Pediatric Radiology (2019) 49:500–508
https://doi.org/10.1007/s00247-019-04345-0

MINISYMPOSIUM: QUALITY AND SAFETY

The state of structured reporting: the nuance of standardized language

Lindsey A. G. Shea [1] · Alexander J. Towbin [2,3]

Received: 7 September 2018 / Revised: 4 December 2018 / Accepted: 11 January 2019 / Published online: 14 March 2019

Abstract
Radiology reports are the principal form of communication with the referring provider. Unfortunately, they can be a form of communication riddled with errors and inscrutable statements burying the intended meaning, failing to achieve the main task for which it was made: communicating key imaging findings as they pertain to the clinical question being posed. Structured reporting is a multifaceted and modular solution to problematic reports, with variable iterations and benefits. Structured reports have been adapted across departments and even national societies, with standardized format, content and language. Newer developments include contextual reporting and common data elements. Herein, we discuss the various forms and levels of structured reporting and the latest advancements, as well as the general acceptance within radiology. We also discuss some areas for improvement as the practice of structured reporting matures.

Keywords Children · Common data elements · Communication · Contextual reporting · Radiology · Standardized reporting · Structured reporting

Introduction

In the age of ubiquitous electronic medical systems and high throughput imaging, the radiology report is the principal mode of communication between a radiologist and an ordering provider [1]. Unfortunately, generating the radiology report is fraught with challenges including speech recognition errors, grammatical errors and inconsistent verbiage, all of which often hinder the ordering provider from quickly locating a piece of information if it is not included within the impression [2–9].

In response to these issues, as well as the desire to improve radiologist efficiency and patient outcomes, structured reporting has become increasingly present in radiology [10]. In this manuscript, we discuss the evolution of structured reporting from the perspective of the end user, describe the different levels of structure within a radiology report, share two recent advances in radiology reporting, and explore the acceptance of structured reporting among radiologists. Given the complexity of terminology used in describing structured reporting — particularly given colloquial use of several terms interchangeably — we also include a glossary for quick reference (Table 1).

Standardization — radiologist users

Individual radiologists

Structured reporting is — at its core — about standardizing reports. This standardization can occur at multiple levels from the point of view of the end users (Fig. 1). The most basic level of standardization is at the individual level. When speech recognition software was first implemented, the software vendors highlighted the ability of individual radiologists to create their own templates or "macros." As this practice rolled out, some radiologists became proficient in template creation, building hundreds of macros for insertion within their templates. This mode of standardization allowed radiologists to create templates to fit their preferences while still gaining some of the workflow efficiency and language standardization benefits.

✉ Alexander J. Towbin
alexander.towbin@cchmc.org

[1] Department of Radiology and Imaging Sciences, Indiana University School of Medicine, Indianapolis, IN, USA

[2] Department of Radiology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave., MLC 5031, Cincinnati, OH 45229, USA

[3] Department of Radiology, University of Cincinnati College of Medicine, Cincinnati, OH, USA

Table 1 Glossary of terms for structured reporting

Term	Definition
Template	Pre-designed format for generating a report; once presented to the radiologist for use in dictation of a specific study, the structured template becomes a structured report
Report	Principal mode of communication between a radiologist and an ordering provider; entered into the electronic medical record
Structured report	Template containing specific organized prompts for dictation; structured reports can contain structured format, structured content and structured language
Structured format	Template containing the same basic style layout of information; elements of structured format can include the main subheadings of a report (clinical history, comparison, procedure comments, findings, impression) and common grammatical decisions such as displaying the major subheadings using all capital letters
Structured content	Template containing the above structured format as well as prompts for specific findings, such as the organs within the abdominal compartment for an abdominal template
Structured language	Content where all users use the same words to describe a finding; the BI-RADS lexicon is an example of structured language
Standard, structured report	A structured template that is used by all dictating members of a given section, department or institution
Study-specific template/report	Template that is based off the specific study order, such as CT abdomen/pelvis with contrast agent
Contextual report	Template that is based off the indication for an order, such as "appendicitis" or "Meckel diverticulitis"
Common data elements	Structured pieces of information that are stored uniformly across institutions and contain underlying metadata
Free-text report	Dictation without pre-ordained content; may resemble a prose or structured report
Pick list	Field within a report that contains multiple prepopulated text options from which a dictating radiologist can choose a single phrase
Nested template	Template or pick list that, upon selection, populates additional structured content, including a second level of dictation fields

Unfortunately, this practice has several major disadvantages. First, creating an individual library of macros requires significant additional up-front work for each radiologist. Even if a radiologist chooses to subscribe to another radiologist's library rather than generating one de novo, he or she must still be familiar with the content of the template/macro library. Functionally, what happens in many practices is that a handful of radiologists are knowledgeable and use these libraries. The rest of the radiologists in the practice use a very small number of templates/macros. This limits the effectiveness of the templates/macros, in terms of both efficiency gains and language standardization.

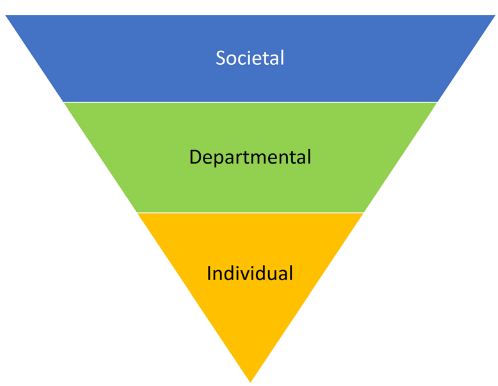


Fig. 1 Schematic shows how standardization of structured reports can occur at multiple levels with regard to the end user. The schematic shows that as the number of users increases (going from bottom to top), the impact or width of the triangle increases. The most basic level of standardization is at the individual level (*yellow*). This grows either through a dedicated individual's curation of a macro library or through multiple individuals creating multiple libraries. Eventually, the division or department (*green*) begins to create standard structured reports. Finally, societies (*blue*) become empowered to create national standard reports for specific indications

Divisional/departmental standardization

As structured reporting has become more commonplace, standardization of reporting has spread to divisions and departments. In this scenario, everyone in the department or the division uses the same structured template to report on the same procedure. In this sense, the department or division is using standard structured reports.

Many of the major potential benefits of structured reporting are first realized when such templates are employed. First, the standard structured report can be auto-populated so that it is present when the study is opened in the dictation system because the same template is being used uniformly. This improves efficiency because it eliminates the need to search for the correct template in the library. In addition, because radiologists are using the same report each time they dictate a specific study, they become more facile with how to use the report most effectively.

Beyond dictation, standard structured reporting increases billing efficiency by assuring that all required components are present in a given report for the appropriate compensation to be awarded. By containing a field for each key element, a template can obviate the need for radiologists to memorize the requirements for billing specific imaging studies. This benefit was highlighted in a recent publication describing the conversion of coding from an International Statistical Classification of Diseases and Related Health Problems version 9 (ICD-9)-based system to an ICD10-based system [11].

Standard structured reporting is also the level at which the report consumers begin to notice the standardization. An individual radiologist can work to standardize his or her reporting, but it remains difficult for the ordering provider to understand nuanced differences in reporting or descriptors when each radiologist is reporting via his or her own templates and terms. When standard structured reports are used, the ordering provider might start to understand the differences in descriptors used to identify findings as well as where specific findings would be expected within the report text.

Finally, standard structured reporting has the potential to help teach trainees. We have noticed this trend at Cincinnati Children's Hospital Medical Center, where we have used standard structured reporting since 2010. Over the last 8 years, our trainees have often commented how the standard structured report helps them to identify what is important to include as they develop their own search pattern, both in terms of positive and negative findings. The ability of reports to facilitate learning has been reported at other institutions as well [12].

Societal/national standardization

Perhaps the highest level of standardization among users is at the societal or national level. The earliest foray of societal/national standardization came about through the Mammography Quality Standards Act (MQSA) administered by the United States Food and Drug Administration. This act legislated the practice of mammography and set standards by which mammography was to be performed and described. In response to this legislation, the American College of Radiology (ACR) created the BI-RADS lexicon [13]. This lexicon helps to ensure that all radiologists are using the same definition for each imaging descriptor and with the same expected management resulting from that descriptor.

For many years, the BI-RADS lexicon represented the only widely used societal/national standardized system. In recent years, there has been an explosion of other lexicons for common adult-based diseases. These include the LI-RADS system for hepatocellular carcinoma, TI-RADS for thyroid carcinoma and PI-RADS for prostate carcinoma, all developed by the ACR [14–16].

Other societies have also created their own reporting lexicons. Perhaps the one most widely used in radiology is the lexicon created by the Fleischner Society for lung imaging. This lexicon was first published in 1984, then updated in 1996 and 2008 [17–19]. More recently, national societies have begun compiling libraries of standard structured templates, many of them in conjunction with the Radiological Society of North America (RSNA), which maintains the largest library of structured templates at http://www.radreport.org/.

While there is definite benefit from a standardized lexicon, the value of societal/national standardization of reporting might be only incremental as compared to departmental standardization. Perhaps the largest benefit of using a societal or national standard structured report is in the evaluation of population health. This benefit becomes even more pronounced if standard common data elements are included in the report. This is discussed in more detail later in the text.

Standardization — report types

Structured format

Reports, like radiologists, have multiple levels of potential structure and standardization (Fig. 2). At the most basic level, structured reporting emphasizes consistent formatting. Larson et al. [5] described their first level of departmental standardization as deciding on a standard report format. After several meetings to deliberate, Larson et al. reported that the department decided that each report should include the following five sections: clinical history, comparison, procedure comments, findings and impression. While the terminology differs

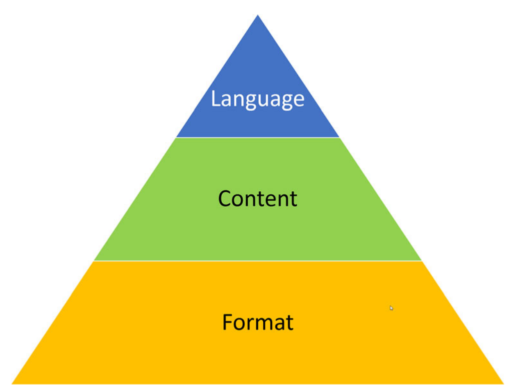


Fig. 2 Schematic shows the increasing standardization of a structured report. Initially the report format (*yellow*) must be standardized. This standard format serves as a foundation for all further reporting. Next, the content (*green*) of each individual report must be created. Although similarities can exist across reports, there are often differences in the content of the standard structured report for each imaging study. Finally, the language (*blue*) can be standardized. At this step, the terms used to describe each disease entity are defined

slightly, these five sections are similar to those recommended by the ACR in its practice parameter for communicating diagnostic imaging findings [20]. Other practices such as that at Indiana University have done similar work, including footers specifying callback information for the interpreting section.

The major benefit of a standardized format is that all reports have the same appearance. This change makes it easier for ordering providers and patients to read reports. A potential side benefit of a standard report format is that it might spur radiologists within a practice to begin thinking about how else they can standardize their reports.

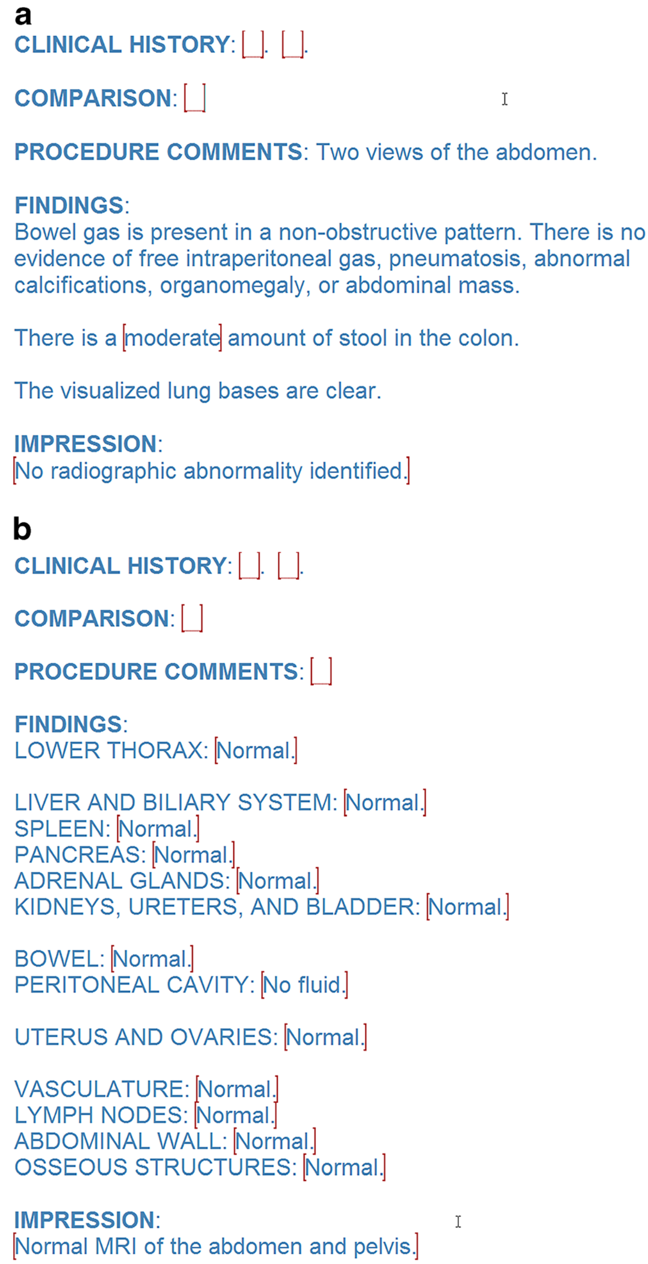
Structured content

The next level of structured reporting deals with content. When most radiologists think of a structured report, they are thinking about the structured content. Structured content can take on two basic styles: a list style or a prose style (Fig. 3).

As radiologists transition from individual free dictation to structured reporting, there is often a visceral reaction to adoption of a list-style report. It is thought that this reaction is because the two report styles are so jarringly different. Although radiologists might have a negative reaction, the preponderance of data has shown that ordering providers prefer this style of reporting [21]. It is important to note that the list-style report does have some challenges. This is most notable in a disease process, such as a large tumor, where a single finding spans multiple sections of the report.

Even though we believe that the list-style of reporting has major benefits, we do not propose that all reports use this style. We have found that less complex studies, such as radiographs, benefit from a prose style of structured reporting in which there are prompts or headers for all the content to be included, but free dictation is used in the resultant description. Interestingly, we have found that as our department's standard, structured reports have evolved — many of the reports that initially used a more prose-based format have morphed to a simple list style because of increased reporting requirements and radiologist preference [11]. We have found that once radiologists shift reporting to a list-based style, they often prefer the structure that the increased organization affords.

The major benefit of structured content is the ability to create study-specific reports — or templates — that are triggered by a specific imaging exam. Study-specific reports allow a radiologist or radiology department to have distinct content for distinct studies. For example, an appendix ultrasound can have a different template with different content as compared to an abdominal ultrasound. At this point, prepopulated, study-specific reports are only possible if there is a custom order for each study. What this means is that a study-specific report for an MR enterography examination can only be created if there is a specific order for this examination within the electronic medical record that can be



a

CLINICAL HISTORY: [ ]. [ ].

COMPARISON: [ ]

PROCEDURE COMMENTS: Two views of the abdomen.

FINDINGS:
Bowel gas is present in a non-obstructive pattern. There is no evidence of free intraperitoneal gas, pneumatosis, abnormal calcifications, organomegaly, or abdominal mass.

There is a [moderate] amount of stool in the colon.

The visualized lung bases are clear.

IMPRESSION:
[No radiographic abnormality identified.]

b

CLINICAL HISTORY: [ ]. [ ].

COMPARISON: [ ]

PROCEDURE COMMENTS: [ ]

FINDINGS:
LOWER THORAX: [Normal.]

LIVER AND BILIARY SYSTEM: [Normal.]
SPLEEN: [Normal.]
PANCREAS: [Normal.]
ADRENAL GLANDS: [Normal.]
KIDNEYS, URETERS, AND BLADDER: [Normal.]

BOWEL: [Normal.]
PERITONEAL CAVITY: [No fluid.]

UTERUS AND OVARIES: [Normal.]

VASCULATURE: [Normal.]
LYMPH NODES: [Normal.]
ABDOMINAL WALL: [Normal.]
OSSEOUS STRUCTURES: [Normal.]

IMPRESSION:
[Normal MRI of the abdomen and pelvis.]

Fig. 3 Standardized content structure. **a** Screen capture from PowerScribe 360 (Nuance Communications, Burlington, MA) shows a prose-style structured report for an abdominal radiograph. **b** Screen capture shows a list-style structured report for an MRI of the abdomen and pelvis in a female

transmitted to the dictation software. If the radiology department instead chooses to perform an enterography exam using an MR abdomen/pelvis order but a specific MR enterography protocol, then the prepopulated template cannot be tailored to describe the pertinent positive and negative findings expected in the evaluation of inflammatory bowel disease.

Another major benefit of structured content is the ability to create structured recommendations. This allows ordering providers to instantly understand the information contained in the report and its implications in a consistent manner, no matter which radiologist signed the report. Perhaps the most studied use of standard structured recommendations is in the setting of ultrasound for appendicitis. Several departments have built reports for this indication detailing the potential imaging findings and including a structured impression [3, 22–27]. Interestingly, while several reports were built independently and in parallel at different institutions, they are remarkably similar in their content. These reports have helped to improve the diagnostic accuracy of appendicitis imaging and help to guide management in the emergency department.

Additional benefits of study-specific templates and reports are in their ability to help guide a trainee's search pattern and to allow specialists to identify the information most important to their practice. As trainees grapple with the magnitude of information available in a single study, it is crucial that they begin to develop their own algorithm for assessing pathology. A study-specific report provides an overview of the crucial features in a given exam and allows for a scaffold on which trainees can begin to formulate their own mechanism of approaching imaging studies. Reproducibility of the format and content allows for familiarity of the referring specialist with where information is generally housed within the report. This makes for easy parsing of not only the impression, but also the body of findings. As trainees grow in skill and confidence, they rely on this crutch less. One criticism of this approach is that trainees spend more time reviewing the dictation rather than the images. No studies have evaluated this argument. Specifically, no studies have compared dictation times or error rates in trainees using structured reports versus those dictating with free prose.

Structured language

The highest level of structured reporting, then, is when we formalize not only the format and content but also the language used to describe the imaging findings. Structured language is the hardest level to achieve and, until recently, was uncommonly used within radiology. Early examples of structured language were used in the BI-RADS system in mammography and the Fleischner Society glossary of terms for thoracic imaging [13, 17–19]. In the setting of trauma, where one might be expected to use American Association for the Surgery of Trauma (AAST) grading of injuries, standardized language might be employed via prepopulated lists, communicating findings more precisely and in less subjective ways, as well as alleviating the need for radiologists to continually look up metrics [28].

More recently, specialty societies have begun to build structured content including structured language. This includes the RADS lexicons from the ACR as well as multi-society consensus documents [13–16]. An example of a multi-society consensus guideline is the Society of Abdominal Radiology (SAR) consensus recommendations for evaluation, interpretation and utilization of CT and MR enterography in patients with small-bowel Crohn disease [29]. While the SAR is the primary sponsor, the American Gastroenterological Association and Society for Pediatric Radiology (SPR) each contributed members to help create the document and the boards of directors for both societies approved the final manuscript. The SPR has sponsored similar multi-specialty consensus documents, one of the most notable of which is the multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilatation [30]. These consensus documents help to establish the standardized language used in radiology reporting.

Although there is major benefit in all radiologists using the same language to report a finding, there are challenges, the major being that of complexity. As more and more societies create more and more content and the number of classification systems grows, it is becoming impossible for any radiologist to know every classification system and use the correct lexicon to describe every finding. We believe that radiologists will struggle not just with using the lexicon correctly, but perhaps even with knowing that the lexicon exists.

We believe this problem can be solved with technology. Applications like the computer-assisted reporting and decision support tools can help radiologists at the point of dictation by allowing for quick review and inclusion of classifications and lexicons [31]. However, even with these systems, the radiologist must still trigger the use of a specific classification decision support toolset. We believe that smarter dictation systems must be developed to perform real-time natural language processing based on the contextual information in the electronic medical record system, the imaging study, and the ongoing dictation to recommend potential pertinent classification systems.

Advances in reporting

Contextual reporting

A novel variant of structured reporting is contextual reporting. This type of report takes advantage of new technology within the speech recognition software systems that allows for nested templates. A single template is created that contains the standardized structured template for each exam for a given modality and indication or imaging specialty (Fig. 4). After the primary template is inserted, structured elements relating to the indication or specialty are populated. For example, in the head CT obtained for trauma, pertinent negatives relating to acute hemorrhage and fractures might be included, whereas in the report for new-onset seizure, pertinent negatives might include the absence of calcifications, hemorrhage or tumors.

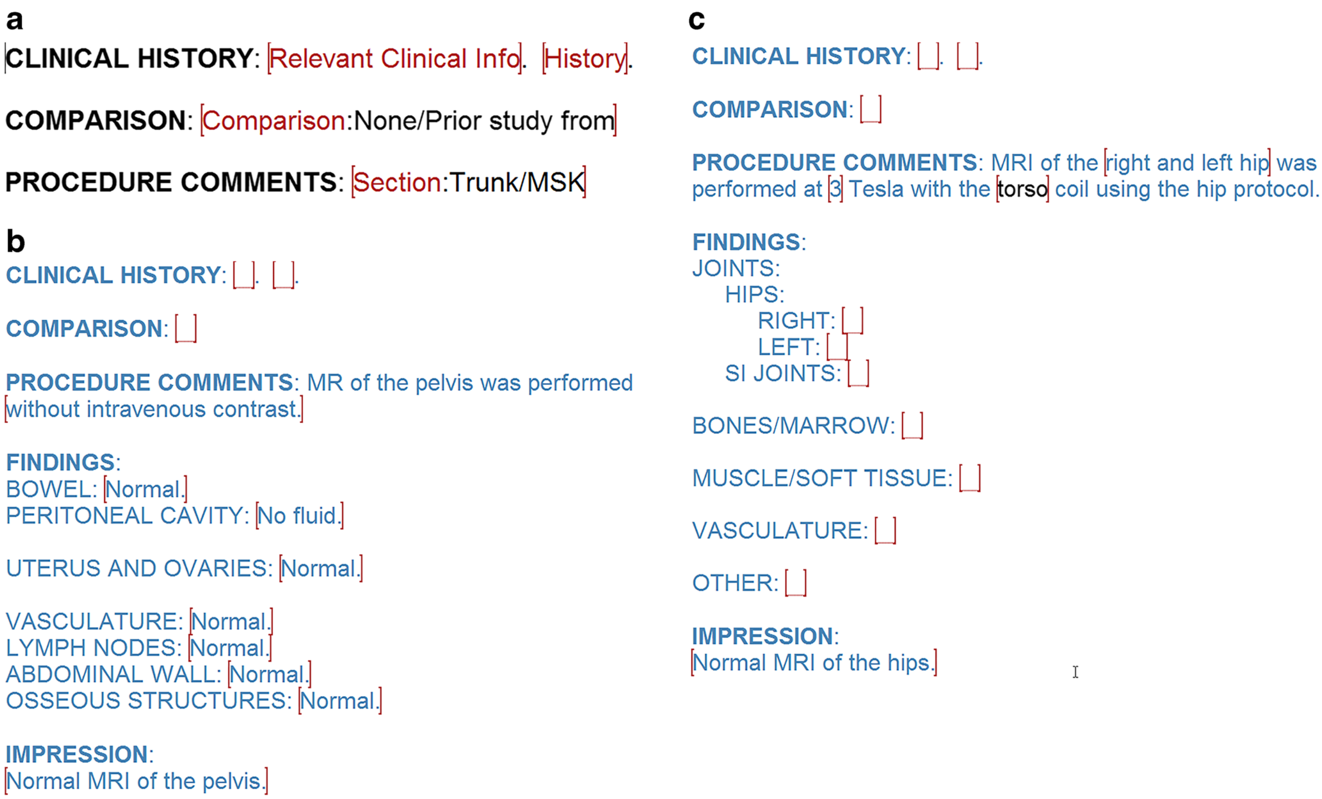


Fig. 4 Screen capture shows a contextual report. **a** Initially a generic report is populated when an MRI of the pelvis is opened for a female patient. **b** In the procedure comments section, if the phrase "trunk" is selected, the abdominal/genitourinary-based content populates the remainder of the report. **c** However if "MSK" is selected in the procedure comments section, musculoskeletal-based content populates the remainder of the report

This example highlights that while some commonality among reports exists, other elements are vastly different.

Contextual reports address the main limitation of study-specific templates; namely, there no longer needs to be a distinct order for each exam, as in the case of MR enterography versus MR abdomen/pelvis performed using an enterography protocol, as mentioned. Structured reporting is triggered by the imaging order; conversely, contextual reporting corresponds to the imaging indication or the imaging specialty. Although there might be important reasons to create some distinct study-specific orders (such as a separate MR enterography order that differs from the MR abdomen/pelvis order), this does not make sense for most indications. For example, it does not make sense in most pediatric radiology departments to create three distinct orders for an MR of the abdomen obtained for neuroblastoma, hepatoblastoma and Wilms tumor. However, there is a need for a distinct report for each of these tumor types. Similarly, the technique, findings and impression of a skeletal survey performed for a suspicion of nonaccidental trauma might be different compared to a skeletal survey performed for a suspected bone dysplasia. In this instance, a contextual report would allow for quick inclusion of the desired text where appropriate and omission where not.

Because the technology is new, contextual reporting is not widespread. Recently the neuroradiology division of Kaiser Permanente created and published a series of 50 contextual templates [12]. The division also described several benefits of contextual reporting. Perhaps most important, contextual reporting offers the opportunity to create disease- or indication-specific checklists within a structured template. This feature helps to teach trainees about each disease process and can help to remind all radiologists of what to look for in rare diseases.

Another reported benefit of contextual reporting is a decrease in the error rate and an increase in the efficiency of report creation [12]. Both benefits are thought to be a result of a decrease in the number of words dictated by radiologists who use contextual reports. According to the authors, this occurs because "all of the major items are discussed within the contextual template" [12].

Contextual reporting does have limitations, the largest being the number of templates that must be created to build a thorough library. Templates can be built in one of two ways. The more complex method of template authorship involves creating a nested template where an early pick-list selection drives the remainder of the report. The second method of creation is to create many distinct templates and force the radiologist to select one before dictating.

Both choices rely on the radiologist knowing that a report exists for the indication with which the patient is presenting. Undoubtedly, radiologists will not all realize that templates exist for rare indications. In these instances, the radiologist would likely select a more generic or less specific template. This problem could be solved if templates were pre-populated based on a structured indication within the order.

A second challenge with contextual reporting is how to select an appropriate template when an imaging study is performed for two separate indications. This scenario requires the radiologist to know the differences between the two reports and then select the report that best captures the imaging findings for both potential indications.

Common data elements

Radiology reports contain vast amounts of information. Unfortunately, even as reports have become more structured, the data contained within reports remain unstructured. Having unstructured data makes it difficult for radiologists and ordering providers to track changes in a disease over time, for departments to contribute data to registries, and for researchers to study population-based outcomes. A common data element is a structured piece of information (either numerical or categorical) that is "collected and stored uniformly across institutions" [32]. A common data element not only stores the answer to a predefined question but can also store metadata related to the answer such as anatomical location, image number and image coordinates. In this manner, common data elements "allow reports to be built from tiny collections of information that contain not only words, but also context, meaning, and relationships" [32].

Common data elements are a new concept and have not been widely distributed. The ACR and the RSNA are working together to define the structure needed to build common data elements and the infrastructure to house a common data element library. These organizations are also working with vendors so that the common data elements can be incorporated into speech recognition software and flow to downstream systems such as electronic medical records or national registries.

As an example, a common data element could include primary malignant lesion size. Using the formalized language required within the dictation, this lesion size may be "pulled" from the dictation and stored along with the specific image of the lesion on which the measurement was taken from the series. As this field progresses, one could imagine the ability to incorporate additional data, such as the specific type of lesion and treatment history — either from the indication or the electronic medical record that generated the order — and likewise the ability to relay that data back to other programs, again perhaps into the electronic medical record for easy incorporation into an oncologist's next clinic note.

In a sense, common data elements are the next step in the evolution of structured language and structured reporting. As societies create structured ontologies, common data elements can be incorporated into contextual templates, allowing the radiologist to input the appropriate information in a structured field. This information could be accessible to the electronic medical record, enabling clinicians to more easily track disease and researchers to better track outcomes so that we can refine our algorithms using imaging to better predict outcomes.

Acceptance of structured reporting

Structured reporting is now widely accepted by radiologists. One survey published in 2015 found that 90% of (mostly academic) departments use at least some structured reports, and more than 50% have developed structured reporting for more than half of their studies [10]. While there was early debate among radiologists regarding the implementation of structured reporting, most surveys have found widespread satisfaction with the end results. The same survey found that only 13% of respondents were dissatisfied or very dissatisfied with structured reports [10]. Interestingly, radiology practices that used more structured reports were more likely to endorse higher satisfaction and fewer reporting errors than practices that employed fewer structured reports [10]. This survey mimics the early experience of Larson et al. [5]. After implementing departmentwide standard structured reports, Larson et al. found that 91% of radiologists preferred structured reporting to free-text reporting.

Even with these high acceptance rates, there is still not universal support for standard structured reporting. Generally the most common struggle when implementing standard structured reports is the argument that structured reporting limits radiologist autonomy and personal expression. This concern can be addressed in several ways. First, templates should be developed with the buy-in and support of the radiologists within a department. Specifically, the radiologists within a given subspecialty area should collaborate to determine what findings should be included — both positive and negative — and with what language to generate a succinct and impactful report. This type of consensus building helps radiology practices identify how different their language truly is among the employed radiologists and to start to agree on important findings and pertinent negatives to include in reports. Second, it is important for radiologists to realize that using structured reports does not preclude dictation in most studies. Generally, templates are structured so that the content and language are the same for normal and common abnormal findings. Most radiologists prefer not to add additional information to a normal report. However, even with normal studies many practices encourage their radiologists to add information within the report to address the specific clinical question.

A second major concern regarding structured reporting is the potential for a structured report to contain additional errors, specifically errors of commission. This type of error results when a structured element is left in a report contradicting findings reported in a different portion of the report. For example, a report might contain the phrase "The appendix is normal" in the paragraph following the description of appendicitis. Fortunately, the research evaluating errors has found that standard structured reporting decreases certain error types (including errors of commission) [4, 6]. Hawkins et al. [4, 6] attributed the decreased error rate associated with structured reports to careful construction of the reports. Strategies to reduce errors of commission include creating male- and female-specific reports and not prepopulating fields in which errors commonly occur. For example, at Cincinnati Children's Hospital Medical Center the "comparison" section of all reports was initially prepopulated with the most common entry, "none." Through routine auditing, it was found that this entry was commonly retained inappropriately. Because each radiologist in the department uses the same structured reports, this error was eliminated by removing the prepopulated choice.

Conclusion

In the end, there are overwhelming data to show that ordering providers *and* radiologists prefer structured reporting. As radiology continues to evolve, structured reporting is expected to continue to grow in importance. Ongoing efforts to standardize language coupled with new concepts like contextual reporting and common data elements are expected to help drive the future of reporting. Adding more structured data has the potential to allow radiologists and ordering providers to better care for our shared patients and to enable researchers to better understand the role of imaging in population health.

Compliance with ethical standards

Conflicts of interest None

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

1. Heitkamp DE, Cuskaden JH, Tahir B, Gunderman RB (2016) PACS and the erosion of professional relationships. Acad Radiol 23:905–907
2. Larson DB, Froehle CM, Johnson ND, Towbin AJ (2014) Communication in diagnostic radiology: meeting the challenges of complexity. AJR Am J Roentgenol 203:957–964
3. Larson DB, Trout AT, Fierke SR, Towbin AJ (2015) Improvement in diagnostic accuracy of ultrasound of the pediatric appendix through the use of equivocal interpretive categories. AJR Am J Roentgenol 204:849–856
4. Hawkins CM, Hall S, Hardin J et al (2012) Prepopulated radiology report templates: a prospective analysis of error rate and turnaround time. J Digit Imaging 25:504–511
5. Larson DB, Towbin AJ, Pryor RM, Donnelly LF (2013) Improving consistency in radiology reporting through the use of department-wide standardized structured reporting. Radiology 267:240–250
6. Hawkins CM, Hall S, Zhang B, Towbin AJ (2014) Creation and implementation of department-wide structured reports: an analysis of the impact on error rate in radiology reports. J Digit Imaging 27: 581–587
7. Towbin AJ, Perry LA, Larson DB (2017) Improving efficiency in the radiology department. Pediatr Radiol 47:783–792
8. Towbin AJ, Hawkins CM (2017) Use of a web-based calculator and a structured report generator to improve efficiency, accuracy, and consistency of radiology reporting. J Digit Imaging 30:584–588
9. Lee B, Whitehead MT (2017) Radiology reports: what you think you're saying and what they think you're saying. Curr Probl Diagn Radiol 46:186–195
10. Powell DK, Silberzweig JE (2015) State of structured reporting in radiology, a survey. Acad Radiol 22:226–233
11. McBee MP, Laor T, Pryor RM et al (2018) A comprehensive approach to convert a radiology department from coding based on international classification of diseases, ninth revision, to coding based on international classification of diseases, tenth revision. J Am Coll Radiol 15:301–309
12. Mamloud MD, Chang PC, Saket RR (2018) Contextual radiology reporting: a new approach to neuroradiology structured templates. AJNR Am J Neuroradiol 39:1406–1414
13. American College of Radiology (2018) Breast imaging reporting and data system (BI-RADS). https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/Bi-Rads. Accessed 19 Aug 2018
14. American College of Radiology (2018) Liver imaging reporting and data system (LI-RADS). https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/LI-RADS. Accessed 19 Aug 2018
15. American College of Radiology (2018) Thyroid imaging reporting and data system (TI-RADS). https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/TI-RADS. Accessed 19 Aug 2018
16. American College of Radiology (2018) Prostate imaging reporting and data system (PI-RADS). https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/PI-RADS. Accessed 19 Aug 2018
17. Tuddenham WJ (1984) Glossary of terms for thoracic radiology: recommendations of the nomenclature committee of the Fleischner Society. AJR Am J Roentgenol 143:509–517
18. Austin JH, Muller NL, Friedman PJ et al (1996) Glossary of terms for CT of the lungs: recommendations of the nomenclature committee of the Fleischner Society. Radiology 200:327–331
19. Hansell DM, Bankier AA, MacMahon H et al (2008) Fleischner Society: glossary of terms for thoracic imaging. Radiology 246: 697–722
20. American College of Radiology (2014) ACR practice parameter for communication of diagnostic imaging findings. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CommunicationDiag.pdf?la=en. Accessed 19 Aug 2018
21. Bosmans JM, Weyler JJ, De Schepper AM, Parizel PM (2011) The radiology report as seen by radiologists and referring clinicians: results of the COVER and ROVER surveys. Radiology 259:184–195

22. Trout AT, Towbin AJ, Fierke SR et al (2015) Appendiceal diameter as a predictor of appendicitis in children: improved diagnosis with three diagnostic categories derived from a logistic predictive model. Eur Radiol 25:2231–2238
23. Athans BS, Depinet HE, Towbin AJ et al (2016) Use of clinical data to predict appendicitis in patients with equivocal US findings. Radiology 380:557–567
24. Mangona KLM, Guillerman RP, Mangona VS et al (2017) Diagnostic performance of ultrasonography for pediatric appendicitis: a night and day difference? Acad Radiol 24: 1616–1620
25. Carpenter JL, Orth RC, Zhang W et al (2017) Diagnostic performance of US for differentiating perforated from nonperforated pediatric appendicitis: a prospective cohort study. Radiology 282: 835–841
26. Telesmanich ME, Orth RC, Zhang W et al (2016) Searching for certainty: findings predictive of appendicitis in equivocal ultrasound exams. Pediatr Radiol 46:1539–1545
27. Fallon SC, Orth RC, Guillerman RP et al (2015) Development and validation of an ultrasound scoring system for children with suspected acute appendicitis. Pediatr Radiol 45:1945–1952
28. Moore EE, Cogbill TH, Jurkovich GJ et al (1995) Organ injury scaling: spleen and liver (1994 revision). J Trauma 38:323–324
29. Bruining DH, Zimmermann EM, Loftus EV Jr et al (2018) Consensus recommendations for evaluation, interpretation, and utilization of computed tomography and magnetic resonance enterography in patients with small bowel Crohn's disease. Radiology 286:776–799
30. Nguyen HT, Benson CB, Bromley B et al (2014) Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilatation (UTD classification system). J Pediatr Urol 10: 982–998
31. Alkasab TK, Bizzo BC, Berland LL et al (2017) Creation of an open framework for point-of-care computer-assisted reporting and decision support tools for radiologists. J Am Coll Radiol 14:1884–1189
32. Rubin DL, Kahn CE Jr (2017) Common data elements in radiology. Radiology 283:837–844