in brackets indicate pick choices separated by the | character. Underlining indicates default text. In this report, there are three choices for findings: "normal," "viral," and "viral without hyperinflation." There are two choices for the impression: "normal" or "viral." **(b)** Example of a normal report using the standardized structured report template in **a**.

the fall of 2009. The group officially met beginning in February 2010. A timeline of the completion of the reports by annual study volume is shown in Figure 2. As shown in the figure, completion of relatively few reports corresponded to a high percentage of the volume of studies in the department. By September 2011, 6 months after convening the work group, 66% (138 000 of 209 000 studies) of studies by annual volume had an approved structured report available on the dictation system. Within 2 years, 94% (200 000 of 212 000 studies) of studies had an approved structured report available. The initiative was completed by September 2011.

The structured report committee elected to use the following section headers as the standard for all radiology reports: clinical history, comparison, procedure comments, findings, and impression. An example of the normal two-view chest radiograph, one of our most common reports, is shown in Figure 3. The clinical history field was automatically populated from the information provided by the electronic order entry system, although the radiologists were encouraged to modify the given history as appropriate. Standard language was adopted for procedure comments, including the number of views for radiographs, procedure details for cross-sectional studies (including the use of contrast media), and use of equipment, contrast media, and fluoroscopy time for interventional and fluoroscopic procedures.

Standard report formats were categorized as narrative format, ordered list format, or a hybrid narrative and ordered list format. Narrative format reports were those in which prose was used in sentences and paragraphs in a logical progression, often mirroring the typical search pattern. Ordered list format reports were those in which line headings were used to refer to organs or systems, followed by brief descriptive terms, such as *normal*. Hybrid reports combined elements of the narrative and ordered list formats, either with a series of ordered sentences that did not necessarily form a paragraph (ordered prose format) or the full ordered list with full prose expounding on organ systems of special interest (ordered list with narrative format). Examples are shown in Figure 4.

Of the three report formats, 150 (66%) of 228 reports followed the narrative format, 44 (19%) of 228 reports followed the ordered list format, and 34 (15%) of 228 reports followed the hybrid narrative and ordered list format. A total of 18 (8%) of the 228 reports were sex specific, which included all reports that included evaluation of pelvic organs.

Reports corresponding to the highest-volume studies tended to be succinct and minimized specific descriptive language of pertinent negative findings. All radiographic reports fell into this category. Reports corresponding to more specialized studies tended to be more thorough and specific. For example, cardiac and fetal magnetic resonance (MR) reports contained an extensive list of findings, liver elastography MR reports included ranges of stiffness that correspond to

Figure 4

Example 1. Structured report of ultrasound of the scrotum, demonstrating narrative format.	**CLINICAL HISTORY:** [ ]. **COMPARISON:** [None I Prior study from] **PROCEDURE COMMENTS:** Ultrasound of the scrotum was performed, including Doppler. **FINDINGS:** Right testis: [ ] cm, volume of [ ] mL. Left testis: [ ] cm, volume of [ ] mL. The testes are normal in size, shape, and echotexture, and are located within the scrotum. The epididymides are normal. There is no hydrocele, varicocele, or abnormal mass. Scanning through the inguinal canal shows normal cord structures without evidence of twisting or hernia. [There is normal testicular blood flow as documented by both color Doppler evaluation and spectral Doppler waveforms.] There is no evidence of testicular torsion. **IMPRESSION:** [Normal scrotal ultrasound including Doppler.]
Example 2. Structured report of contrast-enhanced CT of the female abdomen and pelvis, demonstrating ordered list format.	**CLINICAL HISTORY:** [ ]. **COMPARISON:** [None I Prior study from] **PROCEDURE COMMENTS:** [CT of the chest, abdomen, and pelvis was performed with intravenous contrast. I CT of the chest, abdomen, and pelvis was performed with intravenous and oral contrast.] **FINDINGS:** **CHEST:** SUPPORT DEVICES: [None.] LUNG PARENCHYMA: [Normal.] TRACHEA AND CENTRAL AIRWAYS: [Normal.] PERIPHERAL BRONCHI: [Normal.] LYMPH NODES: [Normal.] HEART/GREAT VESSELS: [Normal.] PULMONARY VASCULATURE: [Normal.] OTHER MEDIASTINAL STRUCTURES: [Normal.] PLEURA: [Normal.] CHEST WALL: [Normal.] **ABDOMEN/PELVIS:** LIVER AND BILIARY SYSTEM: [Normal.] SPLEEN: [Normal.] PANCREAS: [Normal.] ADRENAL GLANDS: [Normal.] KIDNEYS, URETERS, AND BLADDER: [Normal.] BOWEL: [Normal.] APPENDIX: [The appendix is identified and is normal. I The appendix is not identified.] PERITONEAL CAVITY: [No free fluid. I A small amount of nonspecific free fluid is present in the pelvis.] UTERUS AND OVARIES: [Normal.] VASCULATURE: [Normal.] LYMPH NODES: [Normal.] ABDOMINAL WALL: [Normal.] OSSEOUS STRUCTURES: [Normal.] **IMPRESSION:** 1. [Normal CT of the chest.] 2. [Normal CT of the abdomen and pelvis.]

Figure 4: Examples of report types. Text in brackets indicates pick choices separated by the I character. Underlining indicates default text *(Fig 4 continues).*

stages of fibrosis, and infant hip ultrasonography (US) reports included typical findings and impressions, recommendations, or both for each of the hip types in the Graf classification.

Several of the standard normal reports for the same current procedural terminology code differed depending on the indication for the examination. For example, the normal skull radiography report differed depending on whether radiography was performed due to trauma or whether it was performed to evaluate for craniosynostosis. The head US report differed depending on whether US was performed in a premature neonate or whether it was performed in an older infant to evaluate macrocrania. In these cases, the user could select the appropriate standardized normal report depending on the indication provided for the examination. In some cases, unique examination codes were created so that

Figure 4 (continued)

Example 3. Structured report of CT of the head, demonstrating hybrid ordered list/narrative format (ordered prose).	**CLINICAL HISTORY:** [ ]. **COMPARISON:** [None I Prior study from] **PROCEDURE COMMENTS:** [CT of the head was performed without IV contrast. Trauma head CT protocol was performed without IV contrast.] **FINDINGS:** [The ventricles and extra-axial spaces are normal in size and configuration. Brain parenchymal attenuation is normal. There is no mass or intracranial hemorrhage. The osseous structures appear normal. The imaged sinuses are clear. I The ventricles and extra-axial spines are normal in size and configuration. Brain parenchymal attenuation is normal. There is no evidence of intracranial hemorrhage or other traumatic abnormality. The osseous structures appear normal, without fracture. The extracranial soft tissues are normal. The imaged sinuses are clear.] **IMPRESSION:** [Normal noncontrast head CT. I Normal noncontrast head CT. No traumatic abnormality.]
Example 4. Structured report of MRI enterography of the male abdomen and pelvis, demonstrating hybrid ordered list/narrative format (ordered list with narrative).	**CLINICAL HISTORY:** [ ]. **COMPARISON:** [None I Prior study from] **PROCEDURE COMMENTS:** MRI of the abdomen and pelvis was performed with and without intravenous contrast. VoLumen was used as the oral contrast agent. One 0.3 mg dose of glucagon was administered subcutaneously at the beginning of the exam, and a second 0.3 mg dose of glucagon was administered intravenously prior to gadolinium injection. **FINDINGS:** LOWER THORAX: [Normal.] LIVER AND BILIARY SYSTEM: [Normal. I Normal but incompletely imaged.] SPLEEN: [Normal. I Normal but incompletely imaged.] PANCREAS: [Normal.] ADRENAL GLANDS: [Normal.] KIDNEYS, URETERS, AND BLADDER: [Normal.] BOWEL: Normal. [No mucosal hyperenhancement, mural stratification, bowel wall thickening, strictures, or fistula. The bowel peristalses normally. The terminal ileum is normal.] PERITONEAL CAVITY: [Normal. No inflammatory stranding, lymphadenopathy, engorged vasa recta, fatty proliferation, or abscess. No free fluid, focal fluid collection, or free air.] VASCULATURE: [Normal.] LYMPH NODES: [Normal.] ABDOMINAL WALL: [Normal.] OSSEOUS STRUCTURES: [Normal.] **IMPRESSION:** [Normal MR enterography. No findings of inflammatory bowel disease.]

Figure 4: *(continued).* Examples of report types. Text in brackets indicates pick choices separated by the I character. Underlining indicates default text. *IV* = intravenous.

the system could automatically distinguish examinations by indication. For example, the order for single-quadrant US of the abdomen performed according to the hypertrophic pyloric stenosis protocol was distinct from the order for single-quadrant US of the abdomen performed according to the ileocolic intussusception protocol. These orders were mapped to distinct examination codes and were associated with distinct structured reports, even though they corresponded to the same current procedural terminology code. This enabled the respective reports to be automatically populated depending on the indication, yet it also ensured that the correct charges would be billed.

While most of the reports were developed by the committee members, some were specifically developed in conjunction with referring clinicians. Examples included reports for scoliosis radiography, MR imaging of the pelvis for anorectal malformation, and MR sleep study of the airway. Furthermore, on several occasions, specialty clinicians requested additions or modifications to reports, which were executed after the established vetting process. All of these were requests for minor changes.

Use of the standardized structured report proved to be useful in the setting of research. In one study, the structured report for the US evaluation of appendicitis helped departmental researchers estimate the probability of acute appendicitis in a

given patient, based on the specific findings and impression in the report (15). Automatic population of the structured report helped ensure that radiologists adhered to a common terminology when they estimated the likelihood of appendicitis (Fig 5).

Results of report audits are shown in Figure 6. After a short initial period of moderate compliance, radiologist adherence to the department's definition of appropriate use of both the standard report format and the normal report was greater than 90% in every instance. Compliance for both measures was near 100% by the end of the study period.

When it was discovered that a radiologist repeatedly did not adhere to the normal report template for normal studies, the individual was approached privately and asked either to work through the established channels to change the report for the department or to accept and use the normal report template. Several reports were changed in this manner. While several report templates were changed throughout this process, all of these changes were minor and were limited to text additions or deletions or language changes.

The amount of time devoted to the project was not specifically tracked, but the authors estimate that several hundred total hours of radiologist time were spent developing, revising, and deploying the reports; approximately half of this time was spent by the two subcommittee members.

While we did not specifically measure initial radiologist reaction, we subjectively found that the project was initially met with a moderate degree of skepticism on the part of the radiologists. However, once the system had been implemented, radiologist feedback to the leadership team was largely positive. Results of the radiologist survey conducted 2 years after deployment of the first reports are provided in the Table. Twenty-three (64%) of the 36 radiologists responded to the survey. As shown in the table, most of the radiologists had a favorable impression of structured reporting as it had been implemented. They reported that they preferred structured reporting to free text reporting; that they preferred using department templates to creating, maintaining, and using their own templates; and that they believed that structured reporting had positively affected their efficiency. We received no reports of clinician dissatisfaction with the new structure of the reports; however, clinicians occasionally expressed concerns with the language of some of the reports, which were then modified accordingly.

Figure 5

CLINICAL HISTORY: [ ]

COMPARISON: [ ]

PROCEDURE COMMENTS:
[Graded compression ultrasound was performed in the potential locations of the appendix.]

FINDINGS:
The appendix [is | is not] visualized.

RIGHT LOWER QUADRANT TRANSDUCER TENDERNESS:
Tenderness: [No | Mild | Moderate | Marked] tenderness with compression.
Rebound: [No | Mild | Moderate | Marked] rebound tenderness.

APPENDICEAL DIAMETER (with compression): [N/A].
PERIAPPENDICEAL FAT INFILTRATION: [N/A | Absent | Present].

APPENDICOLITH: [N/A | Absent | Present].
VASCULARITY OF THE APPENDIX: [N/A | Normal | Hypervascular].
PERI-APPENDICEAL FLUID: [N/A | None | Mild | Moderate | Marked].
COMPRESSIBILITY OF THE APPENDIX: [N/A | Compressible | Non-compressible].

OTHER COMMENTS: [ ]

IMPRESSION:
[Normal appendix visualized. No findings to support a diagnosis of appendicitis. |
Appendix visualized. Findings suggest an intermediate likelihood of acute appendicitis. |
Appendix visualized. Findings consistent with acute appendicitis. |
Appendix not visualized. However, there are no ultrasound findings to support a diagnosis of appendicitis. |
Appendix not visualized, but secondary findings are present that could be associated with acute appendicitis.]

Figure 5: Structured report of single-quadrant US of the abdomen for appendicitis. Text in brackets indicates pick choices separated by the | character. Underlining indicates default text. N/A = not applicable.

Figure 6

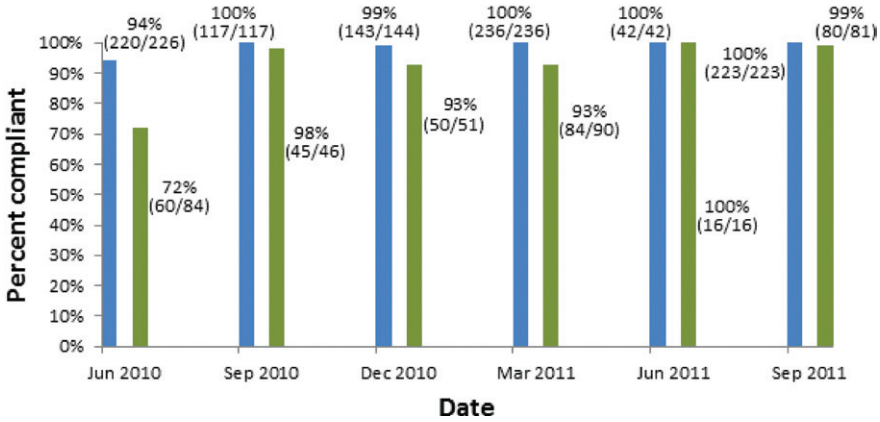

Figure 6: Percentage chart (or *p* chart) shows structured report quarterly audit results. Percentages indicate the number of reports that meet criteria for appropriate use of structured report format (blue bars) and use of the available normal report template (in cases where the radiologists deem the study to be normal [green bars]) divided by the number of reports audited.

Radiologists' Survey Responses Regarding Impressions of Structured Reporting

Question and Response	No. of Responses
1) What is your overall impression with structured reporting as it has been implemented in the department?	
1, very unfavorable	0 (0)
2, somewhat unfavorable	0 (0)
3, neither favorable nor unfavorable	1 (5)
4, somewhat favorable	8 (32)
5, very favorable	14 (64)
Total responses	23 (100)
2) Which do you prefer: free text reporting or structured reporting?	
1, strongly prefer free text	0 (0)
2, somewhat prefer free text	2 (9)
3, no preference	0 (0)
4, somewhat prefer structured reporting	7 (27)
5, strongly prefer structured reporting	14 (64)
Total responses	23 (100)
3) Which would you prefer: creating, maintaining, and using your own report templates or using standard department report templates?	
1, strongly prefer own templates	2 (5)
2, somewhat prefer own templates	0 (0)
3, no preference	2 (9)
4, somewhat prefer department templates	9 (41)
5, strongly prefer department templates	10 (45)
Total responses	23 (100)
4) How satisfied are you with the language used in the structured reports?	
1, very unsatisfied	0 (0)
2, somewhat unsatisfied	0 (0)
3, neither satisfied nor unsatisfied	2 (5)
4, somewhat satisfied	12 (55)
5, very satisfied	9 (41)
Total responses	23 (100)
5) How do you believe structured reporting impacts your efficiency?	
1, substantial negative impact	0 (0)
2, small negative impact	0 (0)
3, no significant impact	0 (0)
4, small positive impact	8 (33)
5, substantial positive impact	14 (67)
Total responses	22 (100)
6) How do you think structured reporting impacts the accuracy of your report?	
1, substantial negative impact	0 (0)
2, small negative impact	1 (5)
3, no significant impact	5 (24)
4, small positive impact	10 (43)
5, substantial positive impact	6 (29)
Total responses	22 (100)
7) How has structured reporting impacted your research efforts?	
1, substantial negative impact	0 (0)
2, small negative impact	0 (0)
3, no significant impact	13 (55)
4, small positive impact	6 (27)
5, substantial positive impact	1 (5)
Not applicable	3 (14)
Total responses	23 (100)

Note.—Twenty-three (64%) of the 36 radiologists responded. Data in parentheses are percentages. Mean scores were as follows for questions 1–7, respectively: 4.6, 4.4, 4.1, 4.3, 4.6, 4.0, and 3.4.

Discussion

We found that it was possible to implement department-wide structured reporting with a high rate of adoption by the radiologists. Several factors contributed to the success of this improvement initiative.

This project would not have been possible without the improved technical capability of the speech recognition software. While report templates have been available for decades, the new technology also enabled structured reporting in addition to standardized reporting. The former feature allows for structured flexibility in addressing both normal variants and common abnormal findings, while the latter feature provides the capability to automatically populate reports associated with specific radiology information system examination codes. Automatic report population also facilitates consistent adherence to the structured report associated with each examination type.

From the beginning of the implementation of the new speech recognition software system, the department leadership team made the critical decision to not allow individual templates. Radiologists were still encouraged and even expected to address a clinician's specific question on every report, regardless of whether the report was normal or abnormal. However, given the large number of radiologists and referring clinicians, the team concluded that any value that might be added by the subtly crafted language of an individual radiologist's report of a normal examination would be lost if each radiologist in the practice routinely described the same normal findings with his or her own unique subtly crafted language.

Each report requires technical and clerical support to ensure that the report adheres to the common format, is associated with the correct examination code, and remains free of any errors. While it is feasible to maintain an array of 228 reports for the department, if each of the 36 radiologists had generated his or her customized reports, thousands of customized reports could easily have been created

that would have to be maintained. If a radiologist or clinician discovered a report error or desired a consistent change in report language for all reports for billing or other purposes, each of his or her reports would have to be changed individually. In addition to the technical challenges this would impose, the political and logistic challenges of having to obtain permission from every radiologist before making even minor report changes would be extremely onerous without a predetermined process for reaching consensus.

Once the value of interreporter consistency was recognized, we faced the challenge of developing reports that would be acceptable to all affected radiologists in the department. The committee attempted to balance the need for uniformity with the need to respect each radiologist's expertise and opinions. By the end of the process, all radiologists found the reports acceptable. We believe that for a department to be successful in implementing common structured reporting, it must recognize that this is an organizational challenge as much as it is a technical challenge (16).

To reach a diplomatic solution, the work group endeavored to establish a fair and consistent process to create and update reports. While department-wide standards were applied to the extent possible, each division was allowed flexibility to create the report in the manner it felt best suited its specialty within the established guidelines. All reports were vetted with all affected individuals, and all comments were addressed, regardless of whether they resulted in a change in the report. Once the reports were activated, any discovered errors were corrected as soon as possible, usually within minutes of notification. Many reports were further modified after they had been implemented. In fact, no report was ever considered completed.

Report auditing was vital to monitoring the rate of adoption of the structured reports. Individual feedback provided gentle reminders to the radiologists to use the reports and signaled the importance that each radiologist played in the success of the project. Adoption increased to 100% (all 117 reports adhered to the approved format at the September 2010 audit) with auditing and the application of a financial incentive bonus. However, radiologists were incentivized only to not change the standard template and to use the normal report for normal studies. The audit did not penalize radiologists for including incidental findings or addressing specific clinical concerns regarding normal or abnormal studies. Furthermore, in recognition of the fact that situations might arise in which it might not be appropriate to apply the criteria, a reasonable goal of 90% was established to allow flexibility for exceptions as needed.

Results of the survey indicate that compliance was not based on only the financial incentive; rather, radiologists also viewed the structured reporting program favorably. This undoubtedly contributed to the success of the program. This positive reaction is consistent with the findings of Hawkins et al (3), who evaluated radiologist use of the standardized structured report for 1 week when the automatic report population feature was suspended prior to initiation of the performance incentive. They found that radiologists actively selected the standardized structured reports even though they were not required to choose them (3). We believe that this reception was at least partly attributable to consensus-building efforts.

Some authors have reported that the use of a checklist may improve diagnostic accuracy (11). Subjectively, we did not appreciate a difference in detection errors after introduction of the structured reports. However, we continue to routinely find erroneous reports of negative findings due to radiologists forgetting to change the normal template; they most commonly fail to remove normal findings from one section of the default report that conflict with descriptions of abnormal findings added to another section. Another known error occurs when a radiologist describes abnormal findings, is interrupted, and fails to change the impression of the normal report. We have found that these types of errors can be minimized with appropriate report structure and feedback to radiologists. Several report templates have been modified in response to these errors, primarily minimizing language that describes normal findings, which minimizes the changes required for a report of an abnormal examination.

The structured reporting program we have implemented provides for standardized report formatting and organization and, to a degree, for standardized reporting language. However, we acknowledge that others may advocate more rigorous conceptions of structured reporting (17) (18). While our version of structured reporting may be more flexible than that envisioned by some, we conclude, as other authors have, that allowing some flexibility is worth the compromise to improve its practicality (13,19).

The primary purpose of this project was to effectively implement a common department-wide structured reporting system. While we subjectively observed other aspects of the project, such as the effect of structured reporting on report consistency and radiologist productivity, we did not specifically measure these effects. Furthermore, we did not formally assess clinicians' reactions or effect on patient care.

Because we view building consensus as a critical exercise in establishing structured reporting, we believe it would be inadvisable for another department to simply copy and implement these or any other reports (16,20). Furthermore, we do not advocate that our reports should be viewed as the standard in the field of pediatric radiology. Instead, we believe that each department should perform this exercise on their own, creating reports that address their local needs and meet local standards.

Our findings indicate that obstacles to standardized structured reporting may be overcome by achieving radiologist consensus and by balancing the need for department-wide standardization with flexibility for radiologists to be able to dictate abnormal findings as they see fit. Whereas nearly all publications regarding radiology structured reporting focus on the technical aspects, we believe that

if advocates focus on the "people issues" (21) at a level commensurate with the technical issues, structured reporting may find more widespread success. Specifically, we found it essential to *(a)* balance the desire for uniformity with compromise and respect for expertise, *(b)* include representation from all specialty areas, *(c)* not over-restrict radiologists in their descriptions of abnormal findings and impressions, *(d)* be consistent in application of departmental standards, *(e)* be reasonable and extremely responsive when changes are requested, and *(f)* sparingly use a modest incentive bonus.

In conclusion, we were successful in developing and implementing a department-wide standardized structured reporting program within our department, and we have achieved a high degree of adoption. We acknowledge that it can be difficult for a large group of independent radiologists with strongly held beliefs to achieve consensus on an issue as sensitive as the radiologic report. We found that by focusing on the organizational challenges and technical aspects, we were able to enjoy the benefits of structured reporting, including improved consistency in reporting, automatic population of examination-specific reports, and more efficient report monitoring for quality assurance and research.

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