

# Automating patient dose audit and clinical audit using RIS data

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**Abstract**— Dose Audits have to be carried out in x-ray departments. Integrated Radiological Services (IRS) Limited has historically performed these for sites in the North West of England by having a technician on-site to collect patient dose information. This data would then be entered in an application called QADDS (Quality Assurance Dose Data System) where a dose could be calculated. However, whilst being effective, the process was time consuming and lead to large resource expenditure for relatively small amounts of data. Large amounts of data for examinations are routinely recorded by radiographers on their site's Radiology Information System (RIS). In theory, RIS data should be able to form the basis of a patient dose audit. Furthermore, a bespoke application should be able to transfer this data from RIS to QADDS with the minimum of human input.

This paper charts the development of such an application to insert data from RIS into QADDS beginning by first showing that the idea of using RIS data was feasible in that the correct data was present in RIS and that the data could be accessed in a usable format. It then shows how erroneous data from the RIS was trapped and used to form a clinical audit report on the accuracy of data entered into the RIS, as well as how a report was created reporting on tubeload to show if x-ray tubes were being over utilized.

**Keywords**— Patient Dose Audit, RIS Data, Clinical Audits, Tubeload.

## I. INTRODUCTION

Within x-ray departments, dose audits have to be carried out in accordance with IR(ME)R 2000[1] and IPeM 88[2] on a 3 yearly basis, or if there is change to equipment or radiographic practice. Integrated Radiological Services (IRS) Limited has historically performed these audits for their customers (mainly hospital trusts in the North West of England).

To do this, a technician would be sent on-site to gather x-ray data such as kV, mAs and focus to skin distance (FSD). This data would then be fed into QADDS (Quality Assurance Dose Data System), an application developed by IRS

for calculating and storing patient dose data in a central repository which was redeveloped in 2005 to take advantage of the emergence of web application technology.

The QADDS database would then be queried by a statistical software package to produce a report.

Whilst this system was effective in meeting the requirements for dose audits it meant that an IRS technician would have to be on a department for weeks at a time to gather the required number of records to perform a satisfactory dose audit.

Even then dose audits would only include records for a relatively short period of time. Any reports created from this data would provide a good 'snapshot' of doses being given within a department, but would not provide enough information to help with spotting trends, etc. There was also likely to be a greater effect for any records that produced abnormally high or low doses. There is recommendation that a minimum of 10 doses is required to perform an audit [1]. Studies have shown however, that such a low number can lead to poor or misleading results [3] and that a greater number of records will lead to a much more meaningful dose audit.

The last 3-4 years has seen the proliferation of RIS within x-ray departments. Radiographers now routinely enter data on all exposures that are then saved in a database. In theory this data should be requisite to form records in QADDS and allow for large-scale patient dose audits [4]. As the data is held in a structured format, automation of the transfer should be possible which would mean that time is saved as records would not have to be manually typed into QADDS and would reduce the chance of human error when entering the records. However, as human input is required in the first instance to get data into RIS, filtration mechanisms will be required to ensure the quality of the data used to produce audits.

This paper describes the method of inserting data from RIS into QADDS, the necessary filtration of data and the offshoot design of a clinical audit report based around the quality of the initial RIS data.

## II. METHOD

### A. Feasibility

When previously carrying out patient dose audits, the following data was needed for the record to be entered into QADDS.

- Date
- Modality
- Patient ID
- Gender
- Age
- Size
- Height
- Weight
- Examination
- Projection
- kV
- mAs
- Focus
- FSD
- Tube Room
- Operator

This list of fields is based around a ‘Gold Standard’ [5] for patient dose records as such records can then permit more detailed assessments of radiological practice as part of optimization strategies. Surface Entrance Air Kerma (SEAK) and Entrance Surface Dose (ESD) would then be calculated using the following formulae [6]

$$SEAK = OP_{kv} \times mAs \times \left( \frac{1}{FSD^2} \right)$$

$$ESD = SEAK \times 1.3$$

$OP_{kv}$  was determined by referencing the given kV against a range of normalized outputs at different kVs for the given room. If an exact match could not be found, a value would be extrapolated using a standard technique. FSD is assumed in meters.

The 30% mark-up on SEAK used to produce ESD is derived from the average mark-up specified by the Monte Carlo factors [2] for individual examinations.

Initial meetings were set up with several RIS managers from different sites to discuss the concept and to determine if the data required by QADDS was present in RIS, and what format the data could be exported to.

Most of the fields needed were present, with the exception of FSD. It was felt, however, that an assumption could be made on FSD based around local radiographic procedure. A study of previous dose data from audits carried out by IRS showed that all FSD were within 1 standard deviation of the local guideline distance and so it was thought that an assumption in this case would be satisfactory.

The data itself could be exported into 3 different formats; XML, comma separated values (CSV) and Excel. It was felt that XML would be the preferential format to begin development of a solution with as it provided the data in a well structured format e.g. all kV values would be written as “<kV>[value]</kV>”

### B. Proof of Concept

Now that it had been shown that using RIS data to populate QADDS for the purposes of carrying out patient dose audits was feasible, development of a prototype could begin to ‘prove the concept’.

Work began on developing an application for the Microsoft Windows platform that would interrogate an XML file with RIS data in it, and insert records in the QADDS database. This initial development was done using a sample of 2000 records from a single room for a single examination and focussed on plain film examinations. The reason for using a single room and examination was that the room and exam names/codes used in RIS often differed to those in QADDS. It was therefore necessary for a user to input the QADDS room and exam name into the supplied text boxes on the prototype application.

When development was completed, the 2000 records in the XML file were inserted by the application in under a minute. Compare this with the 2 weeks it took a member of staff to enter the same 2000 records manually and it is clear that this was a step in the right direction

### C. Refinements

Something that was made clear during the prototyping was that not all of the data entered into RIS was done so properly. Quite often there would be missing data, or kV and mAs values of ‘0’. The application needed to have filters in place to catch any such data. A filter system was developed that also reported back on the number of records

present in the file, how many were entered into QADDS and how many were skipped. Each record that was skipped had details of why this was so to aid with debugging.

Development was also undertaken in order to transform the data in formats other than XML into the same structure as the XML file. This meant that the application was now able to handle data in a variety of different formats.

Although the prototype was a success, it still required a user to input data and would only handle files containing single rooms and exam types. Refinements were made to the application and to the database structure of QADDS itself to allow each room and exam name to be tagged with a 'RIS Name' as well as allowing exams to have their assumptions for FSD and focus defined individually. Once this was done, user interaction was reduced to exporting the data from RIS. However, the application still required a user to be logged into Windows and to open the application.

To this end, the application was re-developed into a Windows service. This would allow the application to run automatically as soon as Windows started up and did not require a user to be logged in.

The service was developed so that it could monitor a specific folder for any of the file RIS data types. When it found one, it would insert the data within into QADDS. This gave sites the ability to send files via file transfer protocol (FTP) to the QADDS server and have their data uploaded instantly.

#### D. Clinical Audit

As previously mentioned, text reports were now being produced detailing numbers of records inserted and skipped. Although these were originally designed to aid the debugging process, it was felt that this data would be a useful tool for department managers. It would allow them to view details of whether their RIS was being populated properly. Functionality was added to export this data to Excel and expanded the data to include a complete breakdown of records by examination, room and operator.

These reports were shown to RIS managers who were asked to comment on what they liked, what they didn't like, and what they would like to see included. This led to the development of reports detailing the tubeload [7-8] each room had been subjected to.

$$Tubeload = \sum (kV \times mAs)$$

This could be used along side the total number of examinations per room to see if a tube was being over utilised, which could lead to a premature drop in performance and need for replacement.

#### E. Rollout

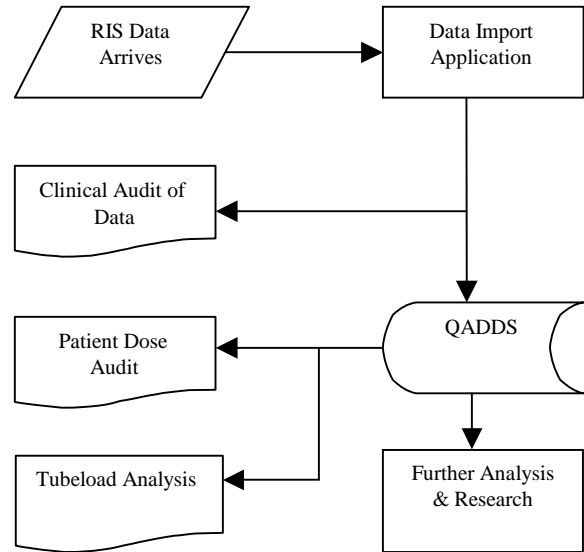


Fig. 1 – Workflow for analysing and reporting on RIS data

The workflow in Figure 1 shows the process now in place to receive and deal with RIS data. The use of RIS data to create patient dose and clinical audit reports was rolled out as a service to the four sites that had helped with the overall process by offering data and feedback. There are still other avenues that can be explored with this data and further analysis and research will continue.

### III. RESULTS

QADDS now has over 100,000 patient dose records that can be audited.

The majority of this data came from Site A with whom IRS had worked closely to develop the entire process. They provided 86,138 records for an 18-month period for 6 of their general x-ray rooms. Of these records it was shown that 82,840 (96%) were auditable. A full dose audit was carried out on these rooms; all of the exams audited were within the national diagnostic reference levels [9].

### IV. CONCLUSIONS

The goal of using RIS data to perform patient dose audits has been achieved. The process of transferring the data from RIS into QADDS is nearly fully automated and requires no additional user input.

A process has now been set up whereby sites send data to IRS on a regular basis and have it reported on in a much more expedient manner than previously.

The clinical audit reports that were first developed as an offshoot have been well received, as has the analysis of tubeload.

These three reports combine to give managers an optimization tool, a means to indentify if staff and equipment are being under or over used, as well as being able to highlight possible staff training needs.

As there are now large amounts of data being pooled in a central repository, there is a basis for large-scale patient dose audits both regionally and nationally [4].

Further work is to be carried out to support all modalities as well as looking to other sources of data such as DICOM headers.

The possibility exists of working with RIS providers to provide a direct link between RIS and QADDS so that every time a dose is recorded in RIS, it is transferred to QADDS.

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