Fundamental Advancements in Structured Reporting in Radiology

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ABSTRACT

The structuring of radiology reports has generated a healthy conversation within the diagnostic medical imaging world. We aim to provide a narrative review of fundamental advancements in structured radiology reporting, along with their benefits and drawbacks, placing special emphasis on the significance of report composition, format, and language, which can assist radiologists and the multidisciplinary medical team to communicate more clearly and efficiently. The narrative's findings and data were primarily derived from scholarly, peer-reviewed journals such as PubMed, PubMed Central, Google Scholar, and MEDLINE, although we also made use of ephemeral publications and search engines such as Google. Among the search phrases utilized were artificial intelligence, diagnostic medical imaging, fundamental advancements, standardization and structured radiology reports. The worries, questions, and limitations of radiology report structuring on the other hand, include potential user experience problems, limited flexibility of the report template's contents and reluctance to change, particularly among the older radiologists. We look at the efforts made towards structured radiology reports, which include utilizing standard imaging lexicons, creating reporting templates and incorporating clinical decision support tools. A lot of work is still required from radiologists, healthcare providers, and software developers to make sure that the structured output is eventually accepted, even though it can be laborious and expensive because of challenges like the requirement for testing, authenticating, custom mapping and debugging metrics. The potential for modern technological advancement to enhance the structured reporting process is examined, including artificial intelligent (AI) driven solutions. The review concludes by outlining some of the fundamental advances in structured reporting in radiology, including contextual reporting, natural language processing, common data components, RSNA radiology reporting initiatives, Radlex, BI-RADS, and the most recent, CAD-RADS, as well as AI-reporting solutions, emphasizing their benefits and drawbacks whilst also paying special attention to the significance of report composition, format and language.

Keywords: Artificial Intelligence, Diagnostic Medical Imaging, Fundamental Advancements, Standardization, Structured Radiology Reports.

INTRODUCTION

The field of radiology has seen significant advancements in recent years, including the development of novel digital diagnostic imaging modalities, picture archiving and communication systems (PACS), Teleradiology, and radiology-based artificial intelligence (AI), with the job of a radiologist virtually reduced to three key elements of interpreting and analyzing images, composing and writing reports, as well as providing extra guidance to patients and referring physicians. In academics, the training of residents and fellows is an additional key responsibility [1].

The radiologist's report, a key document that forms the basis of professional radiology practice, has in particular, undergone a fundamental transformation. Originally, it was a private correspondence between the radiologist and the referring physician that was never kept secret, but historically stored in the medical archival system

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under restricted access, rarely being directly viewed by the patients [2-4].

Both the physicians and patients can view the radiologist`s report through web portals because it is available now as an electronic document [4, 5]. This has been fully supported by the December 13th, 2016, enactment of the 21st Century Cures Act, which requires patients to have instant access to radiology reports in their electronic health records [6, 7].

Since then, the radiology report format and objective has been continuously changing to align with contemporary patient expectations as well as regulatory and legal requirements. During the first seventy-five years following William Roentgen's 1895 discovery of the x-rays, the radiologist reported their findings to the referring physician in writing. The individual who was then responsible for informing the patient of the results and offering clinical advice was not the radiologist, but the referring physician. The 1970`s marked the beginning of a paradigm shift in circumstances when radiologists were sued for negligence in failing to disclose crucial results to the patients [8, 9].

In a world driven by consumerism and entrepreneurial radiology, there are signs these days that the radiologist's communication role is being expanded further. This entails more than just dictating, writing, and signing written reports; but also involves direct communication of urgent or unexpected significant findings to the referring physicians, as well as meeting the legal obligation to further communicate radiographic findings to patients, including a discussion of the patient`s clinical management [9].This is the basis of the famous countersuit narrative that Dr. Berlin L, wrote about in an opinion essay that was published in the Journal of the American College of Radiology in March 2021, when he explained in his written column how a lawsuit against a radiologist resulted in failure and an unexpected outcome [10].

Structured radiology reporting has evolved due to several factors, such as advances in diagnostic medical imaging, recognition of the importance of standardization, regulatory and legal requirements, as well as the need for improved communication [11, 12]. Radiology reports have traditionally used a narrative free-text format to create unstructured reports in which the content is ambiguous and potentially compromised by style, excessive length, language, or significant clinical errors, making it difficult for physicians to find the information they need to manage patients and the crucial answers to address other important clinical questions. Thus, structured radiology reporting formats began to become more popular among the radiological community. This move has been lauded as a possible way to enhance the caliber of radiology reports, for which radiology students at medical schools are increasingly being trained to use structured formats for their report composition [13–15].

The radiology report is crucial for accurate patient management, serving as the primary communication channel between the radiologist and the referring physician [16]. However, part of the problem with radiology reports, however, stems from the lack of understanding of how vital this document has become to even the non-radiologist healthcare-workers [17, 18]. Again, when one considers that most radiologists do not receive formal reporting education throughout their training, and that even the most widely used radiology textbooks and websites do not cover report composition, this lapse becomes even more apparent [18]. Routinely, the primary means by which radiology residents acquired reporting skills is through a role-model apprenticeship approach, which has its benefits and drawbacks. One benefit is receiving one-on-one, personalized instruction from program teachers, who provide guidance on what to say and how to say it. However, the wide range of variability across faculty radiologists is a significant drawback of this strategy. Additionally, this informal method lacks standardization and may lead to disagreement not just when training residents but also when evaluating their reporting skills. Therefore, training institutions must adjust their curricula to prepare radiology residents for the expanding format of radiology reports [18-21].

Radiologists are facing a decline in their profession, often facing lawsuits over written reports, with the most common claim being "failure to diagnose." The second most frequent reason radiologists face malpractice lawsuit is "not communicating the results clearly enough". In fact, statistics show that up to 80% of medical malpractice cases have communication problems as one of the primary causes. This is hardly surprising as according to a Joint Commission Report, inadequate communication was responsible for almost 70% of poor health outcomes, 80% of malpractice cases and 65% of hospital sentinel events, defined as a patient safety event that causes death, permanent injury, or severe temporary harm—all of these effects were somewhat attributable

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to the ineffective communication rather than a lack of expertise or experience. Forty-five percent (45%) of unsuccessful communication claims result in payment to the plaintiff, a fact that is much more intriguing when all radiological malpractice cases are put together [22–24].

Radiologists are now responsible for both communicating the results of radiologic examinations and offering their interpretations. Both the American College of Radiology (ACR) and the law courts have made it clear that radiologists must inform referring physicians verbally of any urgent or noteworthy predicted findings. In the event that the radiologist or his designated representative is unable to get in contact with the referring physician, the radiologist may verbally relay the findings of his report to the physician's chosen substitute. If neither the physician nor the designee can be reached within a reasonable time frame, or if either is unknown, the report should be communicated directly to the patient [24].

For over a century, radiologists, patients, attorneys, judges, jurors, and the general public have been perplexed by the question of whether a missed radiologic diagnosis qualifies as malpractice. It is doubtful if a sufficient solution to this puzzle will be found anytime soon. Many are of the opinion that if a radiologist misses a significant finding in his report that can be seen retrospectively on radiographs, the error can only be attributed to negligence. As such defending such a highly skilled and well-remunerated professional in court for failing to identify a radiologic abnormality can be challenging especially when the same abnormality upon re-examination years later is visible to both the radiologist and other witnesses [24-27].

We therefore aim to present a narrative review of fundamental advancements in structured radiology reporting, along with their benefits and drawbacks. We place particular emphasis on the significance of report composition, format, and language in order to help radiologists improve the clarity, brevity, credibility, and readability of their written reports.

RELATED LITERATURE

The literature has a number of research articles on structured reporting in radiological practice that have varying degrees of interest.

A. Historical Perspectives

December 1895 saw the birth of radiology, when practically by accident, Wilhelm Conrad Rontgen discovered Xrays in his laboratory in Germany. After he published his discovery in a research paper titled "On a New Kind of Rays," less than a year passed, and X-ray utilization has already become a common practice in diagnostic medical imaging. Since then, radiologists have specialized in evaluating these images and composing medical reports that explain their findings [28].

One of the most ancient radiological reports in literature was a handwritten account by a New York physician Dr. William Morton in May 1896. In it, he discussed the results of an abdominal radiograph with a colleague, noting the absence of renal calculus and all the visible skeletal features that were evident [29].

Nevertheless, Dr. Preston Hickey, a Michigan radiologist known for inventing the terms "radiograph" and "interpretation" in diagnostic medical imaging, is the one usually credited with having initiated any serious push towards structured radiology reporting in 1899. The American Roentgen Ray Society (ARRS) accepted his proposal in 1922, asking that each candidate must submit one hundred radiography reports for evaluation, with membership awarded only when the clarity and diagnostic utility of the reports were deemed adequate [29,30].

Historically, the field of diagnostic medical imaging and patients have born the clinical inapplicability of poor radiology reports. This viewpoint was reinforced in 1923 when Charles Enfield, a radiologist from Kentucky, declared in the Journal of the American Medical Association (AMA) that a perfect report binds the radiologist to his opinion, while a report that doesn't explain its findings communicates a lot but almost nothing [31].

In another study conducted in Tucson, Arizona in 1988, Clinger's team [32], received an eight out of ten (8/10) for overall report quality. Three years later, radiologists were added to the study by Naik et al [33], at the

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University of Toronto, and their preferences were compared with those of the referring physicians. Their study re-ignited interest in "itemized," or structured reporting in the radiological community, with a convincing number of radiologists and a good number of referring physicians favoring structured reporting format [33-35].

At the 2004 American Roentgen Ray Society (ARRS) meeting, structured radiology reporting received a significant boost as the incoming president of the society, Christopher B. Merritt, delivered a keynote speech on radiology reporting, which highlighted the significance of adopting new technology to standardize and structure clinical care, research, and compliance [36]. In 2005, Sistrom CL and his colleagues [37], in another publication, described a framework for enhanced radiology reporting that identified three improvement priorities, that is structured format, consistent content and standard lexicon.

The opinions of radiologists have traditionally been documented in written reports, in contrast to other medical specialties. Radiologists usually commit to making a diagnosis even after they are fully aware of the consequences of written reports and the limitations of imaging modalities. The best strategy to minimize medico-legal problems is to avoid making any mistakes while composing a radiology report. Yet, because radiology is becoming increasingly important as a last resort before taking drastic action, the emphasis is on these reports. To improve radiology reporting, a comprehensive program must therefore, involve specialized didactic education, supervised practice, and a detailed assessment of reporting capabilities [37, 38].

B. Overview and Significance

Radiologists have a special referral role on the medical team because they provide a written evaluation of the patient's condition that is meant to be read, understood, and acted upon by other practitioners. This is in sharp contrast to medical or surgical specialists, who see and treat patients directly. In other words, the radiologist's report serves as both the referring doctor's and the radiologists' primary means of direct communication—and occasionally, it's their only means of exchange regarding the patient. Consequently, the referring physician seeks a simple diagnosis or differential diagnosis and recommendations free of radiology jargons. While the technical aspects of reporting are essential for the radiologist's assessment, it is necessary to keep the referring physician's position in mind when attempting to reconcile these competing demands [39-41].

A report is classified as structured when it contains all important information and diagnostic impressions, adheres to previously specified guidelines and descriptors, and has a predefined design. The structured report format demands that every field be filled out; this prevents vague or evasive descriptions and thus, resulting in a more accurate and efficient report that impacts positively on the patient's management. Another important characteristic of the structured reporting is that it has the ability to improve clinical research and teaching activities by increasing the search and comparison of information [42, 43].

METHODOLOGY

In order to accomplish the objective of the study, we conducted a narrative review of data sources between January and June 2024, on the fundamental advancements in structured radiology reporting, including their benefits and drawbacks. Most of the findings and data presented in this narrative were derived from reports and articles published in scholarly, peer-reviewed journals available through electronic-reference archives, such as PubMed, PubMed Central, Google Scholar and MEDLINE. We also used ephemeral or fugitive publications from government documents, white papers and evaluation materials like annual, research, technical and project reports, and we expanded our search strategy to include search engines such as Google to locate non-convectional literatures. The co-authors contributed to data collection for this study by separately evaluating literature and doing bibliographic searches to compile reports on fundamental advancements in structured radiology reporting.

A variety of keywords were used to assist the search retrieval, such as artificial intelligence, diagnostic medical imaging, fundamental advancements, standardization and structured radiology reports.

Radiology Reports: What Makes Them Good?

Eight Cs describe the qualities of a good radiology report, but the list now also includes two additional crucial

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components, as depicted in table 1 [44-46].

Table 1: The Crucial Components of a Good Report

correctness
clarity
concision
confidence
consistency
consultation
completeness
communication
standardization
Timelessness

Reporting Terminologies: Standardized, Structured and Unstructured Radiology Reporting Styles

A. Standardized Radiology Reporting

One way to make the medical information in a radiology report easier to read and understand is by simplifying its content through standardized reporting. Standardized- and structured-reporting differ primarily in that the former concentrates on the report's content in a standardized order, as illustrated by the "top to bottom" report layout in figure 1, whereas the latter is supported by an IT-based tool or system that assists the reporter in creating the report [47].

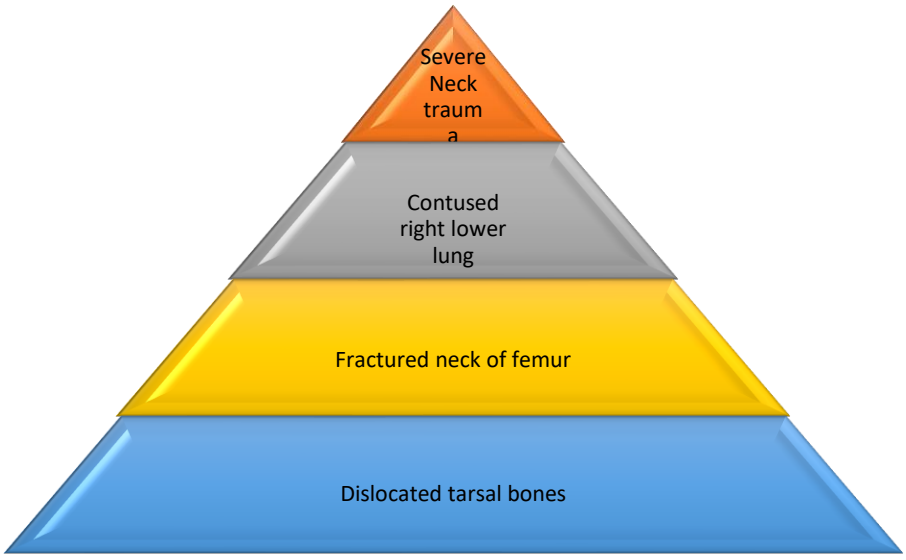

Figure 1: Standardized Report Layout (Top to bottom)

B. Structured Radiology Reporting

When all pertinent data and diagnostic impressions are included, the report complies with pre-established criteria

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and descriptors, and its design is predetermined, it is classified as structured. There are three possible levels to "structure" the radiology report [47-49], as described below:

i) First Level Structured Radiology Reporting: A structured radiology report is organized into sections and subheadings at the first level, with sections on study protocols, clinical data, radiological findings, and conclusions to highlight the key radiological aspects. In addition, typical sections can be used to identify content, while subdivisions can be used to organize longer reports. Examples include the “list or itemized " report, which has fixed headings, whereas " ranked or hierarchical " reports list the most significant things first as depicted in table 2 and figure 2 below, respectively.

Table 2: List or Itemized Report: An Example of Structured Radiology Reporting Level One.

Thyroid gland: normal dimensions
Lung: Right lower lung zone loculated pleural effusion
Biliary system: normal
Adrenal glands: normal
Aorta: normal
Bowel: Ruptured appendix with peritonitis
Ankle: Sprained right ankle

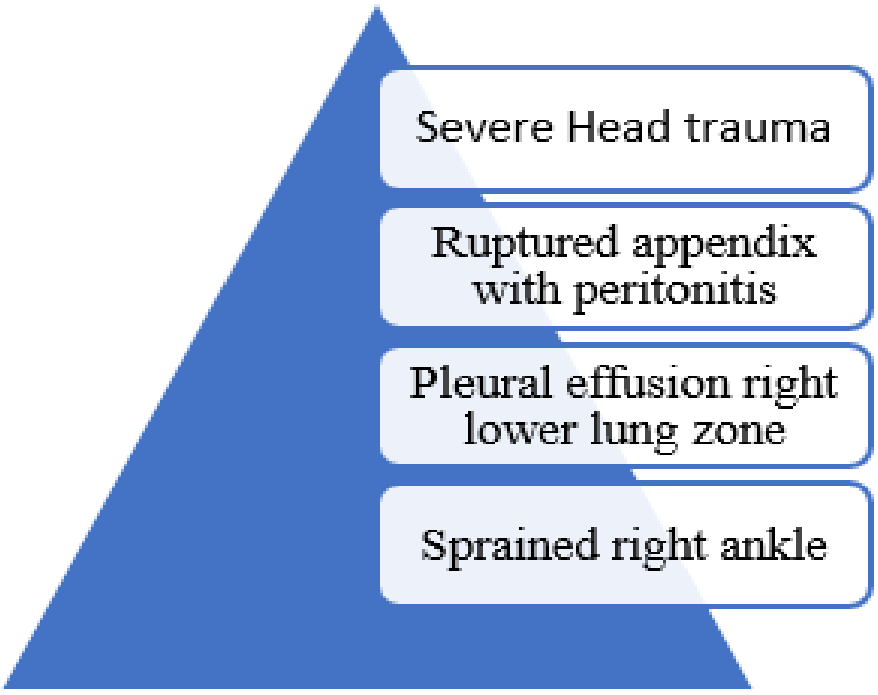

Figure 2: Ranked or Hierarchical Report Layouts: An Example of Structured Radiology Reporting Level One.

ii) Second Level Structured Radiology Reporting: When the report is structured at the *second level*, it provides an explanation of each pertinent specific disease finding. Examples of level two structured reporting layout include cascading or drop-down menus, which allow the reporter to choose from a variety of options without utilizing a pick-list or point-and-click interface. Flow-diagram-guided report layouts require precise inputs, whereas space or gap filling allows reporters to fill in the blanks, as depicted in table 3a-d below:

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Table 3: Structured Reporting Level Two, examples include, a) Cascading or Drop-Down Menu, b) Pick-List or Point-and-Click System, c) Flow-Diagram-Guided and d) Space or Gap-Filling Report.

a) Cascading or Drop-down menu	b) Pick list or point and click interface
Germinal matrix hemorrhage	
1. Confined only to the caudothalamic groove/germinal matrix (Grade I). **2.** <50% ventricular extension (Grade II) 3. ventricular dilatation (Grade III) **4.** hemorrhage into brain parenchymal (Grade IV)	o Confined only to the caudothalamic groove/germinal matrix (Grade I). o <50% ventricular extension (Grade II) o ventricular dilatation (Grade III) o hemorrhage into brain parenchymal (Grade IV)

c) Flow-diagram guided	
Left Cataract	No cataract
Eyes	
Right Cataract	No cataract
d) Space or Gap filling	
Hemorrhage restricted to the …… region which is seen in the …… groove.	

iii) Third Level Structured Radiology Reporting: A standard lexicon is included on the third level of the structured report [49]. Though it might potentially pertain to the vocabulary of any group of people, a lexicon (plural: lexicons or lexica) usually refers to the language of a particular profession or field of study. Several organizations have programs comparable to Radlex (a lexicon of radiological information produced by the Radiological Society of North America—RSNA), which have endeavored to codify and standardize the vocabulary of radiologists or groups of them; for example, Breast Imaging-Reporting and Data System (BI-RADS) features a lexicon unique to mammography [50], but which has been expanded lately to also include ultrasound (US), and magnetic resonance imaging (MRI) by the American College of Radiology(ACR) [51], an abridged version of which describes seven assessment categories of the mammary gland pathology as depicted in table 4 below:

Table 4: Structured Reporting Level Three, Example Include, Birads Classification.

BI-RADS 0: incomplete
BI-RADS 1: negative
BI-RADS 2: benign
BI-RADS 3: probably benign
BI-RADS 4: suspicious for malignancy
BI-RADS 5: highly suggestive of malignancy
BI-RADS 6: known biopsy-proven malignancy

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C. Unstructured Radiology Reporting

Radiology reports have traditionally been written in a narrative free-text format with no headings or subheadings to create unstructured reports, allowing the radiologist to use a personalized reporting style that is distinct in language and structure, which he may prefer because it is perceived to be quite unique to their profession. This is particularly so with older radiologists, who are more resistant to switching to the structured format. The unstructured radiology report's content is however, unclear and potentially compromised by the personalized style, excessive length, or language, making it difficult for referring physicians to find the crucial information needed for patient management [52-54]. Table 5: below compares the two radiology reporting styles.: A is Structured, and B Unstructured styles.

Table 5: Two Radiological Reporting Styles are compared. A is an example of a Structured Radiology Report, while B is Unstructured Report.

Brain Computed Tomography (CT)

Report A	Report B
Technique: Native and contrast studies	Contiguous axial slices in native and contrast studies.
Clinical information: Weakness of the right-side x 2days in 58-year-old female	A lady, aged 58, reported having weakness in her right side for the previous two days.
Comparison: None	There was no previous study for comparison
Findings: Cerebral hemispheres: Normal Basal ganglia: Normal	The Cerebral hemispheres have normal CT density values on the native study
Thalami: Normal	There was normal CT density of the basal ganglia in the native study, and no abnormal calcifications were noted
Brainstem, cerebellar hemispheres and vermis: Appear Normal	The density, morphology and size of the thalami were within normal limits
Ventricular system: Normal	The vermis, cerebellar hemisphere and brainstem structures are normal in size, morphology and density
Midline: No midline shifts	The ventricular system was normal in size with no ventricular dilatation
Basal cisterns: Normal	The midline structures were normally centrally located
Sellar and suprasellar region: Normal	The basal cisterns were normal in size, density and morphology
Skull vault: Normal, no fractures	The morphology and density of the Sellar and suprasellar structures was within normal limits
The orbits and paranasal sinuses: visualized portions normal	The skull vault was normal with no fractures seen
Post- contrast images: Normal	The visualized portions of the orbits and paranasal sinuses were within normal limits
Assessment: Normal study	There was no abnormal post-contrast enhancement.
Radiologist	Normal study
Sign...	
Name…	

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Date….	Radiologist Sign... Name… Date….

The Perceived Benefits of Structured Radiology Reporting

Radiological societies around the world have acknowledged that structured reporting that is well-implemented can yield a number of medical benefits. For instance, the European Society of Radiology (ESR) has requested global cooperation on common radiology reporting templates [55]. The perceived benefits can be tailored to radiologists, report recipients, radiology residents, and researchers, as well as usefully integrated into the clinical decision support (CDS) software, as described below [55,56]:

A. Individual Radiologists

1. Structured reporting can incorporate findings backed up by guidelines and research, improve report consistency, and decrease omissions of crucial details.

2. Furthermore, because the templates and terminology are based on best practices, they can be modified to conform to current guidelines.

3. Both the cognitive load associated with reporting complex findings and the search bias can be reduced by using predefined structured radiology reporting templates.

4. Radiologists can more effectively evaluate relevant changes in serial scans, such as those obtained after treatment, when the previous radiologist has utilized the same report template.

B. Reports Recipients, that is, Patients and Referring Physicians

1. The structured format helps to ensure high-quality care for patient as well as in the facilitation of the automated translation of radiological terminology into patient-friendly reports. This is especially useful when combined with recent advancements in machine learning

2. Structured reports are patient-friendly and therefore, can reassure patients and help them better understand their problems and their role in managing their own health.

3. Structured reporting formats apart from also providing comprehensive information that benefits both the patient and referring physicians' helps in the organization and conveyance of information concisely, thus enabling easy identification of crucial findings that may positively impact treatment choices.

4. Using a structured reporting format ensures that no matter where a patient is imaged, the same critical information is evaluated, hence increasing the value of radiology in the eyes of the referring physician and patients.

5. A clear and understandable presentation of information in a structured format can help shared-care models when patients have access to their reports.

6. Radiologists and referring physicians can communicate more easily when they adopt established lexicon.

C. Radiology Residents and Researchers.

1. Structured report templates aid residents who are unfamiliar with a specific pathology or procedure,

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leading them to pertinent findings and providing a shared lexicon for accurate documentation

2. Structured reports help researchers increase patient care by automating data extraction and analysis while minimizing the problem of missing data.

3. When a structured reporting template is completed correctly, it can be used to create an outcome-based residency competency evaluation

4. Radiology staff who evaluate completed templates can quickly assess a resident's perspective on the source images as well as their interpretation competence and skills.

5. Researchers and quality assurance analysts, for example, might ask targeted questions about the diagnostic and prognostic value of certain observations when evaluating reports made using various RADS systems.

D.. Clinical Decision Support (CDS) Software May also Incorporate Structured Reports.

1. A retrospective study of the effect of imaging on patient outcomes could be facilitated by CDS software, which could provide structured templates to radiologists based on the clinical environment.

The Perceived Questions, Concerns and Demerits with Respect to Implementation of Structured Radiology Reporting.

Despite the clear benefits of structured radiology reporting solutions, radiologists, especially the older ones, are still reluctant to accept structured reporting formats, with implementation challenges differing by institutions and countries. For example, in the United States, just 51% of radiologists utilize it on a regular basis, compared to 55% in Belgium and 46% in Italy [57].

One of the more noteworthy articles on this subject was a 2015 opinion piece by Bosmans et al. [58], which made a comparison between fusion reactors and structured reporting in diagnostic medical imaging. They referred to structured reporting as an endless promise with practical applications that were yet decades away. And despite nearly a decade since this historic pronouncement, structured reporting is still not widely accepted in routine diagnostic imaging practices. Similar to the real fusion reactor, which as of today has not yet reached sustained net-power production, it appears that some engineering obstacles and organizational transformation challenges still need to be overcome for the technology to work, even though theoretically—as the authors suggested—the fusion reactor could be ready and is only "hungry for fuel". It's hard to predict for how many more years radiologists will have to wait until structured reporting becomes a standard component of daily radiology practice. But one thing is clear, it will not only change the way we practice radiology but also open up new ways to interact with radiological reports [58,59].

The following obstacles [60-64], continue to impede the widespread implementation of structured radiology reporting:

A. Radiology Report Contents and Format

1. The present diversity in terms of structured reporting contents and format does not easily accommodate incidental findings that differ from the suspected diagnosis.

2. Reporting complex cases might be time consuming when using template-based formats.

3. Majority of templates use checkboxes and drop-down menus. There is a chance that filling in those templates with a mouse and keyboard will divert attention from the image study compared to using speech recognition, which is frequently utilized for free-text reporting (FTR).

B. Technical Obstacles

1. Information technology (IT) workflow obstacles such as insufficient integration of structured reporting

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templates into the radiology information system (RIS) and restricted interoperability between healthcare IT systems have been identified.

C. Obstacles Facing Radiologists

1. No national guidelines outlining the reporting obligations for radiologists exist as of now.

2. Since radiologists are used to a particular reporting style and feel that a change is not clinically necessary,they themselves may be reluctant to adjusting to structured reporting, especially the older ones among them.

2. Radiologists' productivity decreases as a result of the time and effort required to generate and fill out report templates, necessitating significant adjustments to the individual radiologist's workflow and institutional effort.

3. When using free text in their reports, radiologists can add more content since they respect freedom of expression and feel that using strict reporting templates will reduce the quality and scope of their reports. Therefore, in complex situations, templates may not be sufficient to offer all pertinent information.

4. Interrupting the visual search pattern, or "eye dwell," by closely adhering to structured report formats may result in missed findings, therefore in cases where radiologists focus more on the template rather than the images, they run the risk of making incorrect diagnosis. Thus, for less complex examinations like ultrasounds or x-rays, structured reporting may be more useful than for more complex procedures like CT or MRI.

D. Obstacles for Readers of Structured Reports, that is, Referring Physicians and Patients

1. In a manner comparable to that of the radiologist, concerns have been expressed for the referring physicians and patients. The same checklist pattern and over-structuring that may cause a radiologist to overlook significant findings may have the same effect on the reader, even if the report is presented accurately and clearly [60-64].

Fundamental Advancements in Structured Reporting to Adress Challenges and Obstacles with It's Implementation

The European Society of Radiology (ESR) has released an update on the challenges with structured reporting [62], in response to an earlier study that was published in 2018 [48]. This publication clarifies some of the steps that structured radiology reporting should (need to) take and demonstrates how many national radiological societies are independently creating structured reporting templates. Yet, no cross-institutional implementations of these templates have been reported thus far (with the possible exception of the USA), nor are there any financial incentives to use them.

Two conclusions can be drawn from the forgoing regarding how to overcome the obstacles and challenges to the implementation of structured radiology reporting. Firstly, as radiology becomes increasingly globalized and evidence-based, all forces must unite to harmonize structured reporting templates and develop best practices. Secondly, in order to encourage radiologists to invest in these new technologies and assist the healthcare system in making the most of the information found in these reports, there must be a strong financial incentive for structured reporting or a disincentive for free-text reports [65].

Contextual structured reporting comes in handy and can overcome the perceived rigidity as well as limited flexibility of structured reporting templates, allowing radiologists to be more creative. This involves customizing templates for specific radiological settings, allowing for the use of distinct templates for different clinical scenarios [66].

One noteworthy exception to the typical obstacles that prevent radiology from adopting and using structured reporting is found in breast imaging. The birth of the Breast Imaging Reporting and Data System (BI-RADS) is

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an excellent example of how structured radiological reporting can be applied successfully in clinical practice to impact patient care positively [67].

Aside from BI-RADS and LI-RADS (liver imaging reporting and data system), several other standardized reporting systems have been designed, including PI-RADS (prostate imaging reporting and data system), TI-RADS (thyroid imaging reporting and data system), C-RADS (CT colonography reporting and data system), GI-RADS (gynecologic imaging reporting and data system), Lung-RADS (lung CT screening reporting and data system), as well as more acronyms such as the most recent, CAD-RADS (coronary artery disease reporting and data system), which diagnoses coronary artery disease using CT angiography [68-71].

In surgery, it has been discovered that using structured reporting in operating room case-notes improves the quantity and quality of the information provided [72], for example, structured surgical reports were associated with a significant improvement in the completeness of pre-specified data and were available in the electronic medical record in a shorter period of time [73].

In general, the RSNA Radiology Reporting Initiative [74], has created a free online library of report templates and supports a template standard to promote template distribution across software platforms. Radiology common data components [75], can also be used in conjunction with templates to standardize both nomenclature and report formatting.

When implementing these initiatives, it is crucial for radiologists and radiology organizations to consider patient opinions and feedback to make sure patients' needs are being met and that reports become more patient-friendly and, in particular, patient-centered when they are further structured [76].

METHODS FOR STRUCTURING UNSTRUCTURED RADIOLOGY REPORT FORMATS

The issue of structuring free-diction radiology reports can be resolved by applying natural language processing (NLP) techniques, which are a subspecialty of artificial intelligence (AI) that focuses on utilizing computers to understand and modify human language. Analyzing and interpreting natural language data, such as free text radiology reports, is a task done utilizing NLP techniques. Once the reports are structured, the data can be used for analysis and research [77].

Identification of relevant data, such as patient demographics, medical history, imaging results, and diagnosis, is the first stage in structuring unstructured reports. NLP techniques can then be used to find useful information in text by analyzing it and detecting patterns and keywords. A structured reporting format can thereafter be compiled after obtaining the necessary information. Furthermore, the ESR has created ontologies, standards, and templates in order to maintain consistency in reporting. These standardized reporting formats can be utilized to structure the retrieved information, resulting in result uniformity and consistency [78].

The Place of Artificial Intelligence (Ai) in Structured Radiology Reporting

Although AI has garnered a lot of attention for its use in interpreting and classifying imaging findings [79], it may also benefit radiology reporting systems and other elements of radiological service delivery in general by automating some aspects of report composition. One example of how to improve report comprehensiveness would be to use a basic AI algorithm to extract the data from a comparison study and include it in the report. AI algorithms could also improve the accuracy of reporting and data systems by assessing if an acceptable comparative study is available and automatically inserting whether the threshold growth of a given lesion exists [80]. Likewise, AI might auto-insert recommendations for additional testing or follow-up imaging into reports if significant findings or the need for nonurgent follow-up are recognized [81]. AI could also provide various versions of the same report personalized for each stakeholder, thus enhancing communication [82, 83]. Lately, radiology reports applicable to X-rays can be automatically generated by AI software [84], significantly improving patients' clinical diagnosis. For instance, a learning-based model called Computer Aided Diagnosis (CADx-Report) can be used to produce reports from chest X-ray (CXR) images that are adequately and clinically accurate [85]. Paalvast et al. [86], not only demonstrated the difficulties in developing training materials that are

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sufficiently varied and informative for automatic radiology report creation, but they also demonstrated that the quality of both the original and generated reports was comparable. When compared to other baseline approaches, the experimental results on the MIMIC-Chest X-Ray (MIMIC-CXR) database (a de-identified public resource of chest radiographs with free-text reports, created by a team of researchers and published in Scientific Data) and Indiana University Chest X-ray dataset show that the suggested model of automatic report creation achieves state-of-the-art performance [84,87].

An Outline of Ten Fundamental Guidelines for Writing Structured Reports

The medical specialty of radiology relies heavily on structured radiology reports to facilitate research and data analysis, improve patient care, and boost communication. In order to guarantee that these reports are as useful and effective as possible, radiologists need to follow certain rules and guidelines, ten of which are provided in this narrative review for radiologists to adhere to when writing structured radiology reports. These guidelines aim to improve the reports' overall quality, coherence, and clarity, which will eventually improve patient outcomes and foster more cooperation among healthcare practitioners as described below [78,88]:

1. Adherence to Consistent Nomenclature: When describing imaging findings, adherents should endeavor to use standardized and well-defined medical lexicons to ensure consistency across reports. The size, location, form, borders, and internal features of the lesion(s) of interest must all be adequately described. Standardized descriptors, such as BI-RADS for breast imaging, can be used to guarantee that reports are uniform across institutions.

2. Addition of Clinically Relevant Information: Any relevant clinical history and indications must be included for the examination. This context helps with appropriate interpretation and ensures that the report is relevant to the clinical question at hand.

3. Conveyance of Clear and Concise Findings and Interpretations: It must be ensured that the report conveys the findings and interpretations in a clear and simple manner. Technical jargons should be avoided in favor of straightforward language that referring physicians and other healthcare practitioners can understand.

4. Urgent and Prompt Notification of Critical Findings: Urgent or critical findings in the report must be promptly communicated to referring physicians or the healthcare team to ensure patient safety and prompt management.

5. Reports must be Reviewed and Validated: A peer review and validation procedure for structured reports must be established to maintain accuracy and quality, so as to identify areas for improvement, and adherence to defined standards.

6. Defined Imaging Protocols must be used: It is necessary to use defined imaging protocols so as to ensure consistency and uniformity in the acquisition of images. This reduces variability in the reported findings and aids in comparing long-term results.

7. The Report must be Organized in a Structured Format: With separate sections for clinical information, imaging techniques, and descriptions of lesions. It is imperative that the templates utilized are specific to imaging modalities and clinical situations, as they provide a consistent structure for reporting findings and aid in the methodological organization of information.

8. Update and Evolution of Structured Reporting Templates: The structured reporting templates and guidelines should be updated on a regular basis to reflect new evidence, technology improvements, and user input. Over time, ongoing improvements ensures that the reports remain relevant and useful.

9. Structured Reporting Elements are also included: Specific report elements, like imaging characteristics, location descriptors, and measurements, must be presented in a structured format to make data mining, research, and report completion easier.

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10. Contextual Recommendations must be made: Suggested suitable recommendations based on the radiology findings must be made. Further diagnostic tests, imaging studies and consultations with other specialists may be required.

CONCLUSION

Structured radiology reports represent a major advancement in improving healthcare outcomes through higher-quality data. These reports, which serves as the primary and often the sole channel of communication regarding the patient between the radiologist and the referring physician, are also crucial for accurate patient management. However, part of the problem with radiology reports, stems from the lack of appreciation of how important the report has become for healthcare professionals in general, including those who are not radiologists. This gap is even more glaring when one realizes that the majority of radiologists do not receive formal reporting education throughout their training, and that there is no discussion of report composition in even the most widely used radiology websites or textbooks.

Nevertheless, while there are a lot of benefits to structured reporting, it is also vital to recognize the drawbacks as well, such as the possibility of difficulties capturing complicated cases and the user's reluctance to change. Efforts to structure radiological reports, led by technical breakthroughs, academic institutions, and radiological associations, are critical to the fundamental transformation of medical imaging reports. Radiologists should, therefore, look forward to exciting times ahead because artificial intelligence (AI)-powered technologies cannot replace them but rather reduce their current reporting burden, freeing up radiologists' time for multidisciplinary clinical and patient-related activities and making the radiological reporting process more pleasant, efficient and accurate.

All the same, given their advantages over traditional reporting and the growing globalization and evidence-based nature of radiology, structured reports have a bright future. But all stakeholders must agree to work together to coordinate continuing research, provide impactful inputs, be creative, and design acceptable structured reporting templates. Only then can best practices be created. Furthermore, there needs to be a significant financial incentive for structured reporting while simultaneously discouraging the ongoing use of traditional free-text reports in order to motivate radiologists to invest in these new technologies.

RECOMMENDATIONS FOR THE FUTURE DIRECTION OF STRUCTURED RADIOLOGY REPORTING

The future direction of structured radiology reporting is currently being discussed, and other modifications are anticipated and should be adopted, such as:

1. Formally including the design and implementation of structured radiology reporting into the curriculum of the residency training program with particular emphasis on the medico-legal and ethical aspects of the report so as to prevent residents from misdiagnosing patients and withholding crucial imaging findings. [89].

2. Alternative reporting methods should be made available based on the indications of each study, and there should be a shift towards “contextualized” structured radiological reporting [90].

3. The Radiology Cares` campaign of the RSNA must be supported through the deployment of a structured report of measures based on value rather than volume [91].

4. Adoption of hybrid reporting, which combines natural language processing (NLP) and structured reporting, to increase structured content in a database that enables more thorough research and quality assurance. This is done by utilizing an NLP-enabled Management of Radiology Report Template (MRRT)-compliant reporting platform [92].

5. Artificial intelligence-based web applications should be created so that people in poor health can

automatically generate their risk assessments and scores [93].

Data Availability

Not applicable

Conflict of Interest

There are no conflicts of interest

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