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# How to make clinical data actionable: an example of radiology quality management and peer-review system

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**Abstract.** Today medical data analysis is experiencing rapid development. Large volumes of uniform and verified data are required for the application of innovative analysis solutions. This ideology was the foundation for Unified Radiological Information Service (URIS), launched in Moscow. Currently, 75 clinics are connected to the URIS. In 2016 we developed remote quality assurance system and discrepancy detection module (DDM). The software is designed to review studies, provide feedback and accumulate “big data”. We have compared the number of discrepancies before and after DDM implementation (4473 anonymized CT and MRI studies). In 12 months the number of discrepancies decreased by more than a half.

**Keywords:** discrepancy, quality assurance, big data.

## 1 Introduction

Yearly number of radiological examinations is on the rise both around the globe and in the Russian Federation. Primarily, this is due to the increased availability of high-end diagnostic equipment. Around 1.5 million CT and MRI examinations are per- formed per year in public healthcare organizations of Moscow. However, provision of quality diagnostic services requires both modern equipment and well-trained, qualified personnel.

The transition from analogue to digital equipment has allowed for analysis of data accumulating in specialized storage centers. Modern digital radiological examination consists of DICOM files (images & metadata) and report (study findings and conclusion). Data comprising the study may be divided into 3 types: images, text and meta- data. Different approaches to data analysis can be used depending on information type. The results may be applied both in practice and research. The quality control in radiology via statistical analysis of medical data aims to detect deviations from standards and unreported findings [1].

Semi-automated analysis of radiological reports is also an important tool for quality control. For this scenario, the most interesting and promising approach is se- mantic analysis. Further development will allow us to compare radiological report with the available images; discrepancies and missed findings will be automatically high- lighted [2].

Analysis of radiological metadata is a statistical and business analysis of DICOM file fields. The architecture of DICOM files stores important statistical information (patient data, examination, institution, equipment and medical personnel). By extracting and analyzing this information in real time one can monitor status of the radiological service, and check trends (for example, equipment downtime). This allows for prompt patient redirection and workflow optimization for both individual institutions and healthcare system [3].

Today medical data analysis is experiencing rapid development. One of the most promising image post processing methods are CAD (Computer-Aided Detection) systems, which perform semi-automated segmentation of pathological lesions, for example, neoplasms. Performance of CAD systems may be further augmented using neural networks. The systems may be used for big data analysis and detection of previously unidentified foci. For example, liver is one of the abdominal organs partially scanned in chest CT due to its close relation to the diaphragm. Even an experienced radiologist can miss liver lesion if it is not related to patient symptoms and zone of interest. Implementation of CAD systems makes it possible to verify up to 100% of studies [4].

The most common diagnostic errors were missed diagnoses, compared to those that were late or incorrect. Diagnostic errors are clinically and financially costlier today than ever before. In the past, more limited treatment options meant less potential for lost clinical benefit from appropriate ones. The tools available for tracking and preventing diagnostic errors, such as health information technology (HIT), were less sophisticated. Advances in HIT and big data offer new instruments for measuring and reducing diagnostic errors. However, systematic efforts to measure and analyze these errors have been limited. [5].

Many investigators have turned to the topic of radiologic discrepancies. It's hard not to agree with the opinion of A. Brady that «radiologist reporting performance can- not be perfect, and some errors are inevitable» and «strategies exist to minimize error causes and to learn from errors made» [6]. The position of D.B. Larson et al. that the classical approach to scoring-based peer-review tends to drive radiologists against each other and practice leaders is also reasonable. They successfully have implemented a different model based on peer feedback, learning, and improvement in many radiology practices in the United States [7].

However, the assessment of a radiologist's performance is an important tool in the management of a large radiology department, especially if it is not one hospital, but dozens of state clinics. It has to be clear, easy, automated process, but there are no similar solutions on the market now. That is why we developed remote quality assurance system and discrepancy detection module (DDM) or peer-review, which was implemented in the government outpatient clinics of Moscow.

To evaluate the effectiveness of electronic quality assurance system in radiology departments.

## 2 Materials and Methods

Large volumes of uniform and verified data are required for the application of these innovative solutions in quality control. This is especially true for solutions using neural network algorithms. It is also necessary to have an appropriate hardware infra- structure for storing information. As in any other controlled process, the quality management system needs key parameters for successful evaluation of current situation and improvement in long-term. Advances in technical capabilities of radiological equipment and DICOM standard allow to capture metrics from each apparatus, concentrating all the information in a single center. This allows to remotely monitor the equipment, provide timely technical support, and perform quality control.

This ideology was the foundation for Unified Radiological Information Ser- vice (URIS) - regional radiological information system - launched in Moscow, 2015. Currently, 75 outpatient clinics are connected to the URIS. The service comprises 130 CT and MRI units, 422 radiologists, and 321 technicians. At the time of writing nearly 900 000 studies and their reports (CT, MRI, PET-CT, chest radiographs and mammograms) have been uploaded to the system.

Information from all departments is concentrated in a single Centre Radiology Research and Practice Centre of Moscow. Integration of radiology departments into a single network made it possible to organize electronic quality assurance system in radiology, which includes:

- discrepancies-tracking system;
- consultation of challenging diagnostic cases by subspecialized radiologist;
- learning system;
- remotely monitor the equipment (collection of metrics from each apparatus);
- to provide timely technical support.

Every 10 minutes selected metrics (serviceability data, number of patient, ex- aminations performed) are uploaded from radiological equipment to the system. Information on equipment downtime and associated decrease in number of studies is accessible online via Radiology Research and Practical Centre dashboard. The data can be forwarded to associated medical organizations in a timely manner.

In 2016 we developed remote quality assurance system and discrepancy detection module (DDM). The software is designed to review studies, provide feedback and accumulate “big data”. We have compared the number of discrepancies before and after DDM implementation (4473 anonymized CT and MRI studies). $P<0.05$ was considered statistically significant.

Up to 10% of all studies are sent for peer-review. This quality control focuses on two points: technical execution (artefacts, selection of study boundaries, patient placement, scanning technique, contrast enhancement timing and phases, pulse sequences, etc.) and diagnostic performance (pathology detection, interpretation discrepancies, terminological errors, etc.).

The final evaluation of diagnostic performance consists of four levels: 1 - no discrepancy; 2 - general remarks (comments on terminology, protocol design, etc.), 3 - clinically insignificant discrepancy (no effect on treatment and/or quality of life) and 4 - clinically significant discrepancy (affecting the treatment and/or quality of life).

Quality control of radiological studies is carried out by the aforementioned group of experts. The studies are distributed depending on the competence of the experts (i.e., modality, anatomical area, etc.). Study anonymization is performed automatically during the upload. This allows for unbiased quality control. In 2016 10915 studies (5.2% of all uploaded) were audited. In Q1-Q3 2017 12284 studies (7,2%) were audited.

Assessment of clinically significant discrepancies by several experts. If one expert believes that the discrepancy is significant, the system sends the study to another expert, if the second expert does not agree, then the study is directed for the final evaluation to the third expert of the same sub-specialty. This allows for a more objective evaluation. This logistics allow to make review more objective.

## 3 Results

After a year of system's working We observed a decrease in significant and non- significant discrepancies from 6.4±2.9% (64) to 2.8±0.8% (104) and from 19.6±3.0% (197) to 9.5±0.7% (352). The number of reports without any discrepancies increased from 51.7±2.9% (520) to 69.1±0.7% (2560). The number of general remarks (terminology, scan protocol) remained roughly the same, 22.4±3.0% (226) vs 18.6±1.59% (691).

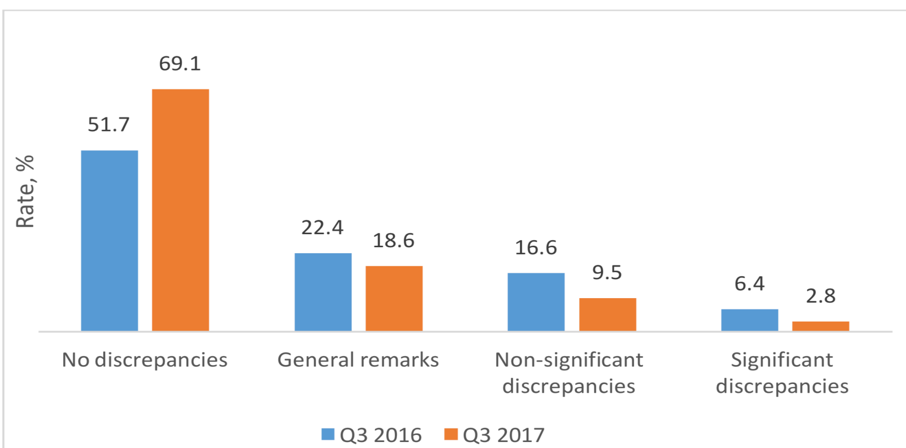


**Fig. 1.** Effectiveness of electronic quality assurance system: rate (%) of discrepancies and correct radiologic reports before (Q3 2016) and after (Q3 2017) implementation the system

Performance evaluation of 207 radiologists, 168 technicians, 9396 studies showed that the distribution of the radiology department staff's efficiency has the form of the exponential curve, which means that 89% of radiologist's and 83% of technician's performance is more than 90%. Activities to improve the quality of work can be concentrated only on 11-17% of specialists (Fig.2 and 3).

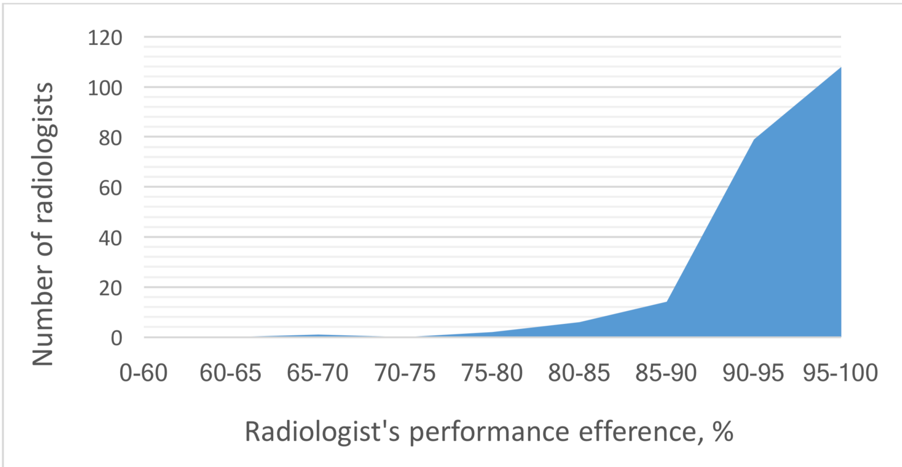


**Fig. 2.** Radiologist's performance distribution curve (CT, MRI)

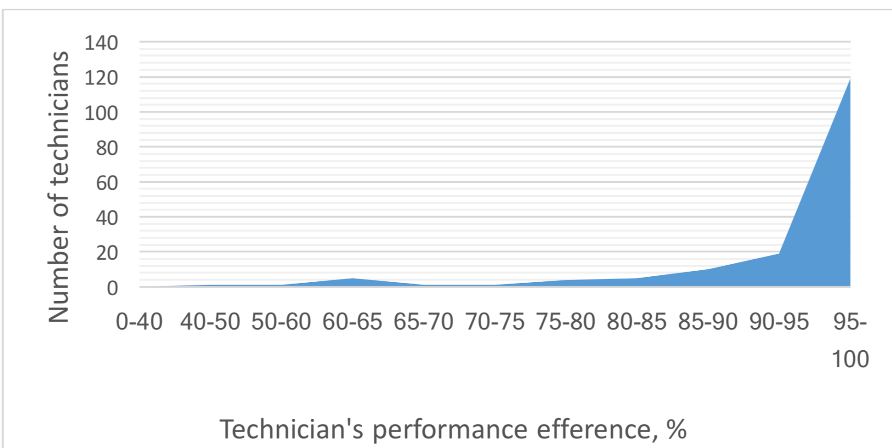


**Fig. 3.** Technician's performance distribution curve (CT, MRI)

Audit of abdominal CT's via URIS showed that up to 66% of outpatient studies had been performed without intravenous contrast enhancement.

In 6% of cases clinically significant discrepancies were detected. Clinically insignificant discrepancies were detected in 19% of cases. Most frequently discrepancies were found for pancreas (28%), lymph nodes, peritoneum (18%), anterior abdominal wall (18%), liver (12%), pelvis (12%), intestines (9%).

Most discrepancies were detected for musculoskeletal system - up to 74-80% of studies have been performed with technical and diagnostic discrepancies.

Frequency of discrepancies in various disease groups was up to 46% in oncology examinations (9% - clinically significant, 37% - insignificant), up to 32% in infections (7% and 27%, respectively) and 24% for cardiovascular disorders (5% and 19%, respectively). In cases of trauma, discrepancies occurred more often with MRI (70%), whereas with CT and radiography the percentage of discrepancies was only 26%.

A correlation was established between an inadequate scanning parameter (for example, CT without contrast enhancement) and diagnostic discrepancies in cancer patients (correlation coefficient = 0.6, $p<0.05$). In trauma patients, the correlation was found between discrepancies and inadequate technique (correlation coefficient = 0.5, $p<0.05$) and artefacts (correlation coefficient = 0.3, $p<0.05$).

Most technical errors were detected for MRI of pelvis - up to 55% (patient & slice positioning in 43%, field-of-view selection in 23%, pulse sequence selection in 19%). Regarding CT, the most problematic area was the neck, in particular, the larynx - up to 42% of the studies had been performed without functional tests or contrast enhancement.

Possibility of connecting to a large number of clinics and any PACS system allows to gather “big data” for systematic measure and analyzing discrepancies.

An example of such an analysis is presented below. Performance evaluation of 207 radiologists, 168 technicians, 9396 studies showed that the distribution of the radiology department staff’s efficiency has the form of the exponential curve, which means that 89% of radiologist’s and 83% of technician’s performance is more than 90%. Activities to improve the quality of work can be concentrated only on 11-17% of specialists.

Analysis of indicators affecting individual performance showed statistically significant correlation between clinically significant discrepancies and (1) work experience in CT/MRI of less than 1-year (positive correlation coefficient = 0.5, $p<0.05$) and (2) availability of "second opinion" from the colleagues (negative correlation coefficient = 0.3, $p<0.05$).

Results of audit are used in Learning system, which includes remote and class- room curricula. Webinars are the most convenient form for analysis typical discrepancies and study of problem radiological topics. It allows to attract the largest number of participants and record webinars for free access on the official web-site. In 2017 (at the time of writing) 89 webinars were held, the number of participants in the center’s webinars exceeded 10200 learners from 20 regions of Russia. Sixty-seven training courses with 1955 learners were conducted as well. Additionally, the system allows to identify appropriate cases for conferences or as training aids.

In addition to monitoring equipment status, integration of radiology departments into a single network made it possible to organize a consultation system. Challenging diagnostic cases are sent to the

"Radiology Research and Practical Centre" and distributed to the expert consultants, each with their own specialization. At the time of writing, 22 board-certified experts from leading outpatient and inpatient facilities in Moscow with clinical experience of at least 7 years were connected to URIS. Number of consultations performed via URIS in 2015 and 2016 was 1110 and 1777, respectively. In the Q1-Q3 of 2017 the number was equal to 2622.

## 4 Conclusion

Thus, the continuous quality management system in radiology is based on the principles of PDCA (Plan-Do-Check-Act). These principles have been successfully implemented in Moscow by the means of URIS. Today, URIS is a unique Russian platform for innovative solutions in the field of medical information processing, the main of which is regional remote quality assurance system, which includes:

- discrepancies-tracking system;
- feedback;
- consultation of challenging diagnostic cases;
- learning system;
- remotely monitor the equipment and providing timely technical support.

The analysis of the system for 1 year showed, that regional remote quality assurance system improved department effectiveness. In 12 months the number of discrepancies decreased by more than a half.

We believe that for effective quality management in radiology, it is important to maintain a balance between monitoring, support and training, with an emphasis on the culture of lifelong learning and development of IT systems to support radiologists.

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